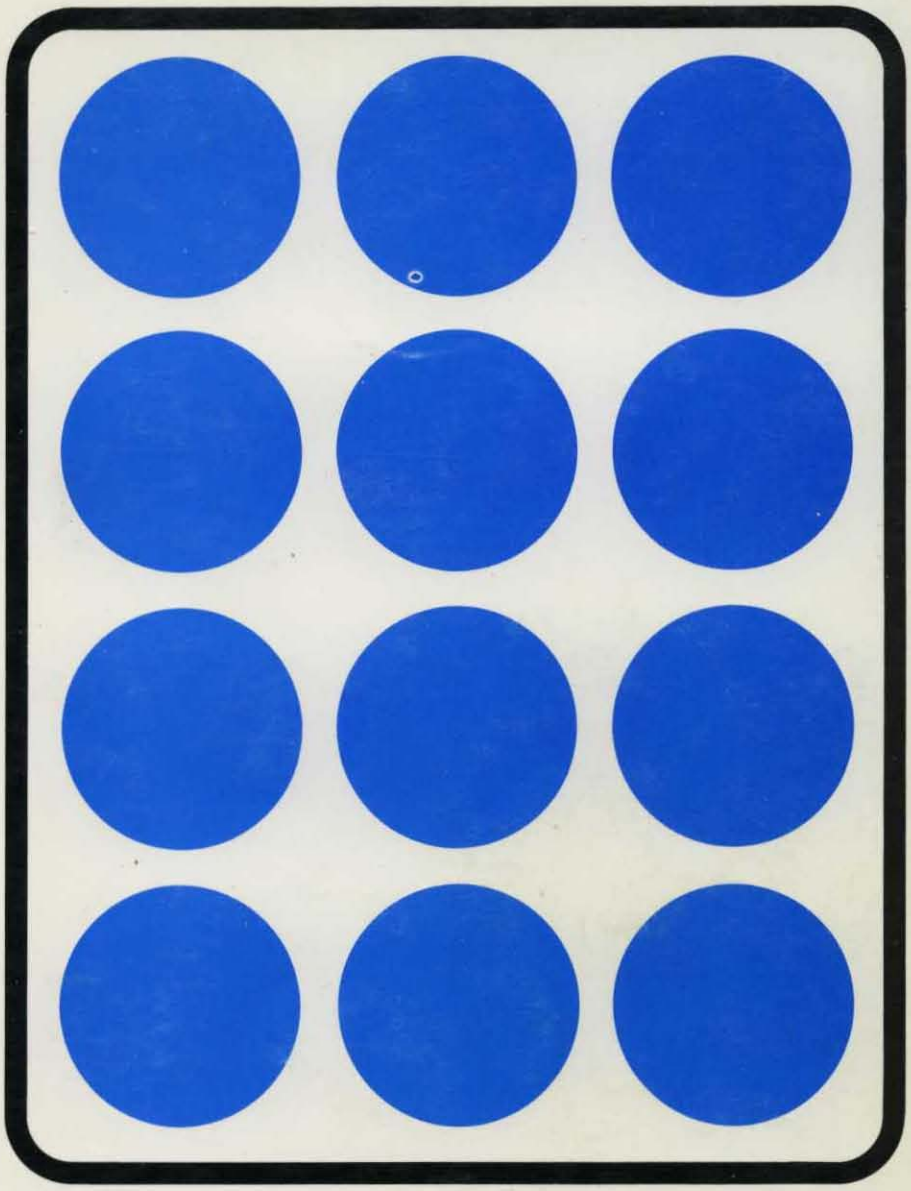
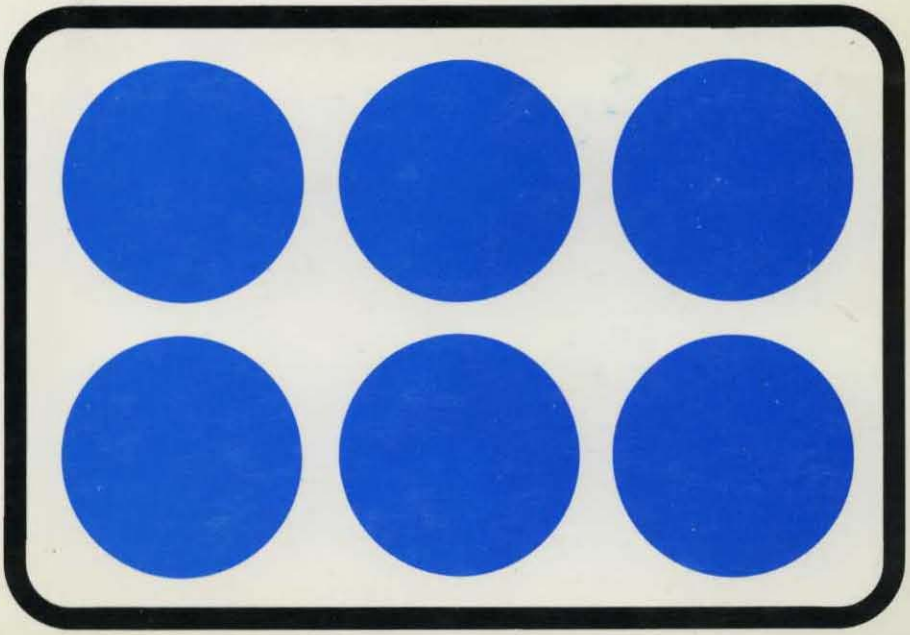


1992 DISK/TREND® REPORT

RIGID DISK DRIVES



1992 DISK/TREND® REPORT

RIGID DISK DRIVES

October, 1992

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FOREWORD

The rigid disk drive industry has completed another hectic year, and several of the leading independent manufacturers of noncaptive drives have even managed to increase profitability. It was very helpful that personal computer manufacturers underestimated their disk drive requirements, that a shortage of drives for PC's lasted almost a year, and that drive manufacturers could see little reason to reduce their prices.

However, good things don't last forever. Only the newest drives are still on allocation, price competition is back, and drive manufacturers are still scrambling to get to the market early with major new products. As usual, those who can maintain the product development pace demanded by this industry are most likely to be prosperous next year.

The DISK/TREND Report has now been reporting on the rigid disk drive industry for sixteen years, most of which have been enjoyable as well as exciting. And we expect to be at it again next year. Our 1992 report on optical disk drives was published in July, and this report on rigid disk drives will be followed, as usual, with a separate report on flexible disk drives to be released in November.

We are always willing to help you at any time by providing additional information on the industry which we may have available. Your suggestions for improvements in the DISK/TREND report are always welcome and are sincerely appreciated.

James N. Porter

Robert H. Katzive

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INTRODUCTION

The DISK/TREND Report has a new look this year. The typography has been updated, but we've been careful to maintain the same organization of all data throughout the report to avoid confusing long-term users.

A few more DISK/TREND product groups have been changed. The product group covering fixed disk drives with less than 30 megabytes capacity was very appropriate for the first 15 years of the DISK/TREND Report, but not today. With shipments of drives below 30 megabytes dropping to levels well below a million units per year, we've combined these drives and the 30-60 megabyte group into a new product group covering Fixed disk drives, less than 60 megabytes.

The opposite situation was true for fixed disk drives with 100-300 megabyte capacities, a DISK/TREND product group since 1982. This product group had become too large in shipments, and now represents two distinct clusters of product capacities. So in this year's report that group has been split into two new product groups: Fixed disk drives, 100-200 megabytes and Fixed disk drives, 200-300 megabytes.

Product groups are based on FORMATTED capacities. As we mentioned last year, it was becoming clear during the last few years that it would be necessary to change our traditional system of assigning individual disk drives to DISK/TREND product groups based on unformatted capacities. That system was followed since the first DISK/TREND Report in 1977, but in recent years the advent of embedded controllers has meant that an overwhelming majority of drives are now specified in formatted capacities. Therefore, we've changed our system, and all drives are now grouped by formatted capacities. In the situations where individual drives without embedded controllers are still specified with unformatted capacities, we have estimated the typical formatted capacity for each drive and placed it in the appropriate group, even though the unformatted capacity is shown in the specifications section.

New information on price per megabyte. For many years we've been very skeptical about much of the information on price per megabyte used in the industry. The problem is usually either that the information is too broad to be meaningful, or that data describing a single level of distribution is used to describe the industry in general. To help correct the problem we've prepared a standard table which now appears in each section of this report -- and which should avoid the usual confusion by clearly showing the five year price per megabyte trend for each product group, broken down by distribution channel, with a further break down by drive disk diameter. The summary section also has separate tables for captive and noncaptive shipments, with price per megabyte data for each product group.

SUMMARY: RIGID MAGNETIC DISK DRIVES

Industry size

As expected, this year's DISK/TREND data confirmed a slight dip in the industry's total rigid disk drive revenues for 1991, which were down 3.7% from the previous year. Unfortunately, total revenues for 1992 are also expected to be slightly lower, this time 2.5% below last year. The problem has been the same in each year: Captive disk drive revenues were declining rapidly enough to drag the industry's overall revenue total into the negative area.

The manufacturers of captive disk drives, those sold with computer systems made by the same company, are not going out of business. In fact, unit shipments of captive drives are increasing. The difficulty is that older drives using large disks are rapidly being displaced by newer drives using smaller disks and selling at much lower prices. Competitive pricing pressures on computer systems have also forced major producers of captive drives to make severe price cuts on disk drives. For example, at the beginning of 1992 IBM's list price for 160 megabyte drives sold with PS/2 personal computers was $1,485, but by summer the price was down to $725. The forecasted 1992 worldwide revenues for captive drives are $9.9 billion, down 10.6%. After some mild sales fluctuations, total captive revenues are projected to be at about the same level in 1995.

Noncaptive drive sales are expected to show healthy growth this year, with OEM/Integrator revenues up 6.7%, to $6.8 billion, and PCM/Reseller revenues up 8.3%, to $3.9 billion. Shipment growth has slowed in the traditional disk drive markets for mainframes and minicomputers, but drive shipments for personal computers, engineering workstations and network file servers have continued to expand despite an economic recession and muddled governmental economic policies. Noncaptive disk drive revenues were 40.5% of the rigid disk drive worldwide total in 1991, but in 1995 are expected to grow to 51.7% of the total.

Rigid disk drive unit shipment totals have continued to climb. 32.6 million rigid disk drives were shipped in 1991, with the total projected to reach 52.4 million in 1995. These shipments represented 4,710 terabytes of capacity in 1991, and the industry is expected to ship 20,277 terabytes in 1995. 3.5" drives now dominate the industry's shipments, and are expected to hold 63.1% of 1995's shipments, but 2.5" drives will capture 20.4% and 1.8" drives, 13.7%.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

RIGID MAGNETIC DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	7,556.1	11,139.3	6,805.1	9,963.3	7,103.3	10,407.4	7,037.9	10,447.0	6,582.3	10,076.6
Other U.S. Captive	495.8	988.2	580.4	1,034.6	619.2	1,044.4	746.8	1,338.0	856.8	1,598.3
TOTAL U.S. CAPTIVE	8,051.9	12,127.5	7,385.5	10,997.9	7,722.5	11,451.8	7,784.7	11,785.0	7,439.1	11,674.9
PCM/Reseller	1,681.0	2,614.5	1,864.0	2,848.6	2,132.4	3,167.2	2,292.1	3,354.4	2,549.1	3,662.6
OEM/Integrator	3,023.5	4,932.5	3,477.2	5,599.5	4,008.1	6,469.6	4,417.5	7,210.0	4,622.0	7,539.4
TOTAL U.S. NONCAPTIVE	4,704.5	7,547.0	5,341.2	8,448.1	6,140.5	9,636.8	6,709.6	10,564.4	7,171.1	11,202.0
TOTAL U.S. REVENUES	12,756.4	19,674.5	12,726.7	19,446.0	13,863.0	21,088.6	14,494.3	22,349.4	14,610.2	22,876.9
Non-U.S. Manufacturers										
Captive	32.6	2,537.2	24.9	2,323.8	29.5	2,155.6	74.1	1,977.5	110.5	1,801.2
PCM/Reseller	433.5	980.8	453.2	1,044.1	506.4	1,164.4	515.7	1,180.3	563.9	1,246.4
OEM/Integrator	358.3	1,439.5	461.5	1,199.4	544.0	1,358.6	701.2	1,706.7	847.5	1,999.8
TOTAL NON-U.S. REVENUES	824.4	4,957.5	939.6	4,567.3	1,079.9	4,678.6	1,291.0	4,864.5	1,521.9	5,047.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	13,580.8	24,632.0	13,666.3	24,013.3	14,942.9	25,767.2	15,785.3	27,213.9	16,132.1	27,924.3

Marketing channels

As the degree of technical difficulty in developing and manufacturing rigid disk drives increases with the growth in sales volume, the number of participating drive manufacturers continues to shrink. Last year's total of 57 companies is down to 47 this year. 16 companies dropped off the list, but most had contributed very little to the shipment statistics during the last few years. Six new additions include two U.S. firms and one each from Korea, Taiwan, Japan and Brazil.

Two of the "new" companies on the list are actually manufacturing disk drive product lines purchased from others. The Japanese firm Xebec acquired rights to all of the existing production drives of Kalok in the first half of 1992, and the Taiwanese firm Myrica purchased rights during the same period to manufacture the Rodime product line, out of production since mid-1991. Rodime, the first company to produce a 3.5" drive, remains in existence, not as a drive manufacturer, but as a licensor of its famous patents on the 3.5" drive form factor.

If you are using the DISK/TREND Report for the first time, it is important to note that we use sales revenue totals in the same way that individual drive manufacturers show them in their financial reports. The price used for each drive is the estimated value at the first time it is sold to a nonaffiliated buyer, at captive end user, PCM/Reseller or OEM/Integrator levels. Prices are based on disk drives alone, without separate 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. For example, captive drive revenues for 1991 totaled $14.7 billion, 59.5% of the worldwide total for all distribution channels. But 1991 captive drive shipments totaled $4.7 billion, only 14.3% of all worldwide shipments. The reason for the large difference in the percentages is found in the higher end user prices at which captive drives are sold and the fact that a higher percentage of captive drives are expensive high-end models.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1991 Revenues $M	1991 Revenues %	1992 Forecast $M	1992 Forecast %	1993 Forecast $M	1993 Forecast %	1994 Forecast $M	1994 Forecast %	1995 Forecast $M	1995 Forecast %
U.S. Manufacturers										
IBM Captive	11,139.3	45.2%	9,963.3	41.4%	10,407.4	40.3%	10,447.0	38.3%	10,076.6	36.0%
	-6.0%		-10.6%		+4.5%		+.4%		-3.5%	
Other U.S. Captive	988.2	4.0%	1,034.6	4.3%	1,044.4	4.0%	1,338.0	4.9%	1,598.3	5.7%
	-39.3%		+4.7%		+.9%		+28.1%		+19.5%	
PCM/Reseller	2,614.5	10.6%	2,848.6	11.8%	3,167.2	12.2%	3,354.4	12.3%	3,662.6	13.1%
	-1.0%		+9.0%		+11.2%		+5.9%		+9.2%	
OEM/Integrator	4,932.5	20.0%	5,599.5	23.3%	6,469.6	25.1%	7,210.0	26.4%	7,539.4	26.9%
	+23.5%		+13.5%		+15.5%		+11.4%		+4.6%	
Total U.S. Manufacturers	19,674.5	79.8%	19,446.0	80.8%	21,088.6	81.6%	22,349.4	81.9%	22,876.9	81.7%
	-2.2%		-1.2%		+8.4%		+6.0%		+2.4%	
Non-U.S. Manufacturers										
Captive	2,537.2	10.3%	2,323.8	9.6%	2,155.6	8.3%	1,977.5	7.2%	1,801.2	6.4%
	-14.6%		-8.4%		-7.2%		-8.3%		-8.9%	
PCM/Reseller	980.8	3.9%	1,044.1	4.3%	1,164.4	4.5%	1,180.3	4.3%	1,246.4	4.4%
	+18.2%		+6.5%		+11.5%		+1.4%		+5.6%	
OEM/Integrator	1,439.5	6.0%	1,199.4	5.3%	1,358.6	5.6%	1,706.7	6.6%	1,999.8	7.5%
	-13.8%		-16.7%		+13.3%		+25.6%		+17.2%	
Total Non-U.S. Manufacturers	4,957.5	20.2%	4,567.3	19.2%	4,678.6	18.4%	4,864.5	18.1%	5,047.4	18.3%
	-9.4%		-7.9%		+2.4%		+4.0%		+3.8%	
Worldwide Recap										
Captive	14,664.7	59.5%	13,321.7	55.5%	13,607.4	52.8%	13,762.5	50.6%	13,476.1	48.3%
	-10.8%		-9.2%		+2.1%		+1.1%		-2.1%	
PCM/Reseller	3,595.3	14.6%	3,892.7	16.2%	4,331.6	16.8%	4,534.7	16.7%	4,909.0	17.6%
	+3.6%		+8.3%		+11.3%		+4.7%		+8.3%	
OEM/Integrator	6,372.0	25.9%	6,798.9	28.3%	7,828.2	30.4%	8,916.7	32.7%	9,539.2	34.1%
	+12.5%		+6.7%		+15.1%		+13.9%		+7.0%	
Total All Manufacturers	24,632.0	100.0%	24,013.3	100.0%	25,767.2	100.0%	27,213.9	100.0%	27,924.3	100.0%
	-3.7%		-2.5%		+7.3%		+5.6%		+2.6%	

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

Product mix

The average disk drive capacity shipped with new personal computers continues to rise faster than expected. 100-200 megabyte drives have become the product group with the highest shipment volume in 1992, with an estimated 11.6 million drives. That product group is expected to still be the largest in 1995, with 16.4 million drives, but starting to decline. Naturally, its principal rival in 1995 will be the next higher group, with 200-300 megabytes capacity, at 14.7 million drives, and still growing. Underlying the spectacular shipment growth for these capacity ranges will be the continually increasing disk storage requirements of new software such as Microsoft Windows, Windows NT, and IBM's OS/2.

Although the 200-300 megabyte group is expected to maintain the highest average annual shipment growth rate in the 1991-95 period, at 112.5%, the highest capacity drives will also continue to increase shipments at a high rate. Fixed disk drives with 1-2 gigabyte capacity are expected to have an average annual 1991-95 shipment growth rate of 62.6%, with 1995 shipments of 3.2 million drives. The growth rate for drives with more than 2 gigabytes will be 71.4%, with 1995 shipments of 2.2 million drives. Shipments of high capacity drives at such levels is a new development for the industry, and indicates the growing importance of networks of all types, and their rapidly increasing storage requirements.

Since 1989, the industry has shipped more 3.5" drives than any other form factor. Boosted initially by the personal computer market and later by workstation and file server requirements, 3.5" drives provided 79.9% of 1991's unit shipments, a total of 26 million drives. Increased shipments are expected this year and in 1993, but the 1994 and 1995 shipments of 3.5" drives are projected to hover at about 33 million units per year, then decline.

The long-term problem for the 3.5" drive format, and for the larger drives which preceded it, is the industry's 35 year old trend to continually improved areal density. Before the 1995 forecast horizon of this year's DISK/TREND Report, the industry is expected to produce drives with high enough recording densities to store at least 150 megabytes on a single 2.5" disk. When this density is achieved, single disk 2.5" drives will be able to compete directly with 3.5" drives of the same capacity, without the cost disadvantage of using more disks and

heads to achieve a capacity range with critical market importance. When 2.5" drives in the 100-200 megabyte range start to become available at the same price as 3.5" drives, it is expected that many manufacturers of desktop personal computers will use them instead of 3.5" drives, in order to take advantage of 2.5" drives' smaller size, lower power, less heat and quieter operation.

The currently available 2.5" drives have been an essential part of the success story for notebook computers in the four to seven pound range, providing small size, low power requirements and continually increasing storage capacity. While not expected to threaten leadership by 3.5" drives through 1995, shipments of 2.5" drives are expected to reach 10.7 million units in that year, due to the combination of the growing notebook computer market, the existing application for most 2.5" drives, and the expected emergence of the desktop personal computer market as a target.

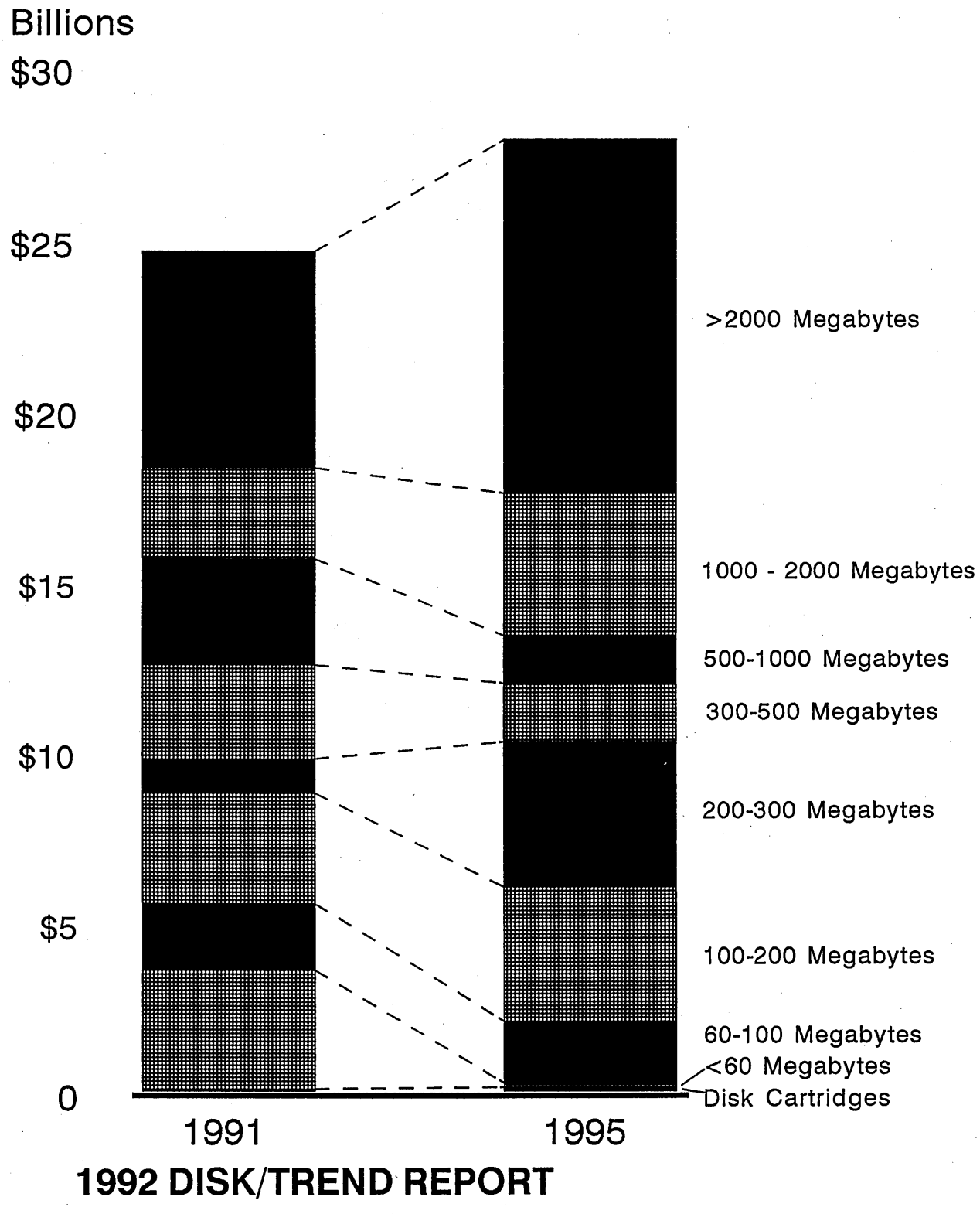
It is more difficult to assess the market development to be expected for 1.8" and smaller drives during the next few years. 1.8" drives shipping today have 64 megabyte capacities, and 1.3" drives have 21 megabytes. Eventually, the areal density curve's inevitable increases will make possible very large capacities in these small drives, but today's capacity limitations are market limitations. The existing notebook computer markets use 80 and 120 megabyte 2.5" drives for the mainstream systems in existing product lines, due to the requirements of software preferred by the majority of customers, and these capacities will trend upward in future years.

DISK/TREND projections predict shipments of 7.2 million 1.8" drives and smaller in 1995, but it is going to take significant improvements in the technology to achieve that sales level. For 1.8" drives it will be critical to achieve a minimum of 80 megabytes on one disk, in order to squeeze the form factor down to the 10.5 millimeter height of the PCMCIA type 3 standard for a removable memory card, to reduce the parts count so prices can be competitive, and to achieve a capacity large enough to enjoy a wide market. This can probably be done in the next year, or perhaps sooner if some of the current development programs for contact recording can be successfully commercialized. For 1.3" drives, it is a matter of finding emerging applications with large enough volume requirements, and which will respond to the drives' outstanding durability, small size and low cost, despite limited initial capacity.

Figure 1

CHANGING PRODUCT MIX

Worldwide Rigid Disk Drive Revenue



1992 DISK/TREND REPORT

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1991 Revenues $M	1991 Revenues %	1992 Forecast $M	1992 Forecast %	1993 Forecast $M	1993 Forecast %	1994 Forecast $M	1994 Forecast %	1995 Forecast $M	1995 Forecast %
DISK CARTRIDGE DRIVES	70.1 +27.7%	.3%	75.9 +8.3%	.3%	93.8 +23.6%	.4%	112.6 +20.0%	.4%	126.0 +11.9%	.5%
FIXED DISK DRIVES less than 60 Megabytes	3,470.4 -27.4%	14.1%	1,678.8 -51.6%	7.0%	658.8 -60.8%	2.6%	222.1 -66.3%	.8%	115.6 -48.0%	.4%
FIXED DISK DRIVES 60 - 100 Megabytes	1,950.5 +10.4%	7.9%	2,435.7 +24.9%	10.1%	2,320.9 -4.7%	9.0%	2,285.5 -1.5%	8.4%	1,807.8 -20.9%	6.5%
FIXED DISK DRIVES 100 - 200 Megabytes	3,240.2 +15.7%	13.2%	4,015.7 +23.9%	16.7%	4,508.4 +12.3%	17.5%	4,431.4 -1.7%	16.3%	3,934.1 -11.2%	14.1%
FIXED DISK DRIVES 200 - 300 Megabytes	988.9 +207.2%	4.0%	1,530.1 +54.7%	6.4%	2,734.5 +78.7%	10.6%	3,566.7 +30.4%	13.1%	4,249.5 +19.1%	15.2%
FIXED DISK DRIVES 300 - 500 Megabytes	2,759.6 +8.4%	11.2%	1,608.8 -41.7%	6.7%	1,356.3 -15.7%	5.3%	1,389.1 +2.4%	5.1%	1,720.1 +23.8%	6.2%
FIXED DISK DRIVES 500 Megabytes to 1 GB	3,131.7 +17.2%	12.7%	1,847.1 -41.0%	7.7%	1,411.6 -23.6%	5.5%	1,292.2 -8.5%	4.7%	1,403.5 +8.6%	5.0%
FIXED DISK DRIVES 1 - 2 Gigabytes	2,670.3 -33.5%	10.8%	4,275.4 +60.1%	17.8%	3,845.5 -10.1%	14.9%	3,844.2 --	14.1%	4,185.9 +8.9%	15.0%
FIXED DISK DRIVES more than 2 Gigabytes	6,350.3 -3.7%	25.8%	6,545.8 +3.1%	27.3%	8,837.4 +35.0%	34.2%	10,070.1 +13.9%	37.0%	10,381.8 +3.1%	37.1%
Total Worldwide Revenue	24,632.0 -3.7%	100.0%	24,013.3 -2.5%	100.0%	25,767.2 +7.3%	100.0%	27,213.9 +5.6%	100.0%	27,924.3 +2.6%	100.0%
% U.S. Manufacturers	79.8%		80.9%		81.8%		82.1%		81.9%	

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

Figure 2

UNIT SHIPMENT SUMMARY

Worldwide Shipments in Millions of Units

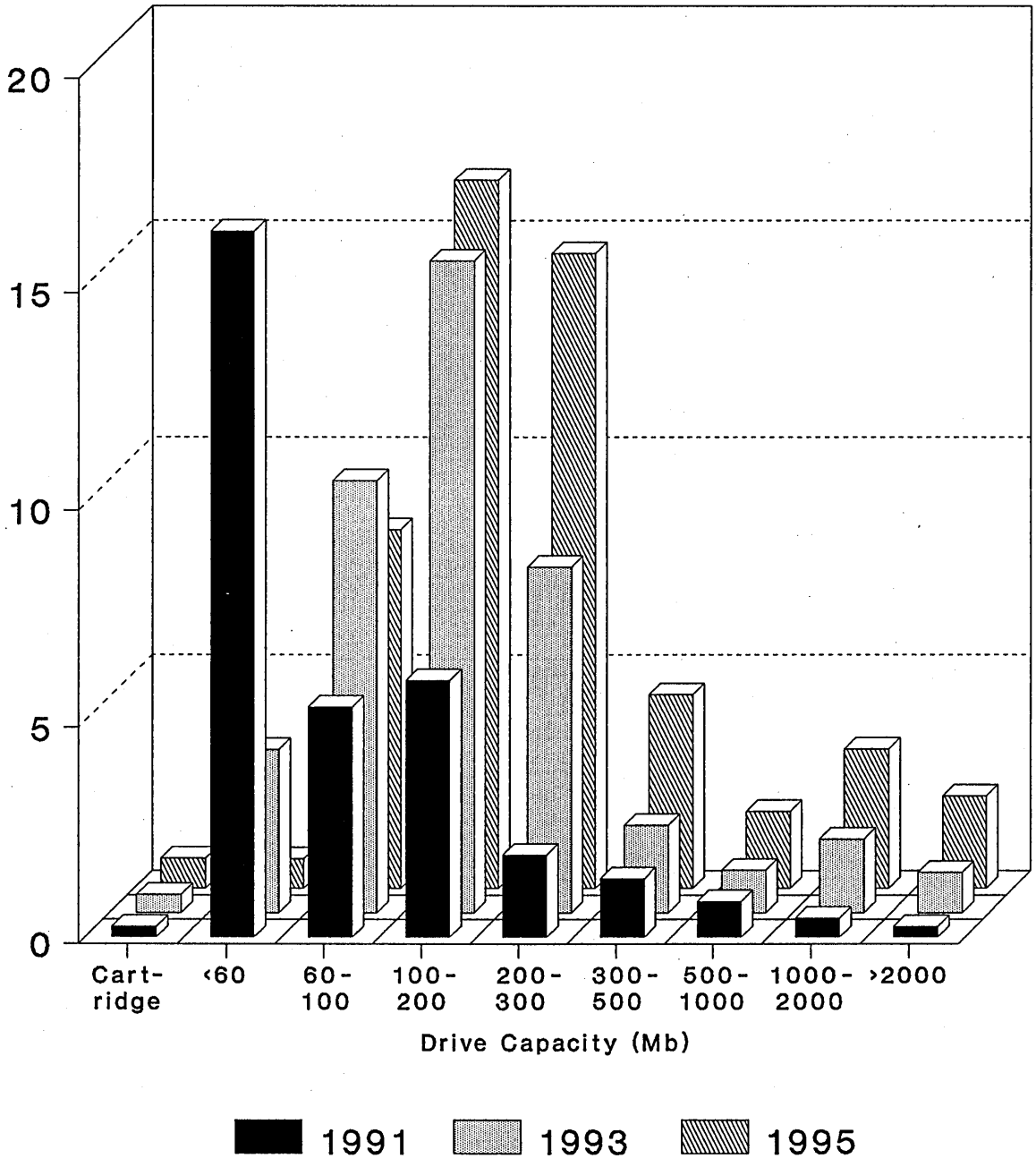


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1991 Shipments Units	1991 Shipments %	1992 Forecast Units	1992 Forecast %	1993 Forecast Units	1993 Forecast %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %
DISK CARTRIDGE DRIVES	242.4	.7%	305.4	.8%	420.0	1.0%	565.0	1.2%	705.0	1.3%
	+59.0%		+26.0%		+37.5%		+34.5%		+24.8%	
FIXED DISK DRIVES less than 60 Megabytes	16,287.0	50.0%	9,011.9	23.9%	3,785.0	8.8%	1,165.0	2.4%	690.0	1.3%
	-9.9%		-44.7%		-58.0%		-69.2%		-40.8%	
FIXED DISK DRIVES 60 - 100 Megabytes	5,331.2	16.4%	8,807.6	23.4%	9,970.0	23.2%	10,130.0	21.1%	8,285.0	15.8%
	+44.1%		+65.2%		+13.2%		+1.6%		-18.2%	
FIXED DISK DRIVES 100 - 200 Megabytes	5,953.5	18.3%	11,566.3	30.7%	15,045.0	35.1%	17,030.0	35.5%	16,355.0	31.2%
	+78.5%		+94.3%		+30.1%		+13.2%		-4.0%	
FIXED DISK DRIVES 200 - 300 Megabytes	1,906.8	5.9%	4,034.6	10.7%	7,990.0	18.6%	11,015.0	23.0%	14,655.0	28.0%
	+282.0%		+111.6%		+98.0%		+37.9%		+33.0%	
FIXED DISK DRIVES 300 - 500 Megabytes	1,358.7	4.2%	1,662.8	4.4%	2,035.0	4.7%	2,715.0	5.7%	4,500.0	8.6%
	+32.8%		+22.4%		+22.4%		+33.4%		+65.7%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	823.8	2.5%	871.1	2.3%	995.0	2.3%	1,265.0	2.6%	1,785.0	3.4%
	+37.8%		+5.7%		+14.2%		+27.1%		+41.1%	
FIXED DISK DRIVES 1 - 2 Gigabytes	447.4	1.4%	1,062.2	2.8%	1,715.0	4.0%	2,475.0	5.2%	3,245.0	6.2%
	+38.7%		+137.4%		+61.5%		+44.3%		+31.1%	
FIXED DISK DRIVES more than 2 Gigabytes	238.5	.6%	362.9	1.0%	934.0	2.2%	1,548.0	3.2%	2,150.0	4.1%
	+42.8%		+52.2%		+157.4%		+65.7%		+38.9%	
Total Worldwide Shipments	32,589.3	100.0%	37,684.8	100.0%	42,889.0	100.0%	47,908.0	100.0%	52,370.0	100.0%
	+16.9%		+15.6%		+13.8%		+11.7%		+9.3%	
% U.S. Manufacturers	87.8%		87.7%		85.4%		82.6%		80.4%	
Total Capacity (Terabytes)	4,710.8		7,298.7		10,970.7		15,420.0		20,277.1	

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

Figure 3

DISK DIAMETER SUMMARY

Worldwide Shipments in Millions of Units

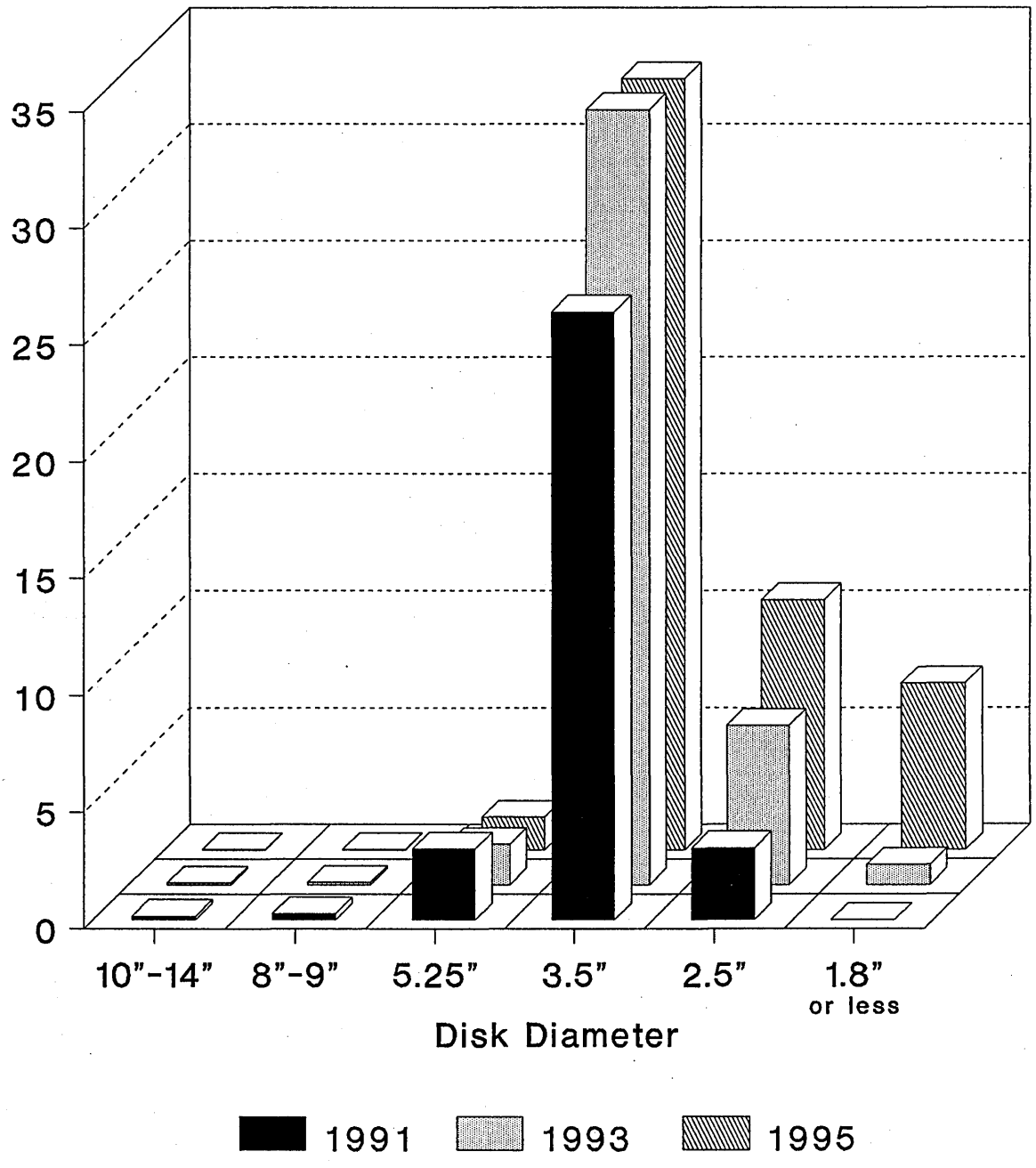


TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
SUMMARY BY DISK DIAMETER

UNIT SHIPMENTS IN THOUSANDS	1991 Shipments Units	1991 Shipments %	Forecast 1992 Units	1992 %	1993 Units	1993 %	1994 Units	1994 %	1995 Units	1995 %
10 - 14 INCH	158.1 -27.4%	.5%	100.5 -36.4%	.3%	85.0 -15.4%	.2%	55.0 -35.3%	.1%	26.0 -52.7%	--
8 - 9 INCH	267.2 -20.0%	.8%	165.3 -38.1%	.4%	113.0 -31.6%	.3%	61.0 -46.0%	.1%	29.0 -52.5%	.1%
5.25 INCH	3,041.1 -54.7%	9.3%	2,069.0 -32.0%	5.5%	1,741.0 -15.9%	4.1%	1,665.0 -4.4%	3.5%	1,408.0 -15.4%	2.7%
3.5 INCH	26,036.4 +31.7%	79.9%	30,350.0 +16.6%	80.5%	33,230.0 +9.5%	77.5%	33,422.0 +.6%	69.8%	33,047.0 -1.1%	63.1%
2.5 INCH	3,085.5 +264.3%	9.5%	4,899.0 +58.8%	13.0%	6,855.0 +39.9%	16.0%	9,835.0 +43.5%	20.5%	10,705.0 +8.9%	20.4%
1.8 INCH OR LESS	1.0 --	--	101.0 --	.3%	865.0 +756.4%	2.0%	2,870.0 +231.8%	6.0%	7,155.0 +149.3%	13.7%
Total Worldwide Shipments	32,589.3 +16.9%	100.0%	37,684.8 +15.6%	100.0%	42,889.0 +13.8%	100.0%	47,908.0 +11.7%	100.0%	52,370.0 +9.3%	100.0%

Notes: 1. Percentage figures with plus/minus signs refer to year-to-year growth rates.

2. Disk cartridge drives with with disk diameters less than 5.25" have been combined with 3.5" drives in this table.

Figure 4

CAPACITY SHIPMENT SUMMARY

Worldwide Shipments in Terabytes

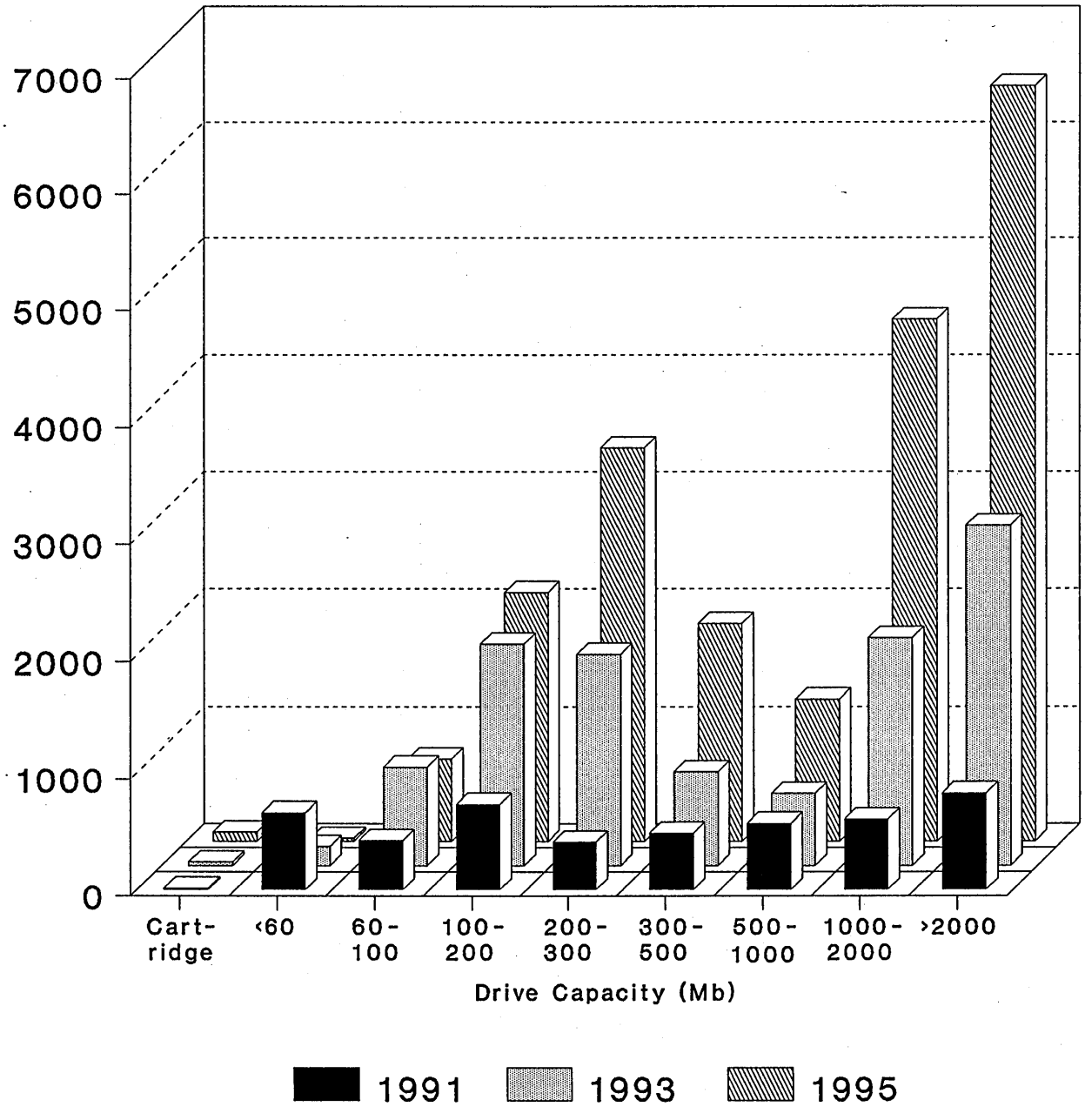


TABLE 6

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	1991 Shipments Tbytes	1991 Shipments %	Forecast 1992 Tbytes	1992 %	1993 Tbytes	1993 %	1994 Tbytes	1994 %	1995 Tbytes	1995 %
DISK CARTRIDGE DRIVES	12.0 +55.8%	.3%	18.5 +54.2%	.3%	30.3 +64.2%	.3%	50.9 +67.6%	.3%	78.4 +54.1%	.4%
FIXED DISK DRIVES less than 60 Megabytes	657.8 -16.7%	14.0%	394.8 -40.0%	5.4%	164.2 -58.4%	1.5%	47.4 -71.1%	.3%	27.9 -41.0%	.1%
FIXED DISK DRIVES 60 - 100 Megabytes	421.6 +24.6%	8.9%	712.4 +69.0%	9.8%	840.9 +18.0%	7.7%	857.5 +2.0%	5.6%	704.7 -17.8%	3.5%
FIXED DISK DRIVES 100 - 200 Megabytes	729.1 +72.0%	15.5%	1,440.5 +97.6%	19.7%	1,884.7 +30.8%	17.2%	2,173.4 +15.3%	14.1%	2,122.3 -2.3%	10.5%
FIXED DISK DRIVES 200 - 300 Megabytes	409.8 +292.2%	8.7%	900.1 +119.6%	12.3%	1,800.0 +100.0%	16.4%	2,498.5 +38.8%	16.2%	3,355.6 +34.3%	16.5%
FIXED DISK DRIVES 300 - 500 Megabytes	484.8 +23.3%	10.3%	637.5 +31.5%	8.7%	800.7 +25.6%	7.3%	1,095.5 +36.8%	7.1%	1,852.3 +69.1%	9.1%
FIXED DISK DRIVES 500 Megabytes to 1 GB	567.5 +30.2%	12.0%	580.0 +2.2%	7.9%	613.5 +5.8%	5.6%	790.6 +28.9%	5.1%	1,212.1 +53.3%	6.0%
FIXED DISK DRIVES 1 - 2 Gigabytes	603.3 +41.8%	12.8%	1,367.9 +126.7%	18.7%	1,938.3 +41.7%	17.7%	3,059.2 +57.8%	19.8%	4,453.6 +45.6%	22.0%
FIXED DISK DRIVES more than 2 Gigabytes	824.9 +22.1%	17.5%	1,247.0 +51.2%	17.1%	2,897.9 +132.4%	26.3%	4,846.7 +67.3%	31.4%	6,469.7 +33.5%	31.9%
Total Capacity (Terabytes)	4,710.8 +26.4%	100.0%	7,298.7 +54.9%	100.0%	10,970.7 +50.3%	100.0%	15,420.0 +40.6%	100.0%	20,277.1 +31.5%	100.0%
% U.S. Manufacturers	82.9%		84.3%		84.2%		83.3%		82.2%	

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

Price per megabyte

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

It is hoped that these tables will help to clarify the price per megabyte trends in various sectors of the rigid disk drive industry -- trends which have frequently been confused by murky and overgeneralized data. It is important to realize that the summary tables in this section include data for many different types of drives, and that a severe price decline may be influenced more by changes in product mix than by price reductions for a specific type of drive. You may notice some data in the tables that doesn't seem to fit the overall pattern, but these situations are usually caused by the unique products or policies of individual manufacturers.

One interesting pattern revealed by comparing the captive and noncaptive summary tables is that the price difference between the two distribution channels is becoming less each year, in most of the capacity groups. For example, in 1991 the average price per megabyte for captive drives in the 100-200 megabyte range was 3.9 times higher than for noncaptive drives. In 1995, the average captive drive price per megabyte is expected to be 2.3 times higher. The reason behind this trend is that captive drive producers are finding it difficult to maintain high drive prices with system sales in the face of increasing price competition from nonintegrated system manufacturers which buy low-cost noncaptive drives.

The effect of continually increasing production of small diameter drives on noncaptive pricing is the major cause of the ever downward trend shown throughout the summary price per megabyte tables and those in each of the product sections. The noncaptive price per megabyte of the drives with highest shipments in 1995, the 100-200 megabyte range, is forecasted to be $1.60. Noncaptive drives with more than 2 gigabyte capacity will be down to 60 cents.

Figure 5

PRICE PER MEGABYTE SUMMARY

Noncaptive Worldwide Shipments ($/MB)

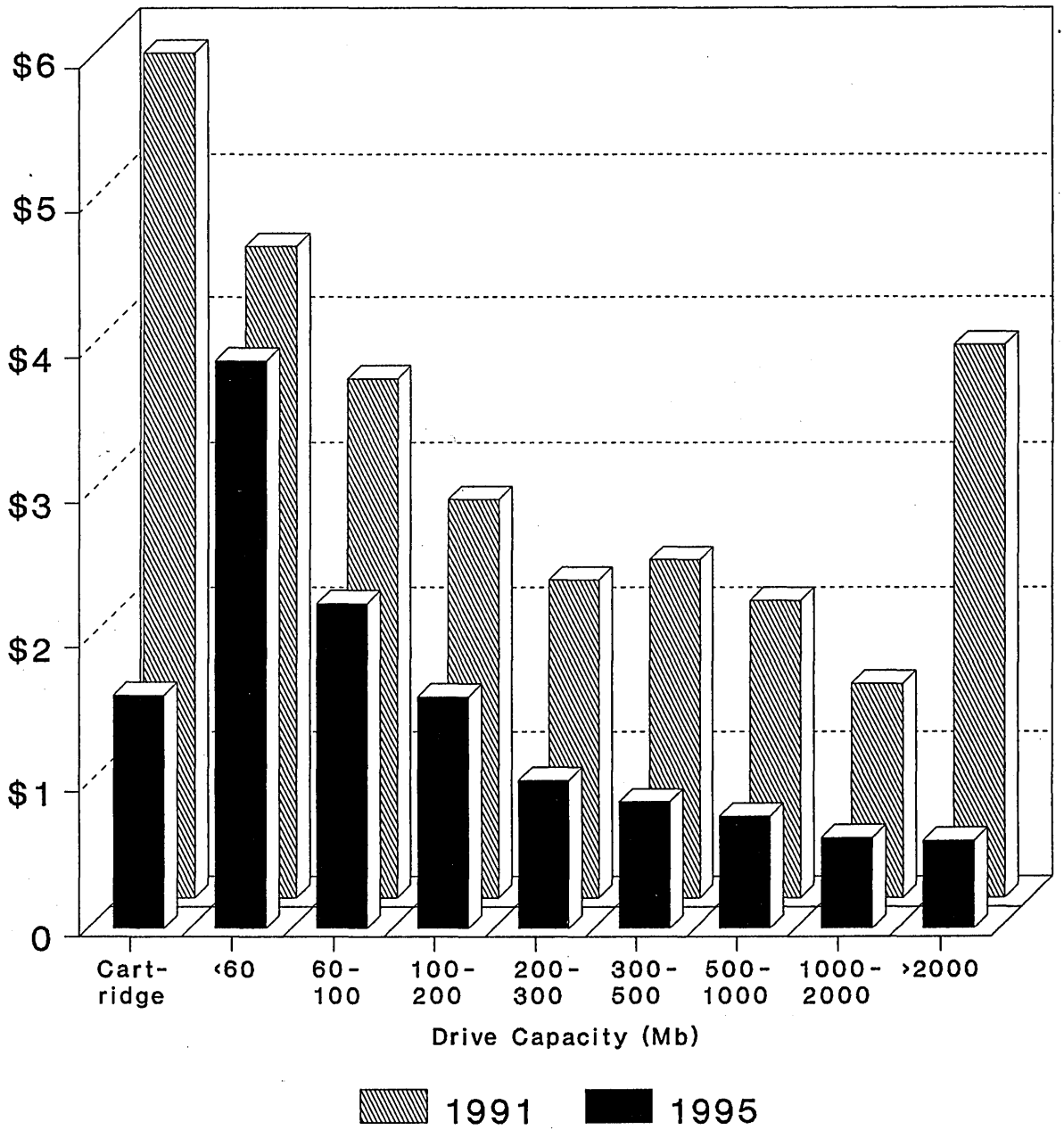


TABLE 7

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1991	1992	1993	1994	1995
DISK CARTRIDGE DRIVES	5.84 -34.0%	4.10 -29.8%	3.09 -24.7%	2.21 -28.4%	1.61 -27.4%
FIXED DISK DRIVES less than 60 Megabytes	4.50 -24.8%	3.68 -18.1%	3.59 -2.6%	4.04 +12.6%	3.92 -2.8%
FIXED DISK DRIVES 60 - 100 Megabytes	3.59 -20.8%	2.74 -23.8%	2.41 -11.9%	2.35 -2.4%	2.25 -4.3%
FIXED DISK DRIVES 100 - 200 Megabytes	2.76 -34.5%	2.05 -25.5%	1.89 -8.2%	1.71 -9.3%	1.60 -6.2%
FIXED DISK DRIVES 200 - 300 Megabytes	2.20 -15.6%	1.55 -29.7%	1.25 -19.3%	1.12 -10.7%	1.02 -8.9%
FIXED DISK DRIVES 300 - 500 Megabytes	2.34 -25.5%	1.82 -22.3%	1.49 -17.8%	1.16 -22.2%	.87 -25.0%
FIXED DISK DRIVES 500 Megabytes to 1 GB	2.06 -15.5%	1.48 -28.2%	1.24 -16.2%	1.01 -18.3%	.77 -23.8%
FIXED DISK DRIVES 1 - 2 Gigabytes	1.48 -48.8%	1.07 -28.1%	.88 -17.2%	.72 -19.0%	.62 -13.9%
FIXED DISK DRIVES more than 2 Gigabytes	3.82 -42.1%	2.03 -46.9%	1.20 -41.0%	.80 -33.1%	.60 -25.6%

Notes: 1. Percentage figures with plus/minus signs refer to year-to-year growth rates.

2. Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total capacity of all drives of that type sold.

TABLE 8

CAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1991	1992	1993	1994	1995
DISK CARTRIDGE DRIVES	--	--	--	--	--
	--	--	--	--	--
FIXED DISK DRIVES less than 60 Megabytes	12.81	9.92	8.44	7.38	7.04
	-52.8%	-22.5%	-14.9%	-12.6%	-4.6%
FIXED DISK DRIVES 60 - 100 Megabytes	9.34	6.91	5.52	5.02	4.36
	-28.0%	-26.1%	-20.1%	-9.0%	-13.3%
FIXED DISK DRIVES 100 - 200 Megabytes	10.70	6.69	5.10	4.29	3.67
	-24.0%	-37.4%	-23.8%	-15.8%	-14.5%
FIXED DISK DRIVES 200 - 300 Megabytes	21.75	6.59	4.15	3.46	2.91
	-38.4%	-69.7%	-37.1%	-16.5%	-16.1%
FIXED DISK DRIVES 300 - 500 Megabytes	11.61	6.11	4.33	3.36	2.91
	-17.8%	-47.4%	-29.2%	-22.3%	-13.5%
FIXED DISK DRIVES 500 Megabytes to 1 GB	12.88	8.43	4.80	3.27	2.41
	-28.3%	-34.5%	-43.0%	-31.9%	-26.3%
FIXED DISK DRIVES 1 - 2 Gigabytes	12.13	6.27	4.78	3.42	2.87
	-41.1%	-48.3%	-23.7%	-28.6%	-15.9%
FIXED DISK DRIVES more than 2 Gigabytes	10.51	8.75	5.09	3.74	3.07
	-17.7%	-16.7%	-41.9%	-26.5%	-18.0%

Notes: 1. Percentage figures with plus/minus signs refer to year-to-year growth rates.

2. Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total capacity of all drives of that type sold.

Noncaptive market

Although only 40.5% of 1991's total rigid disk drive revenues were derived from noncaptive sales, 85.7% of the industry's unit shipments were noncaptive. During the last ten years, independent disk drive manufacturers have moved quickly to exploit technology advances which have enabled them to respond with appropriate products for the computer industry's fastest growth sectors: Desktop and portable personal computers, engineering workstations and network file servers. In the process, they led the industry in developing high volume production capability for small drive formats, starting with 5.25", then 3.5", and more recently with 2.5". OEM drives in each of these form factors arrived in the market well before captive drives and set the patterns for the entire industry.

Again this year, the DISK/TREND Report includes a separate set of tables which summarize worldwide data for noncaptive drives. Tables 9, 10 and 11 show revenue, unit shipments and shipped capacity expressed in terabytes for total noncaptive drive sales, by summarizing all PCM/Reseller and OEM/Integrator data from each of the nine DISK/TREND product groups.

With continued growth in noncaptive drive shipments, structural changes in the industry are apparently inevitable. Today's leaders in noncaptive drives are mostly American companies, which were able to successfully sell to rapidly growing system manufacturers because they were able to deliver new disk drive configurations early in each product life cycle. Young California and Colorado companies had the right formula for success, as they listened to customers' requests, made management decisions quickly, and moved rapidly to the most cost-effective manufacturing sites. The surviving U.S. start-up companies of the 1980's are now large firms, several with annual sales between $1-3 billion.

But new challenges now face the noncaptive drive leaders. Large size usually slows down even well managed organizations. Unfortunately, there is no time for the industry leaders to pause and reflect. The competition is still there -- though little of it now comes from new start-ups, since venture capital firms don't have much interest in such competitive industries. If the leading U.S. noncaptive drive manufacturers slow down, they will soon lose market share to firms from other countries -- and to system manufacturers such as IBM, DEC and H-P, now all active in noncaptive disk drive markets, and finding success.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1991 Revenues $M	1991 Revenues %	1992 Forecast $M	1992 Forecast %	1993 Forecast $M	1993 Forecast %	1994 Forecast $M	1994 Forecast %	1995 Forecast $M	1995 Forecast %
DISK CARTRIDGE DRIVES	70.1 +27.7%	.7%	75.9 +8.3%	.7%	93.8 +23.6%	.8%	112.6 +20.0%	.8%	126.0 +11.9%	.9%
FIXED DISK DRIVES less than 60 Megabytes	2,683.8 -25.0%	27.0%	1,321.6 -50.8%	12.5%	537.3 -59.3%	4.4%	154.4 -71.3%	1.2%	102.4 -33.7%	.7%
FIXED DISK DRIVES 60 - 100 Megabytes	1,243.1 +25.8%	12.5%	1,631.9 +31.3%	15.2%	1,801.2 +10.4%	14.9%	1,782.6 -1.0%	13.3%	1,351.3 -24.2%	9.3%
FIXED DISK DRIVES 100 - 200 Megabytes	1,584.6 +17.2%	15.9%	2,492.1 +57.3%	23.3%	2,993.6 +20.1%	24.6%	3,242.9 +8.3%	24.1%	2,992.5 -7.7%	20.8%
FIXED DISK DRIVES 200 - 300 Megabytes	893.2 +232.2%	9.0%	1,353.4 +51.5%	12.7%	2,043.7 +51.0%	16.8%	2,421.5 +18.5%	18.0%	2,962.0 +22.3%	20.5%
FIXED DISK DRIVES 300 - 500 Megabytes	723.8 +2.1%	7.2%	968.2 +33.8%	9.1%	1,111.6 +14.8%	9.2%	1,211.2 +9.0%	9.1%	1,568.3 +29.5%	10.9%
FIXED DISK DRIVES 500 Megabytes to 1 GB	797.6 +7.2%	8.0%	648.8 -18.7%	6.0%	535.5 -17.5%	4.4%	582.2 +8.7%	4.3%	717.5 +23.2%	5.0%
FIXED DISK DRIVES 1 - 2 Gigabytes	647.5 +19.3%	6.5%	882.5 +36.3%	8.3%	1,228.5 +39.2%	10.1%	1,749.7 +42.4%	13.0%	2,348.9 +34.2%	16.2%
FIXED DISK DRIVES more than 2 Gigabytes	1,323.6 +51.0%	13.2%	1,317.2 -.5%	12.2%	1,814.6 +37.8%	14.8%	2,194.3 +20.9%	16.2%	2,279.3 +3.9%	15.7%
Total Worldwide Revenues	9,967.3 +9.1%	100.0%	10,691.6 +7.3%	100.0%	12,159.8 +13.7%	100.0%	13,451.4 +10.6%	100.0%	14,448.2 +7.4%	100.0%
% U.S. Manufacturers	75.7%		79.0%		79.2%		78.5%		77.5%	

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

TABLE 10

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1991 Shipments Units	1991 Shipments %	Forecast 1992 Units	1992 %	1993 Units	1993 %	1994 Units	1994 %	1995 Units	1995 %
DISK CARTRIDGE DRIVES	242.4	.9%	305.4	.9%	420.0	1.1%	565.0	1.4%	705.0	1.6%
	+59.0%		+26.0%		+37.5%		+34.5%		+24.8%	
FIXED DISK DRIVES less than 60 Megabytes	14,791.6	53.0%	8,142.0	25.3%	3,443.0	9.4%	945.0	2.3%	645.0	1.4%
	-8.5%		-45.0%		-57.7%		-72.6%		-31.7%	
FIXED DISK DRIVES 60 - 100 Megabytes	4,360.6	15.7%	7,310.1	22.6%	8,829.5	24.0%	8,930.0	21.8%	7,030.0	15.8%
	+52.2%		+67.6%		+20.8%		+1.1%		-21.3%	
FIXED DISK DRIVES 100 - 200 Megabytes	4,761.8	17.0%	9,806.0	30.3%	12,694.5	34.4%	14,805.0	36.1%	14,235.0	31.7%
	+86.3%		+105.9%		+29.5%		+16.6%		-3.9%	
FIXED DISK DRIVES 200 - 300 Megabytes	1,888.5	6.8%	3,904.8	12.1%	7,177.5	19.5%	9,471.0	23.1%	12,635.0	28.2%
	+284.7%		+106.8%		+83.8%		+32.0%		+33.4%	
FIXED DISK DRIVES 300 - 500 Megabytes	846.8	3.0%	1,391.8	4.3%	1,890.0	5.1%	2,579.0	6.3%	4,365.0	9.8%
	+31.6%		+64.4%		+35.8%		+36.5%		+69.3%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	583.6	2.1%	689.0	2.1%	702.0	1.9%	897.0	2.2%	1,300.0	2.9%
	+28.3%		+18.1%		+1.9%		+27.8%		+44.9%	
FIXED DISK DRIVES 1 - 2 Gigabytes	318.1	1.1%	575.8	1.8%	1,203.0	3.3%	1,933.0	4.7%	2,690.0	6.0%
	+132.7%		+81.0%		+108.9%		+60.7%		+39.2%	
FIXED DISK DRIVES more than 2 Gigabytes	126.9	.4%	232.9	.6%	520.0	1.3%	906.0	2.1%	1,224.0	2.6%
	+163.3%		+83.5%		+123.3%		+74.2%		+35.1%	
Total Worldwide Shipments	27,920.3	100.0%	32,357.8	100.0%	36,879.5	100.0%	41,031.0	100.0%	44,829.0	100.0%
	+18.7%		+15.9%		+14.0%		+11.3%		+9.3%	
% U.S. Manufacturers	88.2%		88.1%		85.6%		82.7%		80.3%	
Total Capacity (Terabytes)	3,413.0	100.0%	5,506.6	100.0%	8,232.2	100.0%	11,715.6	100.0%	15,853.2	100.0%

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

TABLE 11

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPPED IN TERABYTES	1991 Capacity Units	1991 Capacity %	1992 Forecast Units	1992 Forecast %	1993 Forecast Units	1993 Forecast %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %
DISK CARTRIDGE DRIVES	12.0 +55.8%	.4%	18.5 +54.2%	.3%	30.3 +64.2%	.4%	50.9 +67.6%	.4%	78.4 +54.1%	.5%
FIXED DISK DRIVES less than 60 Megabytes	596.4 -16.5%	17.5%	358.8 -39.8%	6.6%	149.8 -58.2%	1.8%	38.2 -74.5%	.4%	26.0 -31.8%	.2%
FIXED DISK DRIVES 60 - 100 Megabytes	345.9 +24.6%	10.2%	596.0 +72.3%	10.8%	746.7 +25.3%	9.1%	757.4 +1.4%	6.4%	599.9 -20.8%	3.7%
FIXED DISK DRIVES 100 - 200 Megabytes	574.3 +79.0%	16.8%	1,212.8 +111.2%	22.1%	1,587.4 +30.9%	19.3%	1,896.5 +19.5%	16.3%	1,865.9 -1.6%	11.9%
FIXED DISK DRIVES 200 - 300 Megabytes	405.4 +293.6%	11.9%	873.3 +115.4%	15.9%	1,633.4 +87.0%	19.9%	2,168.0 +32.7%	18.5%	2,912.6 +34.3%	18.4%
FIXED DISK DRIVES 300 - 500 Megabytes	309.5 +24.6%	9.0%	532.7 +72.1%	9.6%	744.1 +39.7%	9.0%	1,042.6 +40.1%	8.9%	1,800.1 +72.7%	11.3%
FIXED DISK DRIVES 500 Megabytes to 1 GB	386.3 +13.9%	11.4%	437.9 +13.4%	8.0%	431.1 -1.5%	5.3%	573.7 +33.1%	4.9%	927.8 +61.7%	5.9%
FIXED DISK DRIVES 1 - 2 Gigabytes	436.6 +130.5%	12.7%	827.1 +89.4%	15.0%	1,391.3 +68.2%	16.9%	2,446.2 +75.8%	20.9%	3,814.6 +55.9%	24.1%
FIXED DISK DRIVES more than 2 Gigabytes	346.6 +103.2%	10.1%	649.5 +87.4%	11.7%	1,517.7 +133.7%	18.3%	2,741.9 +80.7%	23.3%	3,827.6 +39.6%	24.0%
Total Capacity (Terabytes)	3,413.0 +37.1%	100.0%	5,506.6 +61.3%	100.0%	8,232.2 +49.5%	100.0%	11,715.6 +42.3%	100.0%	15,853.2 +35.3%	100.0%
% U.S. Manufacturers	81.1%		83.0%		82.5%		81.4%		80.6%	

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

TABLE 12

1991 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1991 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Conner Peripherals	--	--	358.4	10.0	1,209.2	19.0	1,567.6	6.4
Digital Equipment	776.4	5.3	--	--	--	--	776.4	3.2
Hewlett-Packard	211.9	1.4	26.1	.7	42.7	.7	280.7	1.1
IBM	11,139.3	76.0	13.5	.4	161.1	2.5	11,313.9	45.9
Kalok	--	--	73.3	2.0	8.0	.1	81.3	.3
Maxtor	--	--	417.9	11.6	510.6	8.0	928.5	3.8
Micropolis	--	--	117.0	3.3	229.6	3.6	346.6	1.4
Quantum	--	--	165.3	4.6	907.1	14.2	1,072.4	4.4
Seagate Technology	--	--	1,200.8	33.4	1,413.9	22.2	2,614.7	10.6
SyQuest Technology	--	--	60.5	1.7	2.8	--	63.3	.3
Western Digital	--	--	148.0	4.1	392.1	6.2	540.1	2.2
Other U.S.	--	--	33.7	.9	55.4	.9	89.0	.4
U.S. Total	12,127.5	82.7	2,614.5	72.7	4,932.5	77.4	19,674.5	79.9
NON-U.S. MANUFACTURERS								
Fuji Electric	--	--	--	--	45.2	.7	45.2	.2
Fujitsu	1,012.3	6.9	219.9	6.1	629.1	9.9	1,861.3	7.6
Hitachi	300.4	2.0	711.5	19.8	175.4	2.8	1,187.3	4.8
JVC	--	--	--	--	127.6	2.0	127.6	.5
NEC	1,112.8	7.6	--	--	194.4	3.1	1,307.2	5.3
Toshiba	81.5	.6	17.9	.5	76.0	1.2	175.4	.7
Other Non-U.S.	30.2	.2	31.5	.9	191.8	3.0	253.5	1.0
Non-U.S. Total	2,537.2	17.3	980.8	27.3	1,439.5	22.6	4,957.5	20.1
WORLDWIDE TOTAL	14,664.7	100.0	3,595.3	100.0	6,372.0	100.0	24,632.0	100.0

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

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

Codes: 1.3 = 1.3" C = Captive
1.8 = 1.8" P = PCM
2 = 2.5" O = OEM
3 = 3.5"
5 = 5.25"
8 = 8 - 9.5"
10 = 10.5"-10.8"
14 = 14"

TABLE 13

CURRENT PRODUCT LINES
MANUFACTURERS OF RIGID MAGNETIC DISK DRIVES

DISK/TREND PRODUCT GROUP		1	2	3	4	5	6	7	8	9
U.S. Manufacturers	Type	Disk Cartridge Drives	Fixed Disk Drives <60 MB	Fixed Disk Drives 60-100 MB	Fixed Disk Drives 100-200 MB	Fixed Disk Drives 200-300 MB	Fixed Disk Drives 300-500 MB	Fixed Disk Drives 500 MB-1 GB	Fixed Disk Drives 1 GB-2 GB	Fixed Disk Drives >2 GB
Areal Technology	O			2	2					
Aura Associates	O		1.8	1.8						
Brand Technologies	O					3	3	3		
Conner Peripherals	P,O		1.8,3	2,3	2,3	3	3	3	3	
Digital Equipment	C,O					2,5	3,5	3,5	3,5,8	5
DMA Technologies	O	5								
Hewlett-Packard	C,P,O		1.3			3	3,5	3,5	3,5	5
IBM	C,P,O		2,3,5	2,3,5	2,3,5	3,5	3,5	3,5,8,14	3,5,10,14	10,14
Integral Peripherals	O		1.8	1.8						
Kalok	P,O				3	3				
Maxtor	P,O			2,3	2,3	3	3,5	3,5	3,5	
MFM Technology	O	5								
Micropolis	P,O				5		5	5	3,5	5
Microscience International	P,O		3	3	3	3	3	5	5	
Ministor Peripherals	O		1.8	1.8						
Quantum	P,O		2,3	2,3	2,3	3	3	3	3	
Seagate Technology	P,O		2,3,5	1.8,2,3	2,3,5	2,3,8	3,5,8	3,5,8	3,5,8	5,8
Sequel	O			5	5,8	8	5			
Storage Technology	P									14
SyQuest Technology	P,O	2,3,5								
Western Digital	P,O		3	2,3	2,3	3	3			
Asian Manufacturers										
Alps Electric	O		3	2	2,3	3				
Daeyoung	O		3							
Fuji Electric	O		2,3	2,3	2,3	3				
Fujitsu	C,P,O		2,3,5	2,3	5,3	3,5	3,5,8,10	3,5,8,10	3,5,8,10	5,8
Hitachi	C,P,O		5	5	5	3	3,5,8	5,8,14	3,5,8,14	5,8
JVC (Victor Company)	O		2,3	2,3	2					
Magtron	O							5	5	
Mitsubishi Electric	C							8		
Myrica	O				3	3		3		
NEC	C,O		1.8,3		3,5		3,5	5,8	5,8	8
Ricoh	O	5								
Samsung Electronics	C,P,O		3	3	3					
Teac	P,O		3	3	3	3				
Toshiba	C,O		2,3	2	2,3			3		
Xebec	P,O		3	3	3					
Zentek	P,O		2	2,3	3	3	3			
European Manufacturers										
DZU	O		5			14	14	14		
EZI	O					5	5			
Sagem	O					5				
South American Manufacturers										
Digirede	O		5	5	5					
Edisa Informatica	C,O					5	5	5		
Elebra	P,O			5			8			
Microlab	P,O		3,5	3	3	3				
Multidigit	P,O		3	5	5					
Qualitron	O		5	5						
Wintec Tecnologia	P,O	3								

TECHNICAL REVIEW

Competing technologies

The rigid disk drive industry has always earned a well deserved reputation for a frantic pace of technological change. Since IBM's 1989 demonstration of gigabit per square inch recording, the rate of change has increased as manufacturers expand their efforts to provide smaller, faster, more reliable, higher capacity, less expensive disk drives. The magnetic storage industry infrastructure has supported its customer needs through increases in areal density, thinner disk substrates, greater functionality chips, smaller heads, lower flying heights, smaller motors and many other areas offering improvement in disk drive and recording technology.

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

The technologies which are currently the leading candidates to provide major competition to magnetic disk drives in applications where characteristics such as speed, removability, or environmental tolerance give them unique advantages, are discussed in the following sections.

* Semiconductor memory -- applications and trends: Semiconductor memory offers fast response time and high reliability, characteristics that have won it a secondary storage role in some large and small systems. When very fast access to data or programs is required, semiconductor memory can serve as a substitute for rigid drives. Personal computer operating systems can allow part of main memory to be designated for use as a fast virtual disk. However, fast semiconductor memory is expensive, ranging from a few hundred to a few thousand dollars per megabyte, which limits its use to situations where its high speed or lack of moving parts are vitally necessary to meet system requirements. The least expensive semiconductor memories are volatile, and require the continuous

availability of power to avoid loss of data. Nonvolatile semiconductor memory is more expensive, usually slower, and is does not yet match the capacity per chip of DRAM, the most common form of volatile semiconductor memory.

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

The packaging of memory modules is evolving rapidly, especially memories used with portable systems. The Personal Computer Memory Card International Association (PCMCIA) has standardized the interface for plug-in cards used to expand system memory, emulate a disk drive, or provide other peripheral functions. The PCMCIA effort has been a major factor in promoting the acceptance of plug-in memory as a disk drive alternative, although some disk drives, such as Hewlett-Packard's 1.3" "Kittyhawk" drive and 1.8" drives from several sources will also have the capability to be plugged into a "type 3" PCMCIA card interface. Some issues regarding software support of the PCMCIA interface are not yet fully worked out, and the use of the PCMCIA interface may not guarantee functional interchange among devices that are electrically and physically PCMCIA compliant.

Specialized portable computers are expected to make extensive use of removable semiconductor memory packaged in a flat "credit card" format with PCMCIA interfaces. Pin interconnect and packaging standards have been worked out, with the final result being a 68 pin connector and a family of package heights ranging from 3.3 millimeters to 10.5 millimeters thick. The cards are able to accept a variety of memory forms, including disk drives, PROM, ROM, SRAM, DRAM, flash and, eventually, ferroelectric memory.

High density, high capacity packaging for large semiconductor memory is also in production. For instance, solid-state subsystems using "wafer-scale integration" and ranging from 80 to 480 megabytes on 6 inch diameter wafers have been proposed. Several wafers are combined to obtain the necessary storage. Another possible packaging technique is the stacking of chips vertically to make a three dimensional package. Assuming that a 4 megabit chip design were used, a module could have 320 megabit capacity in a package roughly a half inch square and a quarter inch high. However, formidable heat dissipation and fabrication problems

are associated with this technique. The most probable early applications are in military or aerospace equipment, possibly by mid-decade. IBM has acquired three dimensional packaging technology from Irvine Sensors Corporation, which demonstrated an equivalent to a 40 megabyte disk drive using an 80 chip stack.

It is questionable whether the development rate of semiconductor memory technology can proceed for the next 10 years at the same rate of improvement exhibited in the last 20 years. As the complexity, packaging problems, and performance requirements of semiconductor memory have increased, so also are the investments in time and capital required to produce succeeding generations of chips. The pace of semiconductor memory price decreases is consequently expected to slow, and the high investment costs may inspire an increasing number of companies to pool resources in order to contain development expenses. It appears that until the end of the decade, and perhaps beyond, the cost and performance improvements of rigid magnetic drives will keep solid-state competitors at bay in all but a few applications.

* Volatile semiconductor memories: DRAM is the most commonly employed form of semiconductor memory. It is used in systems of all sizes for general purpose system memory, video memory, and other applications where its volatility is not a major handicap. It is also used on large systems as a supplement to magnetic storage to provide fast mass storage. DRAM chips are currently readily available in 4 megabit configurations. Production in 16 megabit configurations has started and chips should be widely available in 1993. Matsushita, Toshiba, IBM and Hitachi are expected to be volume producers. Large quantity production of 64 megabit DRAM chips is not expected until after 1995.

  SRAM memory chips are in volume production in 1 megabit configurations as of mid-1992 and are expected in 4 megabit configurations by late 1993. Power requirements are less than DRAM and speed is high, permitting SRAM to be used as a memory add-on in portable, power limited equipment. However, SRAM is considerably more expensive than DRAM. SRAM is sometimes used in removable memory cards that contain a small battery that provides the power needed by SRAM memories to retain data.

* Nonvolatile semiconductor memories: Flash memory can provide adequate mass storage where capacity need be only a few megabytes, power limitations are severe, a hostile environment exists, and product price is not a paramount factor. Flash memory, a form of EEPROM in which a block of memory cells can be erased by an electrical signal, is nonvolatile and can be used as fixed or removable storage. Flash memory is often discussed as a major competitor to rotating memory, but its more significant applications will be as program storage, a reprogrammable BIOS in computer systems, to provide obsolescence protection in other types of equipment by allowing periodic code updates, and to

provide functionality changes in printers, fax machines, and other electronic equipment.

While flash memories are rugged, portable, reliable and use little power, they are not without functional disadvantages. When rewriting, 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 in some flash memories. This means that whatever is in the cell block must be saved to RAM and restored after the erase/write cycle on the flash memory chip. As a result, read operations can be very fast compared to a magnetic drive, but writing may be slower. There is also a limit to the number of times the memory device can be rewritten. At present, flash memory cells degrade after about 100,000 write/erase cycles. Some chips are specified at only 10,000 cycles. Some flash memories still require 12 volt power, but more recent products operate on 5 volts and development on 3.3 volt chips is underway at several companies.

Flash memories using 1, 4, and 8 megabit chips are currently in production. They are being manufactured by Intel, AT&T, SunDisk, Seeq Technology, Toshiba and other firms. SunDisk offers a card with 20 megabytes of capacity that mimics the 512 byte sector organization of a magnetic disk drive and includes an IDE interface, appearing as a disk drive to the host system. This card uses 8 megabit chips. Future generations of flash memory chips are expected at 16 megabit and 64 megabit densities. 40 megabyte flash memory cards using 8 megabit chips are expected to be available in 1993.

The price range for flash memory was about $30 to $60 per megabyte in mid-1992. Intel is already at the $30 per megabyte level. The most realistic projections for flash memories suggest OEM prices in the range of 10 to 20 dollars per megabyte in 1995, still much higher than anticipated for magnetic disk drives. Where only a few megabytes of storage are required and the rate of rewrites is not too high, flash memory can be economically attractive.

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

Ramtron, which has been the most visible developer of ferroelectric memory technology, has licensed it to NMB Semiconductor Company, ITT and Seiko. Ramtron and NMB are jointly developing a 4 megabit ferroelectric memory chip as well as 16 megabit DRAM chips. National Semiconductor also has a ferroelectric memory development effort under way. Ramtron's effort will produce 16 kilobit chips in 1992 and may produce 256 kilobit chips in 1993, 1 megabit chips in 1994 and 4 megabit chips in 1995.

Supporters of ferroelectric memories project that in the 1994-1995 time frame, chips with 1 to 4 megabit capacity could be available selling at $10 to $20 per megabyte. 16 megabit chips, possibly available in 1996, could sell in the $3 to $4 per megabyte range. Additional packaging and system costs will be incurred to fabricate the equivalent of a disk drive.

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

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

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

  One of the more ambitious holographic storage programs is being conducted by MCC (Microelectronics and Computing Corporation), a

research consortium sponsored by major U.S. technology firms. MCC demonstrated working prototypes of holographic memories in a 5.25" form factor in 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. 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. Once the prototypes are working, it will be up to the companies supporting the research effort to convert the technology into working, practical products. Among the supporters of the MCC effort have been DEC, NCR, Eastman Kodak, General Dynamics and E-Systems.

In 1991, IBM revealed research efforts using holographic storage techniques in conjunction with inexpensive organic amorphous media. However, this material, and similar materials announced by other researchers, must be used at very low temperatures.

Research is also proceeding in the area of nonholographic three-dimensional optical storage, but many of the same temperature and material problems must be overcome. In 1991, the University of California at Irvine disclosed an experimental device capable of storing 6.5 trillion bits in an organically doped plastic module the size of a sugar cube. Two different lasers are needed to write and read data, and the device must be operated at cryogenic temperatures to avoid data loss.

* Optical disk drives: Optical drives range from 3.5" units with 128 megabyte capacity to 14" drives with several gigabytes of capacity. With track densities of 15,000 tracks per inch and linear bit densities of 18,000 bits per inch or more, optical disk drives are capable of higher areal densities than magnetic disk drives now in use. The development of blue diode lasers capable of room temperature operation could quadruple capacity to the gigabit per square inch range, but such a device is not expected to be available for several years. However, slightly shorter wavelength lasersare expected to provide a 40 percent improvement in areal density within the next two years. The ultimate limit of optical areal density may be much higher. In mid-1992, Bell Laboratories reported they had written data in the laboratory at 45 billion bits per square inch using fiber optics to replace conventional optical elements.

  While the areal density of optical drives is high, the volumetric density is inferior to that of magnetic drives because optical media is thick, head assemblies are large, only one disk is typically present, and typically only one head is present in the drive. Current optical drive technologies cannot provide performance equivalent to magnetic disk technology, nor can optical drives yet compete on a product cost basis. Therefore, optical disk drives are preferred only where removability of the media is an advan-

tage, such as use in an automated library or for security concerns. Even in some removable applications, magnetic disk cartridge drives such as SyQuest's 105 megabyte 3.5" drive compete strongly with 3.5" optical drives, offering better performance, lower price and nearly the same capacity. Optical drives seem more likely to complement rigid magnetic disk drives rather than replace them, serving as vehicles for backup, software distribution, and off-line or library storage.

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

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

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

* Nonreversible optical disks: The first optical disk recording systems to enter the market were "nonreversible" or "write-once" systems. The initial products manufactured were 12" in diameter, but the trend is to 5.25" or smaller diameter drives. 4.72" CD-ROM compatible write-once drives for professional use were introduced by Yamaha in 1989 and by Sony in 1990, and lower cost 4.72" write-once drives from Philips, Sony and JVC entered the market in 1992. 4.72" drives are expected to be the dominant form of write-once drives in 1995 due to the expected displacement of 5.25" write-once drives by multifunction drives. Because each manufacturer has championed his own approach, write-once recording is poorly standardized, with the exception of 4.72" drives for which de facto standards exist as the result of strong standards for CD-ROM drives.

Write-once drives operate by using a diode laser with suitable optics and

positioning mechanisms to produce a concentrated beam that can remove, deform, or change the reflectivity of material at the focal point of the beam. For readback, a diode laser, operating at a lower power, scans the disk, and the varying light reflected from regions of differing reflectivity is translated into bit patterns. Once an area of the disk is written, it cannot be changed or rewritten, although it could be overwritten and destroyed. Hewlett-Packard, Sony and others offer write-once capability using rewritable magneto-optic media coded so that the drive recognizes it as write-once media and operates accordingly. Drives with this MO-WORM capability are expected to displace pure write-once drives, because they are more flexible and their prices will decline faster due to higher volume shipments of drives using magneto-optic technology.

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

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

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

  Magneto-optical recording has seen development activity for more than twenty years, and rewritable phase change optical recording emerged as a competitor in 1990. The performance of magneto-optical drives exceeds that of write-once drives. Because it takes somewhat less laser power to change the state of a bit than required by write-once drives, the drive can rotate faster at a given laser power, reducing latency and improving data transfer rate. Recent rewritable drives have reached 3,600 RPM spin rates and Fujitsu has announced a 5,400 RPM model. However, average seek times are just beginning to breach the 30 millisecond mark, and it will be years before rewritable optical performance can approach the best magnetic drive technology. Improving optics, shorter wavelength, higher power lasers and other improvements will gradually permit closing the performance gap.

  Today's 5.25" drives typically offer either 326 megabyte (ISO standard) or 512 megabyte per side capacity. An advance to 652 megabyte per side is expected in 1993, and one gigabyte per side is anticipated in late 1994. IBM and Sony have presented proposals on the 652 megabyte version to

various standards bodies; early approval of a standard by ECMA is anticipated. The gigabyte per side issues are currently under consideration in several standards technical subcommittees. The ISO standard 3.5" drives have 128 megabytes per side, and one 256 megabyte drive using a different format is also available. A general increase to 256 megabytes per side is anticipated in the 1993/1994 time frame, and drives with 512 megabytes per side are being actively considered by a number of firms.

Magneto-optical disk drives use a low power laser and a magnetic field 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 in production do not yet overwrite in place: A complete sector must be erased before the sector can be rewritten. The industry has been working on this problem for many years, and current industry expectations are for magneto-optic drives without overwrite latencies to be available in 1994.

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

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

Rewritable optical storage is well into the manufacturing stage. Over 170,000 5.25" and 3.5" drives were shipped in 1991. IBM, Sony and other firms shipped 3.5" drives in quantity in 1991. Rewritable 5.25" drives were shipped in volume from Matsushita, Canon, Sony, Maxoptix and Ricoh, and both IBM and Hewlett-Packard began volume shipments of 5.25" optical drives in 1992. Nikon began shipping a 12" magneto-optic drive in 1992, the first rewritable 12" drive to enter the market.

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

* Read-only optical disks: The read-only optical disk category is dominated by the CD-ROM, which has capacities of 550 to 600 megabytes, but slow access times. In 1992, NEC, Sony, Pioneer and others introduced CD-ROM drives operating at doubled or quadrupled RPM, improving average access time and data transfer rate. It is technically feasible to develop read-only media for read/write drives, and a few firms are producing read-only media for 3.5" optical disk drives. 3.5" drive standards include definitions of read-only capability, which is expected to be important in software distribution and multimedia related applications.

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

* 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. The highest manufacturing levels are still maintained by Hitachi, with most production used by Nippon Telephone and Telegraph for a variety of telecommunication applications. Hitachi is currently exploring 64 megabit bubble devices.

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

  The nonvolatility of magnetic bubbles and their cost-effectiveness where small capacities are needed makes them more attractive than disk drives 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 now must defend their specialized markets against encroachments from flash memory.

* High capacity flexible disk drives: It is within the capabilities of today's technology to fabricate a 3.5" floppy disk drive offering over 40 megabytes of storage capacity, and drives with 20 megabyte capacity are already in volume production. 80 megabyte 3.5" drives are being considered for mid-decade announcement. The 5.25" Bernoulli disk drives offered by Iomega have now reached 90 megabytes in capacity and compete strongly with removable 5.25" rigid cartridge type disk drives. Where aggressively priced, these high capacity floppy drives could compete in the very low end of magnetic and optical disk drive markets and against tape drives for backup applications. However, their low capacities, thick form factors and relatively slow performance make them unlikely candidates to displace rigid drives.

  10 and 20 megabyte 5.25" flexible disk drives available in the market over the past several years achieved only marginal success. However, the 3.5" drives with capacity in the 20 megabyte range which have been announced by Brier Technology and Insite Peripherals have created considerable interest. Several other Japanese floppy drive manufacturers are considering standards for 10 and 20 megabyte floppy disk drives.

  Unfortunately, none of the 3.5" high capacity flexible disk drive formats are compatible with each other, although each approach provides read and write downward compatibility with one and two megabyte 3.5" floppy disks. Insite's 3.5" drive uses standard magnetic media with an optical servo pattern on the disk surface, combined with optical tracking methods. Brier uses a dual layer writing technique to embed its servo data beneath the data on each track. The companies in the Japanese standards group plan to use conventional embedded servo technology.

Disk drive enhancements

When IBM introduced the first moving head rigid magnetic disk drive in 1956, it created a highly competitive industry whose technology has undergone continuous and rapid improvement. While IBM provided disk drive technology leadership for two decades, IBM's efforts were eventually eclipsed by aggressive competitors manufacturing small diameter drives. But the 1980's saw a resurgence in IBM technology contributions, especially in packaging -- including IBM's 320 megabyte 3.5" drive with 8 disks, an 857 megabyte 5.25" drive with 12 disks, and a 2.5" 40 megabyte drive only 12.7 millimeters high introduced in 1991. IBM also introduced the first disk drives using magnetoresistive heads in 1991. The critical areas being addressed by IBM and others are discussed below.

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

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

  Each reduction of flying height requires a new level of sophistication in the preparation of disk substrates, coatings, overcoatings, heads and test equipment. For instance, it appears that glass substrates may be required to obtain the required smoothness and flatness for the lowest flying heights. Determining reliable processes for manufacturing, coating, texturing and testing disk media using glass substrates are major challenges, and the ability of substrate and media producers to ramp up production to the required levels is an unproven capability.

  Several approaches to contact recording are being developed. Censtor is developing an unusual low mass, low contact area head design in which the head is normally in contact with the disk. While wear does occur, the rate of wear of the critical parts of the head is low enough to permit head lifetimes to exceed expected drive lifetimes. The head area and loading is small enough to control stiction effects, and the in-contact thin film head is capable of operating at 200,000 to 300,000 BPI. VISqUS Technology, acquired by Conner Peripherals in 1991, has been developing a "water

skiing" technique in which the friction of head/disk contact is controlled by floating a head on a continually refreshed liquid bearing surface. Lubricant that spins off the disk due to centrifugal force is filtered and recirculated back to the disk surface. IBM has publicly discussed a "tail dragging" approach that suspends a small head from a larger flying head. The large area of the flying head keeps the head at a stable height and orientation while positioning the smaller active head at the surface of the disk. Censtor and Conner are closest to having manufacturable designs, and Censtor is working with several drive manufacturers to adapt its designs to specific disk drive development efforts.

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

  Sliders have continued to decline in size under the pressure to make ever smaller HDAs. The 70% form factor micro-slider (70% of the volume of a mini-slider) is being used in thin 3.5" and 2.5" diameter drives and the 50% form factor nano-slider will see wide use in 3.5", 2.5", 1.8", and 1.3" diameter drives. As spacing between disks diminished, use of the smaller sliders became mandatory. Additional advantages of the small sliders include less mass to inhibit rapid positioner movement or cause damaging head/disk interference. The smaller size also relieves stiction problems, although some new drive designs also utilize ramp loaded heads, eliminating the possibility of stiction and reducing power requirements for starting drive motors. The 70% sliders are in large volume production currently, while 50% sliders entered general production in 1992, although the IBM 1 gigabyte, 3.5" drive that began to ship in the last half of 1991 also uses 50% sliders.

  Ferrite heads continue to be widely used, but thin film heads are taking over in situations requiring very high areal densities. MIG (metal-in-gap) heads are sometimes able to substitute for thin film heads in 3.5" and 2.5" mid-range drive applications and are less expensive, but thin film heads are probably the technology of choice for 3.5" drives with capacities of 500 megabytes and above. Waiting in the wings are magneto-resistive heads, which may appear in both high performance and very small form factor drives. IBM introduced the first disk drives using MR heads in 1991.

  Conventional and composite ferrite heads, now available from multiple sources, are routinely produced with good manufacturing yields, and are

competitively priced, but newer drives have transitioned to metal-in- gap and thin film heads. These head categories have also reached high production levels and have become more price competitive with ferrite monolithic and composite heads. Single crystal ferrite heads and cores, which began volume production in 1991, provide improved performance and should extend the life of ferrite head technology. Risk is relatively low, as single crystal technology has been used in video heads for a number of years.

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

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

Lower cost MIG heads have proven capable of operation in many applications originally targeted by thin film heads, so until the late eighties the demand for thin film heads was much slower to develop than many prospective producers had hoped. As a result, thin film head production capacity lagged, and as a consequence, the production surge of small drives using very high recording densities that began in 1989-90 created a shortage of thin film heads. Production levels are now in rough balance with demand, however.

Magneto-resistive thin film heads are expected to gradually be introduced in sub-2.5" form factor disk drives to provide adequate readback signal to noise ratios without resorting to ultra-high spin rates. They will also appear in high end drives where their ability to read very narrow tracks enhances drive areal density and minimizes crosstalk from adjacent tracks. While internally generated noise and low yield remain challenges to be overcome before MR heads are widely available from multiple vendors, they will be necessary to achieve the gigabit per square inch areal density targeted for later in this decade by many drive producers. IBM, which has been developing MR heads for many years, first shipped them in the 1 gigabyte 3.5" drive that started to ship in the last half of 1991.

MR heads are usually fabricated in an assembly including an inductive thin

film head for writing and the MR head for readback of data. The width of the write head is usually larger than the width of the read head to provide some protection against off track positioning and noise from adjacent tracks. Because these head assemblies are complex and yields are not yet high, the near term use of MR heads is expected to be limited to situations requiring their unique capabilities.

* Recording disks: Disk media production processes have undergone continuing refinement to achieve ever-thinner applications of more uniform recording layers. Progress in improving media surface lubricants and protective overcoatings has been equally impressive, if at times uneven. Carbon overcoatings have been getting thinner to reduce head-recording layer separation. The thinnest are now down to about .4 microinch. Substrate smoothness has been a critical issue for several years as flying heights have diminished.

  The oxide coated media of early disk drives has largely been displaced by thin film media, because oxide coated media was unable to satisfy increasing areal density requirements. Even IBM, a longtime oxide champion, now ships large quantities of drives with thin film media, and is using thin film disks on the new 3390-3 drive with 10.8" disks introduced in September, 1991. While barium ferrite might be able to extend the areal density capabilities of coated disks, the surface roughness of barium ferrite is too great for reliable operation at today's lowering flying heights. If barium ferrite is used, it will probably occupy only a few product niches.

  Many of the early manufacturers of thin film disks lacked adequate process control and were unable to sustain high production yields or to meet delivery commitments on a consistent basis. Plating was the primary method used to produce early generations of thin film disks, but plating has been supplanted by sputtering as the preferred production technique. The sputtering process is more capable of producing the higher coercivities, thin layers and tight tolerances required by disk drives operating at high areal densities and low flying heights. Although plated disks with coercivities up to 1,400 oersteds are in production, most drive producers believe that plated media practically tops out at 1,200 oersteds. The migration to sputtered media was enhanced by the departure of Domain Technology from the ranks of media producers, which left much of the field to suppliers of sputtered disks.

  Manufacturers find the sputtering process 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 sources of sputtered 8" media. Sputtered disk producers are concentrating on 5.25", 3.5", and 2.5" media because the bulk of the near term demand is in those sizes, and some are manufacturing 1.8" media. Production of 1.3" media is limited, because

there is currently only one major customer. Media with coercivity in the 1,200 to 1,500 oersted range is routinely produced, and some companies have demonstrated fabrication of media up to 2,300 oersted coercivity on production quality sputtering systems.

While most thin film media production has been from independent producers, IBM and several Japanese companies also produce much of their own media requirements. Some drive manufacturers, such as Conner, Western Digital and Seagate also produce some of their media needs. This has had the effect of reducing external disk purchases by these drive manufacturers, but the effect on the independent disk media manufacturers has been masked by the very strong demand for 3.5" and 2.5" drives. However, some companies producing lower coercivity media internally may elect to shift to outside sources rather than retool aging facilities to produce advanced media.

Aluminum has always been the substrate of choice for rigid disk media, but some high capacity 2.5" disk drives, such as those of Areal Technology and Toshiba, use glass or glass/ceramic as a substrate material. The Hewlett-Packard 1.3" Kittyhawk drive also uses glass media. Glass substrates are potentially smoother and flatter than aluminum, have fewer impurities that can cause defects, and can be made very thin. These characteristics allow for lower flying heights and the inclusion of more disks in a stack, both highly desirable features. However, because of low production volume, glass disks currently cost significantly more than aluminum substrates. There is also limited industry production capacity at present. However, as flying heights decline below 4 microinches, it is likely that glass and ceramic substrates will gradually displace aluminum. Producers of aluminum substrates have continued to improve their technology, but are finding it increasingly difficult to maintain adequate flatness as substrate thickness declines. The stresses produced when very thin disks are clamped to the spindle appear to cause more deformation in aluminum disks than in glass disks.

Disk substrate thickness is declining in order to allow placement of more disks in small diameter drive HDAs. In 1989, 50 mil substrates were standard practice for 3.5" diameter drives, but 31.5 mil substrates have seen increasing use since IBM introduced them in the "Lightning" 3.5" drive introduced in 1989. The next step is expected to be a move to 20-25 mil substrates, possibly in drives appearing in 1993. 2.5" drive substrates, now at 35 mils, may move to that range even sooner. The 1.3" Kittyhawk drive uses 15 mil thick substrates.

* Areal density: Many drives currently in production have areal densities exceeding 100 million bits per square inch and areal density continues to rapidly increase. Drives using MR heads and having areal densities exceeding 250 million bits per square inch are expected to become available in late 1992.

TPI in excess of 2,000 is common and some small drives operate at over 2,500 TPI. The industry still has plenty of room for innovation in this area. IBM's 3390-3 operates at 2,984 TPI, and some firms are investigating the use of optical tracking techniques to obtain even higher TPI. IBM has shown the feasibility in the laboratory of creating media with very narrow tracks with submicron dimensions. However, considerable work will have to be done to develop heads capable of working with such narrow track widths. The 1989 IBM demonstration of gigabit per square inch recording used track densities in excess of 6,300 TPI, and this represents a future target for drive designs late in the decade. Hitachi's 2.3 gigabit per square inch demonstration featured 17,000 TPI, a figure that may not be seen in a production drive for a long time.

IBM's gigabit per square inch demonstration operated at 158,000 bits per inch, which was exceeded slightly by Hitachi at 165,000 BPI. Today's small drives may operate with bit density between 50,000 and 60,000 BPI, and this figure is expected to eventually exceed 200,000 BPI as MR heads and contact recording become widely used.

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

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

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

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

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

  The term RAID (Redundant Array of Inexpensive Disks) denotes multiple drive configurations generically, with specific configurations ranging from multiple, uncoordinated disk drives to striped, synchronized drives defined within the RAID designation as RAID-0, RAID-1, RAID-2, etc., through RAID-5. The RAID nomenclature, which derives from papers published by the University of California, has been formally defined only up to the RAID-5 level, but various firms are developing advanced redundant architectures informally defined as RAID-6 or RAID-7.

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

  Disk array markets are expected to eventually grow to significant size, but product complexity and proliferation, lack of standardization, customer confusion and ignorance of array capabilities will retard market development for some years.

* Performance: Significant improvements in data transfer rates and average access times are expected during the next few years. The single most important factor in initiating these improvements will be the increase in disk rotation rate, which both decreases latency and increases data transfer rate. A secondary, but significant technique may be the use of multiple heads per surface and/or multiple heads per slider to permit parallel access to large amounts of data without head movement. Conner Peripherals, borrowing from the mainframe world, has offered a multiple actuator 3.5" drive.

  After many years of 3,600 RPM specifications, drive rotation rates leaped in 1989 when Imprimis announced a family of high capacity 5.25" drives operating at 5,400 RPM. Most of the 1 gigabyte 3.5" drives announced to date offer 4,300 RPM or faster spin rates, and Maxtor offers a 1.2 gigabyte 3.5" drive rotating at 6,300 RPM. Industry expectations are for drives rotating at 7,200 RPM in the near future. Some firms are even considering the use of motors operating in the 9,000 to 10,000 RPM range for use with disk drives having diameters under 2.5".

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

  Average seek times have now dipped down to the 9 millisecond range for the fastest drives, although 14 to 16 millisecond seek times are more common in high performance 5.25" and 3.5" drives. Higher energy magnetic materials and lower mass microslider heads are contributing to the improved performance. In some cases, special alloys permitting lighter positioning mechanisms that help reduce seek time are being considered. Some drives are specified with read seek times that are a millisecond or two faster than the write seek time as a result of drive intelligence permitting usable readback signals to be acquired before the head has fully settled after a seek.

* Form factor: Sub-3.5" drives are an increasingly significant part of the market. Driven by demands from manufacturers of notebook computers, small footprint, low height, low power drive designs are proliferating. Drive height has steadily declined, with IBM's 12.7 millimeter high 2.5" 43 megabyte representing the 1991 benchmark on drive height. 1.8" drives were first shipped in 1991 by Integral Peripherals, and several major producers will be shipping 1.8" drives in 1992. The smallest drive announced as of mid-1992 is Hewlett-Packard's 1.3" Kittyhawk drive, which has a height of 10.5 millimeters.

  Competition in providing higher capacity and thinner sub-3.5" disk diame-

ter drives is keen. 15 to 19 millimeter heights are available for new low-end drives for desktop computers, so that half of an existing "half high" disk drive bay can be free for other peripheral devices. 2.5" drives are already in the 10 to 12.7 millimeter high range, to allow maximum volume for batteries in notebook computers, and 1.8" and 1.3" drives conforming to the 10.5 millimeter PCMCIA height requirement will soon be in production.

Technologically, form factor reduction is being driven by improvements in areal density, smaller heads, thinner media, greater IC functionality, and higher energy magnetic materials that permit fabrication of smaller motors and actuators without reducing performance. One of the most critical factors is the reduction in the surface area required to mount electronics needed by the drive. An increasing degree of functional integration in chips is needed and is being provided. In some drive designs, fewer than 10 chips are needed and some drive designers anticipate being able to design with a five chip (or less) set in the near future.

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

The voltage required by the drive is also a factor. Future drives for portable systems will probably be capable of operating within specification over a range of voltage from 3.0 to 3.3 volts. This permits the drive to be operated directly from a battery supply without incurring the cost and power dissipation of a voltage regulator.

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

* Interfaces and controllers: The majority of small disk drives have intelligent embedded controllers and are able to communicate directly with a host system data bus. Embedded SCSI and PC/AT (IDE) controllers are widely used in drives for personal computer applications, and embedded SCSI is also used with the majority of drives used with workstations, serv-

ers and equivalent applications. For small diameter drives under 500 megabytes capacity, some version of SCSI will probably be employed in 20 to 25 percent of the drives shipped in 1992. SCSI interfaces are most frequently encountered in workstations, file servers and Apple equipment. PC/AT interfaces far outnumber SCSI interfaces in the IBM compatible personal computer market, though most PS/2 models do use SCSI drives. For 1.8" and smaller drives, the pin connections used for ATA (AT Attachment) cards that fit physically into PCMCIA sized slots and connectors still need finalization.

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. Embedded intelligent interfaces allow the use of techniques such as varying bit density by zones over the band of recording tracks and advanced data coding. Other features, such as on-board error monitoring and diagnostics, error correction, digital servos, segmented caching, zero latency read/write and multiport buffering can be included but made transparent to the using system. However, there is a delicate balance between overall system performance and the design of the intelligent controller. For instance, the use of too large a buffer can slow data retrieval if all of the buffer contents must be examined to service each request for data from the system.

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

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

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

that would otherwise have to be discarded. The effective improvement in media yield provides a strong incentive to adopt error correction techniques.

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

DEFINITIONS

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

Market classification

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

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

Examples:

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

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

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

Examples:

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

* Shipments made by Micropolis or Western Digital are noncaptive.

PCM/Reseller: Disk drives sold or leased by "plug compatible manufacturers" or their distributing organizations directly to end users for use with systems sold by another manufacturer. Also includes drives sold in the "aftermarket" -- shipments by drive manufacturers to subsystem producers, distributors, retail chains, mail order firms and individual dealers. It includes drives to be connected to systems of all types, including personal computers, minicomputers and mainframes, or drives sold as add-on devices by distributors and dealers.

Examples:

* Disk drive-on-a-card products such as those of Quantum Commercial Products.

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

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

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

Examples:

* Drives produced by Seagate Technology or Conner Peripherals for sale to system manufacturers.

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

Geographic classification

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

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

Examples:

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

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

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

Example:

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

Units of measurement

Spindles: The basic unit in counting disk drives. One spindle or spindle disk assembly consists of the disk drive mechanism required to utilize a single disk or disk stack. All DISK/TREND unit totals are counted in spindles. In order to avoid distortion of shipment information for large fixed disk drives used with mainframe systems, certain plug compatible models have been arbitrarily counted on the basis that two or more spindles are equivalent to one IBM 3380 or 3390 spindle.

Revenue: Based on sales of disk drives alone, as normally sold by individual manufacturers. Controllers sold as separate units are not included in disk drive revenue, nor are spare parts or service. When individual disk drive models include integral control functions, such as may be required for the first drive on a string of drives, the actual value of the complete unit is used. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM/Re-seller or OEM/Integrator levels. All prices are in 1992 constant dollars.

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

Examples:

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

* Innovations such as nonstandard size disks or new physical configurations may require establishment of new DISK/TREND product groups.

Application classification

Shipments of disk drives are classified by the following computer applications:

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 mid-range general purpose processors typically serving multiple users, including network file servers. Examples: IBM System AS/400, DEC 433MP, Hewlett-Packard 3000.

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

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

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

Consumer and hobby computers: Systems sold primarily to consumers for nonbusiness applications. Examples: Commodore 64, MSX systems, most Atari models. Multimedia systems for home use, such as the Commodore CDTV, are also included in this category.

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

1992 DISK/TREND REPORT

DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

DMA Technologies	360
MFM Technology	11/11, 20R
Ricoh	RH5260, RH5500
SyQuest Technology	SQ555, SQ5110, SyDOS 88e

3.5" disk diameter

SyQuest Technology	SQ3105A

2.5" disk diameter

SyQuest Technology	SQ2542A

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.

For more than 20 years, disk cartridge drives were used mostly with small business computer systems, initially utilizing 14" drives, with a later migration to 8" models. None of the companies which led in shipments of 14" disk cartridge drives during the heyday of this group -- Control Data, Diablo or Western Dynex -- are now active in the disk drive industry. In fact, all production of 14" and 8" drives has been phased out.

5.25" drives provide most of the current shipments in this product group, with initial shipments of smaller drives now starting.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	64.5	71.4	91.3	112.6	126.0
All manufacturers	70.1	75.9	93.8	112.6	126.0

1991's unit shipments of disk cartridge drives were up 59% in 1991, to 242,400 drives worldwide. 5.25" drives accounted for almost all of the 1991 shipments, and new drives with smaller diameter disks are also expected to contribute to 1992 shipments. 1992 is again expected to produce an increase in total unit shipments, but the growth rate for 1992 is forecasted at a more moderate 26%, due to the negative impacts of increased competition from other removable disk drive formats and the recession.

Although worldwide revenues for disk cartridge drives grew 27.7% in 1991, an increase of only 8.3% is forecasted for 1992 due to slower growth in unit shipments and continuing pressure on average selling prices, despite an increase in the typical capacity of drives shipped in 1992. Because of these pressures the estimated average PCM/Reseller price per megabyte for 5.25" drives in this product group is expected to decline from $5.76 in 1991 to $4.10 in 1992.

SyQuest increased its dominant share of the disk cartridge drive market even further in 1991. After achieving early growth in security markets, the firm became the leader in add-on removable disk storage for Macintosh systems used in graphics and desktop publishing applications, and more recently added a program focused on the same applications used with IBM personal computers. SyQuest shipped 230,000 drives in 1991, 94.9% of the worldwide total of all disk cartridge drives.

While the initial growth of 3.9" and 5.25" disk cartridge drive shipments was largely driven by the demand for removable media in security markets, in which data must be stored in locked facilities under government or private requirements, shipments in recent years have been stimulated mostly by use of newer graphics and desktop publishing software on personal computers. Removable disk cartridges make it possible to keep individual projects on separate cartridges, which can be quickly mounted in disk drives as updates become necessary.

SyQuest started shipments of its 88 megabyte 5.25" model in the first quarter of 1991, and has experienced strong demand for the higher capacity. The major competition for SyQuest is not currently provided by other manufacturers of rigid disk cartridge drives, but by Iomega, maker of the high capacity Bernoulli floppy

disk drive. Iomega's 44 megabyte 5.25" drive supplemented in 1991 with a 90 megabyte model, with the result that SyQuest and Iomega are competing directly in both the Macintosh and IBM personal computer markets for the same graphics and desktop publishing applications.

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

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

Although 5.25" drives are expected to continue to dominate shipments of disk cartridge drives in 1993, volume shipments of both 2.5" and 3.5" drives will be underway by early next year. With the appearance of smaller drives, the growth rate for 5.25" models is expected to slow down. The forecasted growth rate for unit shipments of 5.25" drives in 1993 is only 4.9%, dropping into the negative range starting in 1994.

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

However, the availability of the new smaller drives may erode some of the current dominance of the aftermarket distribution channel for drives in this product group. SyQuest's 105 megabyte 3.5" and 42 megabyte 2.5" models have a good chance of becoming established in OEM markets -- the first time in

the last ten years that disk cartridge drives have had this opportunity. Both drives' smaller sizes are consistent with the industry's current physical formats, and the 3.5" drive's 105 megabyte capacity is in the range now most in demand for the personal computer market. With many end users already sold on the use of removable media for selected applications, the time for renewed growth of OEM shipments for disk cartridge drives may have arrived. DISK/TREND data indicates that 94.7% of all disk cartridge drive 1992 unit shipments will be sold through PCM/Reseller channels, but forecasts a drop to 66.7% in 1995, with the balance sold to OEM/Integrators.

Technical trends

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

The basic recording technologies now in use for products in this group will continue to predominate for years. The smaller drives expected in the near future may be expected to embody the mechanical design lessons accumulated during years of production of larger removable disk drives, but will be able to take advantage of the rapid design advancements in recent years in recording heads, disks, head positioning and electronic components originally intended for fixed disk drives. The 3.5" and 2.5" disk cartridge drives now becoming available are probably not the end of the line for this product group, and 1.8" drives with removable disks are a likely next step.

Forecasting assumptions

1. Significant shipments of 3.5" and 2.5" disk cartridge drives will start in early 1993, with successful sales to both system manufacturers and the aftermarket.

2. Production for 5.25" disk cartridge drives with capacities over 40 megabytes will peak in 1993, with a migration of graphics and desktop publishing applications to smaller disk cartridge drives.

TABLE 14

DISK CARTRIDGE DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	48.6	60.7	47.5	66.6	51.3	76.3	52.0	84.0	51.0	87.4
OEM/Integrator	2.9	3.8	2.5	4.8	10.8	15.0	19.3	28.6	23.1	38.6
TOTAL U.S. NONCAPTIVE	51.5	64.5	50.0	71.4	62.1	91.3	71.3	112.6	74.1	126.0
TOTAL U.S. REVENUES	51.5	64.5	50.0	71.4	62.1	91.3	71.3	112.6	74.1	126.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	2.5	5.6	2.0	4.5	--	2.5	--	--	--	--
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	2.5	5.6	2.0	4.5	--	2.5	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	54.0	70.1	52.0	75.9	62.1	93.8	71.3	112.6	74.1	126.0
OEM Average Price ($000)		.352		.298		.231		.197		.172

TABLE 15

DISK CARTRIDGE DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991		Forecast							
	Shipments		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	176.4	220.4	199.3	280.3	235.0	350.0	260.0	420.0	280.0	480.0
OEM/Integrator	8.5	10.8	10.2	16.1	47.0	65.0	98.0	145.0	135.0	225.0
TOTAL U.S. NONCAPTIVE	184.9	231.2	209.5	296.4	282.0	415.0	358.0	565.0	415.0	705.0
TOTAL U.S. SHIPMENTS	184.9	231.2	209.5	296.4	282.0	415.0	358.0	565.0	415.0	705.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	5.0	11.2	4.0	9.0	--	5.0	--	--	--	--
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	5.0	11.2	4.0	9.0	--	5.0	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	189.9	242.4	213.5	305.4	282.0	420.0	358.0	565.0	415.0	705.0
Total Capacity (Terabytes)	9.4	12.0	13.1	18.5	20.5	30.3	32.4	50.9	46.3	78.4
Cumulative Shipments (Units in thousands)										
IBM	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0
Non-IBM	1,430.4	2,290.1	1,643.9	2,595.5	1,925.9	3,015.5	2,283.9	3,580.5	2,698.9	4,285.5
WORLDWIDE TOTAL	1,483.7	2,369.1	1,697.2	2,674.5	1,979.2	3,094.5	2,337.2	3,659.5	2,752.2	4,364.5

TABLE 16

DISK CARTRIDGE DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues		Forecast							
			1992		1993		1994		1995	
	8"	5.25"	5.25"	<=3.5"	5.25"	<=3.5"	5.25"	<=3.5"	5.25"	<=3.5"
U.S. MANUFACTURERS										
PCM/Reseller	--	60.7	63.6	3.0	61.3	15.0	53.0	31.0	36.1	51.3
OEM/Integrator	.3	3.5	4.8	--	4.8	10.2	3.2	25.4	2.0	36.6
TOTAL U.S. REVENUES	.3	64.2	68.4	3.0	66.1	25.2	56.2	56.4	38.1	87.9
NON-U.S. MANUFACTURERS										
PCM/Reseller	--	5.6	4.5	--	2.5	--	--	--	--	--
TOTAL NON-U.S. REVENUES	--	5.6	4.5	--	2.5	--	--	--	--	--
WORLDWIDE RECAP										
PCM/Reseller	--	66.3	68.1	3.0	63.8	15.0	53.0	31.0	36.1	51.3
	--	+45.7%	+2.7%	--	-6.3%	+400.0%	-16.9%	+106.7%	-31.9%	+65.5%
OEM/Integrator	.3	3.5	4.8	--	4.8	10.2	3.2	25.4	2.0	36.6
	-83.3%	-48.5%	+37.1%	--	--	--	-33.3%	+149.0%	-37.5%	+44.1%
Total Revenues	.3	69.8	72.9	3.0	68.6	25.2	56.2	56.4	38.1	87.9
	-83.3%	+33.5%	+4.4%	--	-5.9%	+740.0%	-18.1%	+123.8%	-32.2%	+55.9%
ANNUAL SHARE, BY DIAMETER	.4%	99.6%	96.1%	3.9%	73.2%	26.8%	50.0%	50.0%	30.2%	69.8%

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

TABLE 17

DISK CARTRIDGE DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments		Forecast							
			1992		1993		1994		1995	
	8"	5.25"	5.25"	<=3.5"	5.25"	<=3.5"	5.25"	<=3.5"	5.25"	<=3.5"
U.S. MANUFACTURERS										
PCM/Reseller	--	220.4	270.3	10.0	285.0	65.0	265.0	155.0	195.0	285.0
OEM/Integrator	.1	10.7	16.1	--	20.0	45.0	15.0	130.0	10.0	215.0
TOTAL U.S. SHIPMENTS	.1	231.1	286.4	10.0	305.0	110.0	280.0	285.0	205.0	500.0
NON-U.S. MANUFACTURERS										
PCM/Reseller	--	11.2	9.0	--	5.0	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	--	11.2	9.0	--	5.0	--	--	--	--	--
WORLDWIDE RECAP										
PCM/Reseller	-- --	231.6 +74.1%	279.3 +20.6%	10.0 --	290.0 +3.8%	65.0 +550.0%	265.0 -8.6%	155.0 +138.5%	195.0 -26.4%	285.0 +83.9%
OEM/Integrator	.1 -83.3%	10.7 -36.7%	16.1 +50.5%	-- --	20.0 +24.2%	45.0 --	15.0 -25.0%	130.0 +188.9%	10.0 -33.3%	215.0 +65.4%
Total Shipments	.1 -83.3%	242.3 +61.6%	295.4 +21.9%	10.0 --	310.0 +4.9%	110.0 +1,000.0%	280.0 -9.7%	285.0 +159.1%	205.0 -26.8%	500.0 +75.4%
ANNUAL SHARE, BY DIAMETER	--	100.0%	96.8%	3.2%	73.9%	26.1%	49.7%	50.3%	29.1%	70.9%
TOTAL CAPACITY (Terabytes)	--	12.0	17.5	1.0	21.6	8.8	22.4	28.5	18.4	60.0

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

TABLE 18

DISK CARTRIDGE DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	.1	.1	--	--
PERSONAL COMPUTERS Business and professional, single user	229.8	94.7	687.4	97.5
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	2.3	1.0	--	--
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	10.2	4.2	17.6	2.5
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	242.4	100.0	705.0	100.0

TABLE 19

DISK CARTRIDGE DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1991	Forecast 1992	1993	1994	1995
Captive					
5.25"	--	--	--	--	--
3.5" or less	--	--	--	--	--
Captive Average	--	--	--	--	--
PCM/Reseller					
5.25"	5.76	4.10	3.16	2.50	2.05
3.5" or less	--	3.00	2.87	2.00	1.50
PCM/Reseller Average	5.76	4.04	3.10	2.28	1.68
OEM/Integrator					
5.25"	7.03	5.34	3.41	2.62	2.16
3.5" or less	--	--	2.81	1.95	1.41
OEM/Integrator Average	7.63	5.34	2.98	2.00	1.44

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

TABLE 20

DISK CARTRIDGE DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	8"	5.25"	Total		8"	5.25"	Total	
SyQuest Technology	--	184.0	184.0	96.9	--	230.0	230.0	94.9
Ricoh	--	5.0	5.0	2.6	--	11.2	11.2	4.6
Other U.S.	.1	.8	.9	.5	.1	1.1	1.2	.5
Other Non-U.S.	--	--	--	--	--	--	--	--
TOTAL	.1	189.8	189.9	100.0	.1	242.3	242.4	100.0

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

1992 DISK/TREND REPORT

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Digirede	W525/50
DZU	ES 5300
Hitachi	DK521-5*
IBM	4956-G10
Microlab	DFW 5025*
Qualitron	QW-521*
Seagate Technology	ST225*, ST251*

3.5" disk diameter

Alps Electric	DRR040D**
Conner Peripherals	CP3040**
Daeyoung	DX-3040A*
Fuji Electric	FK309S-50R*, FK311A-50R**
Fujitsu	M2227D2*, M2611S**
IBM	WD-325*, WD-L40**
JVC	JD-E3848V**
Microlab	DFW 3040**
Microscience International	8040**
Multidigit	DW 2061*
NEC	D3841*, D3835**
Quantum	Hardcard 40**, 52AT LPS
Samsung	SHD-2041N*
Seagate Technology	ST151*, ST3051**
Teac	SD-340H**
Toshiba	MK-232FB*, MK-1032FB**
Western Digital	WDAC140**
Wintec	WD-40/A*
Xebec	XE-3040*

2.5" disk diameter

Fuji Electric	FK201A-54R***, FK203A-45Z****
Fujitsu	M2631S***
IBM	WDA-240****
JVC	JD-F2042M****
Quantum	40AT Go.Drive***
Seagate Technology	ST9052A****
Toshiba	MK-1122FC***
Zentek	ZR 2040***

1.8" disk diameter

Aura Associates	AU426****
Conner Peripherals	CP-1034****
Integral Peripherals	1842***, 1841P****
Ministor Peripherals	Miniport 32P****
NEC	D1711****

1.3" disk diameter

Hewlett-Packard	C3013****

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

During the last several years of the DISK/TREND Report, the drives in this product group were split into separate groups covering fixed disk drives with less than 30 megabytes and 30-60 megabytes. However, both capacity ranges have gone into decline, and the older drives with less than 30 megabytes are approaching extinction. Both DISK/TREND groups have been combined, starting with this edition of the report, into a single product group.

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

During the last five years, numerous 3.5" drives were introduced in this product group. Intense competition developed at the 40 megabyte level, which led to a variety of attempts to reduce product costs, with the result that most of the newer 3.5" drives use only one disk, with height limited to one inch.

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 later drive introductions by other firms. In 1988, Conner's single platter 1" high 40 megabyte drive took higher densities a step further, quickly becoming the leader for laptop portables, and serving as a model for numerous competitive drives.

The first 2.5" drive at the 40 megabyte level was PrairieTek's two platter 1" high model. However, most 2.5" drives with 30 and 40 megabyte capacities now

use only one disk, with drive height limited to 17 millimeter range. 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 in packaging, such as drive heights of only 12.7 millimeters, exactly one half inch, originally pioneered by IBM, or less.

Future competition will also come from the wave of 1.8" drives now starting to be introduced, following Integral Peripheral's initial shipments of 20 megabyte 1.8" drives in late 1991, supplemented by the firm's shipments of 42 and 64 megabyte models in the Spring of 1992. Hewlett-Packard's introduction of the first 1.3" drives is being followed with great interest by the industry, as it tries to determine the extent of the market available to a 21 megabyte 1.3" drive.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	2,900.8	1,431.4	536.4	158.2	79.2
All manufacturers	3,470.4	1,678.8	658.8	222.1	115.6

The peak year for shipments of drives with capacities less than 30 megabytes was 1988, and the peak for 30-60 megabyte drives was 1990. Shipments for all drives with capacities less than 60 megabytes continue to drop even faster than predicted, as the storage demands of new software and user operating practices move the typical capacities required by personal computers out of this product group's range for most applications.

Worldwide unit shipments dropped 9.9% in 1991, to 16,287,000 drives, and the decline expected for 1992 is much greater -- down 44.7%, to 9,011,900 drives. The impact on sales revenue has been even greater, with reductions of 27.4% and 51.6% in 1991 and 1992. While 3.5" and 2.5" drives grew in shipments during 1991, both are in decline in 1992, with reductions for each group in the 40% range. 5.25" drives have dropped even faster and are forecasted at only 166,000 units in 1992.

For several years, the combination of the 3.5" form factor with capacities in the 30-40 megabyte range proved to be a major winner. Most of this growth was

driven by personal computer users' demand for more disk capacity than earlier personal computers provided, to cope with new software programs and ever-increasing file storage requirements. Availability of the two disk 3.5" drives with 41.3 millimeter (1.625 inch) height (30 megabytes from IBM; 40 megabytes from almost everyone else) starting in 1987 was a perfect match for the growing demand.

The subsequent introduction of single disk 3.5" drives with 25.4 millimeter height (1 inch) was again very timely. It caught the wave of hard disk upgrades to the early laptop systems, and became another winner in achieving high production levels. U.S. drive manufacturers were the first to establish volume manufacturing capability for 1" high 3.5" drives, and their success in this segment accounts for their higher share of worldwide unit shipments in 1991, estimated at 87.5%.

2.5" drives have benefited from the strong market performance of notebook computers, despite an inconsistent growth pattern. Rapid growth of 1991 shipments for 30 and 40 megabyte 2.5" drives in the first half of 1991 more than offset the decline in 20 megabyte drive shipments. However, overall 2.5" drive shipments collapsed in the Autumn of 1991, due to excess inventories and the temporary market saturation for many types of notebook computers. Demand for 2.5" disk drives in notebook computers is increasing, but not for the drives in this capacity range, as higher capacity models have become widely available from multiple vendors.

An increasing share of drives in this product group are being sold in the PCM/Reseller channel in 1992. An estimated 39.4% of all 3.5" drives in the group will be sold in the PCM/Reseller channel this year. Ironically, the upgrade market for older personal computers continues, even as system manufacturers move to higher capacities. Symptomatic of this situation, the estimated 1992 average OEM/Integrator price for 3.5" drives is 23 cents per megabyte higher than the PCM/Reseller price, reflecting competitive market forces.

Seagate continued its dominant share of noncaptive unit shipments in 1991, with 35.7% of the worldwide total. 1991 was the first year that most of fSeagate's shipments in this capacity range were 3.5" drives: 4.5 million of Seagate's total 5.2 million drives were 3.5" models. Conner Peripherals' shipments were up to

3.2 million drives, 22% of the worldwide noncaptive total, and the company was the strong leader in 2.5" drives with over 1 million units. Quantum held third position at 16.2%, shipping mostly 3.5" drives.

Single user personal computer applications continue to dominate applications for drives with less than 60 megabytes, with 89.7% of the worldwide market for drives in this group in 1991, and are expected to hold 94.4% of the 1995 market, with a minor share expected for consumer and hobby computers.

Marketing trends

In this edition of the DISK/TREND Report, 1.3" drives are combined in a group of 1.8" and smaller drives for forecasting purposes. The currently available 21 megabyte capacity of 1.3" drives precludes usage in most of the recognized computer applications now in existence. However, the outlook for 1.3" drives with today's capacity level is considered promising in several areas, including pen-based computers, a variety of "personal digital assistants", and in a variety of specialized applications, including dedicated application mobile systems, medical and factory systems, and other "nontraditional" applications.

However, 1.3" drives will certainly not be limited to 21 megabytes throughout the 1993-95 period. It is expected that capacity increases to the 30-60 megabyte range, and possibly higher, will be attained by 1995, and that these improvements will strengthen and broaden the market for 1.3" drives. Hewlett-Packard has pioneered the 1.3" drive with a strong product design and an aggressive manufacturing program -- but it is expected that several more drive manufacturers will enter the field before 1995.

Worldwide unit shipments for drives with less than 60 megabytes capacity are expected to decline at an average annual rate of 56% during the 1993-95 period, as the movement to drive capacities above the level included in this product group accelerates. Total revenues are expected to decline at a slightly faster rate, at an annual average of 58%. The somewhat faster revenue decline will be driven by a rapid drop in captive drive programs. The overall average price per megabyte for PCM/Reseller and OEM/Integrator drives will be relatively flat as competition for sales in this group fades.

This DISK/TREND forecast anticipates that most of the existing drives in this product group will be gone by 1995, with remaining production mostly drives of 1.8" or less in diameter. Changing user patterns for personal computers and fundamental changes in software have driven the minimum acceptable disk capacity level for most applications well above the limits of this product group.

It is expected that only 690,000 drives with capacities less than 60 megabytes will be shipped in 1995 and that more than 89% will be 1.8" or smaller:

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
5.25" full size	100.9	24.3	2.0	--	--
	.6%	.3%	--	--	--
5.25" half high	697.5	141.7	10.0	--	--
	4.3%	1.6%	.3%	--	--
3.5" 1.625" high	5,124.3	425.9	70.0	20.0	--
	31.5%	4.7%	1.8%	1.7%	--
3.5" 1" high or less	8,511.3	7,291	2,898.0	500.0	75.0
	52.2%	80.9%	76.6%	42.9%	10.9%
2.5"	1,852.0	1,037.0	340.0	55.0	--
	11.4%	11.5%	9.0%	4.7%	--
1.8" or less	1.0	92.0	465.0	590.0	615.0
	--	1.0%	12.3%	50.7%	89.1%
	16,287.0	9,011.9	3,785.0	1,165.0	690.0

Shipments through all distribution channels are expected to share in the decline of this product group, but not equally. The current strong share held by the PCM/Reseller channel is destined to be displaced by OEM/Integrator shipments as drives 1.8" or smaller become dominant. Captive drives in this capacity range are also expected to shrink to an insignificant shipment level by 1995.

Ironically, total shipments for the smaller drives in this group will also be losing ground during the 1993-95 period to higher capacity models in other DISK/TREND product groups. The shipment decline for drives with less than 60 megabytes will affect all disk diameters, and is driven not by form factor but by software requirements, processor capabilities and user preferences.

Technical trends

The challenges of large production volume and low cost requirements have been the key engineering targets for the older disk drives in this group. The problem was to achieve high production volumes despite use of continually higher recording densities. The challenge of higher areal densities became even more acute with the movement to 2.5" disks, followed by 1.8" disks.

Competitive cost targets have pushed drives of 60 megabytes or less in capacity toward single disk configurations, in order to help reduce the parts count in each drive, and thus the cost. Most 3.5" drives in the 40 megabyte range now use single disks, and single disk drives are in the process of becoming the standard for 2.5" drives, with similar configurations expected for future 1.8" drives.

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

A different set of requirements will be guiding the development work on new 1.3" (and smaller) drives in this capacity range. The objective will be to increase capacity significantly without increasing the parts count, and cost. Rapid jumps in areal density are therefore needed, which will probably prompt drive manufacturers to early utilization of the most advanced head/disk technologies, consistent with availability on a high volume production basis.

Forecasting assumptions

1. Shipments of 5.25", 3.5" and 2.5" drives in this product group will continue to decline, as the market transitions to higher capacity ranges for desktop and portable computer applications.
2. 1.8" and smaller drives in this product group will enjoy rapid growth rates in mobile computer and nontraditional applications until higher capacity drives become available, causing shipment growth to slow to a negligible level in 1995.

TABLE 21

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	360.0	547.0	154.6	228.5	26.1	52.7	9.5	27.5	--	--
Other U.S. Captive	8.2	8.2	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	368.2	555.2	154.6	228.5	26.1	52.7	9.5	27.5	--	--
PCM/Reseller	519.3	906.9	297.8	490.1	118.0	195.9	20.1	34.2	3.1	4.4
OEM/Integrator	708.1	1,438.7	373.8	712.8	158.1	287.8	52.5	96.5	41.4	74.8
TOTAL U.S. NONCAPTIVE	1,227.4	2,345.6	671.6	1,202.9	276.1	483.7	72.6	130.7	44.5	79.2
TOTAL U.S. REVENUES	1,595.6	2,900.8	826.2	1,431.4	302.2	536.4	82.1	158.2	44.5	79.2
Non-U.S. Manufacturers										
Captive	3.0	231.4	5.1	128.7	3.7	68.8	3.1	40.2	1.5	13.2
PCM/Reseller	6.7	13.6	2.1	11.6	1.8	8.9	.4	2.6	--	.8
OEM/Integrator	26.2	324.6	16.2	107.1	8.2	44.7	4.4	21.1	4.8	22.4
TOTAL NON-U.S. REVENUES	35.9	569.6	23.4	247.4	13.7	122.4	7.9	63.9	6.3	36.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,631.5	3,470.4	849.6	1,678.8	315.9	658.8	90.0	222.1	50.8	115.6
OEM Average Price ($000)		.191		.167		.160		.168		.159

TABLE 22

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991 Shipments		Forecast							
			1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	712.0	1,083.0	395.6	591.0	90.3	170.5	40.0	100.0	--	--
Other U.S. Captive	5.2	5.2	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	717.2	1,088.2	395.6	591.0	90.3	170.5	40.0	100.0	--	--
PCM/Reseller	3,184.9	5,512.3	1,944.0	3,173.0	785.0	1,308.0	135.0	230.0	21.0	30.0
OEM/Integrator	3,830.3	7,650.2	2,286.0	4,317.0	1,008.0	1,840.0	315.0	580.0	260.0	470.0
TOTAL U.S. NONCAPTIVE	7,015.2	13,162.5	4,230.0	7,490.0	1,793.0	3,148.0	450.0	810.0	281.0	500.0
TOTAL U.S. SHIPMENTS	7,732.4	14,250.7	4,625.6	8,081.0	1,883.3	3,318.5	490.0	910.0	281.0	500.0
Non-U.S. Manufacturers										
Captive	5.0	407.2	11.0	278.9	10.0	171.5	10.0	120.0	5.0	45.0
PCM/Reseller	39.0	64.3	15.0	68.4	10.0	50.0	2.0	15.0	--	5.0
OEM/Integrator	132.8	1,564.8	91.5	583.6	45.0	245.0	25.0	120.0	30.0	140.0
TOTAL NON-U.S. SHIPMENTS	176.8	2,036.3	117.5	930.9	65.0	466.5	37.0	255.0	35.0	190.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	7,909.2	16,287.0	4,743.1	9,011.9	1,948.3	3,785.0	527.0	1,165.0	316.0	690.0
Total Capacity (Terabytes)	317.9	657.8	208.2	394.8	84.6	164.2	21.3	47.4	12.8	27.9
Cumulative Shipments (Units in millions)										
IBM	5.0	7.4	5.4	8.0	5.5	8.2	5.5	8.3	5.5	8.3
Non-IBM	44.7	83.3	49.0	91.7	50.9	95.3	51.4	96.4	51.7	97.1
WORLDWIDE TOTAL	49.7	90.8	54.5	99.8	56.4	103.6	56.9	104.7	57.3	105.4

TABLE 23

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues				Forecast												
					1992				1993				1994			1995	
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	3.5"	<=1.8"
U.S. MANUFACTURERS																	
IBM Captive	3.0	500.0	44.0	--	1.0	157.5	70.0	--	.5	23.1	9.1	20.0	10.0	--	17.5	--	--
Other U.S. Captive	--	8.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	77.6	809.5	19.8	--	14.8	462.1	13.2	--	--	173.0	5.0	17.9	24.5	1.6	8.1	2.8	1.6
OEM/Integrator	27.6	1,145.7	265.1	.3	5.4	612.4	82.3	12.7	1.3	215.3	28.1	43.1	30.5	4.8	61.2	4.4	70.4
TOTAL U.S. REVENUES	108.2	2,463.4	328.9	.3	21.2	1,232.0	165.5	12.7	1.8	411.4	42.2	81.0	65.0	6.4	86.8	7.2	72.0
NON-U.S. MANUFACTURERS																	
Captive	12.0	215.4	4.0	--	3.8	107.6	13.1	4.2	2.1	48.5	--	18.2	20.0	--	20.2	4.5	8.7
PCM/Reseller	.5	11.2	1.9	--	--	8.7	2.9	--	--	2.9	1.7	4.3	.7	--	1.9	--	.8
OEM/Integrator	17.4	187.3	119.9	--	4.6	44.8	51.3	6.4	--	15.9	18.2	10.6	4.3	2.4	14.4	1.6	20.8
TOTAL NON-U.S. REVENUES	29.9	413.9	125.8	--	8.4	161.1	67.3	10.6	2.1	67.3	19.9	33.1	25.0	2.4	36.5	6.1	30.3
WORLDWIDE RECAP																	
Captive	15.0	723.6	48.0	--	4.8	265.1	83.1	4.2	2.6	71.6	9.1	38.2	30.0	--	37.7	4.5	8.7
	-77.6%	-36.4%	--	--	-68.0%	-63.4%	+73.1%	--	-45.8%	-73.0%	-89.0%	+809.5%	-58.1%	-100.0%	-1.3%	-85.0%	-76.9%
PCM/Reseller	78.1	820.7	21.7	--	14.8	470.8	16.1	--	--	175.9	6.7	22.2	25.2	1.6	10.0	2.8	2.4
	-89.0%	-4.1%	--	--	-81.0%	-42.6%	-25.8%	--	-100.0%	-62.6%	-58.4%	--	-85.7%	-76.1%	-55.0%	-88.9%	-76.0%
OEM/Integrator	45.0	1,333.0	385.0	.3	10.0	657.2	133.6	19.1	1.3	231.2	46.3	53.7	34.8	7.2	75.6	6.0	91.2
	-66.4%	-19.3%	+74.4%	--	-77.8%	-50.7%	-65.3%	--	-87.0%	-64.8%	-65.3%	+181.2%	-84.9%	-84.4%	+40.8%	-82.8%	+20.6%
Total Revenues	138.1	2,877.3	454.7	.3	29.6	1,393.1	232.8	23.3	3.9	478.7	62.1	114.1	90.0	8.8	123.3	13.3	102.3
	-84.8%	-21.1%	+103.4%	--	-78.6%	-51.6%	-48.8%	--	-86.8%	-65.6%	-73.3%	+389.7%	-81.2%	-85.8%	+8.1%	-85.2%	-17.0%
ANNUAL SHARE, BY DIAMETER	4.0%	83.0%	13.0%	--	1.8%	83.1%	13.9%	1.2%	.6%	72.8%	9.4%	17.2%	40.6%	4.0%	55.4%	11.5%	88.5%

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

TABLE 24

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments				Forecast 1992				1993				1994			1995	
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	3.5"	<=1.8"
U.S. MANUFACTURERS																	
IBM Captive	3.0	1,000.0	80.0	--	1.0	450.0	140.0	--	.5	100.0	20.0	50.0	50.0	--	50.0	--	--
Other U.S. Captive	--	5.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	552.8	4,872.5	87.0	--	110.0	2,988.0	75.0	--	--	1,193.0	30.0	85.0	175.0	10.0	45.0	20.0	10.0
OEM/Integrator	156.2	6,371.0	1,122.0	1.0	34.0	3,761.0	470.0	52.0	10.0	1,455.0	170.0	205.0	210.0	30.0	340.0	30.0	440.0
TOTAL U.S. SHIPMENTS	712.0	12,248.7	1,289.0	1.0	145.0	7,199.0	685.0	52.0	10.5	2,748.0	220.0	340.0	435.0	40.0	435.0	50.0	450.0
NON-U.S. MANUFACTURERS																	
Captive	14.2	383.0	10.0	--	2.9	229.0	35.0	12.0	1.5	115.0	--	55.0	55.0	--	65.0	15.0	30.0
PCM/Reseller	.8	55.5	8.0	--	.1	53.3	15.0	--	--	20.0	10.0	20.0	5.0	--	10.0	--	5.0
OEM/Integrator	71.4	948.4	545.0	--	18.0	235.6	302.0	28.0	--	85.0	110.0	50.0	25.0	15.0	80.0	10.0	130.0
TOTAL NON-U.S. SHIPMENTS	86.4	1,386.9	563.0	--	21.0	517.9	352.0	40.0	1.5	220.0	120.0	125.0	85.0	15.0	155.0	25.0	165.0
WORLDWIDE RECAP																	
Captive	17.2	1,388.2	90.0	--	3.9	679.0	175.0	12.0	2.0	215.0	20.0	105.0	105.0	--	115.0	15.0	30.0
	-68.2%	-25.4%	--	--	-77.3%	-51.1%	+94.4%	--	-48.7%	-68.3%	-88.6%	+775.0%	-51.2%	-100.0%	+9.5%	-85.7%	-73.9%
PCM/Reseller	553.6	4,928.0	95.0	--	110.1	3,041.3	90.0	--	--	1,213.0	40.0	105.0	180.0	10.0	55.0	20.0	15.0
	-84.0%	+23.3%	--	--	-80.1%	-38.3%	-5.3%	--	-100.0%	-60.1%	-55.6%	--	-85.2%	-75.0%	-47.6%	-88.9%	-72.7%
OEM/Integrator	227.6	7,319.4	1,667.0	1.0	52.0	3,996.6	772.0	80.0	10.0	1,540.0	280.0	255.0	235.0	45.0	420.0	40.0	570.0
	-57.2%	-.5%	+102.3%	--	-77.2%	-45.4%	-53.7%	--	-80.8%	-61.5%	-63.7%	+218.8%	-84.7%	-83.9%	+64.7%	-83.0%	+35.7%
Total Shipments	798.4	13,635.6	1,852.0	1.0	166.0	7,716.9	1,037.0	92.0	12.0	2,968.0	340.0	465.0	520.0	55.0	590.0	75.0	615.0
	-80.2%	+3.2%	+122.9%	--	-79.2%	-43.4%	-44.0%	--	-92.8%	-61.5%	-67.2%	+405.4%	-82.5%	-83.8%	+26.9%	-85.6%	+4.2%
ANNUAL SHARE, BY DIAMETER	4.9%	83.8%	11.3%	--	1.8%	85.7%	11.5%	1.0%	.3%	78.5%	9.0%	12.2%	44.7%	4.7%	50.6%	10.9%	89.1%
TOTAL CAPACITY (Terabytes)	30.4	565.4	62.0	--	6.9	342.1	42.6	3.2	.5	132.7	14.1	16.8	23.1	2.3	22.1	3.3	24.6

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

TABLE 25

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	1,218.3	7.5	--	--
PERSONAL COMPUTERS Business and professional, single user	14,625.7	89.7	651.3	94.4
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	158.0	1.0	1.4	.2
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	101.0	.6	1.4	.2
CONSUMER AND HOBBY COMPUTERS	175.9	1.1	34.5	5.0
OTHER APPLICATIONS	8.1	.1	1.4	.2
Total	16,287.0	100.0	690.0	100.0

TABLE 26

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1991	Forecast 1992	1993	1994	1995
Captive					
5.25"	30.00	47.40	32.50	--	--
3.5"	12.62	9.36	7.79	6.70	6.66
2.5"	13.33	11.70	10.71	--	--
1.8" or less	--	8.40	8.87	8.01	7.25
Captive Average	12.81	9.92	8.42	7.37	7.04
PCM/Reseller					
5.25"	3.53	2.97	--	--	--
3.5"	4.10	3.46	3.22	3.11	3.11
2.5"	6.03	4.45	4.29	4.00	--
1.8" or less	--	--	5.06	4.34	3.91
PCM/Reseller Average	4.07	3.47	3.38	3.41	3.43
OEM/Integrator					
5.25"	5.76	5.47	2.88	--	--
3.5"	4.32	3.69	3.34	3.30	3.36
2.5"	7.02	4.18	3.93	3.84	--
1.8" or less	--	7.09	6.57	5.00	4.00
OEM/Integrator Average	4.75	3.82	3.71	4.27	3.95

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

TABLE 27

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	5.25"	3.5"	2.5"	1.8"	Total		5.25"	3.5"	2.5"	1.8"	Total	
Seagate Technology	488.0	2914.0	11.0	--	3413.0	47.5	704.0	4557.0	14.0	--	5275.0	35.7
Conner Peripherals	--	1312.0	460.0	--	1772.0	24.7	--	2182.0	1065.0	--	3247.0	22.0
Quantum	--	645.0	6.0	--	651.0	9.1	--	2370.0	25.0	--	2395.0	16.2
Western Digital	--	621.0	--	--	621.0	8.6	--	1179.0	--	--	1179.0	8.0
Maxtor	--	334.0	--	--	334.0	4.6	--	569.0	--	--	569.0	3.8
JVC	--	1.0	15.0	--	16.0	.2	--	50.0	460.0	--	510.0	3.4
Kalok	--	160.0	--	--	160.0	2.2	--	356.0	--	--	356.0	2.4
NEC	--	11.0	--	--	11.0	.2	--	279.0	--	--	279.0	1.9
Fujitsu	--	8.5	--	--	8.5	.1	.7	228.1	--	--	228.8	1.5
Toshiba	--	2.0	30.0	--	32.0	.5	--	42.0	93.0	--	135.0	.9
Fuji Electric	--	--	--	--	--	--	--	130.0	--	--	130.0	.9
Other U.S.	2.5	6.6	55.0	.1	64.2	.9	5.0	30.5	105.0	1.0	141.5	1.0
Other Non-U.S.	.3	104.0	--	--	104.3	1.5	71.5	274.8	--	--	346.3	2.3
TOTAL	490.8	6119.1	577.0	.1	7187.0	100.0	781.2	12247.4	1762.0	1.0	14791.6	100.0

FIXED DISK DRIVES, 60-100 MEGABYTES

1992 DISK/TREND REPORT

FIXED DISK DRIVES, 60 - 100 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Digirede	W525/85
Elebra	W570-ST*
Hitachi	DK522-10*
IBM	4965-E00
Multidigit	DW 8910
Qualitron	QW-560*
Seagate Technology	ST4096
Sequel	XT-1085
Toshiba	MK-56FB

3.5" disk diameter

Conner Peripherals	CP-30060**, CP-30084E**
Fuji Electric	FK314S-90R**
Fujitsu	M2612ES*
IBM	WDA-380*,WDA-L80**
JVC	JD-E3896V**
Maxtor	7080A/S**
Microlab	DFW 3080**
Microscience International	8080**
Qualitron	QW-3196**
Quantum	Hardcard II**, 85AT ELS**
Samsung	SHD-3061A**
Seagate Technology	ST3096A**
Teac	SD-380H**
Tokico	TD3081C*
Western Digital	WDAC160**, WDAC280**
Xebec	XE-3080*
Zentek	ZH 3100*

2.5" disk diameter

Alps Electric	DR232N2***
Areal Technology	MD-2085***, A-90****
Conner Peripherals	CP-2084**, CP-2064E****
Fuji Electric	FK202S-80R***
Fujitsu	M2633S/T***
IBM	WDS-280***, WDA-S260****
JVC	JD-E2085M***, JD-E2064M****
Maxtor	2585A/S***
Quantum	80S/AT Go.Drive***
Seagate Technology	ST9096A***, ST9080A****
Toshiba	MK-2024FC***

2.5" disk diameter (continued)

Western Digital	WDAH280***
Zentek	ZQ 2090***

1.8" disk diameter

Aura Associates	AU853***
Integral Peripherals	1885***, 1882P****
Minister Peripherals	Miniport 64****
Seagate Technology	ST7075****

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

Significant shipments in this product group got under way in 1981 with early entrants such as the 8" Priam and Fujitsu drives, which developed quick acceptance of the 8" form factor at this capacity level, and rapidly displaced earlier 14" drives. In turn, 8" drives were unable to withstand competition starting in 1984 from full size 5.25" drives, later followed by successful half high versions.

1988 saw the start of production shipments for 3.5" drives by many additional companies, plus several of the existing 5.25" drive producers, and 3.5" shipments quickly rose to provide more than half of this product group's total. Many 1" high 3.5" drives are now available, with shipments still increasing, targeted at personal computer applications. Embedded controllers compatible with IBM PC/AT standards, as well as SCSI, are commonly offered.

2.5" drives in this capacity first appeared in 1990. Shipments of 60 megabyte drives started late in 1990, and have grown rapidly, joined in 1991 by 80 megabyte models. Most of the 2.5" drives in the group have two disks, with heights of 19 millimeters or less, with several drives only 17 millimeters high. The first 1.8" drives in this product group, with capacity of 64 megabytes, appeared in 1992.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	1,796.3	2,153.3	1,917.2	1,752.3	1,222.4
zAll manufacturers	1,950.5	2,435.7	2,320.9	2,285.5	1,807.8

Worldwide shipments of 60-100 megabyte drives increased 44.1% in 1991, to 5.3 million units, and are growing even faster in 1992, with the a total of 8.8 million drives forecasted, a 65.2% increase. During most of the yearlong period ending in the Autumn of 1992, hard disk drives for personal computers were in short supply, and this product group benefited from that shortage. In fact, many system manufacturers made heavier usage of 60-100 megabyte drives than desired, due to greater scarcity of drives with higher capacities.

Gains in sales revenue continue to lag growth in shipments. Worldwide revenues for 60-100 megabyte drives were up only 10.4% in 1991 and are estimated to increase 24.9% in 1992. The influences holding down revenue gains are the displacement of higher priced 5.25" drives and the replacement of 1.625" high 3.5" models by 1" high disk drives using fewer disks and carrying lower prices.

Most of the growth for this product group continues to be provided by U.S. manufacturers of noncaptive drives. 3.5" drives, especially 1" high models, achieved particularly rapid shipment growth during 1991 in the PCM/Reseller channel, reflecting strong demand in the aftermarket for replacement and upgrade products in both older systems and newly installed systems. Demand by the OEM/Integrator channel was significantly higher in 1992, especially in the first half of the year. The large production shipments of 2.5" drives which started in 1991 are mostly direct to manufacturers of notebook computers.

The personal computer market continues to absorb most of the worldwide production 60-100 megabyte drives, taking 97% of 1991's shipments. This trend is continuing, with personal computers expected to account for 95.9% of 1995 shipments, but losing a small portion of their market share to consumer and hobby computers.

Conner Peripherals moved into the lead in noncaptive unit shipments in 1991 for 60-100 megabyte drives with 1.3 million drives, 29.7% of the worldwide total -- 70 % of which were 2.5" models. Maxtor moved up to second with 20.8%, all 3.5" drives, and Seagate Technology dropped to third, with 19.3%, mostly 3.5" drives.

Marketing trends

Although the 60-100 megabyte product group is still growing in shipments, DISK/TREND forecasts predict a peak in 1994, followed by a significant decline in 1995. Revenues are expected to decline during the entire 1993-95 period. Hidden within the group totals, however, are major changes in product mix, with major growth expected for small diameter drives.

3.5" drives are expected to peak in shipments in 1993, as average capacities required for desktop computers continue to move up. Continued growth for 2.5" drives is predicted through 1994, but 2.5" drive shipments in the 60-100 megabyte range will decline after that year, as competition from drives 1.8" and smaller becomes significant:

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
8"	.1	--	--	--	--
	--	--	--	--	--
5.25" full size	114.6	58.3	12.5	4.0	--
	2.2%	.7	.1	--	--
5.25" half high	68.2	53.3	10.5	--	--
	1.3%	.6%	.1%	--	--
3.5" 1.625" high	1,013.1	257.0	70.0	--	--
	19.0%	2.9%	.7%	--	--
3.5" 1" high or less	2,902.0	5,495.0	5,882.0	4,371.0	1,205.0
	54.4%	62.4%	59.0%	43.1%	14.6%
2.5" .75" high	1,233.0	2,845.0	3,095.0	2,805.0	1,510.0
	23.1%	32.3%	31.0%	27.7%	18.2%
2.5" .5" high	.2	90.0	560.0	1,100.0	1,360.0
	--	1.0%	5.7%	10.9%	16.4%
1.8" or less	--	9.0	340.0	1,850.0	4,210.0
	--	.1%	3.4%	18.3%	50.8%
	5,331.2	8,807.6	9,970.0	10,130.0	8,285.0

Although 1.8" drives in this product group are expected to have a higher price per megabyte than 2.5" drives for several years, the eventual shipment dominance by 1.8" and smaller drives will be caused by disk drive form factors more suitable to miniaturized notebook computers and by the availability of

drives on PCMCIA cards. 1.8" and smaller drives are expected to generate 50.6% of 1995 shipments.

Technical trends

Technology employed for drives in this product group has been derived mostly from programs developed for the groups above and below it in capacity. The extensive development of 3.5" drives with capacities above 100 megabytes has resulted in achievement of high areal densities, now employed with drives in this group, using heads, disks and other components made available through the pioneering at higher capacities.

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

Interfaces offered on 3.5" and 2.5" drives in this group are also following the patterns established on lower capacity drives. Because of the higher areal densities employed, embedded controllers are used with all new drives, with most disk drive manufacturers offering PC/AT (IDE) controllers, and some also offering SCSI versions. 1.8" drives are also generally offered with PC/AT (IDE) controllers, but many are also sold in PCMCIA compatible versions.

Forecasting assumptions

1. IBM's 3.5" and 2.5" drive shipments will peak in 1992, and shipments of 1.8" drives will start in 1993.

2. Overall shipments of 3.5" drives will peak in 1993, and 2.5" drive shipments will peak in 1994.

3. Shipments of 1.8" and smaller drives will reach significant levels in 1993, and shipments of 1.3" drives in the 60-100 megabyte range will start in 1994.

TABLE 28

FIXED DISK DRIVES, 60 - 100 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991 Revenues		Forecast							
			1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	449.4	665.5	448.3	676.4	202.4	320.7	147.0	245.1	120.0	210.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	449.4	665.5	448.3	676.4	202.4	320.7	147.0	245.1	120.0	210.0
PCM/Reseller	222.8	359.2	213.7	392.6	234.1	420.0	203.8	341.7	192.4	294.3
OEM/Integrator	428.4	771.6	577.5	1,084.3	621.9	1,176.5	596.8	1,165.5	344.9	718.1
TOTAL U.S. NONCAPTIVE	651.2	1,130.8	791.2	1,476.9	856.0	1,596.5	800.6	1,507.2	537.3	1,012.4
TOTAL U.S. REVENUES	1,100.6	1,796.3	1,239.5	2,153.3	1,058.4	1,917.2	947.6	1,752.3	657.3	1,222.4
Non-U.S. Manufacturers										
Captive	--	41.9	--	127.4	--	199.0	29.5	257.8	35.0	246.5
PCM/Reseller	5.3	9.7	5.2	37.1	4.7	37.6	14.5	63.2	43.9	132.7
OEM/Integrator	13.0	102.6	40.5	117.9	45.0	167.1	52.0	212.2	53.7	206.2
TOTAL NON-U.S. REVENUES	18.3	154.2	45.7	282.4	49.7	403.7	96.0	533.2	132.6	585.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,118.9	1,950.5	1,285.2	2,435.7	1,108.1	2,320.9	1,043.6	2,285.5	789.9	1,807.8
OEM Average Price ($000)		.298		.226		.205		.198		.190

TABLE 29

FIXED DISK DRIVES, 60 - 100 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991		Forecast							
	Shipments		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	638.3	945.0	895.6	1,351.0	505.3	800.5	420.0	700.0	400.0	700.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	638.3	945.0	895.6	1,351.0	505.3	800.5	420.0	700.0	400.0	700.0
PCM/Reseller	861.5	1,389.9	991.7	1,822.8	1,154.0	2,090.0	995.0	1,700.0	980.0	1,505.0
OEM/Integrator	1,495.4	2,647.7	2,626.3	4,878.1	3,072.0	5,775.0	3,058.0	5,929.0	1,830.0	3,800.0
TOTAL U.S. NONCAPTIVE	2,356.9	4,037.6	3,618.0	6,700.9	4,226.0	7,865.0	4,053.0	7,629.0	2,810.0	5,305.0
TOTAL U.S. SHIPMENTS	2,995.2	4,982.6	4,513.6	8,051.9	4,731.3	8,665.5	4,473.0	8,329.0	3,210.0	6,005.0
Non-U.S. Manufacturers										
Captive	--	25.6	--	146.5	--	340.0	60.0	500.0	85.0	555.0
PCM/Reseller	25.0	35.6	25.0	163.1	20.0	175.0	60.0	280.0	220.0	670.0
OEM/Integrator	35.0	287.4	160.5	446.1	210.0	789.5	255.0	1,021.0	275.0	1,055.0
TOTAL NON-U.S. SHIPMENTS	60.0	348.6	185.5	755.7	230.0	1,304.5	375.0	1,801.0	580.0	2,280.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,055.2	5,331.2	4,699.1	8,807.6	4,961.3	9,970.0	4,848.0	10,130.0	3,790.0	8,285.0
Total Capacity (Terabytes)	234.9	421.6	380.1	712.4	419.1	840.9	409.8	857.5	321.2	704.7
Cumulative Shipments (Units in millions)										
IBM	2.5	3.6	3.4	5.0	3.9	5.8	4.3	6.5	4.7	7.2
Non-IBM	7.5	12.0	11.3	19.5	15.7	28.6	20.2	38.1	23.6	45.7
WORLDWIDE TOTAL	10.0	15.7	14.7	24.5	19.7	34.5	24.5	44.6	28.3	52.9

TABLE 30

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues				Forecast: 1992				1993				1994				1995		
	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"
U.S. MANUFACTURERS																			
IBM Captive	--	7.5	595.0	63.0	1.4	450.0	225.0	--	.7	240.0	40.0	40.0	--	140.1	--	105.0	60.0	--	150.0
PCM/Reseller	--	31.6	314.5	13.1	21.6	340.9	30.1	--	3.2	352.9	39.9	24.0	--	208.1	36.1	97.5	46.8	28.5	219.0
OEM/Integrator	.3	16.0	392.9	362.4	7.7	637.0	436.4	3.2	4.5	636.6	500.9	34.5	2.0	484.8	504.9	173.8	116.1	341.0	261.0
TOTAL U.S. REVENUES	.3	55.1	1,302.4	438.5	30.7	1,427.9	691.5	3.2	8.4	1,229.5	580.8	98.5	2.0	833.0	541.0	376.3	222.9	369.5	630.0
NON-U.S. MANUFACTURERS																			
Captive	--	22.3	18.0	1.6	7.8	15.6	104.0	--	--	15.0	184.0	--	--	20.0	209.8	28.0	24.5	166.0	56.0
PCM/Reseller	--	1.6	5.3	2.8	3.0	24.1	10.0	--	--	18.6	13.0	6.0	--	11.1	10.8	41.3	5.4	9.3	118.0
OEM/Integrator	--	19.6	56.6	26.4	6.9	11.6	99.4	--	.2	33.0	126.4	7.5	--	26.1	128.5	57.6	6.3	87.9	112.0
TOTAL NON-U.S. REVENUES	--	43.5	79.9	30.8	17.7	51.3	213.4	--	.2	66.6	323.4	13.5	--	57.2	349.1	126.9	36.2	263.2	286.0
WORLDWIDE RECAP																			
Captive	-- --	29.8 -49.1%	613.0 -14.9%	64.6 --	9.2 -69.1%	465.6 -24.0%	329.0 +409.3%	-- --	.7 -92.4%	255.0 -45.2%	224.0 -31.9%	40.0 --	-- -100.0%	160.1 -37.2%	209.8 -6.3%	133.0 +232.5%	84.5 -47.2%	166.0 -20.9%	206.0 +54.9%
PCM/Reseller	-- --	33.2 -80.0%	319.8 +30.9%	15.9 --	24.6 -25.9%	365.0 +14.1%	40.1 +152.2%	-- --	3.2 -87.0%	371.5 +1.8%	52.9 +31.9%	30.0 --	-- -100.0%	219.2 -41.0%	46.9 -11.3%	138.8 +362.7%	52.2 -76.2%	37.8 -19.4%	337.0 +142.8%
OEM/Integrator	.3 -81.3%	35.6 -48.5%	449.5 -10.1%	388.8 --	14.6 -59.0%	648.6 +44.3%	535.8 +37.8%	3.2 --	4.7 -67.8%	669.6 +3.2%	627.3 +17.1%	42.0 --	2.0 -57.4%	510.9 -23.7%	633.4 +1.0%	231.4 +451.0%	122.4 -76.0%	428.9 -32.3%	373.0 +61.2%
Total Revenues	.3 -81.3%	98.6 -66.4%	1,382.3 -5.6%	469.3 --	48.4 -50.9%	1,479.2 +7.0%	904.9 +92.8%	3.2 --	8.6 -82.2%	1,296.1 -12.4%	904.2 --	112.0 --	2.0 -76.7%	890.2 -31.3%	890.1 -1.6%	503.2 +349.3%	259.1 -70.9%	632.7 -28.9%	916.0 +82.0%
ANNUAL SHARE, BY DIAMETER	--	5.1%	71.0%	23.9%	2.0%	60.8%	37.2%	--	.4%	55.9%	39.0%	4.7%	.1%	39.0%	38.9%	22.0%	14.3%	35.1%	50.6%

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

TABLE 31

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments				Forecast														
					1992				1993				1994				1995		
	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"
U.S. MANUFACTURERS																			
IBM Captive	--	5.0	850.0	90.0	1.0	900.0	450.0	--	.5	600.0	100.0	100.0	--	400.0	--	300.0	200.0	--	500.0
PCM/Reseller	--	92.9	1,259.0	38.0	61.8	1,636.0	125.0	--	10.0	1,810.0	190.0	80.0	--	1,125.0	185.0	390.0	260.0	150.0	1,095.0
OEM/Integrator	.1	44.4	1,583.0	1,020.2	22.1	3,037.0	1,810.0	9.0	12.0	3,263.0	2,385.0	115.0	4.0	2,620.0	2,610.0	695.0	645.0	1,850.0	1,305.0
TOTAL U.S. SHIPMENTS	.1	142.3	3,692.0	1,148.2	84.9	5,573.0	2,385.0	9.0	22.5	5,673.0	2,675.0	295.0	4.0	4,145.0	2,795.0	1,385.0	1,105.0	2,000.0	2,900.0
NON-U.S. MANUFACTURERS																			
Captive	--	10.0	13.6	2.0	3.5	13.0	130.0	--	--	15.0	325.0	--	--	25.0	405.0	70.0	35.0	360.0	160.0
PCM/Reseller	--	2.6	25.0	8.0	8.1	115.0	40.0	--	--	95.0	60.0	20.0	--	60.0	55.0	165.0	30.0	50.0	590.0
OEM/Integrator	--	27.9	184.5	75.0	15.1	51.0	380.0	--	.5	169.0	595.0	25.0	--	141.0	650.0	230.0	35.0	460.0	560.0
TOTAL NON-U.S. SHIPMENTS	--	40.5	223.1	85.0	26.7	179.0	550.0	--	.5	279.0	980.0	45.0	--	226.0	1,110.0	465.0	100.0	870.0	1,310.0
WORLDWIDE RECAP																			
Captive	--	15.0	863.6	92.0	4.5	913.0	580.0	--	.5	615.0	425.0	100.0	--	425.0	405.0	370.0	235.0	360.0	660.0
	--	-56.1%	+8.0%	--	-70.0%	+5.7%	+530.4%	--	-88.9%	-32.6%	-26.7%	--	-100.0%	-30.9%	-4.7%	+270.0%	-44.7%	-11.1%	+78.4%
PCM/Reseller	--	95.5	1,284.0	46.0	69.9	1,751.0	165.0	--	10.0	1,905.0	250.0	100.0	--	1,185.0	240.0	555.0	290.0	200.0	1,685.0
	--	-81.3%	+75.6%	--	-26.8%	+36.4%	+258.7%	--	-85.7%	+8.8%	+51.5%	--	-100.0%	-37.8%	-4.0%	+455.0%	-75.5%	-16.7%	+203.6%
OEM/Integrator	.1	72.3	1,767.5	1,095.2	37.2	3,088.0	2,190.0	9.0	12.5	3,432.0	2,980.0	140.0	4.0	2,761.0	3,260.0	925.0	680.0	2,310.0	1,865.0
	-83.3%	-58.9%	+23.5%	--	-48.5%	+74.7%	+100.0%	--	-66.4%	+11.1%	+36.1%	--	-68.0%	-19.6%	+9.4%	+560.7%	-75.4%	-29.1%	+101.6%
Total Shipments	.1	182.8	3,915.1	1,233.2	111.6	5,752.0	2,935.0	9.0	23.0	5,952.0	3,655.0	340.0	4.0	4,371.0	3,905.0	1,850.0	1,205.0	2,870.0	4,210.0
	-83.3%	-74.6%	+32.2%	--	-38.9%	+46.9%	+138.0%	--	-79.4%	+3.5%	+24.5%	--	-82.6%	-26.6%	+6.8%	+444.1%	-72.4%	-26.5%	+127.6%
ANNUAL SHARE, BY DIAMETER	--	3.4%	73.5%	23.1%	1.3%	65.4%	33.3%	--	.2%	59.8%	36.7%	3.3%	--	43.2%	38.5%	18.3%	14.5%	34.7%	50.8%
TOTAL CAPACITY (Terabytes)	--	12.6	322.8	86.2	7.3	471.7	232.8	.6	1.6	497.6	315.1	26.7	.3	367.6	337.5	152.3	101.1	248.3	355.4

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

TABLE 32

FIXED DISK DRIVES, 60 - 100 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	26.1	.5	16.6	.2
PERSONAL COMPUTERS Business and professional, single user	5,170.2	97.0	7,945.2	95.9
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	23.5	.4	16.6	.2
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	65.6	1.2	49.7	.6
CONSUMER AND HOBBY COMPUTERS	45.8	.9	248.6	3.0
OTHER APPLICATIONS	--	--	8.3	.1
Total	5,331.2	100.0	8,285.0	100.0

TABLE 33

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1991	1992	1993	1994	1995
Captive					
5.25"	33.02	46.10	18.57	--	--
3.5"	8.85	6.37	5.21	4.74	4.49
2.5"	11.53	7.61	6.01	5.75	5.12
1.8" or less	--	--	5.00	4.44	3.84
Captive Average	9.34	6.90	5.51	5.02	4.35
PCM/Reseller					
5.25"	4.94	5.12	4.50	--	--
3.5"	3.08	2.54	2.32	2.19	2.13
2.5"	4.80	2.99	2.45	2.26	2.18
1.8" or less	--	--	3.52	2.94	2.35
PCM/Reseller Average	3.24	2.65	2.40	2.41	2.30
OEM/Integrator					
5.25"	7.09	6.27	5.35	7.14	--
3.5"	2.99	2.54	2.31	2.18	2.11
2.5"	5.03	3.04	2.44	2.25	2.16
1.8" or less	--	5.32	4.12	3.07	2.35
OEM/Integrator Average	3.76	2.76	2.41	2.33	2.22

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

TABLE 34

FIXED DISK DRIVES, 60 - 100 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	8"	5.25"	3.5"	2.5"	Total		8"	5.25"	3.5"	2.5"	Total	
Conner Peripherals	--	--	274.0	455.0	729.0	30.2	--	--	378.0	915.0	1293.0	29.7
Maxtor	--	5.9	536.0	--	541.9	22.4	--	9.0	897.0	--	906.0	20.8
Seagate Technology	--	74.0	480.0	4.0	558.0	23.1	--	113.0	722.0	8.0	843.0	19.3
Western Digital	--	--	338.0	62.0	400.0	16.6	--	--	645.0	103.0	748.0	17.2
Quantum	--	--	110.0	1.0	111.0	4.6	--	--	200.0	10.0	210.0	4.8
Other U.S.	--	6.9	--	10.1	17.0	.6	.1	15.3	--	22.2	37.6	.8
Other Non-U.S.	--	3.0	48.0	9.0	60.0	2.5	--	30.5	209.5	83.0	323.0	7.4
TOTAL	--	89.8	1786.0	541.1	2416.9	100.0	.1	167.8	3051.5	1141.2	4360.6	100.0

FIXED DISK DRIVES, 100-200 MEGABYTES

1992 DISK/TREND REPORT

FIXED DISK DRIVES, 100 - 200 MEGABYTES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Sequel	806

5.25" disk diameter

Digirede	W525/190
Fujitsu	M2247S
Hitachi	DK512-17, DK524C-20*
Micropolis	1674-7*
Multidigit	DW 0133
NEC	D5655*, D5852
Seagate Technology	ST2209N*
Sequel	XT-2190

3.5" disk diameter

Alps Electric	DRR311C**
Conner Peripherals	CP-30100**, CP-30170**
Fuji Electric	FK316S-105R**
Fujitsu	M2614ES*, M2617S**
IBM	WD-3160*, WDA-L160**
Kalok	P5-125***
Maxtor	7120S/A**
Microlab	DFW 3120**
Microscience International	8080-20**
Myrica	Rodime 3139A*
NEC	D3661*, D3755**
Quantum	105S ProDrive*, 170AT ELS**
Samsung	SHD3062S**
Seagate Technology	ST3144A**
Teac	SD-3105**
Toshiba	MK-234FB*, MK-1034FC**
Western Digital	WDAC2170**
Xebec	XE-3120*
Zentek	ZH 3140*, ZM 3140**

2.5" disk diameter

Alps Electric	DR232N8***
Areal Technology	A120***, A180***
Conner Peripherals	CP-2124***
Fuji Electric	FK205A-105Z***
IBM	WDA-2120***
JVC	JD-E2130M***
Maxtor	25128A***

2.5" disk diameter (continued)

Quantum	120AT Go.Drive***, 160S GRS***
Seagate Technology	ST9144A***
Toshiba	MK-2124FC***
Western Digital	AL2170***

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

DISK/TREND Reports in previous years have grouped all drives with capacities in the 100-300 megabyte range in a single product group, but that group is being split in half this year at the 200 megabyte level, in recognition of the extremely high shipment levels now in existence for both of the new product groups. The new 100-200 megabyte group is expected to generate higher unit shipments than any other DISK/TREND product group in 1992.

Dominated in sequence by 14", 8" and 5.25" drives, the shipments of drives in the 100-200 megabyte capacity range are now mostly 3.5" drives, more than 90% of the total. However, substantial shipments of 2.5" drives are taking place in 1992, and the first drives with 1.8" disks or smaller are expected in 1993.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	2,648.6	3,254.8	3,613.4	3,414.0	2,906.7
All manufacturers	3,240.2	4,015.7	4,508.4	4,431.4	3,934.1

1991 worldwide shipments for this product group were 5.9 million drives, an increase of 78.5% over the previous year. This year is expected to be even stronger, with a projected total of 11.5 million drives, up 94.3%. The continued strong demand for personal computers, which used 93% of 1991's shipments, underlies this growth, combined with the increased disk storage appetites of today's popular software.

3.5" drives dominate shipments in the 100-200 megabyte range, but 2.5" drives are rising rapidly in 1992, with 912,000 drives estimated for the year.

Notebook computer users, the existing market for most 2.5" drives, have also demonstrated a preference for more capacity.

Total revenue for the product group increased only 15.7% in 1991 and gains are expected to be held to 23.9% in 1992, despite almost a doubling of unit shipments. Because of sharply lower price levels for captive drives, continued displacement of more expensive 5.25" drives and declining shipments of more costly 1.625" high 3.5" drives, revenue gains for the group have not kept up with shipment gains. Meanwhile, the newer 1" high 3.5" drives, with lower parts counts and very competitive prices, have captured the desktop PC market. The overall OEM/Integrator average price per megabyte for 3.5" drives is expected to dip below $2.00 this year.

Quantum led in noncaptive unit shipments for 1991 with 1.3 million drives, 29% of the worldwide total, all 3.5" drives. Conner Peripherals held 19.6% of the total for second place, and Seagate Technology was third with 16.4%.

Marketing trends

Two more years of overall growth in shipments are forecasted for the 100-200 megabyte group, then decline, as the relentless movement to higher disk capacities for personal computers continues. The average annual shipment growth rate for 1993-95 is projected at 13.1%, with 1995 suffering a drop of 4%. After more growth in 1993, total revenues for 100-200 megabyte drives are expected to decline in the 1993-95 period, as noncaptive distribution predominates and prices decline.

Until 1988-89, the big growth for 5.25" drives in this capacity range was fueled by demand for technical workstations and minicomputers, but the even larger market for 3.5" drives is built upon the personal computer market, which is rapidly upgrading to more capable processors and software. The growing disk storage requirements of these new PC systems are boosting shipments of 3.5" drives in the 100-200 megabyte range.

Although the market for 2.5" drives has been created almost entirely to date by notebook computers, it is expected that 2.5" drives in the 100-200 megabyte range will also find a market with desktop personal computers when their OEM

prices are competitive with 3.5" drives of equal capacity. 2.5" drives, in addition to being small in size, also have lower power requirements, generate less heat, and are quieter than 3.5" drives. These cost and marketing advantages will be important to manufacturers of desktop personal computers and will greatly broaden the market available to higher capacity 2.5" drives during the next few years.

The desktop market will probably be essential to the future growth of 2.5" drive shipments, since 1.8" and smaller drives are expected to eat into their traditional notebook computer market starting next year, with substantial displacement by 1995.

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
8"	2.3	.3	--	--	--
	--	--	--	--	--
5.25" full size	131.4	52.5	17.0	--	--
	2.2%	.5%	.1%	--	--
5.25" half high	109.0	25.5	9.0	--	--
	1.8%	.2%	.1%	--	--
3.5" 1.625" high	2,591.5	1,538.0	1,100.0	665.0	350.0
	43.6%	13.3%	7.3%	3.9%	2.1%
3.5" 1" high or less	3,119.0	9,038.0	11,399.0	11,385.0	8,155.0
	52.4%	78.1%	75.7%	66.9%	49.9%
2.5"	.3	912.0	2,460.0	4,550.0	5,600.0
	--	7.9%	16.4%	26.7%	34.2%
1.8" or less	--	--	60.0	430.0	2,250.0
	--	--	.4%	2.5%	13.8%
	5,953.5	11,566.3	15,045.0	17,030.0	16,355.0

Technical trends

The 2.5" and smaller drives in the 100-200 megabyte range now being developed by drive manufacturers make severe demands on the key components used in achieving the high recording densities necessary to meet the small packaging requirements. Not only are areal densities very high, but packaging requirements are severe, involving drive heights as low as half an inch, new head suspensions, embedded controllers, and very fast actuators.

Some of the newer 2.5" drives utilize areal densities which rival the recording densities used with one gigabyte 3.5" drives which started to ship in 1992. There will be a major development emphasis in many drive manufacturing companies to produce both 2.5" and 1.8" drives in the 100-200 megabyte range with single disks. The purpose of these programs, of course, will be to meet two objectives: (1) Reduce the parts count to the same level as existing 3.5" drives and thus open up the desktop PC market with competitive prices, and (2) reduce the package height to the minimum, making possible 1.8" drives with more than 100 megabytes capacity, which meet the 10.5 millimeter height requirement of the PCMCIA type 3 standard.

It is not yet clear which of several contending technology approaches will prevail in this quest. Magnetoresistive thin film heads may be the key for some firms. Others are attempting to achieve density breakthroughs with various approaches to contact recording, such as Conner Peripherals with the VisQUS technology, and Maxtor and Fujitsu with Censtor's miniaturized head and perpendicular recording.

Forecasting assumptions

1. IBM's shipments of drives in this group will continue, but at a declining level, as falling shipments of 3.5" drives are partially offset by shipments of 2.5" and 1.8" drives.

2. 3.5" drives will continue to dominate noncaptive drive shipments until 1995 due to their wide acceptance in the high-end personal computer market, but will start to decline in shipments after 1993.

3. 2.5" drives used for notebook computer applications will increase in shipment volume through 1995, for both notebook computer and desktop PC markets, but 1.8" drives will be available starting in 1993 and will significantly displace 2.5" in portions of the low-end notebook computer market by the end of the forecast period.

TABLE 35

FIXED DISK DRIVES, 100 - 200 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	989.5	1,411.0	854.3	1,255.0	837.6	1,261.0	634.0	970.0	454.8	707.6
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	989.5	1,411.0	854.3	1,255.0	837.6	1,261.0	634.0	970.0	454.8	707.6
PCM/Reseller	319.8	489.8	505.5	790.2	574.7	890.0	568.9	875.1	508.4	765.8
OEM/Integrator	468.0	747.8	695.8	1,209.6	798.9	1,462.4	814.2	1,568.9	714.4	1,433.3
TOTAL U.S. NONCAPTIVE	787.8	1,237.6	1,201.3	1,999.8	1,373.6	2,352.4	1,383.1	2,444.0	1,222.8	2,199.1
TOTAL U.S. REVENUES	1,777.3	2,648.6	2,055.6	3,254.8	2,211.2	3,613.4	2,017.1	3,414.0	1,677.6	2,906.7
Non-U.S. Manufacturers										
Captive	12.6	244.6	6.8	268.6	18.3	253.8	24.0	218.5	28.5	234.0
PCM/Reseller	16.1	19.2	77.0	188.7	94.7	240.1	97.7	252.2	82.0	237.5
OEM/Integrator	51.2	327.8	61.1	303.6	112.2	401.1	176.1	546.7	193.0	555.9
TOTAL NON-U.S. REVENUES	79.9	591.6	144.9	760.9	225.2	895.0	297.8	1,017.4	303.5	1,027.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,857.2	3,240.2	2,200.5	4,015.7	2,436.4	4,508.4	2,314.9	4,431.4	1,981.1	3,934.1
OEM Average Price ($000)		.336		.255		.239		.221		.210

TABLE 36

FIXED DISK DRIVES, 100 - 200 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991		Forecast							
	Shipments		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	752.0	1,073.0	1,062.6	1,561.0	1,395.3	2,100.5	1,275.0	1,950.0	1,125.0	1,750.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	752.0	1,073.0	1,062.6	1,561.0	1,395.3	2,100.5	1,275.0	1,950.0	1,125.0	1,750.0
PCM/Reseller	975.3	1,507.0	2,015.7	3,157.5	2,523.0	3,905.0	2,655.0	4,095.0	2,415.0	3,655.0
OEM/Integrator	1,522.5	2,426.5	2,789.7	4,862.0	3,378.5	6,178.5	3,735.0	7,175.0	3,425.0	6,870.0
TOTAL U.S. NONCAPTIVE	2,497.8	3,933.5	4,805.4	8,019.5	5,901.5	10,083.5	6,390.0	11,270.0	5,840.0	10,525.0
TOTAL U.S. SHIPMENTS	3,249.8	5,006.5	5,868.0	9,580.5	7,296.8	12,184.0	7,665.0	13,220.0	6,965.0	12,275.0
Non-U.S. Manufacturers										
Captive	3.6	118.7	5.0	199.3	19.0	250.0	30.0	275.0	45.0	370.0
PCM/Reseller	47.0	52.6	295.0	719.0	400.0	1,000.0	445.0	1,135.0	390.0	1,110.0
OEM/Integrator	120.0	775.7	218.5	1,067.5	430.0	1,611.0	760.0	2,400.0	900.0	2,600.0
TOTAL NON-U.S. SHIPMENTS	170.6	947.0	518.5	1,985.8	849.0	2,861.0	1,235.0	3,810.0	1,335.0	4,080.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,420.4	5,953.5	6,386.5	11,566.3	8,145.8	15,045.0	8,900.0	17,030.0	8,300.0	16,355.0
Total Capacity (Terabytes)	420.5	729.1	801.2	1,440.5	1,022.9	1,884.7	1,133.7	2,173.4	1,069.8	2,122.3
Cumulative Shipments (Units in millions)										
IBM	1.6	2.3	2.7	3.8	4.1	5.9	5.4	7.9	6.5	9.6
Non-IBM	6.1	10.7	11.4	20.7	18.2	33.6	25.8	48.7	33.0	63.3
WORLDWIDE TOTAL	7.8	13.0	14.2	24.6	22.3	39.6	31.2	56.7	39.5	73.0

TABLE 37

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues				Forecast													
	1992				1993				1994			1995		
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"
U.S. MANUFACTURERS																		
IBM Captive	--	6.0	1,405.0	--	--	2.0	1,218.0	35.0	1.0	1,080.0	180.0	--	750.0	200.0	20.0	477.6	160.0	70.0
PCM/Reseller	--	81.3	408.5	--	--	27.2	754.7	8.3	6.5	865.9	17.6	--	800.1	34.5	40.5	524.0	46.2	195.6
OEM/Integrator	--	33.8	713.8	.2	--	7.9	1,042.7	159.0	6.6	1,101.2	333.5	21.1	976.5	542.9	49.5	641.0	611.1	181.2
TOTAL U.S. REVENUES	--	121.1	2,527.3	.2	--	37.1	3,015.4	202.3	14.1	3,047.1	531.1	21.1	2,526.6	777.4	110.0	1,642.6	817.3	446.8
NON-U.S. MANUFACTURERS																		
Captive	16.2	68.2	160.2	--	--	25.8	211.3	31.5	11.3	154.5	88.0	--	117.0	101.5	--	84.0	96.0	54.0
PCM/Reseller	--	1.8	17.4	--	--	--	158.0	30.7	--	198.1	42.0	--	190.3	52.9	9.0	130.2	58.1	49.2
OEM/Integrator	1.5	26.0	300.3	--	.6	8.4	237.1	57.5	.5	235.5	165.1	--	233.2	298.5	15.0	158.9	352.6	44.4
TOTAL NON-U.S. REVENUES	17.7	96.0	477.9	--	.6	34.2	606.4	119.7	11.8	588.1	295.1	--	540.5	452.9	24.0	373.1	506.7	147.6
WORLDWIDE RECAP																		
Captive	16.2	74.2	1,565.2	--	--	27.8	1,429.3	66.5	12.3	1,234.5	268.0	--	867.0	301.5	20.0	561.6	256.0	124.0
	+24.6%	-81.6%	+51.5%	--	-100.0%	-62.5%	-8.7%	--	-55.8%	-13.6%	+303.0%	--	-29.8%	+12.5%	--	-35.2%	-15.1%	+520.0%
PCM/Reseller	--	83.1	425.9	--	--	27.2	912.7	39.0	6.5	1,064.0	59.6	--	990.4	87.4	49.5	654.2	104.3	244.8
	--	-28.1%	+33.6%	--	--	-67.3%	+114.3%	--	-76.1%	+16.6%	+52.8%	--	-6.9%	+46.6%	--	-33.9%	+19.3%	+394.5%
OEM/Integrator	1.5	59.8	1,014.1	.2	.6	16.3	1,279.8	216.5	7.1	1,336.7	498.6	21.1	1,209.7	841.4	64.5	799.9	963.7	225.6
	-78.3%	-62.3%	+34.8%	--	-60.0%	-72.7%	+26.2%	--	-56.4%	+4.4%	+130.3%	--	-9.5%	+68.8%	+205.7%	-33.9%	+14.5%	+249.8%
Total Revenues	17.7	217.1	3,005.2	.2	.6	71.3	3,621.8	322.0	25.9	3,635.2	826.2	21.1	3,067.1	1,230.3	134.0	2,015.7	1,324.0	594.4
	-11.1%	-67.9%	+42.8%	--	-96.6%	-67.2%	+20.5%	--	-63.7%	+.4%	+156.6%	--	-15.6%	+48.9%	+535.1%	-34.3%	+7.6%	+343.6%
ANNUAL SHARE, BY DIAMETER	.5%	6.7%	92.8%	--	--	1.8%	90.3%	7.9%	.6%	80.7%	18.3%	.4%	69.3%	27.8%	2.9%	51.3%	33.7%	15.0%

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

TABLE 38

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments				Forecast													
	1992				1993				1994			1995		
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"
U.S. MANUFACTURERS																		
IBM Captive	--	3.0	1,070.0	--	--	1.0	1,510.0	50.0	.5	1,800.0	300.0	--	1,500.0	400.0	50.0	1,150.0	400.0	200.0
PCM/Reseller	--	123.7	1,383.3	--	--	41.5	3,089.0	27.0	10.0	3,830.0	65.0	--	3,810.0	150.0	135.0	2,620.0	220.0	815.0
OEM/Integrator	--	53.0	2,373.2	.3	--	12.0	4,325.0	525.0	9.5	4,874.0	1,235.0	60.0	4,650.0	2,360.0	165.0	3,205.0	2,910.0	755.0
TOTAL U.S. SHIPMENTS	--	179.7	4,826.5	.3	--	54.5	8,924.0	602.0	20.0	10,504.0	1,600.0	60.0	9,960.0	2,910.0	350.0	6,975.0	3,530.0	1,770.0
NON-U.S. MANUFACTURERS																		
Captive	1.6	23.1	94.0	--	--	10.3	154.0	35.0	5.0	135.0	110.0	--	130.0	145.0	--	120.0	160.0	90.0
PCM/Reseller	--	1.6	51.0	--	--	--	629.0	90.0	--	850.0	150.0	--	880.0	225.0	30.0	635.0	270.0	205.0
OEM/Integrator	.7	36.0	739.0	--	.3	13.2	869.0	185.0	1.0	1,010.0	600.0	--	1,080.0	1,270.0	50.0	775.0	1,640.0	185.0
TOTAL NON-U.S. SHIPMENTS	2.3	60.7	884.0	--	.3	23.5	1,652.0	310.0	6.0	1,995.0	860.0	--	2,090.0	1,640.0	80.0	1,530.0	2,070.0	480.0
WORLDWIDE RECAP																		
Captive	1.6	26.1	1,164.0	--	--	11.3	1,664.0	85.0	5.5	1,935.0	410.0	--	1,630.0	545.0	50.0	1,270.0	560.0	290.0
	+45.5%	-77.9%	+76.1%	--	-100.0%	-56.7%	+43.0%	--	-51.3%	+16.3%	+382.4%	--	-15.8%	+32.9%	--	-22.1%	+2.8%	+480.0%
PCM/Reseller	--	125.3	1,434.3	--	--	41.5	3,718.0	117.0	10.0	4,680.0	215.0	--	4,690.0	375.0	165.0	3,255.0	490.0	1,020.0
	--	-18.2%	+126.7%	--	--	-66.9%	+159.2%	--	-75.9%	+25.9%	+83.8%	--	+.2%	+74.4%	--	-30.6%	+30.7%	+518.2%
OEM/Integrator	.7	89.0	3,112.2	.3	.3	25.2	5,194.0	710.0	10.5	5,884.0	1,835.0	60.0	5,730.0	3,630.0	215.0	3,980.0	4,550.0	940.0
	-80.6%	-57.9%	+100.2%	--	-57.1%	-71.7%	+66.9%	--	-58.3%	+13.3%	+158.5%	--	-2.6%	+97.8%	+258.3%	-30.5%	+25.3%	+337.2%
Total Shipments	2.3	240.4	5,710.5	.3	.3	78.0	10,576.0	912.0	26.0	12,499.0	2,460.0	60.0	12,050.0	4,550.0	430.0	8,505.0	5,600.0	2,250.0
	-51.1%	-50.2%	+100.5%	--	-87.0%	-67.6%	+85.2%	--	-66.7%	+18.2%	+169.7%	--	-3.6%	+85.0%	+616.7%	-29.4%	+23.1%	+423.3%
ANNUAL SHARE, BY DIAMETER	--	4.0%	96.0%	--	--	.7%	91.5%	7.8%	.2%	83.2%	16.4%	.2%	70.9%	26.7%	2.4%	52.1%	34.2%	13.7%
TOTAL CAPACITY (Terabytes)	.3	38.4	690.4	--	--	12.3	1,310.5	117.7	4.0	1,548.4	325.1	7.2	1,494.3	627.5	51.6	1,047.7	804.7	270.0

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

TABLE 39

FIXED DISK DRIVES, 100 - 200 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	71.4	1.2	49.1	.3
PERSONAL COMPUTERS Business and professional, single user	5,536.7	93.0	15,815.2	96.7
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	170.3	2.9	163.6	1.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	169.1	2.8	245.3	1.5
CONSUMER AND HOBBY COMPUTERS	4.2	.1	65.4	.4
OTHER APPLICATIONS	--	--	16.4	.1
Total	5,953.5	100.0	16,355.0	100.0

TABLE 40

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1991	1992	1993	1994	1995
Captive					
8"	81.00	--	--	--	--
5.25"	20.04	17.31	15.51	--	--
3.5"	10.37	6.63	5.05	4.30	3.73
2.5"	--	6.15	5.14	4.35	3.59
1.8" or less	--	--	--	3.33	3.56
Captive Average	10.69	6.69	5.09	4.29	3.67
PCM/Reseller					
8"	--	--	--	--	--
5.25"	3.95	3.98	4.06	--	--
3.5"	2.51	2.03	1.86	1.70	1.62
2.5"	--	2.51	2.10	1.71	1.50
1.8" or less	--	--	--	2.50	2.00
PCM/Reseller Average	2.67	2.07	1.87	1.72	1.68
OEM/Integrator					
8"	15.40	--	--	--	--
5.25"	4.36	4.13	4.31	--	--
3.5"	2.74	1.97	1.82	1.70	1.62
2.5"	--	2.36	2.03	1.65	1.45
1.8" or less	--	--	2.91	2.50	2.00
OEM/Integrator Average	2.80	2.03	1.89	1.70	1.56

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

TABLE 41

FIXED DISK DRIVES, 100 - 200 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	8"	5.25"	3.5"	2.5"	Total		8"	5.25"	3.5"	2.5"	Total	
Quantum	--	--	746.0	--	746.0	28.0	--	--	1380.0	--	1380.0	29.0
Conner Peripherals	--	--	629.0	--	629.0	23.6	--	--	933.0	--	933.0	19.6
Seagate Technology	--	78.0	533.0	--	611.0	22.9	--	94.0	689.0	--	783.0	16.4
Maxtor	--	16.8	192.0	--	208.8	7.8	--	42.0	310.0	--	352.0	7.4
Fujitsu	.1	1.1	37.4	--	38.6	1.4	.7	2.3	294.0	--	297.0	6.2
NEC	--	9.0	23.0	--	32.0	1.2	--	15.0	218.0	--	233.0	4.9
Western Digital	--	--	105.0	--	105.0	3.9	--	--	193.0	--	193.0	4.1
Toshiba	--	--	59.0	--	59.0	2.2	--	6.0	109.0	--	115.0	2.4
Kalok	--	--	53.0	--	53.0	2.0	--	--	105.0	--	105.0	2.2
Other U.S.	--	18.1	126.7	.2	145.0	5.5	--	40.7	146.5	.3	187.5	4.0
Other Non-U.S.	--	2.4	35.0	--	37.4	1.5	--	14.3	169.0	--	183.3	3.8
TOTAL	.1	125.4	2539.1	.2	2664.8	100.0	.7	214.3	4546.5	.3	4761.8	100.0

FIXED DISK DRIVES, 200-300 MEGABYTES

1992 DISK/TREND REPORT

FIXED DISK DRIVES, 200 - 300 MEGABYTES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Seagate Technology	ST6344J
Sequel	807

5.25" disk diameter

Digital Equipment	RA 70, RF31F*
EZI	1300, 2300
Fujitsu	M2248E/S
IBM	671-284
Sagem	MSA 252-200

3.5" disk diameter

Alps Electric	DRR112C**
Brand Technologies	BT9220A*
Conner Peripherals	CP-3200F*, CP-30200**
Fuji Electric	FK317S-240R**
Fujitsu	M2618S**
Hewlett-Packard	C2233*
Hitachi	DK312C-25*, DK-324C-21A**
IBM	9371-10*, WD-L200**
Kalok	Kalok P5-250****
Maxtor	7213S/A**
Microlab	DFW 3200*
Microscience International	7200*, 8200**
Myrica	Rodime 3259A*
Quantum	240AT LPS**
Seagate Technology	ST3283A**
Teac	SD-3210**
Western Digital	WDAP4200*, WDAC2250**
Zentek	H3370*

2.5" disk diameter

Digital Equipment	DSP2022S/A***
Seagate Technology	ST9235A***

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

Until this year, all disk drives with capacities in the 100-300 megabyte range were included in a single group. However, that group had become extremely large in annual shipments and it has now been split at the 200 megabyte level, in recognition of the industry's current product clusters. Unit shipments in the new 200-300 megabyte product group are expected to exceed 4 million drives in 1992 and rapid growth is projected for the group.

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

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	933.9	1,374.4	2,463.8	3,151.3	3,675.7
All manufacturers	988.9	1,530.1	2,734.5	3,566.7	4,249.5

The 200-300 megabyte group achieved the highest rate of growth in annual shipments of any DISK/TREND product group during 1991, an increase of 282% over the previous year. Another strong year is under way in 1992, and the forecasted shipment increase of 111.6% will result in worldwide shipments of over 4 million drives. Revenue growth is not as strong, since most of the current shipment increases are still for noncaptive drives, with an expected buildup of higher priced captive shipments still in the future.

The current prosperity for this product group is being generated by rapidly growing sales of 3.5" drives, especially 1" high models. 99.6% of 1992's unit shipments are expected to be 3.5" drives, with early shipments of 2.5" drives just getting started this year. Values to system manufacturers and end users are excellent -- the average price per megabyte for 3.5" drives in 1992 is already down to $1.50 in the OEM/Integrator channel.

The personal computer market produced 73.4% of 1991's worldwide unit

shipments, followed by 13.4% for nonoffice systems and workstations, and 7.2% for minicomputers and networks -- but the personal computer market is expected to consume 91% of 1995's shipments.

Seagate Technology jumped to an early lead in 1991 noncaptive shipments, with 33.1% of the worldwide total. Maxtor and Conner Peripherals were in a dead heat for second place, each with 20.5% of the total shipments.

Marketing trends

Unit shipments of 200-300 megabyte drives are expected to increase at an average annual rate of 56.3% in the 1993-95 period. The product group is forecasted for total shipments of 14.6 million drives in 1995, which will make it the second largest DISK/TREND product group in that year. Sales revenues are expected to increase at an average annual rate of 42.7% during the same period, a relatively strong revenue increase, boosted by significant growth in captive drives at higher average prices.

Despite growth in shipments by smaller diameter drives, 3.5" drives will continue to dominate this product group through 1995:

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
8"	5.2	2.0	1.0	--	--
	.3%	--	--	--	--
5.25"	16.2	4.7	--	--	--
	.8%	.1%	--	--	--
3.5" 1.625" high	1,406.8	727.3	362.0	199.0	105.0
	73.8%	18.0%	4.5%	1.8%	.7%
3.5" 1" high or less	478.6	3,285.6	7,317.0	9,836.0	12,850.0
	25.1%	81.5%	91.6%	89.3%	87.7%
2.5"	--	15.0	310.0	980.0	1,620.0
	--	.4%	3.9%	8.9%	11.1%
1.8" or less	--	--	--	--	80.0
	--	--	--	--	.5%
	1,906.8	4,034.6	7,990.0	11,015.0	14,655.0

The high expectations for rapidly growing shipments in this product group

are based mostly on the expanding disk storage capacities needed for desktop personal computers, a market which will turn heavily to 1" high 3.5" drives for that requirement. The success of Microsoft's Windows software has already pushed the typical drive capacity used with new PC's over 100 megabytes, and the trend is up. Newer versions of IBM's OS/2, Microsoft's Windows and the associated applications software will continue to require greater disk capacity, accelerating growth for this product group and for those with even higher capacity drives.

2.5" drives in this capacity group, which started to ship in 1992, are also expected to benefit from the impact of personal computer software on the notebook computer market. Notebook computers with disk capacity over 200 megabytes are not for everyone, but the market is expected to be large enough to generate a significant portion of the sales forecasted through 1995. Some 2.5" drives will also be utilized with desktop computers, as higher recording densities make it possible for 2.5" drives to compete with 3.5" drives for some desktop applications. 2.5" drives offer advantages in lower power specifications, less heat generation and quieter operation.

Technical trends

As this product group continues its strong increase in shipments, the leading drive manufacturers will concentrate their development efforts on cost reduction. In this type of product, cost reduction frequently requires significant advances in the technology and the assumption of considerable risk.

Well before 1995, it will be possible to produce 3.5" drives in the 200-300 megabyte range using only one disk, instead of the two or three disks currently employed. During the same period, it will probably also be possible to manufacture 200-300 megabyte 2.5" drives with only one disk.

The major reduction in parts count represented by the drive with a single disk will stimulate drive manufacturers to use high density magnetoresistive thin film heads as soon as they are in high volume production for the noncaptive market, as well as continue to drive disk coercivities to higher levels. If contact, or near-contact, recording becomes a production reality in the next few years, it will probably be used in this capacity range early in its life, due to the significant cost reduction opportunity offered. Other cost reductions will be derived from

continued simplification of mechanical subassemblies and combination of more functions on fewer semiconductor chips.

Forecasting assumptions

1. Shipments of IBM's 3.5" drives in this capacity group, started in 1992, are expected to grow to high levels during the forecast period, and high shipments are also expected for new 2.5" drives starting in 1993.
2. 3.5" drives will continue to dominate noncaptive drive shipments until 1995 due to their wide acceptance in the desktop personal computer market.
3. 2.5" drives for other captive and noncaptive applications will be in volume production by 1992, and 1.8" drives will be in volume production for the OEM market in 1995.

TABLE 42

FIXED DISK DRIVES, 200 - 300 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	5.2	8.0	72.8	104.0	401.2	602.0	637.0	980.0	681.0	1,080.0
Other U.S. Captive	33.2	74.7	11.5	22.5	9.9	16.8	13.6	24.2	13.9	28.5
TOTAL U.S. CAPTIVE	38.4	82.7	84.3	126.5	411.1	618.8	650.6	1,004.2	694.9	1,108.5
PCM/Reseller	234.0	331.6	325.1	461.6	443.3	629.2	498.6	712.0	607.8	869.0
OEM/Integrator	372.0	519.6	498.1	786.3	743.6	1,215.8	861.3	1,435.1	991.0	1,698.2
TOTAL U.S. NONCAPTIVE	606.0	851.2	823.2	1,247.9	1,186.9	1,845.0	1,359.9	2,147.1	1,598.8	2,567.2
TOTAL U.S. REVENUES	644.4	933.9	907.5	1,374.4	1,598.0	2,463.8	2,010.5	3,151.3	2,293.7	3,675.7
Non-U.S. Manufacturers										
Captive	--	13.0	--	50.2	--	72.0	3.5	141.0	9.0	179.0
PCM/Reseller	--	1.2	7.4	28.2	15.0	49.5	23.9	71.9	41.7	108.2
OEM/Integrator	7.0	40.8	8.9	77.3	32.8	149.2	59.1	202.5	92.5	286.6
TOTAL NON-U.S. REVENUES	7.0	55.0	16.3	155.7	47.8	270.7	86.5	415.4	143.2	573.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	651.4	988.9	923.8	1,530.1	1,645.8	2,734.5	2,097.0	3,566.7	2,436.9	4,249.5
OEM Average Price ($000)		.463		.340		.285		.257		.235

TABLE 43

FIXED DISK DRIVES, 200 - 300 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991		Forecast							
	Shipments		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1.3	2.0	70.7	101.0	500.3	750.5	910.0	1,400.0	1,135.0	1,800.0
Other U.S. Captive	5.6	12.6	2.6	4.6	13.0	22.0	22.0	39.0	27.0	55.0
TOTAL U.S. CAPTIVE	6.9	14.6	73.3	105.6	513.3	772.5	932.0	1,439.0	1,162.0	1,855.0
PCM/Reseller	481.5	676.8	913.7	1,304.1	1,565.0	2,225.0	1,975.0	2,820.0	2,630.0	3,760.0
OEM/Integrator	812.1	1,127.5	1,492.1	2,349.5	2,624.1	4,302.5	3,365.0	5,621.0	4,230.0	7,255.0
TOTAL U.S. NONCAPTIVE	1,293.6	1,804.3	2,405.8	3,653.6	4,189.1	6,527.5	5,340.0	8,441.0	6,860.0	11,015.0
TOTAL U.S. SHIPMENTS	1,300.5	1,818.9	2,479.1	3,759.2	4,702.4	7,300.0	6,272.0	9,880.0	8,022.0	12,870.0
Non-U.S. Manufacturers										
Captive	--	3.7	--	24.2	--	40.0	5.0	105.0	15.0	165.0
PCM/Reseller	--	2.0	18.0	63.0	50.0	165.0	90.0	270.0	170.0	440.0
OEM/Integrator	16.4	82.2	21.7	188.2	105.0	485.0	220.0	760.0	380.0	1,180.0
TOTAL NON-U.S. SHIPMENTS	16.4	87.9	39.7	275.4	155.0	690.0	315.0	1,135.0	565.0	1,785.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,316.9	1,906.8	2,518.8	4,034.6	4,857.4	7,990.0	6,587.0	11,015.0	8,587.0	14,655.0
Total Capacity (Terabytes)	282.2	409.8	562.1	900.1	1,091.3	1,800.0	1,490.7	2,498.5	1,961.1	3,355.6
Cumulative Shipments (Units in millions)										
IBM	--	.1	.1	.2	.6	.9	1.5	2.3	2.7	4.1
Non-IBM	1.8	2.7	4.3	6.6	8.7	13.8	14.3	23.4	21.8	36.3
WORLDWIDE TOTAL	1.9	2.8	4.5	6.8	9.3	14.8	15.9	25.8	24.5	40.5

TABLE 44

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues			Forecast											
				1992				1993			1994		1995		
	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	8"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"	<=1.8"
U.S. MANUFACTURERS															
IBM Captive	8.0	--	--	4.0	--	100.0	--	2.0	560.0	40.0	700.0	280.0	660.0	420.0	--
Other U.S. Captive	--	74.7	--	--	22.0	.5	--	--	1.8	15.0	3.2	21.0	3.5	25.0	--
PCM/Reseller	--	--	331.6	--	--	461.6	--	--	624.0	5.2	702.8	9.2	846.5	13.8	8.7
OEM/Integrator	1.6	--	518.0	1.6	--	779.1	5.6	1.6	1,146.2	68.0	1,303.1	132.0	1,504.3	182.3	11.6
TOTAL U.S. REVENUES	9.6	74.7	849.6	5.6	22.0	1,341.2	5.6	3.6	2,332.0	128.2	2,709.1	442.2	3,014.3	641.1	20.3
NON-U.S. MANUFACTURERS															
Captive	6.0	--	7.0	2.2	--	48.0	--	--	72.0	--	120.0	21.0	140.0	39.0	--
PCM/Reseller	--	--	1.2	--	--	28.2	--	--	49.5	--	70.3	1.6	105.4	2.8	--
OEM/Integrator	5.6	3.2	32.0	.7	.6	76.0	--	--	140.4	8.8	190.0	12.5	264.0	19.6	3.0
TOTAL NON-U.S. REVENUES	11.6	3.2	40.2	2.9	.6	152.2	--	--	261.9	8.8	380.3	35.1	509.4	61.4	3.0
WORLDWIDE RECAP															
Captive	14.0	74.7	7.0	6.2	22.0	148.5	--	2.0	633.8	55.0	823.2	322.0	803.5	484.0	--
	-68.0%	--	+7.7%	-55.7%	-70.5%	--	--	-67.7%	+326.8%	--	+29.9%	+485.5%	-2.4%	+50.3%	--
PCM/Reseller	--	--	332.8	--	--	489.8	--	--	673.5	5.2	773.1	10.8	951.9	16.6	8.7
	--	-100.0%	+766.7%	--	--	+47.2%	--	--	+37.5%	--	+14.8%	+107.7%	+23.1%	+53.7%	--
OEM/Integrator	7.2	3.2	550.0	2.3	.6	855.1	5.6	1.6	1,286.6	76.8	1,493.1	144.5	1,768.3	201.9	14.6
	+350.0%	-61.0%	+159.2%	-68.1%	-81.3%	+55.5%	--	-30.4%	+50.5%	--	+16.1%	+88.2%	+18.4%	+39.7%	--
Total Revenues	21.2	77.9	889.8	8.5	22.6	1,493.4	5.6	3.6	2,593.9	137.0	3,089.4	477.3	3,523.7	702.5	23.3
	-53.2%	+299.5%	+246.1%	-59.9%	-71.0%	+67.8%	--	-57.6%	+73.7%	--	+19.1%	+248.4%	+14.1%	+47.2%	--
ANNUAL SHARE, BY DIAMETER	2.1%	7.9%	90.0%	.6%	1.5%	97.7%	.2%	.1%	95.0%	4.9%	86.7%	13.3%	83.0%	16.5%	.5%

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

TABLE 45

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments			Forecast											
				1992				1993			1994		1995		
	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	8"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"	<=1.8"
U.S. MANUFACTURERS															
IBM Captive	2.0	--	--	1.0	--	100.0	--	.5	700.0	50.0	1,000.0	400.0	1,100.0	700.0	--
Other U.S. Captive	--	12.6	--	--	4.0	.6	--	--	2.0	20.0	4.0	35.0	5.0	50.0	--
PCM/Reseller	--	--	676.8	--	--	1,304.1	--	--	2,210.0	15.0	2,790.0	30.0	3,680.0	50.0	30.0
OEM/Integrator	.5	--	1,127.0	.5	--	2,334.0	15.0	.5	4,102.0	200.0	5,181.0	440.0	6,540.0	675.0	40.0
TOTAL U.S. SHIPMENTS	2.5	12.6	1,803.8	1.5	4.0	3,738.7	15.0	1.0	7,014.0	285.0	8,975.0	905.0	11,325.0	1,475.0	70.0
NON-U.S. MANUFACTURERS															
Captive	.5	--	3.2	.2	--	24.0	--	--	40.0	--	75.0	30.0	100.0	65.0	--
PCM/Reseller	--	--	2.0	--	--	63.0	--	--	165.0	--	265.0	5.0	430.0	10.0	--
OEM/Integrator	2.2	3.6	76.4	.3	.7	187.2	--	--	460.0	25.0	720.0	40.0	1,100.0	70.0	10.0
TOTAL NON-U.S. SHIPMENTS	2.7	3.6	81.6	.5	.7	274.2	--	--	665.0	25.0	1,060.0	75.0	1,630.0	145.0	10.0
WORLDWIDE RECAP															
Captive	2.5	12.6	3.2	1.2	4.0	124.6	--	.5	742.0	70.0	1,079.0	465.0	1,205.0	815.0	--
	-47.9%	--	+23.1%	-52.0%	-68.3%	--	--	-58.3%	+495.5%	--	+45.4%	+564.3%	+11.7%	+75.3%	--
PCM/Reseller	--	--	678.8	--	--	1,367.1	--	--	2,375.0	15.0	3,055.0	35.0	4,110.0	60.0	30.0
	--	-100.0%	+551.4%	--	--	+101.4%	--	--	+73.7%	--	+28.6%	+133.3%	+34.5%	+71.4%	--
OEM/Integrator	2.7	3.6	1,203.4	.8	.7	2,521.2	15.0	.5	4,562.0	225.0	5,901.0	480.0	7,640.0	745.0	50.0
	+350.0%	-63.6%	+228.7%	-70.4%	-80.6%	+109.5%	--	-37.5%	+80.9%	--	+29.4%	+113.3%	+29.5%	+55.2%	--
Total Shipments	5.2	16.2	1,885.4	2.0	4.7	4,012.9	15.0	1.0	7,679.0	310.0	10,035.0	980.0	12,955.0	1,620.0	80.0
	-3.7%	-22.1%	+298.7%	-61.5%	-71.0%	+112.8%	--	-50.0%	+91.4%	--	+30.7%	+216.1%	+29.1%	+65.3%	--
ANNUAL SHARE, BY DIAMETER	.3%	.8%	98.9%	--	.1%	99.6%	.3%	--	96.2%	3.8%	91.2%	8.8%	88.5%	11.1%	.4%
TOTAL CAPACITY (Terabytes)	1.2	4.1	404.5	.5	1.2	895.3	3.1	.2	1,730.6	69.2	2,263.4	235.2	2,929.3	407.2	19.2

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

TABLE 46

FIXED DISK DRIVES, 200 - 300 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

	1991 Estimate		1995 Projection	
APPLICATION	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI				
General purpose	1.1	.1	--	--
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	138.1	7.2	366.4	2.5
PERSONAL COMPUTERS				
Business and professional, single user	1,398.8	73.4	13,335.9	91.0
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application	111.9	5.9	73.3	.5
NON-OFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	256.3	13.4	732.8	5.0
CONSUMER AND HOBBY COMPUTERS	--	--	146.6	1.0
OTHER APPLICATIONS	--	--	--	--
Total	1,906.8	100.0	14,655.0	100.0

TABLE 47

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1991	1992	1993	1994	1995
Captive					
8"	28.00	20.66	20.00	--	--
5.25"	23.34	22.00	--	--	--
3.5"	10.05	5.82	4.22	3.76	3.27
2.5"	--	--	3.35	2.88	2.44
1.8" or less	--	--	--	--	--
Captive Average	21.75	6.59	4.14	3.46	2.90
PCM/Reseller					
8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	2.28	1.62	1.26	1.12	1.02
2.5"	--	--	1.56	1.27	1.06
1.8" or less	--	--	--	--	1.20
PCM/Reseller Average	2.28	1.62	1.26	1.12	1.02
OEM/Integrator					
8"	10.21	11.55	11.34	--	--
5.25"	3.60	2.80	--	--	--
3.5"	2.13	1.50	1.22	1.10	1.00
2.5"	--	1.81	1.55	1.25	1.04
1.8" or less	--	--	--	--	1.21
OEM/Integrator Average	2.15	1.50	1.24	1.11	1.01

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

TABLE 48

FIXED DISK DRIVES, 200 - 300 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	8"	5.25"	3.5"	Total		8"	5.25"	3.5"	Total	
Seagate Technology	--	--	486.0	486.0	37.1	--	--	626.0	626.0	33.1
Maxtor	--	--	303.0	303.0	23.1	--	--	388.0	388.0	20.5
Conner Peripherals	--	--	278.0	278.0	21.2	--	--	388.0	388.0	20.5
Western Digital	--	--	110.0	110.0	8.4	--	--	202.0	202.0	10.7
Quantum	--	--	110.0	110.0	8.4	--	--	187.0	187.0	9.9
Other U.S.	.1	--	6.5	6.6	.5	.5	--	12.8	13.3	.7
Other Non-U.S.	.3	--	16.1	16.4	1.3	2.2	3.6	78.4	84.2	4.6
TOTAL	.4	--	1309.6	1310.0	100.0	2.7	3.6	1882.2	1888.5	100.0

FIXED DISK DRIVES, 300-500 MEGABYTES

1992 DISK/TREND REPORT

FIXED DISK DRIVES, 300 - 500 MEGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

DZU	EC 5063

10.5" disk diameter

Fujitsu	M2350A, F6421

9" disk diameter

Elebra	W950
Hitachi	DK815-5
Seagate Technology	ST6515J

8" disk diameter

Fujitsu	M2343K, M2381K

5.25" disk diameter

Digital Equipment	RF31*
Edisa	ED 71396
EZI	4410
Fujitsu	M2249E/S
Hewlett-Packard	97544P
Hitachi	DK514-38
IBM	0671-387, 0681-500
Maxtor	XT-8380E/S
Micropolis	1558-15, 1684*
NEC	D5662
Seagate Technology	ST4385N, ST2383N*
Sequel	XT-4380E/S

3.5" disk diameter

Brand Technologies	BT3480*
Conner Peripherals	CP-3360*
Digital Equipment	RF31T*
Fujitsu	M2622S*
Hewlett-Packard	C2235*
Hitachi	DK314C-41*
IBM	0661-371*, 0661-467*
Maxtor	LXT-340S*, MXT-340A**
Microscience International	7400*
NEC	D3872*, D3881*
Quantum	425iS/AT ProDrive*

3.5" disk diameter (continued)

Seagate Technology	ST1480A/N*, ST3500A/N**
Western Digital	WDAC2340**
Zentek	ZH 3490*

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

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

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

In 1989, IBM became the first company to announce and ship 3.5" drives in this capacity range, but numerous other drive manufacturers also introduced 3.5" drives in 1990. In 1991, Seagate announced 426 megabyte models only 1" high, and in 1992 Western Digital announced a 1" high 341 megabyte 3.5" drive using only two disks.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	2,448.7	1,369.5	1,123.7	1,096.8	1,314.6
All manufacturers	2,759.6	1,608.8	1,356.3	1,389.1	1,720.1

Total sales revenues for this product group are currently suffering due to the movement from 5.25" drives to 3.5" models carrying lower prices, combined with IBM's sharply reduced revenue from its 320 and 400 megabyte 3.5" drives -- but total unit shipments continue to climb. Revenue growth was only 8.4% in 1991 and will decline an estimated 41.7% in 1992. Overall unit shipments were up

32.8% in 1991, with another increase of 22.4% expected this year.

The 380 megabyte 5.25" drive, originally introduced by Maxtor in 1984, was a big winner for several leading manufacturers of OEM disk drives, but shipments peaked in 1989. 5.25" drive shipments were down 25.7% in 1991, with a further decline of 59.3% expected in 1992, down to 218,400 drives.

For several years 3.5" drive shipments in this product group were dominated by IBM's "Lightning/Turbo" series, with initial shipments in 1989. Major noncaptive shipments of 3.5" drives from several drive manufacturers did not start until 1991. IBM's shipments of 320/400 megabyte drives peaked in 1991 at an estimated 440,000 units. However, 1992's shipments of these models are expected to be less than half of the 1991 total, due to displacement by the "Corsair" series of 3.5" drives, with capacities over 1 gigabyte. Combined with drastic price reductions, IBM's lower shipments of 3.5" drives in this product group will reduce the company's estimated captive sales revenue for 300-500 megabyte drives from $1.6 billion in 1991 to $410 million in 1992.

The 1989 Lightning introduction represented an interesting change in IBM sales strategy for the noncaptive market. After unsuccessful attempts to sell earlier small diameter disk drives to major system manufacturers on an OEM basis, a different sales program was established for the Lightning. The drive was offered for resale through Western Digital on an OEM basis and through WD's distributors, through System Industries and other add-on subsystems builders, and through CMS Enhancements for the PC aftermarket. IBM realized only moderate success with the Lightning in these programs, but they helped pave the way for more successful programs later, as the firm continued to offer major new drives to other system manufacturers for early delivery.

IBM no longer dominates 3.5" drive shipments in the 300-500 megabyte range, and in 1992 1.2 million drives will be shipped by the other 13 manufacturers which have entered the field. OEM/Integrator shipments are expected to be up 202% in 1992 and PCM/Reseller shipments will climb 360%.

Personal computer applications took over the lead in shipments in this product group in 1991 for the first time, as graphics applications and other advanced software helped to boost the PC software requirement to higher levels. Personal computer applications captured 34.8% of 1991 unit shipments, and

further growth to 42% in 1995 is expected. Minicomputer and multiuser micro applications, including network file servers, held 31.8% of 1991 shipments, and further expansion to 37% in 1995 is expected. Technical workstations will also secure a growing share, but the share for dedicated application office systems will drop as older drives are discontinued.

Seagate continued to dominate 1991 noncaptive shipments in this product group, with 359,000 drives, 42.4% of the worldwide total, by combining leadership in both 5.25" and 3.5" drive shipments. Micropolis was second with 15.4%, and Maxtor held third place with 14.9% of worldwide shipments.

Marketing trends

Shipments of 300-500 megabyte drives are expected to grow at an increasing rate in 1993, 1994 and 1995. During that period the annual average increase in unit shipments is forecasted at 40.5%, culminating in 1995 growth of 65.7%. The changing product mix and declining average selling prices will continue to hold down growth in sales revenue.

The 14" and 8"/9" drives which provided two thirds of this group's revenue in 1988 have reached end of life. 5.25" drive shipments are now forecasted to end in 1994, leaving the 300-500 megabyte capacity range to 3.5" and 2.5" drives:

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
14"	1.3 .1%	.8 --	-- --	-- --	-- --
8"	10.5 .8%	6.6 .4%	1.0 --	-- --	-- --
5.25"	536.9 39.5%	218.4 13.1%	82.0 4.1%	16.0 .6%	-- --
3.5" 1.625" high	810.0 59.6%	1,330.0 80.0%	1,297.0 63.7%	1,029.0 37.9%	855.0 19.0%
3.5" 1" high	-- --	107.0 6.5%	565.0 27.8%	1,325.0 48.8%	3,065.0 68.1%
2.5"	-- --	-- --	90.0 4.4%	345.0 12.7%	580.0 12.9%
	1,358.7	1,662.8	2,035.0	2,715.0	4,500.0

The growing importance of the personal computer market to this product group is reflected in the packaging changes now under way with 3.5" drives. Total shipments of 1.625" high models are peaking this year at an estimated 1.3 million drives and are expected to fall to 855,000 units in 1995. In the meantime, 1" high models, shipped for the first time this year, are expected to account for 3 million drives in the 1995 overall total of 4.5 million drives for the group.

1" high 3.5" drives in the 300-500 megabyte range will clearly dominate the disk storage market for high-end desktop personal computers for several years, challenged only by 3.5" drives with higher capacities. This demand is driven by the storage requirements of a variety of operating systems, graphics applications and data base management programs, combined with a pattern of typical user practices which involve keeping a large amount of data continually on-line. 1" high drives make it possible for system manufacturers to offer disk upgrade options in this capacity range without physical changes to existing systems, and they make it relatively easy for dealers and end users to upgrade existing systems. 1" high drives are also expected to be popular with designers of arrays used in network file servers. 300-500 megabyte drives will be widely used in PC network file servers, and the 1" height will contribute to greatly improved packaging efficiency.

The first 2.5" drives in this capacity group are expected in 1993, with shipments projected to grow to 580,000 drives in 1995. Many 2.5" drives will be used in high-end notebook computers and portable engineering workstations, but 2.5" drives will also find a market with array applications. The small form factor of these drives will make it possible to offer arrays in the 1-2 gigabyte range using a total package size no larger than a 5.25" drive, opening entirely new markets to fault tolerant array subsystems.

One result of these product mix changes will be lower average prices, given the constant progression to smaller drives and higher shipment levels. The average 1991 price per megabyte for OEM/Integrator 3.5" drives was $2.22, falling to an estimated $1.73 in 1992. By 1995, it's expected to decline to 86 cents. The average OEM/Integrator price per megabyte for 2.5" drives is estimated at $1.53 for the first year of shipments in 1993, dropping to 97 cents in 1995.

Technical trends

The demand for more capacity in small spaces will continue. Expect to see extensive use of MIG and thin film heads, sputtered disks using thinner substrates, advanced encoding methods, intelligent interfaces, and extensive use of VLSI in drive electronics. IBM's Lightning drive was a pathfinder for the industry in disk substrate thickness and in drive packaging. It was an impressive usage of 8 disks in the standard 41.3 millimeter height for 3.5" drives, a design made possible by reducing the normal 50 mil disk substrate thickness to only 31.5 mils, which is now a de facto standard. Today, of course, most other firms are using fewer disks for drives in the 300-500 megabyte range.

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

Western Digital announced a two disk 1" high 3.5" drive for delivery by the end of 1992, with a formatted capacity of 341 megabytes, the first two disk drive available in the 300-500 megabyte range. With a recording density of 137 megabits per square inch, this drive is a pathfinder for the type of drive which will predominate in this product group for years to come. It fits the most preferred form factor, and the usage of only two disks makes possible a low parts count, and the lowest possible price.

While most of Western Digital's competitors are busy readying comparable two disk units for the market, the advance planners are looking ahead to the day they will be offering capacities in the 300-500 megabyte range with only one disk. Such drives will require areal densities above 300 megabits per square inch, but densities in this range are likely to be available in production drives by 1995. The requirements will be severe: The highest density miniaturized heads, disks meeting new standards of coercivity and smoothness, close-to-contact recording, and semiconductor components much faster than today's chips. Naturally, all of this must be available on a reliable basis, and competitively priced. It's expected that it will be.

Forecasting assumptions

1. Shipments of 14" drives will end in 1992, 8" drives in 1993, and 5.25" drives in 1994.
2. Sustained growth for high-end personal computers, technical workstations, LANs, and specialized systems will continue to create significant growth for 3.5" drives.
3. First shipments of 2.5" drives in this capacity range will start in 1993.

TABLE 49

FIXED DISK DRIVES, 300 - 500 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,307.8	1,754.8	337.9	472.0	107.0	152.0	34.3	55.6	--	--
Other U.S. Captive	49.4	96.6	32.5	47.7	5.5	7.7	9.5	14.3	11.3	18.8
TOTAL U.S. CAPTIVE	1,357.2	1,851.4	370.4	519.7	112.5	159.7	43.8	69.9	11.3	18.8
PCM/Reseller	113.9	169.3	153.5	234.4	140.9	223.1	144.6	228.3	190.8	293.4
OEM/Integrator	286.5	428.0	452.1	615.4	527.4	740.9	572.8	798.6	743.8	1,002.4
TOTAL U.S. NONCAPTIVE	400.4	597.3	605.6	849.8	668.3	964.0	717.4	1,026.9	934.6	1,295.8
TOTAL U.S. REVENUES	1,757.6	2,448.7	976.0	1,369.5	780.8	1,123.7	761.2	1,096.8	945.9	1,314.6
Non-U.S. Manufacturers										
Captive	1.4	184.4	--	120.9	7.5	85.0	14.0	108.0	23.5	133.0
PCM/Reseller	--	--	--	--	3.0	9.0	5.0	12.5	6.0	24.0
OEM/Integrator	33.3	126.5	33.4	118.4	41.8	138.6	52.2	171.8	75.4	248.5
TOTAL NON-U.S. REVENUES	34.7	310.9	33.4	239.3	52.3	232.6	71.2	292.3	104.9	405.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,792.3	2,759.6	1,009.4	1,608.8	833.1	1,356.3	832.4	1,389.1	1,050.8	1,720.1
OEM Average Price ($000)		.845		.687		.588		.470		.360

TABLE 50

FIXED DISK DRIVES, 300 - 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991		Forecast							
	Shipments		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	338.0	452.0	155.0	213.0	66.6	93.0	25.5	41.0	--	--
Other U.S. Captive	16.7	29.5	20.5	25.9	5.0	7.0	10.0	15.0	15.0	25.0
TOTAL U.S. CAPTIVE	354.7	481.5	175.5	238.9	71.6	100.0	35.5	56.0	15.0	25.0
PCM/Reseller	128.9	190.3	211.7	323.7	239.0	379.0	310.0	490.0	540.0	830.0
OEM/Integrator	355.8	533.9	666.8	905.5	901.0	1,266.0	1,233.0	1,719.0	2,115.0	2,850.0
TOTAL U.S. NONCAPTIVE	484.7	724.2	878.5	1,229.2	1,140.0	1,645.0	1,543.0	2,209.0	2,655.0	3,680.0
TOTAL U.S. SHIPMENTS	839.4	1,205.7	1,054.0	1,468.1	1,211.6	1,745.0	1,578.5	2,265.0	2,670.0	3,705.0
Non-U.S. Manufacturers										
Captive	.1	30.4	--	32.1	5.0	45.0	10.0	80.0	20.0	110.0
PCM/Reseller	--	--	--	--	5.0	15.0	10.0	25.0	15.0	60.0
OEM/Integrator	33.9	122.6	47.0	162.6	70.0	230.0	105.0	345.0	190.0	625.0
TOTAL NON-U.S. SHIPMENTS	34.0	153.0	47.0	194.7	80.0	290.0	125.0	450.0	225.0	795.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	873.4	1,358.7	1,101.0	1,662.8	1,291.6	2,035.0	1,703.5	2,715.0	2,895.0	4,500.0
Total Capacity (Terabytes)	309.6	484.8	421.6	637.5	506.4	800.7	687.2	1,095.5	1,197.7	1,852.3
Cumulative Shipments (Units in millions)										
IBM	.8	1.2	1.0	1.4	1.1	1.5	1.1	1.5	1.1	1.5
Non-IBM	2.2	3.5	3.2	5.0	4.4	6.9	6.1	9.6	8.9	14.1
WORLDWIDE TOTAL	3.1	4.7	4.2	6.4	5.5	8.4	7.2	11.1	10.1	15.6

TABLE 51

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues				Forecast 1992				1993				1994			1995	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	61.8	21.0	1,672.0	--	51.5	10.5	410.0	10.0	7.0	135.0	--	3.6	52.0	--	--	--
Other U.S. Captive	--	--	93.3	3.3	--	--	23.0	24.7	--	--	7.7	--	--	--	14.3	--	18.8
PCM/Reseller	--	--	118.3	51.0	--	--	45.5	188.9	--	11.8	211.3	--	--	221.1	7.2	282.1	11.3
OEM/Integrator	--	2.4	237.0	188.6	--	--	86.9	528.5	--	39.2	657.6	44.1	10.3	662.3	126.0	844.8	157.6
TOTAL U.S. REVENUES	--	64.2	469.6	1,914.9	--	51.5	165.9	1,152.1	10.0	58.0	1,011.6	44.1	13.9	935.4	147.5	1,126.9	187.7
NON-U.S. MANUFACTURERS																	
Captive	13.3	46.4	118.4	6.3	9.0	21.0	56.9	34.0	--	25.0	60.0	--	--	98.0	10.0	117.0	16.0
PCM/Reseller	--	--	--	--	--	--	--	--	--	--	9.0	--	--	12.5	--	22.0	2.0
OEM/Integrator	4.4	3.7	42.0	76.4	1.5	.4	18.9	97.6	--	4.0	129.0	5.6	--	160.0	11.8	230.0	18.5
TOTAL NON-U.S. REVENUES	17.7	50.1	160.4	82.7	10.5	21.4	75.8	131.6	--	29.0	198.0	5.6	--	270.5	21.8	369.0	36.5
WORLDWIDE RECAP																	
Captive	13.3	108.2	232.7	1,681.6	9.0	72.5	90.4	468.7	10.0	32.0	202.7	--	3.6	150.0	24.3	117.0	34.8
	-70.4%	-40.6%	-62.8%	+70.9%	-32.3%	-33.0%	-61.2%	-72.1%	-86.2%	-64.6%	-56.8%	--	-88.7%	-26.0%	--	-22.0%	+43.2%
PCM/Reseller	--	--	118.3	51.0	--	--	45.5	188.9	--	11.8	220.3	--	--	233.6	7.2	304.1	13.3
	--	--	+23.5%	+226.9%	--	--	-61.5%	+270.4%	--	-74.1%	+16.6%	--	-100.0%	+6.0%	--	+30.2%	+84.7%
OEM/Integrator	4.4	6.1	279.0	265.0	1.5	.4	105.8	626.1	--	43.2	786.6	49.7	10.3	822.3	137.8	1,074.8	176.1
	-72.7%	-90.0%	-45.6%	--	-65.9%	-93.4%	-62.1%	+136.3%	-100.0%	-59.2%	+25.6%	--	-76.2%	+4.5%	+177.3%	+30.7%	+27.8%
Total Revenues	17.7	114.3	630.0	1,997.6	10.5	72.9	241.7	1,283.7	10.0	87.0	1,209.6	49.7	13.9	1,205.9	169.3	1,495.9	224.2
	-71.0%	-53.0%	-48.9%	+98.4%	-40.7%	-36.2%	-61.6%	-35.7%	-86.3%	-64.0%	-5.8%	--	-84.0%	-.3%	+240.6%	+24.0%	+32.4%
ANNUAL SHARE, BY DIAMETER	.6%	4.1%	22.9%	72.4%	.7%	4.5%	15.0%	79.8%	.7%	6.4%	89.3%	3.6%	1.0%	86.9%	12.1%	87.1%	12.9%

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

TABLE 52

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments				Forecast 1992				1993				1994			1995	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	6.0	6.0	440.0	--	5.0	3.0	205.0	1.0	2.0	90.0	--	1.0	40.0	--	--	--
Other U.S. Captive	--	--	27.4	2.1	--	--	6.9	19.0	--	--	7.0	--	--	--	15.0	--	25.0
PCM/Reseller	--	--	131.9	58.4	--	--	54.7	269.0	--	15.0	364.0	--	--	475.0	15.0	800.0	30.0
OEM/Integrator	--	1.0	303.6	229.3	--	--	118.5	787.0	--	55.0	1,131.0	80.0	15.0	1,424.0	280.0	2,400.0	450.0
TOTAL U.S. SHIPMENTS	--	7.0	468.9	729.8	--	5.0	183.1	1,280.0	1.0	72.0	1,592.0	80.0	16.0	1,939.0	310.0	3,200.0	505.0
NON-U.S. MANUFACTURERS																	
Captive	.7	3.1	24.1	2.5	.5	1.5	13.1	17.0	--	5.0	40.0	--	--	70.0	10.0	90.0	20.0
PCM/Reseller	--	--	--	--	--	--	--	--	--	--	15.0	--	--	25.0	--	55.0	5.0
OEM/Integrator	.6	.4	43.9	77.7	.3	.1	22.2	140.0	--	5.0	215.0	10.0	--	320.0	25.0	575.0	50.0
TOTAL NON-U.S. SHIPMENTS	1.3	3.5	68.0	80.2	.8	1.6	35.3	157.0	--	10.0	270.0	10.0	--	415.0	35.0	720.0	75.0
WORLDWIDE RECAP																	
Captive	.7	9.1	57.5	444.6	.5	6.5	23.0	241.0	1.0	7.0	137.0	--	1.0	110.0	25.0	90.0	45.0
	-69.6%	-32.6%	-53.6%	+85.3%	-28.6%	-28.6%	-60.0%	-45.8%	-84.6%	-69.6%	-43.2%	--	-85.7%	-19.7%	--	-18.2%	+80.0%
PCM/Reseller	--	--	131.9	58.4	--	--	54.7	269.0	--	15.0	379.0	--	--	500.0	15.0	855.0	35.0
	--	--	+41.4%	+311.3%	--	--	-58.5%	+360.6%	--	-72.6%	+40.9%	--	-100.0%	+31.9%	--	+71.0%	+133.3%
OEM/Integrator	.6	1.4	347.5	307.0	.3	.1	140.7	927.0	--	60.0	1,346.0	90.0	15.0	1,744.0	305.0	2,975.0	500.0
	-72.7%	-93.4%	-31.2%	--	-50.0%	-92.9%	-59.5%	+202.0%	-100.0%	-57.4%	+45.2%	--	-75.0%	+29.6%	+238.9%	+70.6%	+63.9%
Total Shipments	1.3	10.5	536.9	810.0	.8	6.6	218.4	1,437.0	1.0	82.0	1,862.0	90.0	16.0	2,354.0	345.0	3,920.0	580.0
	-71.1%	-69.7%	-25.7%	+209.3%	-38.5%	-37.1%	-59.3%	+77.4%	-84.8%	-62.5%	+29.6%	--	-80.5%	+26.4%	+283.3%	+66.5%	+68.1%
ANNUAL SHARE, BY DIAMETER	.1%	.8%	39.6%	59.5%	--	.4%	13.1%	86.5%	--	4.0%	91.6%	4.4%	.6%	86.8%	12.6%	87.2%	12.8%
TOTAL CAPACITY (Terabytes)	.5	4.1	188.5	291.7	.3	2.6	76.3	558.3	.4	28.5	739.4	32.4	5.6	965.7	124.2	1,643.5	208.8

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

TABLE 53

FIXED DISK DRIVES, 300 - 500 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	5.7	.4	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	432.3	31.8	1,665.0	37.0
PERSONAL COMPUTERS Business and professional, single user	471.5	34.8	1,890.0	42.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	178.5	13.1	112.5	2.5
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	269.3	19.8	810.0	18.0
CONSUMER AND HOBBY COMPUTERS	1.4	.1	22.5	.5
OTHER APPLICATIONS	--	--	--	--
Total	1,358.7	100.0	4,500.0	100.0

TABLE 54

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1991	1992	1993	1994	1995
Captive					
14"	44.33	45.00	--	--	--
8"	30.05	27.88	25.00	--	--
5.25"	11.69	11.59	14.04	11.14	--
3.5"	11.10	4.97	3.76	3.44	3.25
2.5"	--	--	--	2.69	2.14
Captive Average	11.61	6.11	4.32	3.35	2.90
PCM/Reseller					
14"	--	--	--	--	--
8"	--	--	--	--	--
5.25"	2.56	2.38	2.23	--	--
3.5"	2.41	1.83	1.46	1.12	.84
2.5"	--	--	--	1.31	1.05
PCM/Reseller Average	2.51	1.91	1.48	1.12	.84
OEM/Integrator					
14"	22.00	15.00	--	--	--
8"	12.20	--	--	--	--
5.25"	2.27	2.14	2.05	1.95	--
3.5"	2.22	1.73	1.47	1.15	.86
2.5"	--	--	1.53	1.25	.97
OEM/Integrator Average	2.28	1.78	1.49	1.17	.87

Note: 14 inch totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

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

TABLE 55

FIXED DISK DRIVES, 300 - 500 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	
Seagate Technology	--	1.0	147.0	107.0	255.0	49.2	--	1.0	218.0	140.0	359.0	42.4
Micropolis	--	--	77.2	--	77.2	14.9	--	--	130.4	--	130.4	15.4
Maxtor	--	--	43.2	34.0	77.2	14.9	--	--	72.0	54.0	126.0	14.9
Fujitsu	--	--	2.1	26.2	28.3	5.5	.1	--	23.8	69.8	93.7	11.1
Other U.S.	--	--	10.6	64.7	75.3	14.4	--	--	15.1	93.7	108.8	12.8
Other Non-U.S.	--	--	4.4	1.2	5.6	1.1	.5	.4	20.1	7.9	28.9	3.4
TOTAL	--	1.0	284.5	233.1	518.6	100.0	.6	1.4	479.4	365.4	846.8	100.0

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

FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE

1992 DISK/TREND REPORT

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

14" disk diameter

DZU	EC 5065
Hitachi	DKU-97S, DKU-85I-D14

10.5" disk diameter

Fujitsu	F6425G, M2361A

9-9.5" disk diameter

Hitachi	DK815-10, DKU-86I
Mitsubishi Electric	E1880B
NEC	D2366, N7757

8" disk diameter

Fujitsu	M2344K/KS
Hewlett-Packard	7937FL
IBM	9332-600
Seagate Technology	ST8851

5.25" disk diameter

Digital Equipment	RA71
Edisa	ED 71793
Fujitsu	M2263E, C2221B
Hewlett-Packard	97548P
Hitachi	DK711S-60D, DK515-78
IBM	0681-1000, 9336-20
Magtron	MT5760S
Maxtor	XT-8760E/S
Micropolis	1588-S, 1624*
Microscience International	FH-2777
NEC	D5682
Seagate Technology	ST4702N*, ST41097J

3.5" disk diameter

Brand Technologies	BT3800*
Conner Peripherals	CP-3540*, CP-30540**
Digital Equipment	RF35*, DSP3085*
Fujitsu	M2624S*, M2693H*
Hewlett-Packard	C2244*, C2246*
IBM	0663*, 9337-120*
Maxtor	LXT-535*, MXT-540SL**

3.5" disk diameter (continued)

Myrica	3540S*
Quantum	700S ProDrive*, 525AT LPS**
Seagate Technology	ST1980N*, ST3600A/N**
Toshiba	MK-438FB*

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

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

Maxtor's introduction of a 768 megabyte 5.25" drive precipitated a flurry of announcements from many of the same companies already competing for the 380 megabyte 5.25" market. Micropolis also offers a half high 5.25" drive with 668 megabytes capacity.

Maxtor was also the first company to announce a 3.5" drive in this product group, in 1990, but was quickly followed by several major competitors. Eleven drive manufacturers have announced or are shipping 3.5" drives in this capacity range. Conner Peripherals, Maxtor, Quantum and Seagate also offer 1" high models, all added in 1992.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	2,093.8	1,179.3	967.1	972.5	1,169.9
All manufacturers	3,131.7	1,847.1	1,411.6	1,292.2	1,403.5

The industry's tidal wave of small disk drives is overrunning this product group in the same way that lower capacity groups were inundated during the last few years. Shipments of 8" drives peaked in 1989, and 5.25" drives peaked in 1991. The expected leader in 1992 shipments will, of course, be 3.5" drives, with 50.2% of the overall unit shipment total for all disk drives.

As expected, rapid movement to smaller drives has cut sales revenues even when shipments are increasing. While total 1991 sales revenues were up 17.2%, to $3.1 billion, the 1992 estimated revenue total is down 41%, to $1.8 billion.

Overall unit shipments for 500 megabyte - 1 gigabyte drives are also slower this year. After climbing 37.8% in 1991, to 823,800 drives, growth in 1992 is expected to be only 5.7%, to 871,100 units. The cause of 1992's negligible shipment increase is rapid upward migration to disk capacities above this product group by manufacturers of engineering workstations, network file servers and minicomputers. The 1992 decline in shipments for 14", 8" and 5.25" drives was barely matched by the strong increase in shipments of 3.5" drives.

Minicomputers and multiuser microcomputers, including file server applications, became the leading applications in 1991 with 45.4% of shipments, and are projected to climb to 62% in 1995. Nonoffice systems and workstations held 24.7% of 1991 shipments, but are destined to decline to 15% in 1995, as personal computer applications continue to increase in storage requirements. By 1995, it is expected that personal computers will utilize 18% of the shipments of this product group.

Seagate's share of total noncaptive shipments was lower in 1991, but the firm still held the worldwide lead, with 25.9%, for a total of 151,000 drives, mostly 5.25" models. Maxtor was second with 24.3%, and Fujitsu followed with 20.3%.

Marketing trends

Growth in shipments for this product group looks promising for the 1993-95 period, with an average annual increase in shipments of 27.5%. However, continuing product mix changes and declining prices will cause total revenues to drop further until 1995.

Much of the potential growth once considered likely for this product group will probably be diverted to drives with higher capacities. The rapid buildup of shipments for 5.25" drives with over one gigabyte capacity during the last year is expected to be matched by steeply rising shipments of 3.5" drives over one gigabyte, as ready availability of more cost-effective disk drives persuades many system manufacturers to skip over the 500 megabyte - 1 gigabyte range.

It is likely that many personal computers will be equipped with 1" high 3.5" drives in the 500 megabyte - 1 gigabyte range in the next three years, but usage with single user personal computers will not enough to guarantee overall shipment growth for this capacity group. Although the appeal of capacities higher than those offered in this product group will lure away a large portion of the requirements for file servers, minicomputers and other applications, those markets are nevertheless expected to use enough of the 3.5" drives in this capacity range to maintain the projected growth.

By 1995, only 3.5" and smaller drives are expected to be available in this product group:

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
14"	7.4	5.2	2.0	--	--
	.9%	.6%	.2%	--	--
8"	83.6	29.2	10.0	3.0	--
	10.2%	3.4%	1.0%	.2%	--
5.25"	655.2	397.9	154.0	35.0	--
	79.5%	45.6%	15.5%	2.8%	--
3.5" 1.625" high	77.6	409.3	519.0	580.0	595.0
	9.4%	47.0%	52.2%	45.9%	33.3%
3.5" 1" high	--	29.5	310.0	647.0	1,155.0
	--	3.4%	31.1%	51.1%	64.7%
2.5"	--	--	--	--	35.0
	--	--	--	--	2.0%
	823.8	871.1	995.0	1,265.0	1,785.0

Technical trends

Although there are interesting challenges in packaging all of the necessary contents of a disk drive in this capacity range into thin 3.5" and 2.5" form factors, this product group will benefit greatly from development work already under way in other capacity ranges. Perhaps the greatest short-term benefits will be realized in the 1" high 3.5" drives.

Most of the industry's manufacturers of high capacity disk drives have devoted a large amount of resources to development of 3.5" drives in the 1-2

gigabyte range, and within the next few months even those which have experienced delays in their programs will be in production. Most of those drives utilize 8 disks in their initial versions, for capacities in the 1-1.3 gigabyte range. It's a fact that most of the heads, disks, and semiconductors for those drives, plus many of the mechanical components, will also be appropriate for usage in drives designed for 4 disks -- which will have capacities in the 500-600 megabyte range. So it a safe assumption that many of the drive components and subassemblies which would be the most costly to design for drives in the 500 megabyte - 1 gigabyte range are already being developed for other drives, and can be utilized immediately.

The technology which will be used in the 2.5" disk drives currently forecasted for first shipment in 1995 is less certain. The most likely scenario for the critical head/disk technology is that a future generation of magnetoresistive heads using the newest slider contours will be employed, using close-to-contact recording. PRML encoding, or a variation, is likely. Motor speeds of 7,200 RPM will be common. And, of course, many of these developments will also find their way into the 3.5" drives introduced in the same period.

Forecasting assumptions

1. IBM will stop production of 8" and 5.25" drives in this product group by 1993, and will introduce 1" high 3.5" drives in 1993.
2. Shipments of 3.5" drives by other noncaptive and captive drive manufacturers will continue to increase through 1995.
3. First shipments of 2.5" drives in this product group will commence in 1995.

TABLE 56

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	929.2	1,420.0	374.8	571.8	336.0	494.0	307.5	450.0	344.5	520.0
Other U.S. Captive	125.8	173.4	90.4	144.9	30.3	52.1	25.0	45.0	29.6	54.0
TOTAL U.S. CAPTIVE	1,055.0	1,593.4	465.2	716.7	366.3	546.1	332.5	495.0	374.1	574.0
PCM/Reseller	121.0	169.0	101.6	146.0	116.1	160.2	122.4	178.6	138.8	211.1
OEM/Integrator	243.3	331.4	210.2	316.6	166.3	260.8	198.2	298.9	249.0	384.8
TOTAL U.S. NONCAPTIVE	364.3	500.4	311.8	462.6	282.4	421.0	320.6	477.5	387.8	595.9
TOTAL U.S. REVENUES	1,419.3	2,093.8	777.0	1,179.3	648.7	967.1	653.1	972.5	761.9	1,169.9
Non-U.S. Manufacturers										
Captive	15.6	740.7	13.0	481.6	--	330.0	--	215.0	--	112.0
PCM/Reseller	32.8	32.8	27.9	27.9	18.1	25.7	20.3	27.1	18.8	28.2
OEM/Integrator	84.7	264.4	102.6	158.3	66.3	88.8	67.5	77.6	77.2	93.4
TOTAL NON-U.S. REVENUES	133.1	1,037.9	143.5	667.8	84.4	444.5	87.8	319.7	96.0	233.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,552.4	3,131.7	920.5	1,847.1	733.1	1,411.6	740.9	1,292.2	857.9	1,403.5
OEM Average Price ($000)		1.449		.944		.753		.641		.546

TABLE 57

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991		Forecast							
	Shipments		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	89.0	135.0	63.5	96.0	161.0	232.0	205.0	300.0	265.0	400.0
Other U.S. Captive	41.3	56.9	31.7	49.2	10.5	18.0	10.0	18.0	16.0	29.0
TOTAL U.S. CAPTIVE	130.3	191.9	95.2	145.2	171.5	250.0	215.0	318.0	281.0	429.0
PCM/Reseller	105.0	146.6	106.6	152.2	147.0	203.0	185.0	270.0	250.0	380.0
OEM/Integrator	208.1	283.6	248.0	374.5	226.0	355.0	314.0	472.0	470.0	725.0
TOTAL U.S. NONCAPTIVE	313.1	430.2	354.6	526.7	373.0	558.0	499.0	742.0	720.0	1,105.0
TOTAL U.S. SHIPMENTS	443.4	622.1	449.8	671.9	544.5	808.0	714.0	1,060.0	1,001.0	1,534.0
Non-U.S. Manufacturers										
Captive	1.1	48.3	1.0	36.9	--	43.0	--	50.0	--	56.0
PCM/Reseller	25.7	25.7	33.5	33.5	25.0	35.0	30.0	40.0	30.0	45.0
OEM/Integrator	35.3	127.7	98.0	128.8	91.0	109.0	100.0	115.0	124.0	150.0
TOTAL NON-U.S. SHIPMENTS	62.1	201.7	132.5	199.2	116.0	187.0	130.0	205.0	154.0	251.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	505.5	823.8	582.3	871.1	660.5	995.0	844.0	1,265.0	1,155.0	1,785.0
Total Capacity (Terabytes)	348.7	567.5	389.0	580.0	407.3	613.5	526.0	790.6	781.3	1,212.1
Cumulative Shipments (Units in thousands)										
IBM	322.6	571.2	386.1	667.2	547.1	899.2	752.1	1,199.2	1,017.1	1,599.2
Non-IBM	1,333.6	2,223.8	1,852.4	2,998.9	2,351.9	3,761.9	2,990.9	4,726.9	3,880.9	6,111.9
WORLDWIDE TOTAL	1,656.2	2,795.0	2,238.5	3,666.1	2,899.0	4,661.1	3,743.0	5,926.1	4,898.0	7,711.1

TABLE 58

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues				Forecast												
	1992				1993				1994				1995				
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	320.0	1,100.0	--	--	76.8	495.0	--	--	24.0	150.0	320.0	--	--	450.0	520.0	--
Other U.S. Captive	1.6	--	171.8	--	--	--	106.0	38.9	--	--	10.1	42.0	--	--	45.0	48.0	6.0
PCM/Reseller	--	--	160.8	8.2	--	--	92.3	53.7	--	--	41.0	119.2	--	12.8	165.8	211.1	--
OEM/Integrator	--	30.8	287.2	13.4	--	--	134.1	182.5	--	--	50.8	210.0	--	12.8	286.1	371.0	13.8
TOTAL U.S. REVENUES	1.6	350.8	1,719.8	21.6	--	76.8	827.4	275.1	--	24.0	251.9	691.2	--	25.6	946.9	1,150.1	19.8
NON-U.S. MANUFACTURERS																	
Captive	123.5	302.4	312.4	2.4	95.0	157.8	208.8	20.0	36.0	84.0	110.0	100.0	39.0	50.0	126.0	112.0	--
PCM/Reseller	3.0	--	21.2	8.6	--	--	5.5	22.4	--	--	1.8	23.9	--	--	27.1	28.2	--
OEM/Integrator	7.0	140.8	63.6	53.0	.2	57.4	29.5	71.2	--	8.4	10.0	70.4	--	--	77.6	90.6	2.8
TOTAL NON-U.S. REVENUES	133.5	443.2	397.2	64.0	95.2	215.2	243.8	113.6	36.0	92.4	121.8	194.3	39.0	50.0	230.7	230.8	2.8
WORLDWIDE RECAP																	
Captive	125.1	622.4	1,584.2	2.4	95.0	234.6	809.8	58.9	36.0	108.0	270.1	462.0	39.0	50.0	621.0	680.0	6.0
	-49.2%	-46.9%	+31.4%	--	-24.1%	-62.3%	-48.9%	--	-62.1%	-54.0%	-66.6%	+684.4%	-63.9%	-81.5%	+34.4%	+9.5%	--
PCM/Reseller	3.0	--	182.0	16.8	--	--	97.8	76.1	--	--	42.8	143.1	--	12.8	192.9	239.3	--
	--	-100.0%	+151.4%	--	-100.0%	--	-46.3%	+353.0%	--	--	-56.2%	+88.0%	--	-70.1%	+34.8%	+24.1%	--
OEM/Integrator	7.0	171.6	350.8	66.4	.2	57.4	163.6	253.7	--	8.4	60.8	280.4	--	12.8	363.7	461.6	16.6
	-23.9%	-3.1%	-26.5%	+785.3%	-97.1%	-66.6%	-53.4%	+282.1%	-100.0%	-85.4%	-62.8%	+10.5%	-100.0%	-78.9%	+29.7%	+26.9%	--
Total Revenues	135.1	794.0	2,117.0	85.6	95.2	292.0	1,071.2	388.7	36.0	116.4	373.7	885.5	39.0	75.6	1,177.6	1,380.9	22.6
	-47.1%	-41.2%	+20.6%	--	-29.5%	-63.2%	-49.4%	+354.1%	-62.2%	-60.1%	-65.1%	+127.8%	-66.5%	-79.8%	+33.0%	+17.3%	--
ANNUAL SHARE, BY DIAMETER	4.3%	25.5%	67.6%	2.6%	5.2%	15.8%	58.1%	20.9%	2.6%	8.2%	26.6%	62.6%	3.0%	5.9%	91.1%	98.5%	1.5%

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

TABLE 59

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments				Forecast 1992				1993				1994			1995	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	25.0	110.0	--	--	6.0	90.0	--	--	2.0	30.0	200.0	--	--	300.0	400.0	--
Other U.S. Captive	.1	--	56.8	--	--	--	38.0	11.2	--	--	4.0	14.0	--	--	18.0	24.0	5.0
PCM/Reseller	--	--	138.6	8.0	--	--	87.1	65.1	--	--	43.0	160.0	--	15.0	255.0	380.0	--
OEM/Integrator	--	11.0	259.6	13.0	--	--	134.0	240.5	--	--	55.0	300.0	--	15.0	457.0	700.0	25.0
TOTAL U.S. SHIPMENTS	.1	36.0	565.0	21.0	--	6.0	349.1	316.8	--	2.0	132.0	674.0	--	30.0	1,030.0	1,504.0	30.0
NON-U.S. MANUFACTURERS																	
Captive	6.5	18.8	22.4	.6	5.0	10.5	16.4	5.0	2.0	6.0	10.0	25.0	3.0	5.0	42.0	56.0	--
PCM/Reseller	.2	--	17.7	7.8	--	--	5.5	28.0	--	--	2.0	33.0	--	--	40.0	45.0	--
OEM/Integrator	.6	28.8	50.1	48.2	.2	12.7	26.9	89.0	--	2.0	10.0	97.0	--	--	115.0	145.0	5.0
TOTAL NON-U.S. SHIPMENTS	7.3	47.6	90.2	56.6	5.2	23.2	48.8	122.0	2.0	8.0	22.0	155.0	3.0	5.0	197.0	246.0	5.0
WORLDWIDE RECAP																	
Captive	6.6	43.8	189.2	.6	5.0	16.5	144.4	16.2	2.0	8.0	44.0	239.0	3.0	5.0	360.0	480.0	5.0
	-50.0%	-43.1%	+67.9%	--	-24.2%	-62.3%	-23.7%	--	-60.0%	-51.5%	-69.5%	--	-62.5%	-88.6%	+50.6%	+33.3%	--
PCM/Reseller	.2	--	156.3	15.8	--	--	92.6	93.1	--	--	45.0	193.0	--	15.0	295.0	425.0	--
	--	-100.0%	+196.6%	--	-100.0%	--	-40.8%	+489.2%	--	--	-51.4%	+107.3%	--	-66.7%	+52.8%	+44.1%	--
OEM/Integrator	.6	39.8	309.7	61.2	.2	12.7	160.9	329.5	--	2.0	65.0	397.0	--	15.0	572.0	845.0	30.0
	-25.0%	-16.9%	-10.6%	+813.4%	-66.7%	-68.1%	-48.0%	+438.4%	-100.0%	-84.3%	-59.6%	+20.5%	-100.0%	-76.9%	+44.1%	+47.7%	--
Total Shipments	7.4	83.6	655.2	77.6	5.2	29.2	397.9	438.8	2.0	10.0	154.0	829.0	3.0	35.0	1,227.0	1,750.0	35.0
	-47.1%	-33.2%	+28.0%	--	-29.7%	-65.1%	-39.3%	+465.5%	-61.5%	-65.8%	-61.3%	+88.9%	-70.0%	-77.3%	+48.0%	+42.6%	--
ANNUAL SHARE, BY DIAMETER	.9%	10.1%	79.6%	9.4%	.6%	3.4%	45.8%	50.2%	.2%	1.0%	15.5%	83.3%	.2%	2.8%	97.0%	98.1%	1.9%
TOTAL CAPACITY (Terabytes)	4.8	57.0	457.5	48.2	3.4	20.5	281.5	274.6	1.3	7.2	107.4	497.6	2.3	22.7	765.7	1,193.3	18.9

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

TABLE 60

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	75.8	9.2	35.7	2.0
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	373.6	45.4	1,106.6	62.0
PERSONAL COMPUTERS Business and professional, single user	99.5	12.1	321.3	18.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	71.2	8.6	53.6	3.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	203.7	24.7	267.8	15.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	823.8	100.0	1,785.0	100.0

TABLE 61

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1991	1992	1993	1994	1995
Captive					
14"	29.08	28.78	27.69	--	--
8"	21.46	20.57	18.94	17.33	--
5.25"	10.74	7.11	7.67	14.81	--
3.5"	6.00	4.36	3.29	2.94	2.41
2.5"	--	--	--	--	2.22
Captive Average	12.88	8.43	4.80	3.27	2.41
PCM/Reseller					
14"	30.00	--	--	--	--
8"	--	--	--	--	--
5.25"	1.75	1.59	1.46	1.33	--
3.5"	1.78	1.34	1.23	1.02	.78
2.5"	--	--	--	--	--
PCM/Reseller Average	1.77	1.47	1.27	1.03	.78
OEM/Integrator					
14"	17.40	1.60	--	--	--
8"	6.12	6.30	5.60	--	--
5.25"	1.70	1.53	1.41	1.30	--
3.5"	1.72	1.24	1.16	.99	.76
2.5"	--	--	--	--	1.01
OEM/Integrator Average	2.18	1.48	1.22	1.00	.76

Note: 14" totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

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

TABLE 62

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	
Seagate Technology	--	8.0	107.0	--	115.0	30.7	--	11.0	140.0	--	151.0	25.9
Maxtor	--	--	94.5	5.0	99.5	26.6	--	--	134.9	7.0	141.9	24.3
Fujitsu	.2	7.6	17.7	25.9	51.4	13.7	.6	17.6	44.3	56.0	118.5	20.3
Micropolis	--	--	76.3	--	76.3	20.4	--	--	102.3	--	102.3	17.5
Other U.S.	--	--	13.3	9.0	22.3	6.0	--	--	21.0	14.0	35.0	6.0
Other Non-U.S.	--	4.1	5.5	--	9.6	2.6	.2	11.2	23.5	--	34.9	6.0
TOTAL	.2	19.7	314.3	39.9	374.1	100.0	.8	39.8	466.0	77.0	583.6	100.0

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

FIXED DISK DRIVES, 1-2 GIGABYTES

1992 DISK/TREND REPORT

FIXED DISK DRIVES, 1 - 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Hitachi	DKU-85I, DKU-98I

10.8" disk diameter

IBM	3390-1

10.5" disk diameter

Fujitsu	F6425M4, F6425H

9.5" disk diameter

Hitachi	DKU-86I, H-6556-I

9" disk diameter

Digital Equipment	RA92
Hitachi	DK816-20
NEC	D2367, D2377

8" disk diameter

Fujitsu	M2392K
Seagate Technology	ST81236J, ST82038J

5.25" disk diameter

Digital Equipment	RF72
Edisa	ED 71012
Fujitsu	M2266, MF2652P
Hewlett-Packard	97560, C3009
Hitachi	DK516C-16
IBM	9333-3110, 9345-1/2
Magtron	MT6120S
Maxtor	P0-12S, P1-17S
Micropolis	1528D, 1908D
Microscience International	FH-31200
NEC	D5894
Seagate Technology	ST41600N, ST41200N

3.5" disk diameter

Conner Peripherals	CP-31370*
Digital Equipment	RZ26*, DSP3160*

Fujitsu	M2694H*
Hewlett-Packard	C2247*
Hitachi	DK315C-11*, DK315C-14*
IBM	0663-H/L12*, O663-E15*
Maxtor	MXT-1240S*
Micropolis	2112D*
Quantum	1225S ProDrive*
Seagate Technology	ST11200N*

*Maximum 41.3 mm height, or less.

Starting with last year's DISK/TREND Report, disk drives with more than 1 gigabyte capacity were divided into two product groups, split at the 2 gigabyte level, in recognition of the diverging nature of the products and markets, both above and below that level.

There are still drives in this product group which are intended solely for mainframe computer applications, but they are now the minority. IBM's 3380 was the core of this product group during the first half of the 1980's. The original 3380 was first shipped in late 1981, after an extremely expensive (to IBM) delay of over a year from the announced delivery schedule. However, IBM increased the capacity to 2.5 gigabytes with mid-life enhancements to the 3380 family in 1985, and most of the mainframe drive activity moved up to higher capacities, leaving the 3390-1, first shipped in 1989, and newer 5.25" drives (9333 and 9345) as the remaining IBM mainframe drives in this product group.

As shipments of the older 10.5", 9.5", 9" and 8" drives for captive and non-captive markets faded, 5.25" drives currently available from 12 companies became the major products in the 1-2 gigabyte range. Joining them in the last year were 3.5" drives from 10 firms, with more expected. 3.5" drives are expected to provide a major challenge to 5.25" drives in this capacity range during the next three years.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	1,407.4	3,262.3	3,132.2	3,231.0	3,541.1
All manufacturers	2,670.3	4,275.4	3,845.5	3,844.2	4,185.9

The up-and-down revenue pattern for this product group during recent years has been a reflection of the hectic changes under way in both product mix and distribution patterns. Previously the domain of drives designed for mainframes, the 1-2 gigabyte capacity range by 1991 had become an area of rapid growth for 5.25" OEM drives, with declining captive shipments of high-end drives. In 1992 14" and 8"/9" drives will be only 5% of the shipment total, 5.25" drives will be more than half of the total, and 3.5" drives are coming up fast (with a big boost from IBM's captive shipments).

Total sales revenues for 1991 for 1-2 gigabyte drives were down 33.5%, depressed by a sharp falloff of sales for 14" captive drives. 1992 revenues are expected to be up 60.1%, to $4.2 billion, boosted by rapid shipment increases for noncaptive 5.25" drives and IBM's large captive shipments of "Corsair-1/2 3.5" drives for several systems. Worldwide shipments of all drives were up 38.7% in 1991 and are expected to increase 137.4% in 1992, topping 1 million units.

The movement to 5.25" and 3.5" drives has been driven by the usual reasons. The smaller drives require less power, generate less heat and noise, and most significantly, have much lower prices. The average price for all OEM drives in the 1-2 gigabyte range was already down to $3,654 in 1990, dropping to $2,035 in 1991, and is expected to reach an average of $1,520 in 1992. The OEM/Integrator average price per megabyte is dropping below a dollar for the first time this year, to an estimated 98 cents.

Mainframe and supermini applications used to provide the primary market for drives in this group, but these applications were down to only 35% of the unit shipment total for 1991, with a further decline to only 8% forecasted for 1995. Minicomputers and multiuser micros, including file servers, were the leading application in 1991 with 35.2% of unit shipments and are forecasted to climb to 59% in 1995.

Seagate continues to dominate noncaptive shipments in the 1-2 gigabyte range, with a combination of 9", 8" and 5.25" drives. The company shipped a total of 138,000 units in 1991, 43.4% of the worldwide noncaptive total for that year. Fujitsu held second place with 16.9%, followed closely by Micropolis in third position with 16.8%.

Marketing trends

Growth in drive shipments is expected to remain high for 1-2 gigabyte drives in the 1993-95 time period, averaging 45.6% per year, and culminating in total 1995 shipments of 3.2 million drives. The existing momentum of 5.25" drive shipments, combined with rapid acceptance of the 3.5" drives now announced by 10 manufacturers, are projected to result in the almost complete replacement of larger drives by 1994:

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
14"	29.9	2.6	--	--	--
	6.7%	.2%	--	--	--
8"/9"	96.9	50.7	19.0	5.0	--
	21.6%	4.8%	1.1%	.2%	--
5.25"	318.4	607.5	702.0	675.0	506.0
	71.2%	57.2%	40.9%	27.3%	15.6%
3.5" 1.625" high	2.2	401.4	914.0	1,535.0	2,389.0
	.5%	37.8%	53.3%	62.0%	73.6%
3.5" 1" high or less	--	--	80.0	260.0	350.0
	--	--	4.7%	10.5%	10.8%
	447.4	1,062.2	1,715.0	2,475.0	3,245.0

Helping to drive demand for both 5.25" and 3.5" drives will be the emerging market for various types of disk arrays, which will infiltrate the expanding applications for disk storage in network file servers, engineering workstations, minicomputers and mainframes. Most midrange and high-end arrays introduced so far have used 5.25" drives because they are readily available in the desired capacities. But 3.5" drives at the 1 gigabyte level and beyond are already starting to find their way into arrays such as IBM's 9337 subsystem. Further penetration of the array market by 3.5" drives is inevitable because of their advantages in package size, power requirements and price per unit. The 1" high 3.5" drives expected in the market in 1993, such as the IBM "Spitfire" drive now under development, will provide a form factor even more attractive to array designers.

Technical trends

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

For many drive manufacturers the myriad of details associated with packaging as many as eight or more disks in a small drive have been a formidable challenge. IBM helped by setting an industry standard for 31.5 mil disks with its Lightning series of 3.5" drives, and head suspensions have been modified for the narrow disk spacing required. The problems are difficult but they are being solved.

Forecasting assumptions

1. IBM's shipments of Corsair-I and Corsair-2 full size 3.5" drives will decline through 1995 as the result of migration to 2-gigabyte Corsair-4 drives for several key applications starting in 1993. The 1" high Spitfire 3.5" drives expected in 1993 will achieve high production levels for personal computer file servers and other array applications.
2. The last production of 14" drives will be in 1992, and shipments of 8" drives will cease in 1994.
3. 3.5" drives will assume shipment leadership of this product group in 1993, and 1993 will be the peak year for shipments of 5.25" drives.

TABLE 63

FIXED DISK DRIVES, 1 - 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	198.0	373.0	1,480.0	2,058.0	1,305.0	1,845.0	1,135.0	1,586.0	1,026.0	1,470.0
Other U.S. Captive	276.8	631.7	340.0	593.5	240.0	365.0	141.5	241.5	90.0	171.0
TOTAL U.S. CAPTIVE	474.8	1,004.7	1,820.0	2,651.5	1,545.0	2,210.0	1,276.5	1,827.5	1,116.0	1,641.0
PCM/Reseller	74.0	93.6	132.2	168.1	216.0	279.0	355.7	462.0	526.8	676.7
OEM/Integrator	254.2	309.1	358.6	442.7	517.7	643.2	703.5	941.5	858.0	1,223.4
TOTAL U.S. NONCAPTIVE	328.2	402.7	490.8	610.8	733.7	922.2	1,059.2	1,403.5	1,384.8	1,900.1
TOTAL U.S. REVENUES	803.0	1,407.4	2,310.8	3,262.3	2,278.7	3,132.2	2,335.7	3,231.0	2,500.8	3,541.1
Non-U.S. Manufacturers										
Captive	--	1,018.1	--	741.4	--	407.0	--	267.0	--	196.0
PCM/Reseller	8.4	18.8	1.2	2.9	19.1	28.7	30.6	50.4	37.0	70.0
OEM/Integrator	126.4	226.0	161.5	268.8	179.3	277.6	182.4	295.8	220.9	378.8
TOTAL NON-U.S. REVENUES	134.8	1,262.9	162.7	1,013.1	198.4	713.3	213.0	613.2	257.9	644.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	937.8	2,670.3	2,473.5	4,275.4	2,477.1	3,845.5	2,548.7	3,844.2	2,758.7	4,185.9
OEM Average Price ($000)		2.035		1.520		1.011		.893		.861

TABLE 64

FIXED DISK DRIVES, 1 - 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991		Forecast							
	Shipments		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	13.6	25.0	253.0	345.0	256.0	355.0	278.0	385.0	280.0	400.0
Other U.S. Captive	25.3	54.9	62.0	97.5	72.0	115.0	59.0	105.0	50.0	95.0
TOTAL U.S. CAPTIVE	38.9	79.9	315.0	442.5	328.0	470.0	337.0	490.0	330.0	495.0
PCM/Reseller	42.5	53.4	84.8	107.5	205.0	265.0	380.0	495.0	585.0	754.0
OEM/Integrator	142.2	171.6	250.0	308.0	534.0	664.0	800.0	1,070.0	1,010.0	1,440.0
TOTAL U.S. NONCAPTIVE	184.7	225.0	334.8	415.5	739.0	929.0	1,180.0	1,565.0	1,595.0	2,194.0
TOTAL U.S. SHIPMENTS	223.6	304.9	649.8	858.0	1,067.0	1,399.0	1,517.0	2,055.0	1,925.0	2,689.0
Non-U.S. Manufacturers										
Captive	--	49.4	--	43.9	--	42.0	--	52.0	--	60.0
PCM/Reseller	.8	1.8	.1	.3	18.0	27.0	32.0	53.0	40.0	76.0
OEM/Integrator	51.6	91.3	95.0	160.0	161.5	247.0	195.0	315.0	245.0	420.0
TOTAL NON-U.S. SHIPMENTS	52.4	142.5	95.1	204.2	179.5	316.0	227.0	420.0	285.0	556.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	276.0	447.4	744.9	1,062.2	1,246.5	1,715.0	1,744.0	2,475.0	2,210.0	3,245.0
Total Capacity (Terabytes)	367.3	603.3	953.3	1,367.9	1,401.0	1,938.3	2,150.4	3,059.2	3,028.5	4,453.6
Cumulative Shipments (Units in thousands)										
IBM	248.0	444.3	501.0	789.3	757.0	1,144.3	1,035.0	1,529.3	1,315.0	1,929.3
Non-IBM	541.6	976.9	1,033.5	1,694.1	2,024.0	3,054.1	3,490.0	5,144.1	5,420.0	7,989.1
WORLDWIDE TOTAL	789.6	1,421.2	1,534.5	2,483.4	2,781.0	4,198.4	4,525.0	6,673.4	6,735.0	9,918.4

TABLE 65

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues				Forecast											
	1992				1993			1994			1995	
	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"
U.S. MANUFACTURERS																
IBM Captive	312.0	--	51.0	10.0	--	--	570.0	1,488.0	--	375.0	1,470.0	--	70.0	1,516.0	--	1,470.0
Other U.S. Captive	--	352.0	279.7	--	--	66.0	499.5	28.0	--	225.0	140.0	--	80.0	161.5	--	171.0
PCM/Reseller	--	--	93.6	--	--	--	146.9	21.2	--	162.0	117.0	--	162.8	299.2	110.0	566.7
OEM/Integrator	--	52.0	256.8	.3	--	20.0	375.0	47.7	--	346.5	296.7	--	298.9	642.6	207.0	1,016.4
TOTAL U.S. REVENUES	312.0	404.0	681.1	10.3	--	86.0	1,591.4	1,584.9	--	1,108.5	2,023.7	--	611.7	2,619.3	317.0	3,224.1
NON-U.S. MANUFACTURERS																
Captive	222.5	774.0	21.6	--	60.0	612.0	59.4	10.0	272.0	90.0	45.0	70.0	119.0	78.0	100.0	96.0
PCM/Reseller	2.8	16.0	--	--	1.2	1.7	--	--	--	14.4	14.3	--	18.9	31.5	16.0	54.0
OEM/Integrator	6.4	97.9	121.7	--	--	29.0	208.0	31.8	9.1	192.0	76.5	--	155.0	140.8	123.6	255.2
TOTAL NON-U.S. REVENUES	231.7	887.9	143.3	--	61.2	642.7	267.4	41.8	281.1	296.4	135.8	70.0	292.9	250.3	239.6	405.2
WORLDWIDE RECAP																
Captive	534.5	1,126.0	352.3	10.0	60.0	678.0	1,128.9	1,526.0	272.0	690.0	1,655.0	70.0	269.0	1,755.5	100.0	1,737.0
	-64.5%	-5.5%	+348.2%	--	-88.8%	-39.8%	+220.4%	--	-59.9%	-38.9%	+8.5%	-74.3%	-61.0%	+6.1%	-62.8%	-1.1%
PCM/Reseller	2.8	16.0	93.6	--	1.2	1.7	146.9	21.2	--	176.4	131.3	--	181.7	330.7	126.0	620.7
	-79.6%	-74.8%	+700.0%	--	-57.1%	-89.4%	+56.9%	--	-100.0%	+20.1%	+519.3%	--	+3.0%	+151.9%	-30.7%	+87.7%
OEM/Integrator	6.4	149.9	378.5	.3	--	49.0	583.0	79.5	9.1	538.5	373.2	--	453.9	783.4	330.6	1,271.6
	-86.2%	-45.9%	+190.7%	--	-100.0%	-67.3%	+54.0%	--	-81.4%	-7.6%	+369.4%	-100.0%	-15.7%	+109.9%	-27.2%	+62.3%
Total Revenues	543.7	1,291.9	824.4	10.3	61.2	728.7	1,858.8	1,626.7	281.1	1,404.9	2,159.5	70.0	904.6	2,869.6	556.6	3,629.3
	-65.3%	-15.7%	+273.9%	--	-88.7%	-43.6%	+125.5%	--	-61.4%	-24.4%	+32.8%	-75.1%	-35.6%	+32.9%	-38.5%	+26.5%
ANNUAL SHARE, BY DIAMETER	20.5%	48.4%	30.9%	.2%	1.4%	17.0%	43.6%	38.0%	7.3%	36.6%	56.1%	1.8%	23.6%	74.6%	13.3%	86.7%

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

TABLE 66

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments				Forecast											
					1992				1993			1994			1995	
	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"
U.S. MANUFACTURERS																
IBM Captive	20.0	--	3.0	2.0	--	--	35.0	310.0	--	25.0	330.0	--	5.0	380.0	--	400.0
Other U.S. Captive	--	22.0	32.9	--	--	5.5	83.0	9.0	--	45.0	70.0	--	20.0	85.0	--	95.0
PCM/Reseller	--	--	53.4	--	--	--	91.1	16.4	--	135.0	130.0	--	155.0	340.0	110.0	644.0
OEM/Integrator	--	13.0	158.4	.2	--	5.0	263.0	40.0	--	315.0	349.0	--	305.0	765.0	230.0	1,210.0
TOTAL U.S. SHIPMENTS	20.0	35.0	247.7	2.2	--	10.5	472.1	375.4	--	520.0	879.0	--	485.0	1,570.0	340.0	2,349.0
NON-U.S. MANUFACTURERS																
Captive	8.9	38.7	1.8	--	2.5	34.0	5.4	2.0	17.0	10.0	15.0	5.0	17.0	30.0	20.0	40.0
PCM/Reseller	.2	1.6	--	--	.1	.2	--	--	--	12.0	15.0	--	18.0	35.0	16.0	60.0
OEM/Integrator	.8	21.6	68.9	--	--	6.0	130.0	24.0	2.0	160.0	85.0	--	155.0	160.0	130.0	290.0
TOTAL NON-U.S. SHIPMENTS	9.9	61.9	70.7	--	2.6	40.2	135.4	26.0	19.0	182.0	115.0	5.0	190.0	225.0	166.0	390.0
WORLDWIDE RECAP																
Captive	28.9	60.7	37.7	2.0	2.5	39.5	123.4	321.0	17.0	80.0	415.0	5.0	42.0	495.0	20.0	535.0
	-57.1%	+16.3%	+518.0%	--	-91.3%	-34.9%	+227.3%	--	-57.0%	-35.2%	+29.3%	-70.6%	-47.5%	+19.3%	-52.4%	+8.1%
PCM/Reseller	.2	1.6	53.4	--	.1	.2	91.1	16.4	--	147.0	145.0	--	173.0	375.0	126.0	704.0
	-71.4%	-74.2%	+853.6%	--	-50.0%	-87.5%	+70.6%	--	-100.0%	+61.4%	+784.1%	--	+17.7%	+158.6%	-27.2%	+87.7%
OEM/Integrator	.8	34.6	227.3	.2	--	11.0	393.0	64.0	2.0	475.0	434.0	--	460.0	925.0	360.0	1,500.0
	-60.0%	-48.1%	+309.5%	--	-100.0%	-68.2%	+72.9%	--	-81.8%	+20.9%	+578.1%	-100.0%	-3.2%	+113.1%	-21.7%	+62.2%
Total Shipments	29.9	96.9	318.4	2.2	2.6	50.7	607.5	401.4	19.0	702.0	994.0	5.0	675.0	1,795.0	506.0	2,739.0
	-57.3%	-22.5%	+373.8%	--	-91.3%	-47.7%	+90.8%	--	-62.5%	+15.6%	+147.6%	-73.7%	-3.8%	+80.6%	-25.0%	+52.6%
ANNUAL SHARE, BY DIAMETER	6.7%	21.8%	71.2%	.3%	.2%	4.8%	57.3%	37.7%	1.1%	41.0%	57.9%	.2%	27.4%	72.4%	15.6%	84.4%
TOTAL CAPACITY (Terabytes)	29.6	153.9	417.8	2.0	3.2	83.2	871.9	409.6	31.8	912.6	994.0	8.3	949.0	2,102.0	759.0	3,694.6

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

TABLE 67

FIXED DISK DRIVES, 1 - 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	156.6	35.0	259.6	8.0
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	157.6	35.2	1,914.5	59.0
PERSONAL COMPUTERS Business and professional, single user	2.7	.6	259.6	8.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	34.2	7.6	64.9	2.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	95.3	21.4	746.4	23.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	1.0	.2	--	--
Total	447.4	100.0	3,245.0	100.0

TABLE 68

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1991	1992	1993	1994	1995
Captive					
14"	18.82	19.35	--	--	--
8"	11.64	10.54	9.69	8.48	--
5.25"	8.89	7.41	6.63	4.28	3.33
3.5"	5.00	4.75	3.98	3.23	2.85
Captive Average	12.13	6.27	4.78	3.41	2.87
PCM/Reseller					
14"	14.00	12.00	--	--	--
8"	8.00	5.60	--	--	--
5.25"	1.43	1.12	.92	.75	.66
3.5"	--	1.20	.90	.73	.63
PCM/Reseller Average	1.66	1.15	.91	.74	.63
OEM/Integrator					
14"	6.40	--	--	--	--
8"	2.71	2.63	2.43	--	--
5.25"	1.21	.98	.87	.70	.61
3.5"	--	1.12	.86	.70	.60
OEM/Integrator Average	1.45	1.04	.87	.70	.60

Note: 14 inch totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

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

TABLE 69

FIXED DISK DRIVES, 1 - 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	
Seagate Technology	--	10.0	103.0	--	113.0	47.7	--	13.0	125.0	--	138.0	43.4
Fujitsu	.1	5.1	23.6	--	28.8	12.1	1.0	6.8	46.0	--	53.8	16.9
Micropolis	--	--	45.4	.2	45.6	19.2	--	--	53.3	.2	53.5	16.8
Other U.S.	--	--	26.1	--	26.1	11.0	--	--	33.5	--	33.5	10.5
Other Non-U.S.	--	8.1	15.5	--	23.6	10.0	--	16.4	22.9	--	39.3	12.4
TOTAL	.1	23.2	213.6	.2	237.1	100.0	1.0	36.2	280.7	.2	318.1	100.0

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

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

1992 DISK/TREND REPORT

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

10.8" disk diameter	
IBM	3390-3
9.5" disk diameter	
Hitachi	H-6587
9" disk diameter	
NEC	D2387, N7795
8" disk diameter	
Fujitsu	M2671P, F6427K
Seagate Technology	ST83220K, ST82500N/J
5.25" disk diameter	
Digital Equipment	DSP5350, RF 73
Fujitsu	M2654S/P
Hewlett-Packard	C3010
Hitachi	DK517C-37
Micropolis	1924D, 1936D
Seagate Technology	ST42000N, ST43400N

High performance disk drives intended for use with mainframe computers constitute most of this product group. Until last year, all disk drives with capacities of more than 1 gigabyte were included in a single product group. However that group had become a diverse mixture of drives and has been split at the 2 gigabyte level, providing a high-end product group still dominated by drives for mainframe applications, but with a growing population of smaller drives.

Disk drives with individual spindles, or head/disk assemblies, containing capacities above 2 gigabytes first appeared in 1985 with IBM's introduction of the 3380-E, the double capacity model in the 3380 series. That drive was replaced by the triple capacity 3380-K in 1987, which in turn has been made obsolete by the 3390 series. The 3390-2, with the same 3.7 gigabyte capacity as the 3380-K, but offering performance and price improvements, first shipped at the end of

1989. The 3390-3, with 50% more capacity per spindle and further price reductions per megabyte, became available in September, 1991.

The 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, with the exception of a few drives using ferrite heads. The 8" and 9" drives now offer capacities extending over 3 gigabytes, and are used typically in small mainframe, supermini and imaging applications. Some are also finding their way into mainframe PCM applications, with Fujitsu 8" and Hitachi 9.5" drives now included in plug compatible subsystems equivalent to IBM 3380 and 3390 drives.

5.25" drives above 2 gigabytes were available for the first time in 1991, and are now available from six manufacturers. Most 5.25" drives in the group follow the physical packaging of the original 8 disk Maxtor 5.25" drive configuration, except that individual models now include up to 12 disks.

Plug compatible drives sold by major mainframe PCM vendors such as Amdahl, Hitachi Data Systems, Comparex and Memorex Telex have been included in the product specification section, in the interest of clarity. Currently, Fujitsu makes the drives sold by Amdahl, while Hitachi makes the drives sold by Hitachi Data Systems and Comparex. Drives currently offered in the plug compatible market by Memorex Telex are made by Fujitsu and Seagate Technology.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1991	1992	1993	1994	1995
U.S. manufacturers	5,380.5	5,349.6	7,243.5	8,460.7	8,841.3
All manufacturers	6,350.3	6,545.8	8,837.4	10,070.1	10,381.8

Annual revenues for this product group have remained at about six and one half billion dollars for the last three years. However, major changes in the structure of this group are hidden beneath the surface. IBM's estimated revenues from drives with capacities over 2 gigabytes are $1 billion lower in 1992 than they were in 1990, as the result of lower shipments. During the same period, captive drive shipments by non-U.S. manufacturers are almost $400 million higher, due

to increasing shipments of 8"-9.5" as capacities climb into this product group. And noncaptive shipments by U.S. manufacturers of noncaptive drives are also $300 million higher, boosted by rapid growth of 5.25" drives.

Total unit shipments of drives with more than 2 gigabytes capacity are increasing rapidly. 1991's total of 238,500 spindles was up 42.8% over the previous year and 1992 is expected to grow 52.5%, to 362,900 units. Most of 1992's increase is being generated by expanding shipments of 5.25" drives. 52.2% of 1992's total shipments will be 5.25" drives. Despite the fact that drives in this group have traditionally been used mostly for mainframes and superminis, new applications in file servers are already emerging for the smaller drives. It is expected that the first shipments of 3.5" drives with 2 gigabytes capacity will also occur this year, probably by IBM, which has already provided numerous samples of the "Corsair-4" drive to prospective OEM customers for evaluation.

By 1991, the portion of unit shipments for the product group that were used in mainframe and supermini applications was down to 78.9%, and is expected to decline to 24% in 1995. Minicomputers and multiuser micros, including file servers, held only 15.5% of the 1991 total but are expected to jump to 69% of the 1995 applications.

Seagate rose to leadership in noncaptive shipments of drives with capacities over 2 gigabytes in 1991 with 31,000 8"/9" drives and 50,000 5.25" drives, for 63.8% of the worldwide total. Hitachi was second with 29,000 drives, for 22.9% of the total, reflecting the company's strength in the PCM mainframe market.

Marketing trends

The major growth in both revenues and shipments projected for this product group through 1995 is based on rapid projected growth of both 5.25" and 3.5" drives. 3.5" drives haven't yet been shipped in commercial quantities as of the publication date of this edition of the DISK/TREND Report. However, shipments of 337,000 3.5" drives are forecasted for 1993, growing to 1.4 million drives in 1995, 65% of that year's total. Overall unit shipments are expected to grow at an average annual rate of 87.3% during the 1993-95 period. Although the percentage increases for revenues will be much smaller, as disk diameters shrink in size, total projected revenues for the product group will reach $10.3 billion in 1995.

Disk drives in the 8"-14" ranges are expected to stay in production through 1995, but shipments of the 10.5"-14" range peaked in 1990, and the 8"-9.5" range is expected to peak in 1993:

Worldwide total Unit shipments(000)	1991	1992	1993	1994	1995
10.5"-14"	119.5	91.9	--	--	--
	50.1%	25.3	--	--	--
8"-9.5"	68.5	76.5	82.0	53.0	29.0
	28.7%	21.1%	8.8%	3.4%	1.4%
5.25"	50.5	189.5	432.0	655.0	697.0
	21.2%	52.2%	46.2%	42.3%	32.4%
3.5"	--	5.0	337.0	785.0	1,398.0
	--	1.4%	36.1%	50.7%	65.0%
	238.5	362.9	934.0	1,548.0	2,150.0

In the mainframe arena, another mid-life kicker for the 3390 series is now projected for 1993, the exact timing of which will probably depend on the level of IBM's annoyance with Storage Technology's Iceberg array -- assuming it finally enters the market early next year. If the consensus rumor of a three times increase in capacity over the existing 3390-3, to 17 gigabytes per spindle, is accurate, it is expected that the majority of IBM's customers will be pleased enough with the improved price per gigabyte and better utilization of floor space to keep competitive sale penetration of IBM's customer sites to tolerable levels.

Within a year or so after the next 3390 model appears, we expect IBM to introduce the first of its 3.5" drives for the mainframe market, skipping over the 5.25" form factor for high-end mainframes. The "Allicat", or one of the other models in the "cat" series, IBM's current high-end 3.5" drive development program, are expected to be in quantity production by 1995 and will be the backbone of IBM's mainframe disk drive product lines, both in conventional drive strings and in arrays.

3.5" drives with more than 2 gigabyte capacity will also be the key disk drive product for minicomputers, network file servers and most high-end arrays by 1995. IBM's 2 gigabyte Corsair-4 is close to introduction, both as an OEM product and for major captive applications with engineering workstations and

office minicomputers. Others will follow starting in 1993, with availability from several manufacturers expected. It should be noted that 5.25" drives are also expected to maintain shipment growth through 1995 and will continue to provide the lowest OEM price per megabyte. Today's 5.25" average OEM/Integrator price per megabyte of 81 cents is forecasted to drop to 41 cents in 1995.

Technical trends

It appears that IBM has dropped plans for further development of 5.25" drives for the mainframe market and will develop 3.5" drives as its main thrust -- but first comes another 3390 model, probably with a three times capacity increase. Magnetoresistive thin film heads are the key to doubling the existing drive's capacity per track, making it possible to maintain a logical addressing scheme consistent with current drives, and making it easy for users to migrate to the new drive. Combined with a more modest increase in track density, a capacity of 17 gigabytes per HDA is the current guesstimate by outsiders.

The 3.5" drives in IBM's "cat" series of development projects are an ambitious attempt to jump ahead of the industry in recording density, and therefore in cost-effectiveness, by using advanced MR heads and sophisticated encoding schemes. If the "Allicat" is eventually placed in production (and it could well be superseded by later programs), it would probably have a capacity above 3 gigabytes, using an areal density of at least 400 megabits per square inch. 3.5" drives from other drive manufacturers can be expected to be equally ambitious once the industry's suppliers of heads, disks, semiconductors and other critical components are ready.

Forecasting assumptions

1. IBM will introduce the 2 gigabyte 3.5" Corsair-4 drive by the end of 1992, a 17 gigabyte version of the 3390 in 1993, and a high-end 3.5" drive for mainframe applications in 1994.
2. PCM vendors will continue to match IBM's 3390 series with 8"-9.5", or smaller, drives, and will expand their penetration of small mainframe and AS/400 markets with subsystems using 5.25" and 3.5" drives, including array subsystems.
3. Shipments of 5.25" drives in OEM/Integrator markets will continue to grow through 1995, with major shipments of 3.5" drives starting in 1993.

TABLE 70

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1991		Forecast							
	Revenues		1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	3,317.0	4,960.0	3,082.4	4,597.6	3,888.0	5,680.0	4,133.6	6,132.8	3,956.0	6,089.0
Other U.S. Captive	2.4	3.6	106.0	226.0	333.5	602.8	557.2	1,013.0	712.0	1,326.0
TOTAL U.S. CAPTIVE	3,319.4	4,963.6	3,188.4	4,823.6	4,221.5	6,282.8	4,690.8	7,145.8	4,668.0	7,415.0
PCM/Reseller	27.6	34.4	87.1	99.0	238.0	293.5	326.0	438.5	330.0	460.5
OEM/Integrator	260.1	382.5	308.6	427.0	463.4	667.2	598.9	876.4	656.4	965.8
TOTAL U.S. NONCAPTIVE	287.7	416.9	395.7	526.0	701.4	960.7	924.9	1,314.9	986.4	1,426.3
TOTAL U.S. REVENUES	3,607.1	5,380.5	3,584.1	5,349.6	4,922.9	7,243.5	5,615.7	8,460.7	5,654.4	8,841.3
Non-U.S. Manufacturers										
Captive	--	63.1	--	405.0	--	740.0	--	730.0	13.0	687.5
PCM/Reseller	361.7	879.9	330.4	743.2	350.0	762.4	323.3	700.4	334.5	645.0
OEM/Integrator	16.5	26.8	37.3	48.0	58.4	91.5	107.5	179.0	130.0	208.0
TOTAL NON-U.S. REVENUES	378.2	969.8	367.7	1,196.2	408.4	1,593.9	430.8	1,609.4	477.5	1,540.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	3,985.3	6,350.3	3,951.8	6,545.8	5,331.3	8,837.4	6,046.5	10,070.1	6,131.9	10,381.8
OEM Average Price ($000)		5.028		2.939		2.180		1.641		1.348

TABLE 71

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1991 Shipments		Forecast 1992		1993		1994		1995	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	73.0	109.0	61.0	91.0	190.0	280.0	286.0	428.0	421.0	645.0
Other U.S. Captive	.2	.3	11.0	23.0	52.0	94.0	88.0	160.0	110.0	205.0
TOTAL U.S. CAPTIVE	73.2	109.3	72.0	114.0	242.0	374.0	374.0	588.0	531.0	850.0
PCM/Reseller	7.4	8.6	34.0	38.7	105.0	130.0	160.0	215.0	190.0	265.0
OEM/Integrator	61.5	77.0	117.1	144.3	230.0	300.0	385.5	523.0	490.5	711.0
TOTAL U.S. NONCAPTIVE	68.9	85.6	151.1	183.0	335.0	430.0	545.5	738.0	680.5	976.0
TOTAL U.S. SHIPMENTS	142.1	194.9	223.1	297.0	577.0	804.0	919.5	1,326.0	1,211.5	1,826.0
Non-U.S. Manufacturers										
Captive	--	2.3	--	16.0	--	40.0	--	54.0	2.0	76.0
PCM/Reseller	15.4	36.9	14.6	32.6	20.5	42.0	25.0	48.0	52.0	88.0
OEM/Integrator	2.7	4.4	12.5	17.3	29.5	48.0	71.0	120.0	100.0	160.0
TOTAL NON-U.S. SHIPMENTS	18.1	43.6	27.1	65.9	50.0	130.0	96.0	222.0	154.0	324.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	160.2	238.5	250.2	362.9	627.0	934.0	1,015.5	1,548.0	1,365.5	2,150.0
Total Capacity (Terabytes)	537.2	824.9	834.1	1,247.0	1,935.4	2,897.9	3,162.2	4,846.7	4,079.5	6,469.7
Cumulative Shipments (Units in thousands)										
IBM	320.4	497.0	381.4	588.0	571.4	868.0	857.4	1,296.0	1,278.4	1,941.0
Non-IBM	165.4	289.1	354.6	561.0	791.6	1,215.0	1,521.1	2,335.0	2,465.6	3,840.0
WORLDWIDE TOTAL	485.8	786.1	736.0	1,149.0	1,363.0	2,083.0	2,378.5	3,631.0	3,744.0	5,781.0

TABLE 72

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1991 Revenues			Forecast															
	1992							1993				1994				1995			
	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"
U.S. MANUFACTURERS																			
IBM Captive	4,960.0	--	--	4,576.0	--	--	21.6	4,320.0	--	--	1,360.0	3,582.8	--	--	2,550.0	1,625.0	--	--	4,464.0
Other U.S. Captive	--	--	3.6	--	--	226.0	--	--	--	524.8	78.0	--	--	672.0	341.0	--	--	816.0	510.0
PCM/Reseller	12.0	--	22.4	--	--	99.0	--	--	--	212.5	81.0	--	--	310.5	128.0	--	--	220.5	240.0
OEM/Integrator	115.6	148.8	118.1	82.0	114.4	226.6	4.0	121.5	69.7	357.0	119.0	101.5	23.4	457.5	294.0	48.8	--	455.0	462.0
TOTAL U.S. REVENUES	5,087.6	148.8	144.1	4,658.0	114.4	551.6	25.6	4,441.5	69.7	1,094.3	1,638.0	3,684.3	23.4	1,440.0	3,313.0	1,673.8	--	1,491.5	5,676.0
NON-U.S. MANUFACTURERS																			
Captive	--	63.1	--	--	405.0	--	--	--	644.0	96.0	--	--	504.0	171.6	54.4	--	220.0	337.5	130.0
PCM/Reseller	125.0	754.9	--	35.2	708.0	--	--	--	748.0	14.4	--	--	660.0	22.4	18.0	--	540.0	33.0	72.0
OEM/Integrator	--	26.8	--	--	21.0	27.0	--	--	15.0	59.5	17.0	--	5.0	111.0	63.0	--	--	112.0	96.0
TOTAL NON-U.S. REVENUES	125.0	844.8	--	35.2	1,134.0	27.0	--	--	1,407.0	169.9	17.0	--	1,169.0	305.0	135.4	--	760.0	482.5	298.0
WORLDWIDE RECAP																			
Captive	4,960.0	63.1	3.6	4,576.0	405.0	226.0	21.6	4,320.0	644.0	620.8	1,438.0	3,582.8	504.0	843.6	2,945.4	1,625.0	220.0	1,153.5	5,104.0
	-13.1%	+425.8%	--	-7.7%	+541.8%	--	--	-5.6%	+59.0%	+174.7%	--	-17.1%	-21.7%	+35.9%	+104.8%	-54.6%	-56.3%	+36.7%	+73.3%
PCM/Reseller	137.0	754.9	22.4	35.2	708.0	99.0	--	--	748.0	226.9	81.0	--	660.0	332.9	146.0	--	540.0	253.5	312.0
	-26.1%	+55.4%	--	-74.3%	-6.2%	+342.0%	--	-100.0%	+5.6%	+129.2%	--	--	-11.8%	+46.7%	+80.2%	--	-18.2%	-23.9%	+113.7%
OEM/Integrator	115.6	175.6	118.1	82.0	135.4	253.6	4.0	121.5	84.7	416.5	136.0	101.5	28.4	568.5	357.0	48.8	--	567.0	558.0
	+5.1%	+84.1%	--	-29.1%	-22.9%	+114.7%	--	+48.2%	-37.4%	+64.2%	--	-16.5%	-66.5%	+36.5%	+162.5%	-51.9%	-100.0%	-.3%	+56.3%
Total Revenues	5,212.6	993.6	144.1	4,693.2	1,248.4	578.6	25.6	4,441.5	1,476.7	1,264.2	1,655.0	3,684.3	1,192.4	1,745.0	3,448.4	1,673.8	760.0	1,974.0	5,974.0
	-13.2%	+67.5%	--	-10.0%	+25.6%	+301.5%	--	-5.4%	+18.3%	+118.5%	--	-17.0%	-19.3%	+38.0%	+108.4%	-54.6%	-36.3%	+13.1%	+73.2%
ANNUAL SHARE, BY DIAMETER	82.2%	15.6%	2.2%	71.8%	19.1%	8.8%	.3%	50.4%	16.7%	14.3%	18.6%	36.7%	11.8%	17.3%	34.2%	16.1%	7.3%	19.0%	57.6%

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

TABLE 73

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1991 Shipments			Forecast															
				1992				1993				1994				1995			
	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"
U.S. MANUFACTURERS																			
IBM Captive	109.0	--	--	88.0	--	--	3.0	80.0	--	--	200.0	53.0	--	--	375.0	25.0	--	--	620.0
Other U.S. Captive	--	--	.3	--	--	23.0	--	--	--	82.0	12.0	--	--	105.0	55.0	--	--	120.0	85.0
PCM/Reseller	.6	--	8.0	--	--	38.7	--	--	--	85.0	45.0	--	--	135.0	80.0	--	--	105.0	160.0
OEM/Integrator	3.8	31.0	42.2	2.0	26.0	114.3	2.0	3.0	17.0	210.0	70.0	2.0	6.0	305.0	210.0	1.0	--	325.0	385.0
TOTAL U.S. SHIPMENTS	113.4	31.0	50.5	90.0	26.0	176.0	5.0	83.0	17.0	377.0	327.0	55.0	6.0	545.0	720.0	26.0	--	550.0	1,250.0
NON-U.S. MANUFACTURERS																			
Captive	--	2.3	--	--	16.0	--	--	--	28.0	12.0	--	--	24.0	22.0	8.0	--	11.0	45.0	20.0
PCM/Reseller	6.1	30.8	--	1.9	30.7	--	--	--	34.0	8.0	--	--	22.0	14.0	12.0	--	18.0	22.0	48.0
OEM/Integrator	--	4.4	--	--	3.8	13.5	--	--	3.0	35.0	10.0	--	1.0	74.0	45.0	--	--	80.0	80.0
TOTAL NON-U.S. SHIPMENTS	6.1	37.5	--	1.9	50.5	13.5	--	--	65.0	55.0	10.0	--	47.0	110.0	65.0	--	29.0	147.0	148.0
WORLDWIDE RECAP																			
Captive	109.0	2.3	.3	88.0	16.0	23.0	3.0	80.0	28.0	94.0	212.0	53.0	24.0	127.0	438.0	25.0	11.0	165.0	725.0
	-7.9%	+475.0%	--	-19.3%	+595.7%	--	--	-9.1%	+75.0%	+308.7%	--	-33.7%	-14.3%	+35.1%	+106.6%	-52.8%	-54.2%	+29.9%	+65.5%
PCM/Reseller	6.7	30.8	8.0	1.9	30.7	38.7	--	--	34.0	93.0	45.0	--	22.0	149.0	92.0	--	18.0	127.0	208.0
	-6.9%	+72.1%	--	-71.6%	-.3%	+383.8%	--	-100.0%	+10.7%	+140.3%	--	--	-35.3%	+60.2%	+104.4%	--	-18.2%	-14.8%	+126.1%
OEM/Integrator	3.8	35.4	42.2	2.0	29.8	127.8	2.0	3.0	20.0	245.0	80.0	2.0	7.0	379.0	255.0	1.0	--	405.0	465.0
	+8.6%	+80.6%	--	-47.4%	-15.8%	+202.8%	--	+50.0%	-32.9%	+91.7%	--	-33.3%	-65.0%	+54.7%	+218.8%	-50.0%	-100.0%	+6.9%	+82.4%
Total Shipments	119.5	68.5	50.5	91.9	76.5	189.5	5.0	83.0	82.0	432.0	337.0	55.0	53.0	655.0	785.0	26.0	29.0	697.0	1,398.0
	-7.4%	+80.7%	--	-23.1%	+11.7%	+275.2%	--	-9.7%	+7.2%	+128.0%	--	-33.7%	-35.4%	+51.6%	+132.9%	-52.7%	-45.3%	+6.4%	+78.1%
ANNUAL SHARE, BY DIAMETER	50.2%	28.7%	21.1%	25.4%	21.1%	52.2%	1.3%	8.9%	8.8%	46.4%	35.9%	3.6%	3.4%	42.4%	50.6%	1.2%	1.3%	32.5%	65.0%
TOTAL CAPACITY (Terabytes)	511.8	202.5	110.6	518.0	261.6	457.4	10.0	698.1	316.6	1,209.2	674.0	831.6	302.6	1,997.1	1,715.3	442.7	268.9	2,264.8	3,493.3

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

TABLE 74

WORLDWIDE SHIPMENTS OF IBM CAPTIVE AND PCM FIXED DISK DRIVES

USED WITH MAINFRAME COMPUTER APPLICATIONS

	DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000 SPINDLES)									
	1991		FORECAST							
	Shipments		1992		1993		1994		1995	
	US	WW	US	WW	US	WW	US	WW	US	WW
3380J Type (1260 MB)										
PCM	.8	1.8	.1	.2	--	--	--	--	--	--
3380E Type (2520 MB)										
PCM	.1	.7	--	--	--	--	--	--	--	--
3380K Type (3780 MB)										
IBM	7.0	12.0	--	--	--	--	--	--	--	--
PCM	7.0	13.9	2.7	4.5	--	--	--	--	--	--
TOTAL	14.0	25.9	2.7	4.5	--	--	--	--	--	--
3390-2 type (3784 MB)										
IBM	54.0	80.0	--	--	--	--	--	--	--	--
PCM	8.3	22.3	6.3	15.6	1.5	4.0	--	--	--	--
TOTAL	62.3	102.3	6.3	15.6	1.5	4.0	--	--	--	--
9390-3 type (5676 MB)										
IBM	12.0	17.0	59.0	88.0	40.0	60.0	5.0	8.0	--	--
PCM	--	--	5.6	12.5	14.0	30.0	6.0	14.0	3.0	6.0
TOTAL	12.0	17.0	64.6	100.5	54.0	90.0	11.0	22.0	3.0	6.0
9390-X type (17028 MB)										
IBM	--	--	--	--	15.0	20.0	31.0	45.0	16.0	25.0
PCM	--	--	--	--	--	--	4.0	8.0	6.0	12.0
TOTAL	--	--	--	--	15.0	20.0	35.0	53.0	22.0	37.0
5.25 Inch drives										
IBM 9336 (857 MB)	77.0	110.0	58.0	90.0	20.0	30.0	--	--	--	--
IBM 9345 (1500 MB)	2.0	3.0	20.0	30.0	13.0	20.0	3.0	5.0	--	--
PCM (1500 MB)	13.0	15.0	18.0	24.0	35.0	50.0	48.0	70.0	26.0	40.0
TOTAL 5.25 INCH	92.0	128.0	96.0	144.0	68.0	100.0	51.0	75.0	26.0	40.0
3.5 Inch drives										
IBM (3000 MB)	--	--	--	--	--	--	19.0	25.0	150.0	220.0
PCM (3000 MB)	--	--	--	--	--	--	--	--	16.0	35.0
TOTAL 3.5 INCH	--	--	--	--	--	--	19.0	25.0	166.0	255.0
TOTAL SPINDLES	181.2	275.7	169.7	264.8	138.5	214.0	116.0	175.0	217.0	338.0
TOTAL FORMATTED CAPACITY (Terabytes)		706.3		804.9		997.3		1,214.9		1,489.1
		+18%		+14%		+24%		+22%		+23%

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 or more physical spindles in order to equal the capacity of a specific IBM spindle. This table includes drives with less than 2 gigabytes capacity which are used with IBM mainframe computers.

TABLE 75

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1991 Estimate Units (000)	1991 Estimate %	1995 Projection Units (000)	1995 Projection %
MAINFRAME/SUPERMINI General purpose	188.3	78.9	516.0	24.0
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	36.9	15.5	1,483.5	69.0
PERSONAL COMPUTERS Business and professional, single user	--	--	21.5	1.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	--	--	--	--
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	13.3	5.6	129.0	6.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	238.5	100.0	2,150.0	100.0

TABLE 76

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1991	1992	1993	1994	1995
Captive					
14"	10.52	9.16	6.34	4.41	3.81
8"	9.56	8.80	8.07	7.36	7.01
5.25"	6.00	4.91	3.18	2.74	2.53
3.5"	--	3.60	3.39	3.21	2.95
Captive Average	10.51	8.75	5.08	3.74	3.06
PCM/Reseller					
14"	5.39	4.88	--	--	--
8"	6.52	5.05	4.07	3.06	2.27
5.25"	1.27	1.00	.81	.69	.58
3.5"	--	--	.90	.69	.56
PCM/Reseller Average	5.76	3.42	1.91	1.26	.90
OEM/Integrator					
14"	7.55	7.25	7.13	5.07	2.86
8"	2.18	1.79	1.59	1.52	--
5.25"	1.27	.81	.56	.46	.41
3.5"	--	1.00	.85	.60	.46
OEM/Integrator Average	2.17	1.17	.78	.57	.45

Note: 14 inch totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

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

TABLE 77

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1991 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
Seagate Technology	--	26.0	41.0	67.0	77.0	--	31.0	50.0	81.0	63.8
Hitachi	--	10.0	--	10.0	11.5	--	29.0	--	29.0	22.9
Other U.S.	1.7	--	.2	1.9	2.2	4.4	--	.2	4.6	3.6
Other Non-U.S.	4.3	3.8	--	8.1	9.3	6.1	6.2	--	12.3	9.7
TOTAL	6.0	39.8	41.2	87.0	100.0	10.5	66.2	50.2	126.9	100.0

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

RIGID DISK DRIVE SPECIFICATIONS

1992 DISK/TREND REPORT

RIGID MAGNETIC DISK DRIVE SPECIFICATIONS

Coverage

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

Specifications on drive models sold by computer system manufacturers, but purchased on an OEM basis from others, have been included in some cases, for identification purposes. Also included are plug compatible drives sold by major mainframe PCM vendors such as Amdahl, Hitachi Data Systems, Comparex and Memorex Telex, but which are manufactured by other firms. Not listed in many cases are captive drives which are similar to OEM/Integrator models made by the same manufacturer.

Capacities

Starting with this edition of the DISK/TREND Report, formatted capacity has been used to determine the appropriate DISK/TREND product group for each drive. Previously, drives were grouped according to unformatted capacity, but the industry movement to embedded controllers eventually made that practice obsolete, since the majority of drives now are specified in formatted capacities.

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

Average access time

All DISK/TREND specifications use the term "average access time" to describe the combination of average positioning time and average rotational delay. Some in the industry have fallen into the habit of using the term average access time to describe average positioning time, or "seek" time, but this usage fails to

adequately describe the time required for a disk drive to start to respond to a system request. The DISK/TREND specifications show separately the average positioning time, average rotational delay, and average access time, in order to avoid confusion.

Transfer rate

The transfer rate shown in the specifications is the rate at which data is transferred between the drive and the computer to which it is attached, in the case of drives with embedded controllers, or the data rate between the drive and its controller, if the controller is not embedded. If the manufacturer has specified more than one communication mode, such as synchronous and asynchronous, both data rates are indicated.

Interfaces

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

Accuracy

All information in this section has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries have been required.

1992 DISK/TREND product groups for rigid magnetic disk drives

Removable magnetic media:
1. Disk cartridge drives

Fixed magnetic media:
2. Fixed disk drives, less than 60 megabytes
3. Fixed disk drives, 60-100 megabytes
4. Fixed disk drives, 100-200 megabytes
5. Fixed disk drives, 200-300 megabytes
6. Fixed disk drives, 300-500 megabytes
7. Fixed disk drives, 500 MB-1 gigabyte
8. Fixed disk drives, 1 - 2 gigabytes
9. Fixed disk drives, more than 2 gigabytes

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	DRR040C	DRR040D	DR232N2	DR232N8	DR311C
DISK/TREND GROUP	2	2	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	SCSI	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.8	F: 45.34	F: 85.6	F: 134.5	F: 105.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 17,920	F: 26,112	F: 26,112	F: 25,088
Data surfaces per spindle	2	2	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1195	1265	820	1288	2108
Track density (TPI)	1400	1740	2769	2769	2419
Maximum linear density (BPI) (FCI)	33343 22229	33343 22229	48000 36000	60000 45000	49393 37045
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3205	3205	3820	3820	3448
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19	19	15	15	13
Average rotational delay (msec)	9.4	9.4	7.85	7.85	8.7
Average access time (msec)	28.4	28.4	22.85	22.85	21.7
Data transfer rate (KBytes/sec)	6000	5000 synch. 2000 asynch.	8000	8000	8000
FIRST CUSTOMER SHIPMENT	4Q89	1990	6/92	6/92	3/92
COMMENTS	20.8 mm high	20.8 mm high	17 mm high Ramp loading mechanism	17 mm high Ramp loading mechanism	25.4 mm high

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	AMDAHL	AMDAHL
DRIVE	DR311D	DR312C	DR312D	6380-AJ4 6380-BJ4	6380-AK4 6380-BK4
DISK/TREND GROUP	4	5	5	7	8
MARKET	OEM	OEM	OEM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Sputtered
DRIVE: Heads	MIG	MIG	MIG	Ferrite	Ferrite
Interface	SCSI-2	PC AT	SCSI-2	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105.8	F: 211.5	F: 211.5	F: 630	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	F: 25,088	F: 25,088	F: 47,476	F: 47,476
Data surfaces per spindle	2	4	4	8	15
Heads per data surface	1	1	1	2	2
Tracks per surface	2108	2108	2108	1770	2656
Track density (TPI)	2419	2419	2419	1350	1350
Maximum linear density (BPI) (FCI)	49393 37045	49393 37045	49393 37045	21300 15975	24440 18330
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3448	3448	3448	3620	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13	13	13	12	16
Average rotational delay (msec)	8.7	8.7	8.7	8.3	8.3
Average access time (msec)	21.7	21.7	21.7	20.3	24.3
Data transfer rate (KBytes/sec)	8000 synch. 4000 asynch.	8000	8000 synch. 4000 asynch.	3000	3000
FIRST CUSTOMER SHIPMENT	4/92	12/92	1/92	1Q89	1Q89
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	PCM 3380J Drive has 4 spindles Manufactured by Fujitsu	PCM 3380K Drive has 4 spindles Manufactured by Fujitsu

MANUFACTURER	AMDAHL	AMDAHL	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY
DRIVE	6390-A/B24 6390-A/B28 6390-A/B2C 6390-A/B2F	6390-A/B34 6390-A/B38 6390-A/B3C 6390-A/B3F	A90	MD-2065	MD-2085
DISK/TREND GROUP	8	9	3	3	3
MARKET	PCM	PCM	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	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film*	Thin Film*	Thin Film*
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,892	F: 2,838/3,390	F: 91.5	F: 62.4	F: 85.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 56,664	F: 32,000	F: 30,464	F: 30,464
Data surfaces per spindle	15	15	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	2226	3339/3987	1430	1024	1410
Track density (TPI)	2050		2760	2703	2703
Maximum linear density (BPI) (FCI)	32733 24550		71000 53250	54000 36000	67000 44666
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4348	4348	2981	2703	2703
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	10.7	11.5/13	11	12	12
Average rotational delay (msec)	6.9	6.9	10.1	11.1	11.1
Average access time (msec)	17.6	18.4/19.9	21.1	23.1	23.1
Data transfer rate (KBytes/sec)	4500	4500	1875	1250	1250
FIRST CUSTOMER SHIPMENT	4Q91	9/92	3Q92	1/91	4Q91
COMMENTS	PCM 3390 Drive has 4, 8, 12, or 16 spindles Manufactured by Fujitsu	PCM 3390-3 Drive has 4, 8, 12, or 16 spindles Manufactured by Fujitsu	11.7 mm high *Glass disk	15.0 mm high *Glass disk	15.0 mm high *Glass disk

MANUFACTURER	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AURA ASSOCIATES	AURA ASSOCIATES	BRAND TECHNOLOGIES
DRIVE	A120	A180	AU426	AU853	BT9220A
DISK/TREND GROUP	4	4	2	3	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	48 mm OD 12 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film*	Thin Film*	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MIG
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 136.9	F: 183.0	F: 42.6	F: 85.3	F: 200
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,000	F: 32,000	*	*	F: 18,432
Data surfaces per spindle	4	4	2	4	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1070	1430	1104	1104	1208
Track density (TPI)	2760	2760	2550	2550	1376
Maximum linear density (BPI) (FCI)	59000 44250	71000 53250	42000 31500	42000 31500	29700 19800
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	2981	2981	5400	5400	3565
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	12	15	19	19	16.5
Average rotational delay (msec)	10.1	10.1	5.56	5.56	8.4
Average access time (msec)	22.1	25.1	24.56	24.56	24.9
Data transfer rate (KBytes/sec)	1875	1875	4500	4500	8000
FIRST CUSTOMER SHIPMENT	1Q92	1Q92	3Q92	4Q92	8/90
COMMENTS	15.0 mm high *Glass disk	15.0 mm high *Glass disk	12.7 mm high *Varies by zone	15 mm high *Varies by zone	41.3 mm high

MANUFACTURER	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	COMPAREX
DRIVE	BT9220E	BT9220S	BT3480	BT3800	6480AJ 6480BJ
DISK/TREND GROUP	5	5	6	7	7
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	9.5"
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	MIG			Ferrite
Interface	ESDI	SCSI	PC AT, SCSI	PC AT, SCSI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 226	F: 200	F: 480	F: 800	F: 630
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,850	F: 18,432	F:	F:	F: 47,476
Data surfaces per spindle	9	9	6	10	8
Heads per data surface	1	1	1	1	2
Tracks per surface	1208	1208	2229	2229	1327.5
Track density (TPI)	1376	1376	2500	2500	*
Maximum linear density (BPI) (FCI)	29700 19800	29700 19800			*
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3565	3565	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	16.5	16.5	12	12	11
Average rotational delay (msec)	8.4	8.4	8.3	8.3	8.3
Average access time (msec)	24.9	24.9	20.3	20.3	19.3
Data transfer rate (KBytes/sec)	1250	6670 synch. 3000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	3000
FIRST CUSTOMER SHIPMENT	8/90	8/90			1988
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	PCM 3380J Drive has 2 or 4 spindles. *Not announced. Manufactured by Hitachi

MANUFACTURER	COMPAREX	COMPAREX	COMPAREX	COMPAREX	COMPAREX
DRIVE	6480AE 6480BE	6480AK 6480BK	6490-A14 6490-A18 6490-B14 6490-B18 6490-B1C	6490-A24 6490-A28 6490-B24 6490-B28 6490-B2C	6490-A34 6490-A38 6490-B34 6490-B38 6490-B3C
DISK/TREND GROUP	8	8	8	8	9
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	9.5"	9.5"	9.5"	9.5"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	F: 1,890	F: 946	F: 1,892	F: 2,838
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 56,664	F: 56,664	F: 56,664
Data surfaces per spindle	8	8	15	15	15
Heads per data surface	2	4	2	2	2
Tracks per surface	2655	2655	1113	2226	3339
Track density (TPI)	*	*	*	*	*
Maximum linear density (BPI) (FCI)	*	*	*	*	*
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	4260	4260	4260
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13	12.5	8.5	10	12.5
Average rotational delay (msec)	8.3	8.3	7.1	7.1	7.1
Average access time (msec)	21.3	20.8	15.6	17.1	19.6
Data transfer rate (KBytes/sec)	3000	3000	4200	4200	4200
FIRST CUSTOMER SHIPMENT	1988	1988	4Q90	4Q90	2Q92
COMMENTS	PCM 3380E Drive has 2 or 4 spindles. *Not announced. Manufactured by Hitachi	PCM 3380K Drive has 2 or 4 spindles. *Not announced. Manufactured by Hitachi	PCM 3390-1 Drive has 4, 8, or 12 spindles. *Not announced. Manufactured by Hitachi	PCM 3390-2 Drive has 4, 8, or 12 spindles. *Not announced. Manufactured by Hitachi	PCM 3390-3 Drive has 4, 8, or 12 spindles. *Not announced. Manufactured by Hitachi

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-1034 Derringer	CP-3000 Allegheny	CP-3040 Sierra	CP-3044 Sierra	CP-2064 Pancho
DISK/TREND GROUP	2	2	2	2	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	48 mm OD 12 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	Thin Film, MIG	Thin Film, MIG	MIG
Interface	PCMCIA/3, PC AT	PC AT	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 32.1	F: 42.6	F: 40.10	F: 42.65	F: 64
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,456	F: 20,480	F: 20,480	F: 20,480	F: 19,456
Data surfaces per spindle	2	2	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	826	1045	1026	1047	823
Track density (TPI)	2450	1400	1400	1400	2100
Maximum linear density (BPI) (FCI)	60023 45130	30871 20581	30871 20581	30871 20581	39222 26148
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3465	3557	3557	3557	3486
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19	28	25	25	19
Average rotational delay (msec)	8.66	8.4	8.4	8.4	8.6
Average access time (msec)	27.66	36.4	33.4	33.4	27.6
Data transfer rate (KBytes/sec)	5000	1500	4000 synch. 1500 asynch.	1500	1500
FIRST CUSTOMER SHIPMENT	3Q92	3Q90	4Q88	4Q88	4Q90
COMMENTS	10.5 mm high	25.4 mm high	25.4 mm high	25.4 mm high	19 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-2064E Sahara	CP-2084 Pancho	CP-30060 Hopi	CP-30064 Hopi	CP-30069 Hopi
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	MIG	MIG	MIG
Interface	PC AT	PC AT	SCSI	PC AT, EISA	MCA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 64	F: 85.0	F: 60	F: 60	F: 60
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	F: 19,456	F: 19,968	F: 19,968	F: 19,968
Data surfaces per spindle	2	4	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1181	1097	1522	1522	1522
Track density (TPI)	2580	2300	1850	1850	1850
Maximum linear density (BPI) (FCI)	59500 44700	43866 32900	33184 24888	33184 24888	33184 24888
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3742	3486	3399	3399	3399
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	15	19	19	19	19
Average rotational delay (msec)	8	8.6	8.8	8.8	8.8
Average access time (msec)	23	27.6	27.8	27.8	27.8
Data transfer rate (KBytes/sec)	8000	6500 max.	4000 synch. 1500 asynch.	1500	1500
FIRST CUSTOMER SHIPMENT	2Q92	3Q91	4Q90	4Q90	4Q90
COMMENTS	12.5 mm high	19 mm high	25.4 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-30080E Jaguar	CP-30084E Jaguar	CP-2124 Pancho	CP-30100 Hopi	CP-30104 Hopi
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG		MIG	MIG
Interface	SCSI	PC AT	PC AT	SCSI	PC AT/XT, EISA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85.0	F: 85.0	F: 121.6	F: 120	F: 120
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 23,552	F: 23,552	F: 27,136	F: 19,968	F: 19,968
Data surfaces per spindle	2	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1806	1806	1120	1522	1522
Track density (TPI)	2150	2150	2450	1850	1850
Maximum linear density (BPI) (FCI)	42173 31630	42173 31630	59500 44625	33184 24888	33184 24888
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3833	3833	3776	3399	3399
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	17	17	17	19	19
Average rotational delay (msec)	7.8	7.8	7.9	8.8	8.8
Average access time (msec)	24.8	24.8	24.9	27.8	27.8
Data transfer rate (KBytes/sec)	5000 synch. 2000 asynch.	6000 max.		4000 synch. 1500 asynch.	1500
FIRST CUSTOMER SHIPMENT	3Q91	3Q91	4Q91	1Q90	1Q90
COMMENTS	25.4 mm high	25.4 mm high	19 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-30109 Hopi	CP-30170E Jaguar	CP-30174E Jaguar	CP-30200 Cougar	CP-30204 Cougar
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	Thin Film
Interface	MCA	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 120	F: 170.0	F: 170.0	F: 212.6	F: 212.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,968	F: 23,552	F: 23,552	F: 25,088	F: 25,088
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1522	1806	1806	2119	2119
Track density (TPI)	1850	2150	2150	2484	2484
Maximum linear density (BPI)	33184	42173	42173	45610	45610
(FCI)	24888	31630	31630	30407	30407
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3399	3833	3833	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19	17	17	12	12
Average rotational delay (msec)	8.8	7.8	7.8	6.7	6.7
Average access time (msec)	27.8	24.8	24.8	18.7	18.7
Data transfer rate (KBytes/sec)	1500	5000 synch. 2000 asynch.	6000 max.	5000 synch. 2500 asynch.	2500
FIRST CUSTOMER SHIPMENT	1Q90	3Q91	3Q91	3Q91	3Q91
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-30254 Monterey	CP-3200F	CP-3204F	CP-3209F	CP-3360 Summit
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI	PC AT	MCA	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 251	F: 212.6	F: 212.6	F: 212.6	F: 362.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 31,744	F: 19,456	F: 19,456	F: 19,456	F: 25,088
Data surfaces per spindle	4	8	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1985	1366	1366	1366	1806
Track density (TPI)	2450	1700	1700	1700	2150
Maximum linear density (BPI) (FCI)	52270 39301	31800 23850	31800 23850	31800 23850	44325 29550
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	4542	3485	3485	3485	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	14	16	16	16	12
Average rotational delay (msec)	6.6	8.6	8.6	8.6	6.7
Average access time (msec)	20.6	24.6	24.6	24.6	18.7
Data transfer rate (KBytes/sec)	5000	5000 synch. 1500 asynch.	1500	1500	5000 synch. 2500 asynch.
FIRST CUSTOMER SHIPMENT	2Q92	4Q89	4Q89	4Q89	3Q91
COMMENTS	25.4 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-3364 Summit	CP-30540 Aegean	CP-3540 Summit	CP-3544 Summit	CP-5500 Chinook
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI-2	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 362.5	F: 545.9	F: 543.7	F: 543.7	F: 510
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	*	F: 25,088	F: 25,088	F: 23,088
Data surfaces per spindle	8	6	12	12	10
Heads per data surface	1	1	1	1	2
Tracks per surface	1806	2243	1806	1806	2034
Track density (TPI)	2150	2628	2150	2150	2360
Maximum linear density (BPI) (FCI)	44325 29550	54478 40961	44325 29550	44325 29550	45525 30350
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4500	5400	4500	4500	4498
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	10	12	12	12
Average rotational delay (msec)	6.7	5.56	6.7	6.7	6.7
Average access time (msec)	18.7	15.56	18.7	18.7	18.7
Data transfer rate (KBytes/sec)	2500	10000	5000 synch. 2500 asynch.	2500	5000 synch.
FIRST CUSTOMER SHIPMENT	3Q91	4Q92	3Q91	4Q90	4Q91
COMMENTS	41.3 mm high	25.4 mm high *Varies by zone	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	CONNER PERIPHERALS	DAEYOUNG	DIGIREDE	DIGIREDE	DIGIREDE
DRIVE	CP-31370 Baja	DX-3040A	W525/50	W525/85	W525/140
DISK/TREND GROUP	8	2	2	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	PC AT	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,600 F: 1,371.3	F: 42.5	U: 53	U: 85.3	U: 140.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 13,312	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	14	3	5	9	11
Heads per data surface	1	1	1	1	1
Tracks per surface	2386	1040	1024	1024	1224
Track density (TPI)	2694	1200	1022	1022	1022
Maximum linear density (BPI) (FCI)	54478 40961	21122 14082	9934	11555	11555
Recording code	1,7 RLL	2,7 RLL	MFM	MFM	MFM
Rotational speed (RPM)	5400	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	25	27	28	30
Average rotational delay (msec)	5.56	8.3	8.3	8.3	8.3
Average access time (msec)	15.56	33.3	35.3	36.3	38.3
Data transfer rate (KBytes/sec)	10000	4000 max.	625	625	625
FIRST CUSTOMER SHIPMENT	4Q92	2Q91	1987	1987	1987
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high			

MANUFACTURER	DIGIREDE	DIGIREDE	DIGIREDE	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	W525/190	W525R/125	W525R/240	DSP2022A	DSP2022S
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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ST412	ST412	ST412	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 191.2	U: 128	U: 240	U: 260 F: 220	U: 260 F: 220
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624	U: 15,624	*	*
Data surfaces per spindle	15	8	15	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1024	1024	1484	1484
Track density (TPI)	1022	1070	1070	2721	2721
Maximum linear density (BPI) (FCI)	11555	14901 9934	14901 9934	56000 42000	56000 42000
Recording code	MFM	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	30	28	28	9	9
Average rotational delay (msec)	8.3	8.3	8.3	5.6	5.6
Average access time (msec)	38.3	36.3	36.3	14.6	14.6
Data transfer rate (KBytes/sec)	625	937.5	937.5	4000	6000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	1987	1989	1989		7/92
COMMENTS		For use with RLL controller	For use with RLL controller	19 mm high *Varies by zone	19 mm high *Varies by zone

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	RA70	RF31F	RF31	RF31T	DSP3085
DISK/TREND GROUP	5	5	6	6	7
MARKET	Captive	Captive	Captive	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	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	Ferrite	Thin Film	MIG
Interface	DEC, SDI	DEC, DSSI	DEC, DSSI	DSSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 350 F: 280	F: 200	U: 508 F: 381	U: 508 F: 381	U: 1,119 F: 852
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 25,600	F: 25,600	F: 29,184	F: 29,184
Data surfaces per spindle	11	8	8	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1507	984	1861	933	2086
Track density (TPI)	1355	1875	1875	2650	2650
Maximum linear density (BPI) (FCI)	22437 14958	30064 22548	30520 22890	48256 36192	48256 36192
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	3600	3600	5400	5400
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19.5	12.2	16	6.9	9.5
Average rotational delay (msec)	7.5	8.3	8.3	5.6	5.6
Average access time (msec)	27.0	20.5	24.3	12.5	15.1
Data transfer rate (KBytes/sec)	1450	2000	2000	3300	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	4/88	2/91	6/90	7/92	11/91
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	RA71	RF35	DSP3105	DSP3160	RA72
DISK/TREND GROUP	7	7	8	8	8
MARKET	Captive	OEM	OEM	OEM	Captive
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	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Thin Film	Thin Film	MIG
Interface	DEC, SDI	DEC, DSSI	SCSI-2	SCSI-2	DEC, SDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 700	F: 852	U: 1,342 F: 1,050	U: 2,045 F: 1,600	F: 1,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,112	F: 29,184	F: 29,184	*	F: 26,112
Data surfaces per spindle	14	14	14	16	20
Heads per data surface	1	1	1	1	1
Tracks per surface	1915	2086	2570	2599	1915
Track density (TPI)	1928	2650	2756	2756	1928
Maximum linear density (BPI) (FCI)	30469 22851	48256 36192	56000 42000	54000 40500	30469 22851
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12.5	9.5	9.5	10	12.5
Average rotational delay (msec)	8.3	5.6	5.6	5.6	8.3
Average access time (msec)	20.8	15.1	15.1	15.6	20.8
Data transfer rate (KBytes/sec)	2000	3300	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	2000
FIRST CUSTOMER SHIPMENT	10/91	2/92	3/92		10/91
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high *Varies by zone	

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	RA92	RF72	RZ26	DSP5200	DSP5350
DISK/TREND GROUP	8	8	8	9	9
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9"	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	Thin Film	Thin Film	Thin Film
Interface	DEC, SDI	DEC, DSSI	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,987 F: 1,506	U: 1,370 F: 1,000	U: 1,342 F: 1,050	U: 2,600 F: 2,000	U: 4,300 F: 3,500
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 35,328	F: 25,600	F: 29,184	F: 36,352	*
Data surfaces per spindle	13	21	14	21	25
Heads per data surface	1	1	1	1	1
Tracks per surface	3099	1861	2570	2620	3035
Track density (TPI)	2045	1875	2756	2432	2756
Maximum linear density (BPI) (FCI)	22839 15226	30064 22548	55530 41647	43880 32910	44000 33000
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3400	3600	5400	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	13.3	9.5	12	11.5
Average rotational delay (msec)	8.8	8.9	5.6	8.3	5.6
Average access time (msec)	24.8	22.2	15.1	20.3	17.1
Data transfer rate (KBytes/sec)	2800	2000	3300	10000 synch.	20000 synch. 10000 asynch.
FIRST CUSTOMER SHIPMENT	3/90	11/90	7/92	4Q91	
COMMENTS	SA800 consists of up to 16 spindles (in 2 cabinets),up to 24,096 MB	"Hispeed" mode with 10.3 msec. average seek	41.3 mm high		*Varies by zone

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DMA TECHNOLOGIES	DMA TECHNOLOGIES
DRIVE	RA73	RF73	RZ73	360	370
DISK/TREND GROUP	9	9	9	1	1
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	--	--
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SDI	DSSI	SCSI-2	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,600 F: 2,000	U: 2,600 F: 2,000	U: 2,600 F: 2,000	--	--
REMOVABLE	--	--	--	U: 12.75	U: 25.0
Capacity per track (Bytes)	F: 35,840	F: 36,352	F: 36,352	U: 10,416	U: 10,416
Data surfaces per spindle	21	21	21	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	2667	2631	2631	612	1224
Track density (TPI)	2468	2432	2432	612	1222
Maximum linear density (BPI) (FCI)	45000 33750	43880 32910	43880 32910	10894	10894
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	MFM	MFM
Rotational speed (RPM)	3600	3600	3600	3473	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Servo type	Embedded	Embedded	Embedded	Open Loop	Open Loop
Average positioning time (msec)	12.5	12.5	12.5	98 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.6	8.6
Average access time (msec)	20.8	20.8	20.8	106.6	93.6
Data transfer rate (KBytes/sec)	2800	2700	2700	625	625
FIRST CUSTOMER SHIPMENT	8/92	11/91	9/92	5/84	5/88
COMMENTS				41.3 mm high	41.3 mm high

MANUFACTURER	DMA TECHNOLOGIES	DZU	DZU	DZU	DZU
DRIVE	371	ISOT 5300E	ISOT 5502C	SM 5509	EC 5063 C
DISK/TREND GROUP	1	2	2	2	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	--	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	ST412	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 25.62	U: 50.88	U: 44.84	U: 337.7
REMOVABLE	F: 21.2	--	--	--	--
Capacity per track (Bytes)	F: 8,704	U: 10,416	U: 10,416	U: 10,416	U: 20,160
Data surfaces per spindle	2	4	5	7	15
Heads per data surface	1	1	1	1	2
Tracks per surface	1224	615	977	615	1120
Track density (TPI)	1222	625	625	625	475
Maximum linear density (BPI) (FCI)	10894	9617	9617	9617	6248
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	3473	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor		Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	85 (including settling)	40	40	45	22
Average rotational delay (msec)	8.6	8.3	8.3	8.3	8.3
Average access time (msec)	93.6	48.3	48.3	53.3	30.3
Data transfer rate (KBytes/sec)	625	625	625	625	1209
FIRST CUSTOMER SHIPMENT	5/88		1989		1989
COMMENTS	41.3 mm high				

MANUFACTURER	DZU	DZU	EDISA INFORMATICA	EDISA INFORMATICA	EDISA INFORMATICA
DRIVE	EC 5063	EC 5065	ED 71396	ED 71793	ED 71012
DISK/TREND GROUP	6	7	6	7	8
MARKET	OEM	OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	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	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 317	F: 635	F: 332	F: 664	F: 1,002
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F:	F: 28,672	F: 28,672	F: 32,768
Data surfaces per spindle	15	15	8	16	16
Heads per data surface	2	2	1	1	1
Tracks per surface	1122	2242	1447	1447	1911
Track density (TPI)	475	960	1667	1667	1850
Maximum linear density (BPI) (FCI)	6248	6248	30552 20368	30552 20368	40500 27000
Recording code	MFM	MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	4002	4002	4002
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	25	25	16.5	16.5	18
Average rotational delay (msec)	8.3	8.3	7.49	7.49	7.5
Average access time (msec)	33.3	33.3	23.99	23.99	25.5
Data transfer rate (KBytes/sec)	1198	1198	4000 synch. 1500 asynch.	4000 synch. 1500 asynch.	5000 synch. 1500 asynch.
FIRST CUSTOMER SHIPMENT	1985	1989	1Q92	3Q91	1Q92
COMMENTS					

MANUFACTURER	ELEBRA	ELEBRA	EZI	EZI	EZI
DRIVE	W570-ST	W950	1300	2300	4410
DISK/TREND GROUP	3	6	5	5	6
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	230 mm OD 100 mm ID	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	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ST412	Modified SMD	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 77.26*	U: 516	U: 310	F: 261.4	U: 382.55
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 30,240	U: 21,280	F: 17,920	U: 31,616
Data surfaces per spindle	5	12	12	12	11
Heads per data surface	1	2	1	1	1
Tracks per surface	989	1422	1216	1216	1100
Track density (TPI)	960	960	1207	1207	1207
Maximum linear density (BPI) (FCI)	14100 9400	15159 10106	19331 12887	19331 12887	29607 19736
Recording code	2,7 RLL/MFM	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3524	3524	3558
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	28	18	25	25	16.5
Average rotational delay (msec)	8.3	8.3	8.5	8.5	8.43
Average access time (msec)	36.3	26.3	33.5	33.5	24.93
Data transfer rate (KBytes/sec)	937.5*	1825	1250	1250	1875
FIRST CUSTOMER SHIPMENT	2Q91	1986	1991	1991	1991
COMMENTS	41.3 mm high *With RLL controller	Similar to Seagate FSD	Previously manufactured by Siemens	Previously manufactured by Siemens	Previously manufactured by Siemens

MANUFACTURER	EZI	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	4420	FK201A-54R	FK201S-45R	FK203A-45Z	FK309-26
DISK/TREND GROUP	6	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	MIG	MIG	Ferrite
Interface	SCSI	PC AT	SCSI	PC AT	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 334.54	F: 42.8	F: 45.1	F: 45	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	F:	F:	*	U: 10,416
Data surfaces per spindle	11	4	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1100	598	612	833	615
Track density (TPI)	1207	1352	1352	1881	753
Maximum linear density (BPI) (FCI)	29607 19736	37780 28335	37780 28335	51000 38250	15600
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	3558	3450	3450	3500	3350
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16.5	23	23	16	65 (including settling)
Average rotational delay (msec)	8.43	8.7	8.7	8.57	8.96
Average access time (msec)	24.93	31.7	31.7	24.57	73.96
Data transfer rate (KBytes/sec)	4000 synch. 2000 asynch.				625
FIRST CUSTOMER SHIPMENT	1991	1991	1991	1991	4/87
COMMENTS	Previously manufactured by Siemens	19.05 mm high	19.05 mm high	12.7 mm high *Varies by zone	41.3 mm high

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK309S-26R	FK309S-50R	FK311A-26R	FK311A-50R	FK314S-45R
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	SCSI	SCSI	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 22.5	F: 42.5	F: 21.4	F: 42.8	F: 45.12
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 9,216	F: 16,896	F: 17,408	F: 17,408	F:
Data surfaces per spindle	4	4	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	1106
Track density (TPI)	880	880	910	910	1440
Maximum linear density (BPI) (FCI)	14200 9466	25600 17066	26600 17733	26600 17733	33500 25125
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3350	3150	3050	3050	3540
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	47 (including settling)	47 (including settling)	28 (including settling)	28	25
Average rotational delay (msec)	8.95	9.52	9.84	9.84	8.47
Average access time (msec)	55.95	56.52	37.84	37.84	33.47
Data transfer rate (KBytes/sec)	645	1093	1093	1093	
FIRST CUSTOMER SHIPMENT	1Q88	1Q88	2/89	4Q89	1991
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK316A-45R	FK202A-60R	FK202A-80R	FK202S-80R	FK314S-90R
DISK/TREND GROUP	2	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	PC AT	PC AT	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 44.6	F: 63.7	F: 84.9	F: 84.9	F: 91.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F:	F:	F:	F: 20,400
Data surfaces per spindle	2	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1116	759	1012	1012	1113
Track density (TPI)	1752	1881	1881	1881	1440
Maximum linear density (BPI) (FCI)	31800 23850	40400 30300	48500 36375	48500 36375	33500 25125
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3540	3450	3450	3450	3540
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19	19	19	19	25
Average rotational delay (msec)	8.47	8.7	8.7	8.7	8.5
Average access time (msec)	27.47	27.7	27.7	27.7	33.5
Data transfer rate (KBytes/sec)					1500
FIRST CUSTOMER SHIPMENT	1991	1991	1991	1991	4Q90
COMMENTS	25.4 mm high	19.05 mm high	19.05 mm high	19.05 mm high	25.4 mm high

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJITSU
DRIVE	FK205A-105Z	FK316A-105R	FK317S-210R	FK317S-240R	M2225D2
DISK/TREND GROUP	4	4	5	5	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	MIG	MIG	MIG	Ferrite
Interface	PC AT	PC AT	SCSI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105	F: 105.0	F: 210.1	F: 249.5	U: 25.62
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F:	F:	F:	U: 10,416
Data surfaces per spindle	4	4	6	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1073	1315	1319	1510	615
Track density (TPI)	1881	1752	1880	1880	834
Maximum linear density (BPI) (FCI)	55000 41250	31800 23850	44400 33300	49500 37125	14845
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	3500	3540	4020	4020	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Encoder Motor
Servo type	Embedded	Embedded	Embedded	Embedded	Open Loop
Average positioning time (msec)	16	19	16	16	35
Average rotational delay (msec)	8.57	8.47	7.46	7.46	8.3
Average access time (msec)	24.57	27.47	23.46	23.46	43.3
Data transfer rate (KBytes/sec)					625
FIRST CUSTOMER SHIPMENT	1991	1991	1991	1991	2Q87
COMMENTS	19.05 mm high *Varies by zone	25.4 mm high	25.4 mm high	25.4 mm high	41.3 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2226D2	M2227D2	M2611S/SA/SB	M2611T	M2631S
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	ST412	ST412	SCSI	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.43	U: 51.24	F: 45.07	F: 45.07	U: 58 F: 45
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 17,408	F: 16,896	*
Data surfaces per spindle	6	8	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	1334	1334	916
Track density (TPI)	834	834	1681	1681	2000
Maximum linear density (BPI) (FCI)	14845	14845	29571 22178	29571 22178	42500 31875
Recording code	MFM	MFM	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3490	3490	3609
PERFORMANCE					
Actuator type	Rotary, Encoder Motor	Rotary, Encoder Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Embedded	Embedded	Embedded
Average positioning time (msec)	35	35	25	25	18
Average rotational delay (msec)	8.3	8.3	8.6	8.6	8.3
Average access time (msec)	43.3	43.3	33.6	33.6	26.3
Data transfer rate (KBytes/sec)	625	625	2500 synch. 1500 asynch.	7400 max.	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	1Q87	1Q87	4Q88	3Q89	2Q92
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high	25.4 mm high	17 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2631T	M2612ES/ESA/ESB M2612S/SA/SB	M2612ET/T	M2633S	M2633T
DISK/TREND GROUP	2	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	MIG	MIG
Interface	PC AT	SCSI	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 58 F: 45	F: 90.84	F: 90.15	U: 116 F: 90	U: 116 F: 90
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 17,408	F: 16,896	*	*
Data surfaces per spindle	2	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	916	1334	1334	916	916
Track density (TPI)	2000	1681	1681	2000	2000
Maximum linear density (BPI) (FCI)	42500 31875	29571 22178	29571 22178	42500 31875	42500 31875
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3609	3490	3490	3609	3609
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	18	20/25*	20/25	18	18
Average rotational delay (msec)	8.3	8.6	8.6	8.3	8.3
Average access time (msec)	26.3	28.6/33.6*	28.6/33.6	26.3	26.3
Data transfer rate (KBytes/sec)	6300 max.	2500 synch. 1500 asynch.	7400 max.	5000 synch. 3000 asynch.	6300 max.
FIRST CUSTOMER SHIPMENT	2Q92	4Q88	3Q89	2Q92	2Q92
COMMENTS	17 mm high *Varies by zone	41.3 mm high *ESA/S/SA/SB	41.3 mm high	17 mm high *Varies by zone	17 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2247E	M2247S/SA/SB	M2613ES/ESA/ESB M2613S/SA/SB	M2613ET/T	M2614ES/ESA/ESB M2614S/SA/SB
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 181.5	F: 153.1	F: 136.6	F: 135.23	F: 182.36
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	F: 16,640	F: 17,408	F: 16,896	F: 17,408
Data surfaces per spindle	7	7	6	6	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1243	1243	1334	1334	1334
Track density (TPI)	1267	1267	1681	1681	1681
Maximum linear density (BPI) (FCI)	19295 14471	19295 14471	29571 22178	29571 22178	29571 22178
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3490	3490	3490
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	18	18	20/25*	20/25	20/25*
Average rotational delay (msec)	8.3	8.3	8.6	8.6	8.6
Average access time (msec)	26.3	26.3	28.6/33.6*	28.6/33.6	28.6/33.6*
Data transfer rate (KBytes/sec)	1250	2500 synch. 1500 asynch.	2500 synch. 1500 asynch.	7400 max.	2500 synch. 1500 asynch.
FIRST CUSTOMER SHIPMENT	3Q87	1Q88	4Q88	3Q89	4Q88
COMMENTS			41.3 mm high *ESA/S/SA/SB	41.3 mm high	41.3 mm high *ESA/S/SA/SB

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2614ET/T	M2616ES/ESA/ESB M2616SA	M2616ET/T	M2617S/SA/SB	M2617T
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	MIG	MIG
Interface	PC AT	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 180.31	F: 105	F: 105	F: 105	F: 105
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 17,408	F: 16,896	*	*
Data surfaces per spindle	8	4	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1334	1542	1542	2010	2010
Track density (TPI)	1681	1681	1681	2267	2267
Maximum linear density (BPI) (FCI)	29571 22178	32069 24052	32069 24052	39297 29457	39297 29457
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	3490	3490	3490	3490
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	20/25	20	20	16	16
Average rotational delay (msec)	8.6	8.6	8.6	8.6	8.6
Average access time (msec)	28.6/33.6	28.6	28.6	24.6	24.6
Data transfer rate (KBytes/sec)	7400 max.	2500 synch. 1500 asynch.	7400 max.	5000 synch. 3000 asynch.	6300
FIRST CUSTOMER SHIPMENT	3Q89	1Q90	1Q90	9/92	7/92
COMMENTS	41.3 mm high	25.4 mm high	25.4 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2248E	M2248S/SA/SB	M2618S/SA/SB	M2618T	F6421
DISK/TREND GROUP	5	5	5	5	6
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.5" OD 4.0" ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	Ferrite
Interface	ESDI	SCSI	SCSI	PC AT	Fujitsu
CAPACITY/RECORDING DENSITY					1.607 or 1.144 MB Fixed Head Option
Total capacity (Mbytes) FIXED	U: 285.3	F: 244.6	F: 210	F: 210	F: 446/317.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	F: 16,640	*	*	F: 26,793/ 19,069
Data surfaces per spindle	11	11	4	4	10
Heads per data surface	1	1	1	1	2
Tracks per surface	1243	1243	2010	2010	1680
Track density (TPI)	1267	1267	2267	2267	880
Maximum linear density (BPI) (FCI)	19295 14471	19295 14471	39297 29457	39297 29457	12790
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3490	3490	3961
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	18	18	16	16	18
Average rotational delay (msec)	8.3	8.3	8.6	8.6	7.5
Average access time (msec)	26.3	26.3	24.6	24.6	25.5
Data transfer rate (KBytes/sec)	1250	2500 synch. 1500 asynch.	5000 synch. 3000 asynch.	6300	1859
FIRST CUSTOMER SHIPMENT	3Q87	1Q88	9/92	7/92	3Q81
COMMENTS			25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	Drive has 4 spindles

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2249E	M2249S/SA/SB	M2261E	M2261H/HA/HB M2261S/SA/SB	M2262E
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	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	MIG	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 389	F: 333.6	U: 415.1	F: 357.1	U: 570.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	F: 16,640	U: 31,296	F: 27,136	U: 31,296
Data surfaces per spindle	15	15	8	8	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1243	1243	1658	1658	1658
Track density (TPI)	1267	1267	1712	1712	1712
Maximum linear density (BPI) (FCI)	19295 14471	19295 14471	28816 21612	28816 21612	28816 21612
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
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	2500 synch. 1500 asynch.	1875	4000 synch. 1750 asynch.	1875
FIRST CUSTOMER SHIPMENT	3Q87	1Q88	2Q88	2Q88	2Q88
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2262H/HA/HB M2262S/SA/SB	M2343K/KS	M2350A	M2351A	M2381K/KP
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	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	Modified SMD	Modified SMD	Modified SMD	Mod. SMD, IPI-2
CAPACITY/RECORDING DENSITY				1.69 MB Fixed Head Option	
Total capacity (Mbytes) FIXED	F: 492	U: 383.38	U: 474.2	U: 474.2	U: 555.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	U: 40,960	U: 28,160	U: 28,160	U: 49,728
Data surfaces per spindle	11	7.5	10	10	7.5
Heads per data surface	1	2/1	2	2	2/1
Tracks per surface	1658	1248	1682	1684	1490
Track density (TPI)	1712	846	880	880	1193
Maximum linear density (BPI) (FCI)	28816 21612	20767 13844	12790	12790	25211 18908
Recording code	1,7 RLL	2,7 RLL	MFM	MFM	1,7 RLL
Rotational speed (RPM)	3600	3600	3961	3961	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	18	18	16
Average rotational delay (msec)	8.3	8.3	7.5	7.5	8.3
Average access time (msec)	24.3	24.3	25.5	25.5	24.3
Data transfer rate (KBytes/sec)	4000 synch. 1750 asynch.	2458	1859/7436/9295	1859	3000
FIRST CUSTOMER SHIPMENT	2Q88	4Q87	2/84	3/82	1Q88
COMMENTS			Parallel data transfer, 4 or 5 channels		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2622F/FA/FB M2622H/HA/HB	M2622S/SA/SB	M2622T	M2623F/FA/FB M2623H/HA/HB	M2623S/SA/SB
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI-1/2	SCSI-1/2	PC AT	SCSI-1/2	SCSI-1/2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 330.17	F: 330.17	F: 326.7	F: 425.1	F: 425.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	7	7	7	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1435	1435	1435	1435	1435
Track density (TPI)	1751	1751	1751	1751	1751
Maximum linear density (BPI) (FCI)	46383 34787	46383 34787	46383 34787	46383 34787	46383 34787
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4400	4400	4400	4400	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	12	12	12
Average rotational delay (msec)	6.8	6.8	6.8	6.8	6.8
Average access time (msec)	18.8	18.8	18.8	18.8	18.8
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	5000 synch. 3000 asynch.	7400 max.	10000 synch. 4000 asynch.	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	4Q91	1Q91	3Q91	4Q91	1Q91
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2623T	F6423B	F6425G	F6425K4/L4	M2263E
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	Fujitsu	Fujitsu	Fujitsu	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 420.1	F: 630.0	F: 630.0	F: 630.0	U: 778.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 47,476	F: 47,476	F: 47,476	U: 31,296
Data surfaces per spindle	9	8	8	8	15
Heads per data surface	1	2	2	2	1
Tracks per surface	1435	988	1770	1770	1658
Track density (TPI)	1751	1193	1370	910	1712
Maximum linear density (BPI) (FCI)	46383 34787	25300 18975	21300 15975	24420 16280	28816 21612
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	4400	3620	3620	3620	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	13	12	15	16
Average rotational delay (msec)	6.8	8.3	8.3	8.3	8.3
Average access time (msec)	18.8	21.3	20.3	23.3	24.3
Data transfer rate (KBytes/sec)	7400 max.	3000	3000	3000	1875
FIRST CUSTOMER SHIPMENT	3Q91	8/88	12/88	3Q86	2Q88
COMMENTS	41.3 mm high *Varies by zone	Drive has 4 spindles	Drive has 4 spindles	Drive has 4 spindles	

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

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2380A	M2382K/P	M2391D	M2391K	M2624F/FA/FB M2624H/HA/HB
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	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	MIG
Interface	Modified SMD	Mod. SMD, IPI-2	Modified SMD	Modified SMD	SCSI-1/2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,000.2	U: 1,000.2	U: 965	U: 1,062	F: 520.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 49,728	U: 49,728	U: 45,792	U: 50,400	*
Data surfaces per spindle	13.5	13.5	11	11	11
Heads per data surface	2/1	2/1	1	1	1
Tracks per surface	1490	1490	1916	1916	1435
Track density (TPI)	1193	1193	1456	1456	1751
Maximum linear density (BPI) (FCI)	25211 18908	25211 18908	22764 17073	25055 18791	46383 34787
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3709	3620	3600	3600	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	12	12	12
Average rotational delay (msec)	8.1	8.3	8.3	8.3	6.8
Average access time (msec)	24.1	24.3	20.3	20.3	18.8
Data transfer rate (KBytes/sec)	3074-1844	3000	2750	3000	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	1Q89	1Q88	1Q90	1Q90	4Q91
COMMENTS	Parallel data transfer, 4, 5 or 6 channels Total capacity varies in each version				41.3 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2624S/SA/SB	M2624T	M2691H/HA/HB M2691S/SA/SB	M2692H/HA/HB M2692S/SA/SB	M2693H/HA/HB M2693S/SA/SB
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Thin Film	Thin Film	Thin Film
Interface	SCSI-1/2	PC AT	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 520.1	F: 513.5	F: 648.4	F: 793.6	F: 938.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	11	11	9	11	13
Heads per data surface	1	1	1	1	1
Tracks per surface	1435	1435	1819	1819	1819
Track density (TPI)	1751	1751	2208	2208	2208
Maximum linear density (BPI) (FCI)	46383 34787	46383 34787	48724 36543	48724 36543	48724 36543
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4400	4400	4400	4400	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	10	10	10
Average rotational delay (msec)	6.8	6.8	6.8	6.8	6.8
Average access time (msec)	18.8	18.8	16.8	16.8	16.8
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.	7400 max.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	1Q91	3Q91	5/92	5/92	5/92
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6425H	F6425M4/N4	F6427H	M2266H/HA/HB M2266S/SA/SB	M2392D
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	10.5" OD 4.0" ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Sputtered	Oxide Sputtered	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Thin Film	MIG	Thin Film
Interface	Fujitsu	Fujitsu	Fujitsu	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,890	F: 1,260	F: 1,890	F: 1,165	F: 1,842
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 46,080	F: 45,792
Data surfaces per spindle	16	12	15	15	21
Heads per data surface	2	2	1	1	1
Tracks per surface	2654	2360	2655	1658	1916
Track density (TPI)	1370	1160	2080	1634	1456
Maximum linear density (BPI) (FCI)	24440 18330	24425 16283	33310 24980	46635 34976	22764 17073
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3620	3620	4340	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	17	12	14.5	12
Average rotational delay (msec)	8.3	8.3	6.9	8.3	8.3
Average access time (msec)	24.3	25.3	18.9	22.8	20.3
Data transfer rate (KBytes/sec)	3000	3000	4500	4800 synch. 2000 asynch.	2750
FIRST CUSTOMER SHIPMENT	12/88	3Q86	12/90	2Q90	1Q90
COMMENTS	Drive has 4 spindles	Drive has 4 spindles	Drive has maximum 16 spindles		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2392K	M2651H/S	M2652H/HA/HB M2652HD/HDA/HDB 2652S/SA/SB	M2652P	M2694H/HA/HB M2694S/SA/SB
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	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Modified SMD	SCSI-2	SCSI-2	IPI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,027	F: 1,313	F: 1,752	U: 2,001	F: 1,083.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 50,400	F: 45,056	F: 45,056	U: 52,864	*
Data surfaces per spindle	21	15	20	20	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1916	1944	1944	1893	1819
Track density (TPI)	1456	1780	1780	1780	2208
Maximum linear density (BPI) (FCI)	25055 18791	50257 37692	50257 37692	50257 37692	48724 36543
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	5400	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	11	11	11	10
Average rotational delay (msec)	8.3	5.56	5.56	5.56	6.8
Average access time (msec)	20.3	16.56	16.56	16.56	16.8
Data transfer rate (KBytes/sec)	3000	10000 synch. 3000 asynch.	10000 synch. 3000 asynch.	4758	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	1Q90	2Q91	2Q91	2Q91	5/92
COMMENTS					41.3 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	F6427K	M2654S/H	M2671P	C3012 KITTYHAWK	C3013 KITTYHAWK
DISK/TREND GROUP	9	9	9	2	2
MARKET	OEM	OEM	OEM, PCM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	34 mm OD 8 mm ID	34 mm OD 8 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	Fujitsu	SCSI-2	IPI-2	PC AT, PCMCIA	PC AT, PCMCIA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,835	F: 2,055	U: 2,648	U: 23.6 F: 14	U: 35.4 F: 21.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F:	U: 66,096	**	**
Data surfaces per spindle	15	21	15	2	3
Heads per data surface	1	1	1	1	1
Tracks per surface	4007	2179	2671		
Track density (TPI)	2820	1950	2080	2400	2400
Maximum linear density (BPI) (FCI)	33310 24982	50871 38153	33310 24983	51000	51000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL		
Rotational speed (RPM)	4340	5400	4340	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	13	12	12	18	18
Average rotational delay (msec)	6.9	5.56	6.91	5.56	5.56
Average access time (msec)	19.9	17.56	18.91	23.56	23.56
Data transfer rate (KBytes/sec)	4758	4758	4781	900	900
FIRST CUSTOMER SHIPMENT	7/92	7/92	2Q90	3Q92	3Q92
COMMENTS	Drive has maximum of 16 spindles			10.5 mm high *Glass disk **Varies by zone	10.5 mm high *Glass disk **Varies by zone

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C2228B/M	C2233	97544D 97544S	97544E	97544P 97544T
DISK/TREND GROUP	5	5	6	6	6
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI-2, PC AT	SCSI	ESDI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 234	F: 234	F: 332	U: 398	F: 332
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 28,672	U: 34,143	F: 28,672
Data surfaces per spindle	5	5	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1546	1546	1447	1457	1447
Track density (TPI)	1857	1857	1667	1667	1667
Maximum linear density (BPI) (FCI)	41100 27400	41100 27400	30552 20368	30552 20368	30552 20368
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	4002	4002	4002
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	12.6	12.6	16.5	17	16.5
Average rotational delay (msec)	8.3	8.3	7.5	7.5	7.5
Average access time (msec)	20.9	20.9	24	24.5	24
Data transfer rate (KBytes/sec)	10000 synch. 6800 asynch.	10000 synch. 6800 asynch.	4000 synch. 1500 asynch.	2500	5000 synch. 1500 asynch.
FIRST CUSTOMER SHIPMENT	10/91	4Q90	2Q89	1Q89	3Q90
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone			

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C2229B/M	C2234	C2235	97548D 97548S	97548E
DISK/TREND GROUP	6	6	6	7	7
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2, PC AT	SCSI-2, IDE	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 422	F: 328	F: 422	F: 664	U: 796
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	F: 28,672	U: 34,143
Data surfaces per spindle	9	7	9	16	16
Heads per data surface	1	1	1	1	1
Tracks per surface	1546	1546	1546	1447	1457
Track density (TPI)	1857	1857	1857	1667	1667
Maximum linear density (BPI) (FCI)	41100 27400	41100 27400	41100 27400	30552 20368	30552 20368
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	4002	4002
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	12.6	12.6	12.6	16.5	17
Average rotational delay (msec)	8.3	8.3	8.3	7.5	7.5
Average access time (msec)	20.9	20.9	20.9	24	24.5
Data transfer rate (KBytes/sec)	10000 synch. 6800 asynch.	10000 synch. 6800 asynch.	10000 synch. 6800 asynch.	4000 synch. 1500 asynch.	2500
FIRST CUSTOMER SHIPMENT	10/91	4Q90	4Q90	4Q88	4Q88
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone		

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97548P 97548T	97556-0pt050	97556-0pt001, 002	C2221B	C2244
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	PCM	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	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MIG
Interface	SCSI-2	ESDI	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 664	U: 803	F: 677	F: 677	F: 566
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,672	U: 43,056	F: 36,864	F: 36,864	*
Data surfaces per spindle	16	11	11	11	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1447	1697	1670	1670	1918
Track density (TPI)	1667	1865	1865	1865	2304
Maximum linear density (BPI) (FCI)	30552 20368	42000 28000	42000 28000	42000 28000	49987 33325
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4002	4002	4002	4002	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16.5	13.5	13.5	13.5	10.5
Average rotational delay (msec)	7.5	7.5	7.5	7.5	5.56
Average access time (msec)	24	21	21	21	16.06
Data transfer rate (KBytes/sec)	5000 synch. 1500 asynch.	2875	5000 synch. 1500 asynch.	5000 synch. 1500 asynch.	20000 synch. 2500-5000 asyn.
FIRST CUSTOMER SHIPMENT	1Q90	3Q90	3Q90	10/91	1Q92
COMMENTS					41.3 mm high *Varies by zone

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C2245	C2246	97549P 97549T	97558-0pt050	97558-0pt001, 002
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Thin Film	MIG	MIG
Interface	SCSI-2	SCSI-2	SCSI-2	ESDI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 728	F: 890	F: 1,002	U: 1,267	F: 1,069
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 32,768	U: 43,056	F: 36,864
Data surfaces per spindle	9	11	16	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1918	1918	1911	1962	1935
Track density (TPI)	2304	2304	1850	1865	1865
Maximum linear density (BPI) (FCI)	49987 33325	49987 33325	40500 27000	42000 28000	42000 28000
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	4002	4002	4002
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10.5	10.5	18	13.5	13.5
Average rotational delay (msec)	5.56	5.56	7.5	7.5	7.5
Average access time (msec)	16.06	16.06	25.5	21	21
Data transfer rate (KBytes/sec)	20000 synch. 2500-5000 asyn.	20000 synch. 2500-5000 asyn.	5000 synch. 1500 asynch.	2875	5000 synch. 1500 asynch.
FIRST CUSTOMER SHIPMENT	2Q92	3Q92	1Q90	3Q90	3Q90
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone			

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97560-0pt050	97560-0pt001, 002	C2222B	C2223B	C2247
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	PCM	PCM	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	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Thin Film	Thin Film	MIG
Interface	ESDI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,605	F: 1,355	F: 1,069	F: 1,355	F: 1,052
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 43,056	F: 36,864	F: 36,864	F: 36,864	*
Data surfaces per spindle	19	19	15	19	13
Heads per data surface	1	1	1	1	1
Tracks per surface	1962	1935	1935	1935	1918
Track density (TPI)	1865	1865	1865	1865	2304
Maximum linear density (BPI) (FCI)	42000 28000	42000 28000	42000 28000	42000 28000	49987 33325
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4002	4002	4002	4002	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13.5	13.5	13.5	13.5	10.5
Average rotational delay (msec)	7.5	7.5	7.5	7.5	5.56
Average access time (msec)	21	21	21	21	16.06
Data transfer rate (KBytes/sec)	2875	5000 synch. 1500 asynch.	5000 synch. 1500 asynch.	5000 synch. 1500 asynch.	20000 synch. 2500-5000 asyn.
FIRST CUSTOMER SHIPMENT	5/90	5/90	10/91	10/91	1Q92
COMMENTS					41.3 mm high *Varies by zone

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C2482A	C3007	C3009	C3020T/R C3030T/R	C3027U
DISK/TREND GROUP	8	8	8	8	8
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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,355	U: 1,692 F: 1,370	U: 2,213 F: 1,792	U: 1,207 F: 1,027	U: 1,207 F: 1,027
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 36,864	*	*	F: 49,152	F: 49,152
Data surfaces per spindle	19	13	17	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	1935	2255	2255	1100	1100
Track density (TPI)	1865	2000	2000	2000	2000
Maximum linear density (BPI) (FCI)	42000 28000	46666 35000	46666 35000	46666 35000	46666 35000
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4002	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13.5	9	11.5	9	9
Average rotational delay (msec)	7.5	5.56	5.56	5.56	5.56
Average access time (msec)	21	14.56	17.06	14.56	14.56
Data transfer rate (KBytes/sec)	5000 synch. 1500 asynch.	20000 synch.	20000 synch.	10000 synch.	10000 synch.
FIRST CUSTOMER SHIPMENT	7/91	1Q92	1Q92	3Q92	3Q92
COMMENTS		*Varies by zone	*Varies by zone	With 2 gigabytes DDS, DAT in either tower or rack mount	Expansion kit for C3020/21/23/24/31 T/R

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C3035T/R	C3037U	C3010	C3021T/R C3031T/R	C3023T/R
DISK/TREND GROUP	8	8	9	9	9
MARKET	Captive	Captive	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,207 F: 1,027	U: 1,207 F: 1,027	U: 2,473 F: 2,003	U: 2,473 F: 2,003	U: 2,473 F: 2,003
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 49,152	F: 49,152	*	F: 49,152	F: 49,152
Data surfaces per spindle	19	19	19	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	1100	1100	2255	2255	2255
Track density (TPI)	2000	2000	2000	2000	2000
Maximum linear density (BPI) (FCI)	46666 35000	46666 35000	46666 35000	46666 35000	46666 35000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9	9	11.5	11.5	11.5
Average rotational delay (msec)	5.56	5.56	5.56	5.56	5.56
Average access time (msec)	14.56	14.56	17.06	14.56	14.56
Data transfer rate (KBytes/sec)	20000 synch.	20000 synch.	20000 synch.	10000 synch.	10000 synch.
FIRST CUSTOMER SHIPMENT	4Q92	4Q92	1Q92	3Q92	3Q92
COMMENTS	Packaged as 4 drives in either tower or rack mount	Expansion kit for C3020/21/ 23/24/30/31 T/R	*Varies by zone	With up to 8 gigabytes DDS, DAT in either tower or rack mount	Tower or rack mount

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI
DRIVE	C3024T/R	C3028U	C3034T/R	C3038U	DK521-5
DISK/TREND GROUP	9	9	9	9	2
MARKET	Captive	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,473 F: 2,003	U: 2,473 F: 2,003	U: 2,473 F: 2,003	U: 2,473 F: 2,003	U: 51.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 49,152	F: 49,152	F: 49,152	F: 49,152	U: 10,416
Data surfaces per spindle	19	19	19	19	6
Heads per data surface	1	1	1	1	1
Tracks per surface	2255	2255	2255	2255	823
Track density (TPI)	2000	2000	2000	2000	960
Maximum linear density (BPI) (FCI)	46666 35000	46666 35000	46666 35000	46666 35000	9300
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	5400	5400	5400	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.5	11.5	11.5	11.5	25
Average rotational delay (msec)	5.56	5.56	5.56	5.56	8.3
Average access time (msec)	14.56	14.56	14.56	14.56	33.3
Data transfer rate (KBytes/sec)	10000 synch.	10000 synch.	20000 synch.	20000 synch.	625
FIRST CUSTOMER SHIPMENT	3Q92	3Q92	4Q92	4Q92	12/86
COMMENTS	Packaged as 2 drives in either tower or rack mount	Expansion kit for C3020/21/23/24/30/31 T/R	Packaged as 2 drives in either tower or rack mount	Expansion kit for C3020/21/23/24/30/31 T/R	41.3 mm high

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK522-10	DK522C-10	DK512-17	DK512C-17	DK512S-17
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 103.4	F: 87.5	U: 172.3	F: 146.7	U: 172.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,944	F: 17,920	U: 20,944	F: 17,920	U: 20,944
Data surfaces per spindle	6	6	10	10	10
Heads per data surface	1	1	1	1	1
Tracks per surface	823	819	823	819	823
Track density (TPI)	960	960	925	925	925
Maximum linear density (BPI) (FCI)	18500 12333	18500 12333	18500 12333	18500 12333	18500 12333
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3482	3482	3482
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	25	23	23	23
Average rotational delay (msec)	8.3	8.3	8.6	8.6	8.6
Average access time (msec)	33.3	33.3	31.6	31.6	31.6
Data transfer rate (KBytes/sec)	1250	1500 max.	1209	1500 max.	1215
FIRST CUSTOMER SHIPMENT	12/86	1/87	3/85	1/87	3/85
COMMENTS	41.3 mm high	41.3 mm high			

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK524-20	DK524C-20	DK312C-20	DK312C-25	DK324C-21A
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	MIG
Interface	ESDI	SCSI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 200.5	F: 168.9	F: 209	F: 251	F: 215.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U:	F:	F: 19,456	F: 19,456	F: 26,624
Data surfaces per spindle			10	12	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1105	1105	1076	1076	1346
Track density (TPI)	1100	1100	1660	1660	2117
Maximum linear density (BPI) (FCI)	29800 19866	29800 19866	38800 25866	38800 25866	43000 32250
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	25	25	16.8*	16.8*	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	25.1	25.1	25.3
Data transfer rate (KBytes/sec)	1814	4000	4000 synch. 1500 asynch.	4000 synch. 1500 asynch.	4000 synch. 1500 asynch.
FIRST CUSTOMER SHIPMENT	3Q88	4Q88	3Q89	3Q89	8/91
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high *Assumes 4 reads per each write Read: 16 msec. Write: 20 msec.	41.3 mm high *Assumes 4 reads per each write Read: 16 msec. Write: 20 msec.	25.4 mm high

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK314C-41	DK514-38	DK514C-38	DK514S-38	DK815-5
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	224 mm OD 100 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 418.9	U: 382.3	F: 321.8	U: 382.3	U: 525.38
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,600	U: 30,240	F: 25,600	U: 30,240	U: 30,240
Data surfaces per spindle	14	14	14	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1169	903	898	903	1241
Track density (TPI)	1803	1033	1033	1033	860
Maximum linear density (BPI) (FCI)	44222 29466	26000 17333	26000 17333	26000 17333	14585 9723
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16.8	16	16	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	25.1	24.3	24.3	24.3	26.3
Data transfer rate (KBytes/sec)	4000 synch. 1500 asynch.	1815	4000 synch. 1500 asynch.	1815	1815
FIRST CUSTOMER SHIPMENT	2Q91	3Q87	1Q88	3Q87	11/84
COMMENTS	41.3 mm high				

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK515-78	DK515C-78 DK515C-78D	DK515S-78D DK515S-78S	DK711S-60D DK711S-60S	DK815-10
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	224 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	MIG	MIG	Ferrite	Thin Film
Interface	ESDI	SCSI	Modified SMD	Modified SMD	Mod SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 780	F: 660.9	U: 780	U: 600	U: 1,067
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	F: 34,816	U: 40,960	U: 30,240	U: 40,960
Data surfaces per spindle	14	14	14	22	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1361	1356	1391	903	1737
Track density (TPI)	1296	1296	1296	1033	1160
Maximum linear density (BPI) (FCI)	40210 26806	40210 26806	40210 26806	26000 17333	20000 15000
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4876	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	16	12	15
Average rotational delay (msec)	8.3	8.3	8.3	6.15	8.3
Average access time (msec)	24.3	24.3	24.3	18.15	23.3
Data transfer rate (KBytes/sec)	2458	4000 synch. 1500 asynch.	2458	2458	2460
FIRST CUSTOMER SHIPMENT	4Q88	4Q88	2Q89	4Q87	1Q87
COMMENTS				Oversized packaging	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK815-10A	DKU-851-D14 DKU-851-D24	DKU-861-J14 DKU-861-J24 H-6586-J14 H-6586-J24	DKU-871-114 DKU-871-124 H-6587-114 H-6587-124	DKU-971
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	Captive	Captive,OEM,PCM	Captive,OEM,PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	224 mm OD 100 mm ID	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	Modified SMD	IBM	IBM, Hitachi	IBM, Hitachi	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,067	F: 630	F: 630	F: 946	F: 635
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	F: 47,476	F: 47,476	F: 56,664	F: 19,069
Data surfaces per spindle	15	15	15	15	20
Heads per data surface	1	2	1	2	2
Tracks per surface	1737		885	1113	1666
Track density (TPI)	1220				720
Maximum linear density (BPI) (FCI)	19560 14670				6425
Recording code	1,7 RLL			1,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	4260	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Dual, Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13	15	11	8.5	20/18
Average rotational delay (msec)	8.3	8.3	8.3	7.1	8.3
Average access time (msec)	21.3	23.3	19.3	15.6	28.3/26.3
Data transfer rate (KBytes/sec)	2460	3000	3000	4200	1198
FIRST CUSTOMER SHIPMENT	4Q87	4/86	3Q88	9/90	1/81
COMMENTS		Drive has 4 spindles	Drive has 8 spindles	-114: max. 8 HDAs -124: max. 12 HDAs Also compatible mode to H-6586J	Drive has 2 spindles

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DKU-97S	H-6555	H-8576-12 H-8576-22	DK315C-11	DK315C-14
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	224 mm OD 100 mm ID	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	High Dens Oxide	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SMD	Hitachi	Hitachi	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 697.059	F: 500	F: 635	F: 1,100	F: 1,400
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,672	F: 28,884	F: 19,069	F: 30,200	*
Data surfaces per spindle	20	14	20	15	15
Heads per data surface	2	1	2	1	1
Tracks per surface	1682	1237	1666	2488	2488
Track density (TPI)	720	860	720	2800	2800
Maximum linear density (BPI) (FCI)	6425	14585 9723	6425	54000 40500	54000 40500
Recording code	MFM	2,7 RLL	MFM	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4500	4500
PERFORMANCE					
Actuator type	Dual, Rotary, Voice Coil	Rotary, Voice Coil	Dual, Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	20	18	20	10.4	10.4
Average rotational delay (msec)	8.3	8.3	8.3	6.7	6.7
Average access time (msec)	28.3	26.3	28.3	17.1	17.1
Data transfer rate (KBytes/sec)	1240	1815	1198	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.
FIRST CUSTOMER SHIPMENT	9/83	1Q85	4Q80	2Q92	3Q92
COMMENTS		Drive has 1 to 4 spindles	Drive has 2 spindles	41.3 mm high	41.3 mm high *Varies by zone

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK516-12	DK516-15	DK516C-16	DK816-20	DK816-20P
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	224 mm OD 100 mm ID	224 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	ESDI	SCSI	IPI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,229	U: 1,538	F: 1,342	U: 2,000	U: 1,869
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 45,880	U: 45,880	F: 41,472	U: 74,600	U: 74,600
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1787	2235	2172	1790	1790
Track density (TPI)	1512	2000	1954	1256	1256
Maximum linear density (BPI) (FCI)	46375 34780	44060 33045	48525 36393	35470 26602	35470 26602
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	14	13.5	13.5	13.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	22.3	21.8	21.8	21.8
Data transfer rate (KBytes/sec)	2750	2753	5000 synch. 2000 asynch.	4500	9000*
FIRST CUSTOMER SHIPMENT	3Q90	1Q91	3Q90	3Q89	3Q90
COMMENTS					*Parallel data transfer, 2 channels

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DKU-851-E14 DKU-851-E24 H-6585-14 H-6585-24	DKU-861-G14 DKU-861-G24 H-6586-G14 H-6586-G24	DKU-861-K14 DKU-861-K24 H-6586-K14 H-6586-K24	DKU-871-214 DKU-871-224	DKU-981 H-8598-12 H-8598-22
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	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	Thin Film	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: 1,890	F: 1,892	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 56,664	F: 47,476
Data surfaces per spindle	15	15	15	15	20
Heads per data surface	2	1	2	2	2
Tracks per surface		1770 (Physical)	2655	2226	1328 (Physical)
Track density (TPI)					600
Maximum linear density (BPI) (FCI)					15240 10160
Recording code				1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	4260	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Dual, Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	17	13	12.5	10.5	16
Average rotational delay (msec)	8.3	8.3	8.3	7.1	8.3
Average access time (msec)	25.3	21.3	20.8	17.6	24.3
Data transfer rate (KBytes/sec)	3000	3000	3000	4200	3000
FIRST CUSTOMER SHIPMENT	12/85	3Q88	3Q88	9/90	4Q82
COMMENTS	Drive has 4 spindles	Drive has 8 spindles	Drive has 8 spindles	-214: max. 8 HDAs -224: max. 12 HDAs	Drive has 2 spindles 2 actuators per spindle

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI DATA SYSTEMS
DRIVE	H-6556-1	DK517C-26	DK517C-37	H-6587-314 H-6587-324	7390-1
DISK/TREND GROUP	8	9	9	9	7
MARKET	Captive	OEM	OEM	Captive	PCM
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	9.5"	9.5"
Recording medium	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Hitachi	SCSI-2	SCSI-2	Hitachi	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	U: 2,600 F: 2,050	U: 3,700 F: 2,870	F: 2,920	F: 946
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 41,984	F: 41,984	F: 56,664	F: 56,664
Data surfaces per spindle	15	15	21	15	15
Heads per data surface	1	1	1	2	2
Tracks per surface	1770 (Physical)	3307	3307	3436	1113
Track density (TPI)		2800	2800		1900
Maximum linear density (BPI) (FCI)		54000 40500	54000 40500		29000 21750
Recording code		1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	4260	4260
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	12	12	12	8.5
Average rotational delay (msec)	8.3	5.6	5.6	7.1	7.1
Average access time (msec)	23.3	17.6	17.6	19.1	15.6
Data transfer rate (KBytes/sec)	3000	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.	4200	4200
FIRST CUSTOMER SHIPMENT	3/88	2Q92	2Q92	9/90	10/90
COMMENTS	Drive has 4 spindles			-314: max. 8 HDAs -324: max. 12 HDAs Also compatible mode to H-6586K	PCM 3390-1 Drive has 4, 8, or 12 spindles

MANUFACTURER	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS	IBM	IBM
DRIVE	7390-2	7390-F	7390-3	4956-G10(40 MB) 4956-H10(40 MB)	8530-E31
DISK/TREND GROUP	8	8	9	2	2
MARKET	PCM	PCM	PCM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	9.5"	9.5"	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	Thin Film	Thin Film	Thin Film	Ferrite	MIG
Interface	IBM	IBM	IBM	ST412	PS/2-30,Microch
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,892	F: 1,890/1,892	F: 2,838	F: 40	F: 30
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 47,476/ 56,664	F: 56,664	F: 8,704	F: 16,384
Data surfaces per spindle	15	15	15	7	2
Heads per data surface	2	2	2	1	1
Tracks per surface	2226	2655/2226	3339	733	922
Track density (TPI)	1900	1900	1900	815	1302
Maximum linear density (BPI) (FCI)	29000 21750	29000 21750	29000 21750	9398	26700 17800
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	MFM	2,7 RLL
Rotational speed (RPM)	4260	4260	4260	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	10	11/10	12.5	40	27
Average rotational delay (msec)	7.1	7.1	7.1	8.3	8.3
Average access time (msec)	17.1	18.1/17.1	19.6	48.3	35.3
Data transfer rate (KBytes/sec)	4200	4200	4200	625	1275
FIRST CUSTOMER SHIPMENT	10/90	1/91	2/92	9/86	9/89
COMMENTS	PCM 3390-2 Drive has 4, 8, or 12 spindles	PCM 3380-K/ 3390-2 Drive has 4, 8, or 12 spindles Field reformatable	PCM 3390-3 Drive has 4, 8, or 12 spindles	Series/1	25.4 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8530-021	8535-043 8540-043	8551-033	8556-043	8573-031
DISK/TREND GROUP	2	2	2	2	2
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	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	MIG	MIG	MIG
Interface	PS/2-30	PC AT	Microchannel	Microchannel	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20	F: 40	F: 40	F: 40	F: 30
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,920	F: 19,968	F: 19,456	F: 19,968	F: 16,384
Data surfaces per spindle	2	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	774	1038	1120	1038	920
Track density (TPI)	1170	1517	2199	1517	1302
Maximum linear density (BPI) (FCI)	21700 14466	31700 21133	42885 32164	31700 21133	26700 17800
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	27	16	19	16	19
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	24.3	27.3	24.3	27.3
Data transfer rate (KBytes/sec)	1050	1500	5300	1500	1250
FIRST CUSTOMER SHIPMENT	10/88	6/91	5/92	6/91	3/90
COMMENTS	25.4 mm high PS/2	25.4 mm high PS/2	12.7 mm high PS/2 Notebook	25.4 mm high PS/2	25.4 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WD-240	WD-325	WD-L40	WDA-240	WDA-L40
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Captive	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	MIG	MIG	MIG
Interface	Microchannel	ST412	Microchannel	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.9	U: 25.5	U: 51.8 F: 40	F: 43.1	F: 40
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,456	U: 10,416	F: 19,968	F: 19,456	F: 19,968
Data surfaces per spindle	2	4	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1123	612	1038	1123	1038
Track density (TPI)	2199	850	1517	2199	1517
Maximum linear density (BPI) (FCI)	42885 32164	13400	31700 21133	42885 32164	31700 21133
Recording code	1,7 RLL	MFM	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Open Loop	Embedded	Embedded	Embedded
Average positioning time (msec)	19	80 (including settling)	16	19	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	27.3	88.3	24.3	27.3	24.3
Data transfer rate (KBytes/sec)	5000 synch.	625	1500	5700 max.	1500
FIRST CUSTOMER SHIPMENT	3Q91	7/86	4/90	4Q91	6/90
COMMENTS	12.7 mm high	41.3 mm high	25.4 mm high	12.7 mm high	25.4 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDA-L42	WDL-320	WDP-L40	WDS-240	WDS-L40
DISK/TREND GROUP	2	2	2	2	2
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	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	MIG	MIG	MIG
Interface	PC AT	PS/2-30	PC XT	SCSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.5	U: 26.9 F: 20	F: 40	F: 42.9	U: 51.8 F: 40.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F: 12,920	F: 19,968	F: 19,456	F: 19,968
Data surfaces per spindle	2	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1038	774	1038	1123	1038
Track density (TPI)	1618	1170	1517	2199	1517
Maximum linear density (BPI) (FCI)	31700 21133	21700 14466	31700 21133	42885 32164	31700 21133
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	17	27	16	19	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	25.3	35.3	24.3	27.3	24.3
Data transfer rate (KBytes/sec)	4000	1050	1500	5000 synch.	1500
FIRST CUSTOMER SHIPMENT	4Q91	2/89	6/90	3Q91	6/90
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	12.7 mm high	25.4 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDS-L42	4956-G10(72 MB) 4956-H10(72 MB) 4956-J00(72 MB)	4965-E00	5363-P10	5364-003 5364-004 5364-023 5364-024
DISK/TREND GROUP	2	3	3	3	3
MARKET	OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	ESDI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 41.9	F: 72	F: 72	F: 67.56	F: 65.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F: 17,664	F: 17,664	F: 16,640	F: 16,640
Data surfaces per spindle	2	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1038	582	582	580	580
Track density (TPI)	1618	648	648	648	648
Maximum linear density (BPI) (FCI)	31700 21133	18942 12628	18942 12628	18942 12628	18942 12628
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	19.5	30	30	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	27.8	38.3	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	4000 synch.	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	4Q91	2/88	2/88	10/87	2/87
COMMENTS	25.4 mm high	Series/1	Storage expansion unit for Series/1	System unit for System/36 PC	System unit for System/36 PC

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5551-T0A 8573-061	5571-T0A	8540-045	8551-025 8554-045	8555-081 8570-A81,081
DISK/TREND GROUP	3	3	3	3	3
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	MIG
Interface	SCSI, MC	ESDI	PC AT	Microchannel	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 60.8	F: 70	F: 80	F: 80	F: 80
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 18,432	F: 18,815	F: 19,456	F: 18,815
Data surfaces per spindle	6	7	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	762	583	1063	1120	1063
Track density (TPI)	1169	648	1517	2199	1517
Maximum linear density (BPI) (FCI)	21700 14466	18942 12628	31700 21133	42885 32164	31700 21133
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	27	30	16	17	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	38.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1050	1250	1500	5300	1500
FIRST CUSTOMER SHIPMENT	5/88	2Q87	6/91	3/92	6/91
COMMENTS	41.3 mm high PS/2	PS/2	41.3 mm high PS/2	17 mm high PS/2 Notebook and Laptop	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8556-045 8556-055 8557-045,055 8557-255 8580-081 8590-0J5	WD-380	WD-387G	WDA-260	WDA-280
DISK/TREND GROUP	3	3	3	3	3
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI	SCSI, Microch.	Microchannel	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80	F: 80	F: 60	U: 81.0 F: 62.9	F: 86.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,815	F: 18,815	F: 16,384	F: 15,360	F: 19,456
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1063	1063	920	1044	1123
Track density (TPI)	1517	1517	1302	2032	2199
Maximum linear density (BPI) (FCI)	31700 21133	31700 21133	26700 17800	34100 22733	42885 32164
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	23	19	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	31.3	27.3	24.3
Data transfer rate (KBytes/sec)	1500	1500	1250	1100	5700 max.
FIRST CUSTOMER SHIPMENT	10/90	3/90	3/90	4Q90	4Q91
COMMENTS	41.3 mm high PS/2	41.3 mm high	41.3 mm high	22.6 mm high	17 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDA-380	WDA-L80	WDA-S260	WDS-280	WDS-380
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	PC AT	PC AT	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80	F: 85.6	F: 63	F: 85.9	F: 80
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,815	F: 22,272	F: 25,600	F: 19,456	F: 18,815
Data surfaces per spindle	4	2	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1063	1923	1243	1123	1063
Track density (TPI)	1517	2200	2436	2199	1517
Maximum linear density (BPI) (FCI)	31700 17333	39400 29550	59800 44850	42885 32164	31700 17333
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	16.5	17	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.8	24.3	24.3
Data transfer rate (KBytes/sec)	1500	5700	5700	5000 synch.	1500
FIRST CUSTOMER SHIPMENT	6/90	2Q92	2Q92	3Q91	12/89
COMMENTS	41.3 mm high	19.9 mm high	12.7 mm high	17 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDS-L80	5363-P20 5363-P22	5363-S10	5551-T0B 8570-121 8573-121	5571-T0B
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	Captive	Captive	Captive	Captive
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	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	Ferrite	Ferrite	MIG	Ferrite
Interface	SCSI	ESDI	ESDI	Microchannel	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85.6	F: 106.2	F: 106.46	F: 120.5	F: 115
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 22,272	F: 16,640	F: 16,640	F: 16,384	F: 18,432
Data surfaces per spindle	2	7	7	8	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1923	914	914	920	915
Track density (TPI)	2200	1000	1000	1302	1000
Maximum linear density (BPI) (FCI)	39400 29550	19159 12772	19159 12772	26700 17800	19159 12772
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	16	28	28	23	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	36.3	36.3	31.3	36.3
Data transfer rate (KBytes/sec)	5700	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2Q92	10/87	9/90	5/88	4Q87
COMMENTS	19.9 mm high	System unit for System/36 PC	AS/Entry	41.3 mm high PS/2	PS/2

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	6156-001 6156-003	7011-220(#2121) 7011-22W(#2121) 7012-340(#2121) 7012-350(#2121)	7012-320(#2120)	8556-059 8557-049/59,259 8573-161 8580-A16,161 8590-0J9,0L9 8595-0J9	8570-A16,A61, 161
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	MIG	MIG	MIG
Interface	ESDI	SCSI	Microchannel	SCSI	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 114	F: 160	F: 120	F: 160	F: 160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 18,815	F: 16,384	F: 18,815	F: 18,815
Data surfaces per spindle	7	8	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	915	1021	920	1021	1021
Track density (TPI)	1000	1517	1302	1517	1517
Maximum linear density (BPI) (FCI)	19159 12772	31700 21133	26700 17800	31700 21133	31700 21133
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	28	16	23	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	24.3	31.3	24.3	24.3
Data transfer rate (KBytes/sec)	1250	1500	1270	1500	1500
FIRST CUSTOMER SHIPMENT	6/88	4/92	2Q90	10/90	6/91
COMMENTS	Removable disk drive for RT PC 003 holds up to 3 disk modules 310 MB drive is optional	41.3 mm high RS/6000	41.3 mm high System/6000	41.3 mm high PS/2	41.3 mm high PS/2

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9556-0B6 9557-0B6 9576-0U6 9585-0X6	WD-2120	WDS-3158	WD-3158G	WD-3160
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG		MIG	Ferrite	MIG
Interface	SCSI-2	MCA	SCSI	Microchannel	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 104	F: 126	U: 157.3 F: 120.5	U: 157.3 F: 120.5	U: 206.4 F: 160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 25,600	F: 16,384	F: 16,384	F: 18,815
Data surfaces per spindle	2	4	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	2009	1243	925	925	1021
Track density (TPI)	2222	2436	1302	1302	1517
Maximum linear density (BPI) (FCI)	40414 26942	59800 44850	26700 17800	26700 17800	31700 21133
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4320	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	16.5	23	23	16
Average rotational delay (msec)	6.94	8.3	8.3	8.3	8.3
Average access time (msec)	18.94	24.8	31.3	31.3	24.3
Data transfer rate (KBytes/sec)	5000 synch.	6000	1250	1250	1500
FIRST CUSTOMER SHIPMENT	4Q92	2Q92	8/89	5/88	3/90
COMMENTS	19.92 mm high PS/2 *Varies by zone	17 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WD-L100	WDA-2120	WDA-3160	WDA-L160	WDS-3160
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	MIG	MIG	MIG
Interface	SCSI-2	PC AT	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 104.8	F: 126	U: 206.4 F: 160	F: 171.4	F: 160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 25,600	F: 18,815	F: 22,272	F: 18,815
Data surfaces per spindle	2	4	8	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	2009	1243	1021	1923	1063
Track density (TPI)	2222	2436	1517	2200	1517
Maximum linear density (BPI) (FCI)	40414 26942	59800 44850	31700 21133	39400 29550	31700 21133
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	4320	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	16.5	16	16	16
Average rotational delay (msec)	6.94	8.3	8.3	8.3	8.3
Average access time (msec)	18.94	24.8	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	5000 synch.	5700	1500	5700	1500
FIRST CUSTOMER SHIPMENT	12/91	2Q92	6/90	2Q92	12/89
COMMENTS	19.92 mm high *Varies by zone	17 mm high	41.3 mm high	19.9 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDS-L160	0671-284	9371-10 9371-12 9371-14	9556-0BA 9557-0BA 9576-0U6 9577-0UA 9585-0XA	WD-L200
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	MIG	MIG	MIG
Interface	SCSI	ESDI, SCSI	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 171.4	U: 284	F: 295	F: 212	F: 209.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 22,272	U: 21,080	F: 24,576	*	*
Data surfaces per spindle	4	11	14	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1923	1225	949	2009	2009
Track density (TPI)	2200	1168	1201.5	2222	2222
Maximum linear density (BPI) (FCI)	39400 29550	21384 14256	37341 28006	40414 26942	40414 26942
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3283	4317.8	4320	4320
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	16	21.5	12.5	12	12
Average rotational delay (msec)	8.3	9.14	6.95	6.94	6.94
Average access time (msec)	24.3	30.64	19.45	18.94	18.94
Data transfer rate (KBytes/sec)	5000 synch.	1250	4000 max.	5000 synch.	5000 synch.
FIRST CUSTOMER SHIPMENT	2Q92	1Q88	3/90	4Q92	12/91
COMMENTS	19.9 mm high		41.3 mm high 9370	19.92 mm high PS/2 *Varies by zone	19.92 mm high *Varies by zone

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0661-371	0661-467	0671-387	0681-500	5363-S20 5363-S22
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive, OEM	Captive, OEM	OEM	OEM	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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Ferrite	MIG	Ferrite
Interface	SCSI-2	SCSI-2	ESDI, SCSI	SCSI-2	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 371 F: 320.1	U: 467 F: 400	U: 387	U: 579 F: 471	F: 314.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 24,576	U: 21,080	F: 29,696	F: 17,408
Data surfaces per spindle	14	14	15	11	15
Heads per data surface	1	1	1	1	1
Tracks per surface	949	1199	1225	1458	1225
Track density (TPI)	1201.5	1469	1168	1677	1168
Maximum linear density (BPI) (FCI)	37341 28006	38427 28820	21384 14256	30320 26951	21384 14256
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	PRML	2,7 RLL
Rotational speed (RPM)	4317.8	4316	3283	4986	3283
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12.5	11.5	21.5	11.2	22
Average rotational delay (msec)	6.95	6.95	9.14	6.02	9.14
Average access time (msec)	19.45	18.45	30.64	17.22	31.14
Data transfer rate (KBytes/sec)	4000 max.	5000 max.	1250	4000 max.	1250
FIRST CUSTOMER SHIPMENT	8/89	8/90	1Q88	3/90	9/90
COMMENTS	41.3 mm high	41.3 mm high			AS/Entry

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	6150-4300 Opt. 6150-5300 Opt. 6151-4300 Opt. 6151-5300 Opt.	7011-220(#2560) 7011-22W(#2560) 7011-22G	7012-320(#2540) 7013-520(#2542) 7013-530(#2542) 7013-540(#2542) 7204-320	7013-52H(#9244) 7013-53H	7013-530(#2500) 7016-730(#2500) 7203-001(#2300)
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive, OEM	Captive	Captive, OEM	Captive
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	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	MIG	MIG	Thin Film
Interface	ESDI	SCSI-2	SCSI	SCSI-2	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 310	F: 400	F: 320	F: 400	F: 355
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 24,576	F: 24,576	F: 24,576	F: 27,648
Data surfaces per spindle	15	14	14	14	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1199	949	1199	1632
Track density (TPI)	1168	1469	1201.5	1469	1376
Maximum linear density (BPI) (FCI)	21384 14256	38427 28820	37341 28006	38427 28820	31596 21064
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3283	4316	4318	4316	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	21.5	11.5	12.5	11.5	16
Average rotational delay (msec)	9.14	6.95	7	6.95	8.3
Average access time (msec)	30.64	18.45	19.5	18.45	24.3
Data transfer rate (KBytes/sec)	1250	5000 max.	4000 max.	5000 max.	1875
FIRST CUSTOMER SHIPMENT	7/88	4/92	2Q90	2/92	2Q90
COMMENTS	RT PC	41.3 mm high RS/6000	41.3 mm high RS/6000	41.3 mm high RS/6000	RS/6000 Mfg. by Maxtor

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	7013-560(#9245)	8557-05F 9557-0UF,0NF 9585-0XF 9595-0LF,0MF	8565-321 8580-A31,321 8590-0KD 8595-0JD,0KD	8573-401	8590-0LF 8595-0LF 8595-0MF
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive, OEM	Captive	Captive	Captive, OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 400	F: 400	F: 320	F: 400	F: 400
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 24,576	F: 24,576	F: 24,576	F: 24,576
Data surfaces per spindle	14	14	14	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1199	1199	949	1199	1199
Track density (TPI)	1469	1469	1201.5	1469	1469
Maximum linear density (BPI) (FCI)	38427 28820	38427 28820	37341 28006	38427 28820	38427 28820
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4316	4316	4318	4316	4316
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.5	11.5	12.5	11.5	11.5
Average rotational delay (msec)	6.95	6.95	6.95	6.95	6.95
Average access time (msec)	18.45	18.45	19.45	18.45	18.45
Data transfer rate (KBytes/sec)	5000 max.	5000 synch.	4000 max.	2000	2000
FIRST CUSTOMER SHIPMENT	3/92	4Q92	10/90	11/90	4/92
COMMENTS	41.3 mm high RS/6000 Has 2 drives	41.3 mm high PS/2	41.3 mm high PS/2	41.3 mm high PS/2	41.3 mm high PS/2

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8600-001(#2435) 8600-002(#2435)	9336-10	9371-PS/2	9402-C04 9402-C06	9402-D02,D04, D06 9404-D10,D20, D25
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive	Captive	Captive	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 400	F: 471	F: 320	F: 320	F: 400
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 29,696	F: 24,576	F: 24,576	F: 24,576
Data surfaces per spindle	14	11	14	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1199	1458	949	949	1199
Track density (TPI)	1469	1677	1201.5	1201.5	1469
Maximum linear density (BPI) (FCI)	38427 28820	30320 26951	37341 28006	37341 28006	38427 28820
Recording code	1,7 RLL	PRML	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4316	4986	4317.8	4317.8	4316
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.5	11.2	12.5	12.5	11.5
Average rotational delay (msec)	6.95	6.02	6.95	6.95	6.95
Average access time (msec)	18.45	17.22	19.45	19.45	18.45
Data transfer rate (KBytes/sec)	2000	4000	4000 max.	4000	5000 max.
FIRST CUSTOMER SHIPMENT	10/92	9/90	3/90	9/90	5/91
COMMENTS	41.3 mm high PS/2 server 295	AS/400 9406 Disk unit, contains 2-4 disk drives	41.3 mm high 9370	41.3 mm high AS/400	41.3 mm high AS/400

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9404-C10 9404-C20 9404-C25	9406-E35,E45, E50,E60, E70,E80, E90	0663-H11	0663-L11	0681-1000
DISK/TREND GROUP	6	6	7	7	7
MARKET	Captive	Captive	OEM, PCM	OEM, 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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	MR Thin Film	MR Thin Film	MIG
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 320	F: 320	U: 1,111 F: 868	U: 1,111 F: 868	U: 1,054 F: 857
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 24,576	F: 33,792	F: 33,792	F: 29,696
Data surfaces per spindle	14	14	13	13	20
Heads per data surface	1	1	1	1	1
Tracks per surface	949	949	2051	2051	1458
Track density (TPI)	1201.5	1201.5	2238	2238	1677
Maximum linear density (BPI) (FCI)	37341 28006	37341 28006	58874 52332	58874 52332	30320 26951
Recording code	1,7 RLL	1,7 RLL	PRML	PRML	PRML
Rotational speed (RPM)	4317.8	4317.8	4316	4316	4986
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12.5	12.5	9.8	11	11.2
Average rotational delay (msec)	6.95	6.95	6.95	6.95	6.02
Average access time (msec)	19.45	19.45	16.75	17.95	17.22
Data transfer rate (KBytes/sec)	4000 max.	4000	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.	4000 max.
FIRST CUSTOMER SHIPMENT	2/90	3/92	4Q91	4Q91	3/90
COMMENTS	41.3 mm high AS/400	41.3 mm high AS/400 4 internal drives in each model	41.3 mm high	41.3 mm high 0663 low power version	

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0685-B01	7013-520(#2530) 7013-530(#2530) 7013-540(#2530) 7015-930(#2530) 7016-730(#2530)	7013-520(#2510) 7013-530(#2510) 7016-730(#2310) 7203-001(#2310)	9332-600 9332-602	9333-3100
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	MIG	Thin Film	Thin Film	MIG
Interface	IBM	SCSI-2	SCSI	IPI-3	IBM Serial
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,043.1 F: 855.9	F: 857	F: 670	F: 600	F: 857
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 44,280 F: 36,352	F: 29,696	F: 27,648	F: 37,376	F: 29,696
Data surfaces per spindle	6	20	15	8	20
Heads per data surface	2	1	1	1	1
Tracks per surface	3926	1458	1632	2017	1458
Track density (TPI)	1600	1677	1376	1500	1677
Maximum linear density (BPI) (FCI)	16200 10800	30320 26951	31596 21064	23570 17677	30320 26951
Recording code	2,7 RLL	PRML	2,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	3623	4986	3600	3119	4986
PERFORMANCE					
Actuator type	Dual, Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	18	11.2	18	19.5	11.2
Average rotational delay (msec)	8.28	6.02	8.3	9.62	6.02
Average access time (msec)	26.28	17.22	26.3	29.12	17.22
Data transfer rate (KBytes/sec)	3000	4000 max.	1875	2500	4000
FIRST CUSTOMER SHIPMENT	6/86	2Q90	2Q90	9/88	7/91
COMMENTS		RS/6000	RS/6000 Mfg. by Maxtor	568 MB capacity when used with 9370 series	RS/6000 Feature on models 010 and 500

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9336-20	9337-010	9337-020	9337-110	9337-120
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 857	F: 542	F: 970	F: 542	F: 970
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,696	*	*	*	*
Data surfaces per spindle	20	13	13	13	13
Heads per data surface	1	1	1	1	1
Tracks per surface	1458	2469	2469	2469	2469
Track density (TPI)	1677	2685	2685	2685	2685
Maximum linear density (BPI) (FCI)	30320 26951	58874 52332	58874 52332	58874 52332	58874 52332
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	4986	4316	4316	4316	4316
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.2	9.8	9.8	9.8	9.8
Average rotational delay (msec)	6.02	6.95	6.95	6.95	6.95
Average access time (msec)	17.22	16.75	16.75	16.75	16.75
Data transfer rate (KBytes/sec)	4000	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	9/90	9/92	9/92	11/92	11/92
COMMENTS	AS/400 Disk unit, contains 2-4 disk drives	41.3 mm high AS/400 *Varies by zone Array subsystem with 2-7 drives	41.3 mm high AS/400 *Varies by zone Array subsystem with 2-7 drives	41.3 mm high AS/400 *Varies by zone Array subsystem with 4-7 drives	41.3 mm high AS/400 *Varies by zone Array subsystem with 2-7 drives

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9402-E02,E04, E06 9404-E10,E20, E25	0615	0663-E12	0663-E15	0663-H12
DISK/TREND GROUP	7	8	8	8	8
MARKET	Captive	OEM	OEM	OEM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	IPI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 988	U: 1,639	F: 1,044	F: 1,206	U: 1,283 F: 1,004
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	U: 50,668	*	*	F: 33,792
Data surfaces per spindle	13	15	13	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2469	2157	2469	2469	2051
Track density (TPI)	2685	2403	2685	2685	2238
Maximum linear density (BPI) (FCI)	58874 52332	44663 33497	58874 52332	58874 52332	58874 52332
Recording code	PRML	1,7 RLL	PRML	PRML	PRML
Rotational speed (RPM)	4316	5380	4317	4317	4316
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	12	9.4 RD/11.4 WR	9.4 RD/11.4 WR	9.8
Average rotational delay (msec)	6.95	5.58	6.95	6.95	6.95
Average access time (msec)	17.95	17.58	16.35/18.35	16.35/18.35	16.75
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.	4550	10000	10000	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	3/92	5/91	3Q92	3Q92	4Q91
COMMENTS	41.3 mm high AS/400	2 HDAs per drawer	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0663-L12	3380-AJ4 3380-BJ4 3380-CJ2	3390-A14 3390-A18 3390-B14 3390-B18 3390-B1C	3510-0V0 3511-003	7011-220(#2550) 22G, 22W 7012-340(#2550) 350 7013-52H(#2550) 53H
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM, PCM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	14"	10.8"	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	IBM	IBM	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,283 F: 1,004	F: 1,260.4	F: 1,892	F: 1,004	F: 1,004
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 33,792	F: 47,476	F: 56,664	F: 33,792	F: 33,792
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	2	2	1	1
Tracks per surface	2051	1770	2226	2051	2051
Track density (TPI)	2238	2089	2242	2238	2238
Maximum linear density (BPI) (FCI)	58874 52332	15190 10126	27940 20955	58874 52332	58874 52332
Recording code	PRML	2,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4316	3620	4260	4316	4316
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	12	9.5	11	11
Average rotational delay (msec)	6.95	8.3	7.1	6.95	6.95
Average access time (msec)	17.95	24.3	16.6	17.95	17.95
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.	3000	4200	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	4Q91	10/87 (A,B)	12/89	6/92	4/92
COMMENTS	41.3 mm high 0663 low power version	AJ4 & BJ4 have 2 spindles	A14=2 HDAs A18=4 HDAs B14=2 HDAs B18=4 HDAs B1C=6 HDAs	41.3 mm high PS/2 SCSI enclosure	41.3 mm high RS/6000

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	7013-52H(#2570) 53H, 53E, 55E, 55S, 56F, 550, 560	7013-53E(#2550) 7013-55E(#2550) 7013-55S(#2550) 7013-56F(#2550) 7013-550(#2550) 7013-560(#2550)	7015-950(#2570) 7015-95E(#2570) 7015-970(#2570) 7015-97E(#2570)	8595-0LF(#1052) 8595-0MF(#1052) 8595-0MT(#1052)	8600-001(#2433) 8600-002(#2433)
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	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	MR Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,370	F: 1,004	F: 1,370	F: 1,004	F: 1,004
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 33,792	*	F: 33,792	F: 33,792
Data surfaces per spindle	17	15	17	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2101	2051	2101	2051	2051
Track density (TPI)	1801	2238	1801	2238	2238
Maximum linear density (BPI) (FCI)	*	58874 52332	*	58874 52332	58874 52332
Recording code	2,7 RLL	PRML	2,7 RLL	PRML	PRML
Rotational speed (RPM)	5400	4316	5400	4316	4316
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.5	11	11.5	11	11
Average rotational delay (msec)	5.56	6.95	5.56	6.95	6.95
Average access time (msec)	17.06	17.95	17.06	17.95	17.95
Data transfer rate (KBytes/sec)	5000 synch.	5000 synch. 3000 asynch.	5000 synch.	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	4/92	4/92	4/92	6/92	10/92
COMMENTS	RS/6000 *Varies by zone Mfg. by Seagate	41.3 mm high RS/6000	RS/6000 *Varies by zone Mfg. by Seagate	41.3 mm high PS/2	41.3 mm high PS/2 server 295

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9333-3110	9334-2570	9345-B12	9345-B22	9595-0MT
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IBM Serial-Link	SCSI-2	IBM	IBM	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,007	F: 1,370	F: 1,001	F: 1,502	F: 1,004
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,696	*	F: 46,456	F: 46,456	F: 33,792
Data surfaces per spindle	20	17	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1695	2101	1438	2156	2051
Track density (TPI)	2098	1801	2403	2403	2238
Maximum linear density (BPI) (FCI)	30320 26951	*	44663 33497	44663 33497	58874 52332
Recording code	PRML	2,7 RLL	1,7 RLL	1,7 RLL	PRMC
Rotational speed (RPM)	4986	5400	5380	5380	4316
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.2	11.5	10	12	11
Average rotational delay (msec)	6.02	5.56	5.58	5.58	6.95
Average access time (msec)	17.22	17.06	15.58	17.58	17.95
Data transfer rate (KBytes/sec)	4000	5000 synch.	4400	4400	5000 synch. 3000 synch.
FIRST CUSTOMER SHIPMENT	5/92	5/92	1Q92	1Q92	4Q92
COMMENTS	Subsystem for RS/6000, with up to 4 drives	SCSI expansion unit for RS/6000 *Varies by zone Mfg. by Seagate	2 HDAs per drawer	2 HDAs per drawer	41.3 mm high PS/2

MANUFACTURER	IBM	IBM	IBM	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	3380-AK4 3380-BK4	3390-A24 3390-A28 3390-B24 3390-B28 3390-B2C	3390-A34 3390-A38 3390-B34 3390-B38 3390-B3C	1820 Mustang	1841P Ranger
DISK/TREND GROUP	9	9	9	2	2
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Removable Drive
Nominal disk diameter	14"	10.8"	10.8"	48 mm OD 12 mm ID	48 mm OD 12 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	IBM	IBM	IBM	PC AT	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,781.4	F: 3,784	F: 5,676	F: 21.4	--
REMOVABLE	--	--	--	--	F: 42.5
Capacity per track (Bytes)	F: 47,476	F: 56,664	F: 56,664	*	*
Data surfaces per spindle	15	15	15	2	2
Heads per data surface	2	2	2	1	1
Tracks per surface	5310	4452	6678	608	
Track density (TPI)	2089	2242	2984	1942	2409
Maximum linear density (BPI) (FCI)	15190 10126	27940 20955	30008 22506	46100 34600	58500 43875
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3620	4260	4260	3571	3571
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	16	12.5	15	18	18
Average rotational delay (msec)	8.3	7.1	7.1	8.4	8.4
Average access time (msec)	24.3	19.6	22.18	26.4	26.4
Data transfer rate (KBytes/sec)	3000	4200	4200	4000	6000
FIRST CUSTOMER SHIPMENT	10/87	12/89	9/91	3Q91	4Q92
COMMENTS	Drive has 2 spindles	A24=2 HDAs A28=4 HDAs B24=2 HDAs B28=4 HDAs B2C=6 HDAs	A34= 2 HDAs A38= 4 HDAs B34= 2 HDAs B38= 4 HDAs B36= 6 HDAs	15 mm high *Varies by zone Ramp loaded heads	10.5 mm high *Varies by zone Ramp loaded heads

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	JVC
DRIVE	1842 Stingray	1862 Maverick	1882P Cobra	1885 McKinley	JD-E3848V
DISK/TREND GROUP	2	3	3	3	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Removable Drive	Fixed	Fixed
Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	Ferrite
Interface	PC AT, IDE	PC AT	PCMCIA-ATA	PCMCIA-ATA	PC AT, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.5	F: 64.1	--	F: 85.0	F: 42.42
REMOVABLE	--	--	F: 85.0	--	--
Capacity per track (Bytes)	*	*	*	*	F: 24,576
Data surfaces per spindle	3	3	3	3	2
Heads per data surface	1	1	1	1	1
Tracks per surface	830				862
Track density (TPI)	2065	2407	2750	2750	1300
Maximum linear density (BPI) (FCI)	48100 36075	58500 43875	71100 53325	71100 53325	38145 25430
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3571	3571	3571	3571	2332
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	18	18	18	18	25
Average rotational delay (msec)	8.4	8.4	8.4	8.4	12.8
Average access time (msec)	26.4	26.4	26.4	26.4	37.8
Data transfer rate (KBytes/sec)	4000	4000	5000	5000	1250
FIRST CUSTOMER SHIPMENT	1Q92	2Q92	3Q92	3Q92	3Q89
COMMENTS	15 mm high *Varies by zone Ramp loaded heads	15 mm high *Varies by zone Ramp loaded heads	12.5 mm high *Varies by zone Ramp loaded heads	15 mm high *Varies by zone Ramp loaded heads	20.8 mm high

MANUFACTURER	JVC	JVC	JVC	JVC	JVC
DRIVE	JD-E2042M	JD-F2042M	JD-E2064M	JD-E2085M	JD-E3896V
DISK/TREND GROUP	2	2	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	Ferrite
Interface	PC AT	PC AT	PC AT	PC AT	PC AT/XT, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.84	F: 42.84	F: 64.28	F: 85.68	F: 84.84
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 22,016	F: 22,016	*	F: 22,016	F: 24,576
Data surfaces per spindle	2	2	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	973	973	1218	973	862
Track density (TPI)	2016	2016	2466	2016	1300
Maximum linear density (BPI) (FCI)	52400 39404	52400 39404	55338 41504	52400 39404	38145 25430
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3118	3118	3114	3118	2332
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	16	16	25
Average rotational delay (msec)	9.6	9.6	9.6	9.6	12.8
Average access time (msec)	25.6	25.6	25.6	25.6	37.8
Data transfer rate (KBytes/sec)	5000	5000	1000	5000	1250
FIRST CUSTOMER SHIPMENT	3/91	3/92	6/92	9/91	1990
COMMENTS	12.7 mm high	10 mm high	12.7 mm high *Varies by zone	19 mm high	25.4 mm high

MANUFACTURER	JVC	KALOK	KALOK	MAGTRON	MAGTRON
DRIVE	JD-E2130M	P5-125 Point5	P5-250 Point5	MT5760S	MT6120S
DISK/TREND GROUP	4	4	5	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI-2,PCAT,IDE	SCSI-2,PCAT,IDE	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 130.17	F: 125.8	F: 251.9	F: 673 U: 765	U: 1,204 F: 1,063
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	U: 36,864	*
Data surfaces per spindle	4	2	4	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1218	2048	2048	1598	1928
Track density (TPI)	2466	2000	2000	1600	1600
Maximum linear density (BPI) (FCI)	55912 41934	43100 32325	43100 32325	27208 20406	43000 32250
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3114	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	17	17	14	14
Average rotational delay (msec)	9.6	8.3	8.3	8.3	8.3
Average access time (msec)	25.6	25.3	25.3	22.3	22.3
Data transfer rate (KBytes/sec)	1000	10000 synch.	10000 synch.	4000 synch.	6000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	1992	3Q93	4Q92	5/91	5/92
COMMENTS	19 mm high *Varies by zone	12.7 mm high *Varies by zone	12.7 mm high *Varies by zone		*Varies by zone

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	2585A	7080A	7080S	25128A	7120A Cheyenne
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	MIG
Interface	PC AT	PC AT	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85.4	F: 81.4	F: 80.7	F: 128.2	F: 130.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 18,432	F: 18,432	*	F: 21,504
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1092	1170	1155	1092	1516
Track density (TPI)	1993	1490	1490	2550	1800
Maximum linear density (BPI) (FCI)	39000 29000	30625 22969	30625 22969	46000 34500	34087 25565
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3551	3703	3703	3551	3524
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	15	17	17	15	15
Average rotational delay (msec)	8.4	8.1	8.1	8.45	8.5
Average access time (msec)	23.4	25.1	25.1	23.45	23.5
Data transfer rate (KBytes/sec)	8000	1350	5000 synch. 3000 asynch.	8000	6000
FIRST CUSTOMER SHIPMENT	4Q91	1Q90	3Q90	6/92	12/90
COMMENTS	17.5 mm high *Varies by zone	25.4 mm high	25.4 mm high	17.5 mm high *Varies by zone	25.4 mm high

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7120S Cheyenne	7213A	7213S	LXT-213S/A	LXT-340S/A
DISK/TREND GROUP	4	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Ferrite	Thin Film
Interface	SCSI	PC AT	SCSI	SCSI, PC AT	SCSI, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 130.4	F: 212.78	F: 211.57	F: 213	F: 340
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 21,504	*	*	*	*
Data surfaces per spindle	4	2	2	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1516	1690	1690	1320	1560
Track density (TPI)	1800	1973	1973	1591	1613
Maximum linear density (BPI) (FCI)	34087 25565	42700 32000	42700 32000		44000 33000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3524	3551	3551	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	15	15	15	15
Average rotational delay (msec)	8.5	8.45	8.45	8.3	8.3
Average access time (msec)	23.5	23.45	23.45	23.3	23.3
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.	8000	7500 synch.	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	12/90	4/92	4/92	3Q90	3Q90
COMMENTS	25.4 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone 8 recording bands

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	MXT-340A	MXT-340SL	XT-8380EH	XT-8380SH	LXT-535S/A
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Thin Film	Thin Film
Interface	PC AT	SCSI-2	ESDI	SCSI	SCSI-2, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 340	F: 340	U: 410.0	F: 360.31	F: 535
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	U: 31,410	F: 27,648	*
Data surfaces per spindle	5	5	8	8	11
Heads per data surface	1	1	1	1	1
Tracks per surface	2616	2616	1632	1632	1560
Track density (TPI)	2600	2600	1376	1376	1600
Maximum linear density (BPI) (FCI)	41400 31050	41400 31050	31596 21064	31596 21064	44000 33000
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	6300	6300	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8.5 RD/9.0 WR	8.5 RD/9.0 WR	14.5	14.5	12 RD/13 WR
Average rotational delay (msec)	4.76	4.76	8.3	8.3	8.3
Average access time (msec)	13.26/13.76	13.26/13.76	22.8	22.8	20.3/21.3
Data transfer rate (KBytes/sec)	8000	10000 synch. 5000 asynch.	1875	4800 synch.	6000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	4Q92	3Q92	1Q87	1Q88	1Q91
COMMENTS	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone			41.3 mm high *Varies by zone

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	MXT-540AL	MXT-540SL	XT-8760EH	XT-8760SH	MXT-1240S
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film		Ferrite	Thin Film	Thin Film
Interface	PC AT	SCSI-2	ESDI	SCSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 540	F: 540	U: 768.9	F: 675.58	F: 1,240
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	U: 31,410	F: 27,648	*
Data surfaces per spindle	7	7	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2616	2616	1632	1632	2512
Track density (TPI)	2600	2600	1376	1376	2600
Maximum linear density (BPI) (FCI)	41400 31050	41400 31050	31596 21064	31596 21064	42630 31973
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	6300	6300	3600	3600	6300
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8.5 RD/9.0 WR	8.5 RD/9.0 WR	16.5	16.5	8.5 RD/9 WR
Average rotational delay (msec)	4.76	4.76	8.3	8.3	4.76
Average access time (msec)	13.26/13.76	13.26/13.76	24.8	24.8	13.26/13.76
Data transfer rate (KBytes/sec)	8000	10000 synch. 5000 asynch.	1875	4800 synch.	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	3Q92	3Q92	1Q87	1Q88	2Q92
COMMENTS	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone			41.3 mm high *Varies by zone

MANUFACTURER	MAXTOR	MAXTOR	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX
DRIVE	P0-12S	P1-17S	3890-00J4 3890-02J4	3890-00K6 3890-02K6	3892-00K7 3892-02K7
DISK/TREND GROUP	8	8	7	8	8
MARKET	OEM	OEM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Thin Film
Interface	SCSI-2	SCSI-2	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,029	F: 1,503	F: 630.24	F: 1,890	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 47,476	F: 47,476	F: 58,664
Data surfaces per spindle	15	19	13.5	21	15
Heads per data surface	1	1	2	1	1
Tracks per surface	1632	1778	990	1916	2226
Track density (TPI)	1376	1498	1193	1456	2080
Maximum linear density (BPI) (FCI)	36548 27411	42981 32235	25211 18908	25055 18791	30706 23029
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3620	3600	4200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13	13	12	12	12
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.1
Average access time (msec)	21.3	21.3	20.3	20.3	19.1
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.	5000 synch. 3000 asynch.	3000	3000	4260
FIRST CUSTOMER SHIPMENT	2Q91	2Q91	1989	1Q91	4Q91
COMMENTS	*Varies by zone	*Varies by zone	PCM 3380J Drive has 8 or 16 spindles Manufactured by Fujitsu	PCM 3380-K Drive has 8 or 16 spindles Manufactured by Fujitsu	PCM 3390-2 Drive has 8 or 16 spindles Manufactured by Fujitsu

MANUFACTURER	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY
DRIVE	11/11 Micro-Magnum	11/R Micro-Magnum	20/20 Micro-Magnum	20/R Micro-Magnum	5/5 Micro-Magnum
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	5.25" Cartridge	5.25" Cartridge	5.25" Cartridge	5.25" Cartridge	5.25" Cartridge
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST506	ST506	ST506	ST506	ST506
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 13.6	--	U: 24.25	--	U: 6.4
REMOVABLE	U: 13.6	U: 13.6	U: 24.25	U: 24.25	U: 6.4
Capacity per track (Bytes)	U: 10,640	U: 10,640	U: 10,640	U: 10,640	U: 10,032
Data surfaces per spindle	4	2	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	640	640	1120	1120	320
Track density (TPI)	908	908	1250	1250	454
Maximum linear density (BPI) (FCI)	10890	10890	11080	11080	8725
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	3254	3254	3248	3248	3443
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	40	40	40	40	40
Average rotational delay (msec)	9.2	9.2	9.2	9.2	8.7
Average access time (msec)	49.2	49.2	49.2	49.2	48.7
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	1986	1986	1990	1987	1986
COMMENTS					

MANUFACTURER	MFM TECHNOLOGY	MICROLAB	MICROLAB	MICROLAB	MICROLAB
DRIVE	5/R Micro-Magnum	DFW 3040	DFW 5025	DFW 5038	DFW 3060
DISK/TREND GROUP	1	2	2	2	3
MARKET	OEM	OEM, PCM	OEM	OEM	OEM
MEDIA: Generic type	5.25" Cartridge	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	ST506	PC AT	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 42.6	U: 25.6	U: 38.4*	F: 65.2
REMOVABLE	U: 6.75	--	--	--	--
Capacity per track (Bytes)	F: 10,890	F: 20,480	U: 10,416	U: 15,624*	F: 21,504
Data surfaces per spindle	2	2	4	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	311	1045	615	615	1516
Track density (TPI)	454	1400	588	588	1800
Maximum linear density (BPI)	8617	30800	9827	14740	34087
(FCI)		20533		9827	25565
Recording code	MFM	2,7 RLL	MFM	2,7 RLL*	1,7 RLL
Rotational speed (RPM)	3443	3550	3600	3600	3524
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil
Servo type	Embedded	Embedded	Open Loop	Open Loop	Embedded
Average positioning time (msec)	40	20	65 (including settling)	65 (including settling)	15
Average rotational delay (msec)	8.7	8.5	8.3	8.3	8.5
Average access time (msec)	48.7	28.5	73.3	73.3	23.5
Data transfer rate (KBytes/sec)	625	1500	625	937.5*	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	1986	9/91	9/88	3Q91	1992
COMMENTS		25.4 mm high	41.3 mm high	41.3 mm high *With RLL controller	25.4 mm high IDE version available

MANUFACTURER	MICROLAB	MICROLAB	MICROLAB	MICROPOLIS	MICROPOLIS
DRIVE	DFW 3080	DFW 3120	DFW 3200	1654-7	1674-7
DISK/TREND GROUP	3	4	5	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Ferrite	Thin Film/Ferr.	Thin Film/Ferr.
Interface	PC AT	PC AT	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 81.4	F: 130.4	F: 213	U: 182.1	F: 158
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 21,504	*	U: 20,832	F: 18,432
Data surfaces per spindle	4	4	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1170	1516	1320	1249	1249
Track density (TPI)	1490	1800	1591	1100	1100
Maximum linear density (BPI) (FCI)	30625 22968	34087 25565	34087 25565	21185 14123	21185 14123
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3703	3524	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	17	15	15	16	16
Average rotational delay (msec)	8.1	8.5	8.3	8.3	8.3
Average access time (msec)	25.1	23.5	23.3	24.3	24.3
Data transfer rate (KBytes/sec)	1350	6000	5000 synch. 3000 asynch.	1250	4000 synch. 1800 asynch.
FIRST CUSTOMER SHIPMENT	1992	1992	1992	1Q90	1Q88
COMMENTS	25.4 mm high SCSI version available	25.4 mm high	41.3 mm high *Varies by zone PC AT version available	41.3 mm high	41.3 mm high

1992 DISK/TREND REPORT

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1558-15	1578-15	1684	1588D	1588S
DISK/TREND GROUP	6	6	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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	Thin Film	Thin Film
Interface	ESDI	SCSI	SCSI	SCSI-2	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 382.3	F: 331.7	F: 340	F: 668	F: 668
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	F: 18,432	F: 27,648	F: 27,648	F: 27,648
Data surfaces per spindle	15	15	7	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1220	1776	1628	1628
Track density (TPI)	1075	1075	1554	1440	1440
Maximum linear density (BPI) (FCI)	21231 14154	21231 14154	31776 21184	31833 23874	31833 21222
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	16	14	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	24.3	22.3	24.3	24.3
Data transfer rate (KBytes/sec)	1250	4000 synch. 1800 asynch.	4000 synch. 1800 asynch.	5000 synch. 1800 asynch.	4000 synch. 1800 asynch.
FIRST CUSTOMER SHIPMENT	4Q86	2Q87	1Q89	11/88	2Q88
COMMENTS			41.3 mm high		

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1624	1528D 1528S	1548D 1548S	1598D 1598S	1908D 1908S
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	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/Ferr.	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 668	F: 1,346	F: 1,748	F: 1,049	F: 1,408
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 43,008	*	F: 36,864	*
Data surfaces per spindle	7	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2099	2100	2089	1919	2089
Track density (TPI)	1850	1853	1853	1702	1854
Maximum linear density (BPI) (FCI)	40646 30485	49532 37149	49278 36959	42462 31846	50000 37500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	14.5	11	14.5	11.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	5.6
Average access time (msec)	23.3	22.8	17.3	22.8	17.1
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	5000 synch. 1800 asynch.	10000 synch. 4000 asynch.	5000 synch. 1800 asynch.	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	3Q91	7/90	1Q91	3Q89	2Q91
COMMENTS	41.3 mm high *Varies by zone		*Varies by zone		*Varies by zone

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	2112A	2112D 2112S	2112DPD 2112DPS	1924D 1924S	1924WD 1924WS
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT, IDE	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,050	F: 1,050	F: 1,050	F: 2,100	F: 2,100
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	15	15	15	20	20
Heads per data surface	1	1	1	1	1
Tracks per surface	1770	1770	1770	2246	2246
Track density (TPI)	1980	1980	1980	2000	2000
Maximum linear density (BPI) (FCI)	48750 36563	48750 36563	48750 36563	42130 31600	42130 31600
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	10	10	11.5	11.5
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	15.6	15.6	15.6	17.1	17.1
Data transfer rate (KBytes/sec)	4000	10000 synch. 5000 asynch.	20000 synch.** 5000 asynch.**	10000 synch. 4000 asynch.	20000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	3Q91	3Q91	4Q92	2Q91	3Q92
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone **Each data port	*Varies by zone	*Varies by zone

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	1936D 1936S	1936DPD 1936DPS	1936WD 1936WS	8040	8080
DISK/TREND GROUP	9	9	9	2	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	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film		MIG
Interface	SCSI-2	SCSI-2	SCSI-2	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,022	F: 3,022	F: 3,022	F: 42	F: 85
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	F: 20,480	F: 24,064
Data surfaces per spindle	20	20	20	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	2772	2772	2772	1024	1768
Track density (TPI)	2280	2280	2280	1389	2250
Maximum linear density (BPI) (FCI)	53860 40400	53860 40400	53860 40400	32498 21665	45000 33750
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	11.5	11.5	11.5	25	18
Average rotational delay (msec)	5.6	5.6	5.6	8.3	8.3
Average access time (msec)	17.1	17.1	17.1	33.3	26.3
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	20000 synch.** 5000 asynch.**	20000 synch. 5000 asynch.	1500	8000
FIRST CUSTOMER SHIPMENT	3Q92	4Q92	3Q92	5/90	4Q91
COMMENTS	*Varies by zone	*Varies by zone **Each data port	*Varies by zone	25.4 mm high	25.4 mm high

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	8080-20	7200	8200	7400	FH-2777
DISK/TREND GROUP	4	5	5	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads				MIG	Thin Film
Interface	IDE	PC AT, IDE	PC AT, IDE	PC AT	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 107.3	F: 201.38	F: 210	F: 420	U: 777
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,110	F: 22,528	*	*	U: 31,740
Data surfaces per spindle	2	7	4	8	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2056	1277	1904	1904	1658
Track density (TPI)	2600	1561	2250	2250	1499
Maximum linear density (BPI) (FCI)	49904 37438	37341 24894	40000 30000	40000 30000	29575 19717
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3380	3600	3600	3600	3558
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	17	18	16	15	14
Average rotational delay (msec)	8.8	8.3	8.3	8.3	8.43
Average access time (msec)	25.8	26.3	24.3	23.3	22.43
Data transfer rate (KBytes/sec)	2000	1562.5	8000	8000	1875
FIRST CUSTOMER SHIPMENT	4Q92	1991	1Q92	2Q92	1Q91
COMMENTS	25.4 mm high	41.3 mm high	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone	

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MINISTOR PERIPHERALS
DRIVE	FH-3777	FH-21200	FH-31200	FH-31600	MINIPORT 32
DISK/TREND GROUP	7	8	8	8	2
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	48 mm OD 12 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 687	U: 1,200	F: 1,062	F: 1,610	F: 32
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	U: 41,664	F: 36,864	F: 44,032	*
Data surfaces per spindle	15	15	15	15	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1658	1921	1921	2147	958
Track density (TPI)	1499	1678	1678	1813	2400
Maximum linear density (BPI) (FCI)	29575 19717	40622 30466	40622 30466	50262 37697	50000 37500
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3558	3600	3600	3600	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	14	14	14	13	18
Average rotational delay (msec)	8.43	8.3	8.3	8.3	6.67
Average access time (msec)	22.43	22.3	22.3	21.3	24.67
Data transfer rate (KBytes/sec)	2500	1875	2500	10000 synch. 6000 asynch.	
FIRST CUSTOMER SHIPMENT	1Q91	3Q91	3Q91	4Q92	4Q92
COMMENTS					9.8 mm high *Varies by zone

MANUFACTURER	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MINIPORT 32P	MINIPORT 64	MINIPORT 64P	E1880B E1880C E1880D	E1880E E1880F E1880G E1880H
DISK/TREND GROUP	2	3	3	7	7
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Removable Drive	Fixed	Removable Drive	Fixed	Fixed
Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	224 mm OD 100 mm ID	224 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PCMCIA	PC AT	PCMCIA	Mitsubishi	Mitsubishi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 64	--	F: 630	F: 946
REMOVABLE	F: 32	--	F: 64	--	--
Capacity per track (Bytes)	*	*	*	F: 47,476	F: 47,476
Data surfaces per spindle	2	4	4	15	15
Heads per data surface	1	1	1	2	2
Tracks per surface	958	958	958	885	1334
Track density (TPI)	2400	2400	2400	1060	1307
Maximum linear density (BPI) (FCI)	50000 37500	50000 37500	50000 37500	21500 14333	22452 14968
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4500	4500	4500	3620	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	18	18	13	13
Average rotational delay (msec)	6.67	6.67	6.67	8.3	8.3
Average access time (msec)	24.67	24.67	24.67	21.3	21.3
Data transfer rate (KBytes/sec)				3000	3000
FIRST CUSTOMER SHIPMENT	4Q92	3Q92	4Q92	3Q88	4Q90
COMMENTS	10.5 mm high *Varies by zone	12.5 mm high *Varies by zone	13.5 mm high *Varies by zone	E1880B: 1 spindle E1880C: 4 spindles E1880D: 8 spindles	E1880E: 1 spindle E1880F: 5 spindles E1880G: 9 spindles E1880H: 13-16

MANUFACTURER	MULTIDIGIT	MULTIDIGIT	MULTIDIGIT	MULTIDIGIT	MULTIDIGIT
DRIVE	DW 2061	DW 2061R	DW 3063	DW 4063	MC 2021
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	PC XT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.5	U: 38.25*	U: 38.25*	U: 47.08	U: 25.83
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,625*	U: 15,625*	U: 19,231	U: 10,416
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	612	612	612	612	612
Track density (TPI)	804	804	804	804	804
Maximum linear density (BPI) (FCI)	13412	20118 13412	20118 13412	24761 16507	13412
Recording code	MFM	2,7 RLL*	2,7 RLL*	2,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	2925	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Servo type	Open Loop	Open Loop	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	70 (including settling)	70 (including settling)	45 (including settling)	45 (including settling)	70 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	10.25	8.3
Average access time (msec)	78.3	78.3	53.3	55.25	78.3
Data transfer rate (KBytes/sec)	625	937.5*	937.5*	937.5	625
FIRST CUSTOMER SHIPMENT	1988	1988	1990	1989	1989
COMMENTS	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high Drive on Card

MANUFACTURER	MULTIDIGIT	MULTIDIGIT	MULTIDIGIT	MULTIDIGIT	MYRICA
DRIVE	MC 3021	MC 4022	DW 8910	DW 0133	RODIME 3139AP
DISK/TREND GROUP	2	2	3	4	4
MARKET	PCM	PCM	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	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC XT	PC XT	ST412	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.75	U: 47.08	U: 88.88	U: 133.33*	F: 112.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,625	U: 19,231	U: 10,416	U: 15,625*	*
Data surfaces per spindle	4	4	7	7	5
Heads per data surface	1	1	1	1	1
Tracks per surface	612	612	1219	1219	1168
Track density (TPI)	804	804	1100	1100	1700
Maximum linear density (BPI) (FCI)	20118 13412	24761 16507	10228	15342 10228	25804 17202
Recording code	2,7 RLL	2,7 RLL	MFM	2,7 RLL*	2,7 RLL
Rotational speed (RPM)	3600	2925	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	70 (including settling)	45 (including settling)	28	28	16
Average rotational delay (msec)	8.3	10.25	8.3	8.3	8.3
Average access time (msec)	78.3	55.25	36.3	36.3	24.3
Data transfer rate (KBytes/sec)	937.5	937.5	625	937.5*	
FIRST CUSTOMER SHIPMENT	1989	1989	1991	1991	1Q92
COMMENTS	41.3 mm high Drive on Card	41.3 mm high Drive on Card		*With RLL controller	41.3 mm high *Varies by zone

MANUFACTURER	MYRICA	MYRICA	MYRICA	MYRICA	NEC
DRIVE	RODIME 3139TS	RODIME 3259AP RODIME 3259AT	RODIME 3259T RODIME 3259TP RODIME 3259TS	3540S 3540TS	D1711
DISK/TREND GROUP	4	5	5	7	2
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	48 mm OD 12 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	SCSI-2	PC AT	SCSI, SCSI-2	SCSI, SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 112.5	F: 213.0	F: 210.02	F: 540	F: 42.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	F:
Data surfaces per spindle	5	9	9	11	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1148	1235	1216	1568	1104
Track density (TPI)	1700	1700	1700	1905	2564
Maximum linear density (BPI) (FCI)	25826 17217	25804 17202	25826 17217	37688 28244	50667 38000
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	16	16	16	14	19
Average rotational delay (msec)	8.3	8.3	8.3	8.3	5.6
Average access time (msec)	24.3	24.3	24.3	22.3	24.6
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.		5000 synch. 3000 asynch.	10000 synch.	4500
FIRST CUSTOMER SHIPMENT	1Q92	1Q92	1Q92	3Q92	7/92
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone TP and TS are SCSI-2 interface	41.3 mm high *Varies by zone TS has SCSI-2 interface	12.7 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3142	D3735	D3741	D3835	D3841
DISK/TREND GROUP	2	2	2	2	2
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	MIG	Ferrite	MIG	Ferrite
Interface	ST412	PC AT	PC AT	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 53.4	F: 45	F: 45.09	F: 45	F: 45.05
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 20,992	F: 12,800	F: 20,992	F: 12,800
Data surfaces per spindle	8	2	8	2	8
Heads per data surface	1	1	1	1	1
Tracks per surface	642	1074	440	1075	440
Track density (TPI)	850	1800	850	1800	850
Maximum linear density (BPI) (FCI)	14000	30000 22500	17000 11333	30000 22500	17000 11333
Recording code	MFM	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3456	3600	3456	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Torque Motor
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	28	25	23	25	28
Average rotational delay (msec)	8.3	8.7	8.3	8.7	8.3
Average access time (msec)	36.3	33.7	31.3	33.7	36.3
Data transfer rate (KBytes/sec)	625	1500	937.5	1500 asynch.	937.5
FIRST CUSTOMER SHIPMENT	1Q88	6/90	7/89	2/90	12/87
COMMENTS	41.3 mm high	25.4 mm high	41.3 mm high	25.4 mm high	41.3 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3661	D3755 D3756	D3761	D3765	D3855 D3856
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 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	Ferrite	Thin Film	MIG
Interface	ESDI	PC AT	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 134.5	F: 105	F: 114.78	F: 176.5	F: 105
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,992	F: 20,992	F: 17,920	F: 29,690	F: 20,992
Data surfaces per spindle	7	4	7	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	915	1251	915	1486	1251
Track density (TPI)	1311	1800	1311	2036	1800
Maximum linear density (BPI) (FCI)	25484 16989	32000 24000	25484 16989	49403 37052	32000 24000
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3573	3456	3573	3600	3456
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	20	19	20	16.5	25
Average rotational delay (msec)	8.4	8.7	8.4	8.3	8.7
Average access time (msec)	28.4	27.7	28.4	24.8	33.7
Data transfer rate (KBytes/sec)	1250	1500	1250	2365	1500 asynch.
FIRST CUSTOMER SHIPMENT	11/88	6/90	9/89	2Q91	12/89
COMMENTS	41.3 mm high	25.4 mm high	41.3 mm high	25.4 mm high	25.4 mm high D3856 has 19 msec. average positioning time

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3861	D3865	D5652	D5655	D5852
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 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 114.78	F: 176.5	U: 172.76	U: 179.86	F: 147.48
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 29,690	U: 20,992	U: 20,992	F: 17,920
Data surfaces per spindle	7	4	10	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	915	1486	823	1224	823
Track density (TPI)	1311	2036	926	1240	925
Maximum linear density (BPI) (FCI)	25484 16989	49403 37052	18758 12505	19610 13073	18759 12506
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3573	3600	3573	3573	3573
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	20	16.5	23	18	23
Average rotational delay (msec)	8.4	8.3	8.4	8.4	8.4
Average access time (msec)	28.4	24.8	31.4	26.4	31.4
Data transfer rate (KBytes/sec)	1250	2365	1250	1250	1250
FIRST CUSTOMER SHIPMENT	3/89	2Q91	2/86	12/87	5/87
COMMENTS	41.3 mm high	25.4 mm high		41.3 mm high	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3772	D3781	D3872	D3881	D5662
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	PC AT	PC AT	SCSI-2	SCSI-2	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 331.46	F: 426.16	F: 331.46	F: 426.16	U: 385.41
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,200	F: 32,200	F: 32,200	F: 32,200	U: 20,992
Data surfaces per spindle	7	9	7	9	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1468	1468	1468	1468	1224
Track density (TPI)	2000	2000	2000	2000	1240
Maximum linear density (BPI) (FCI)	49000 36750	49000 36750	49000 36750	49000 36750	19660 13106
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3573
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	14	14	14	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.4
Average access time (msec)	22.3	22.3	22.3	22.3	26.4
Data transfer rate (KBytes/sec)	5000 synch. 2365 asynch.	5000 synch. 2365 asynch.	5000 synch. 2365 asynch.	5000 synch. 2365 asynch.	1250
FIRST CUSTOMER SHIPMENT	2Q91	2Q91	2Q91	2Q91	11/87
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5862	D2362	D2366	D2462	D5682
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM	Captive, OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 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	SCSI	Modified SMD	IPI-2	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 328.2	U: 800.7	U: 800.7	U: 800	U: 765.42
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	U: 40,960	U: 40,960	U: 40,960	U: 31,248
Data surfaces per spindle	15	11.5	11.5	11.5	15
Heads per data surface	1	2/1	2/1	2/1	1
Tracks per surface	1221	1700	1700	1700	1633
Track density (TPI)	1240	1070	1070	1070	1480
Maximum linear density (BPI) (FCI)	19660 13106	21400 14266	21400 14266	21400 14266	30760 23070
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3573	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	15	15	15	16
Average rotational delay (msec)	8.4	8.3	8.3	8.3	8.3
Average access time (msec)	26.4	23.3	23.3	23.3	24.3
Data transfer rate (KBytes/sec)	1250	2460	2460	2460	1875
FIRST CUSTOMER SHIPMENT	11/87	2/86	3/87	6/87	4/89
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5882	N7756	N7757	N7759	N7767
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive, OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	NEC	NEC	NEC	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 675.99	F: 486.2	F: 750.5	F: 972	F: 635.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	F: 34,036	F: 38,708	F: 38,708	F: 32,768
Data surfaces per spindle	15	9.5	11.5	11.5	11.5
Heads per data surface	1	2/1	2	2/1	2
Tracks per surface	1630	1506	1686	1686	1686
Track density (TPI)	1480	1000	1070	1070	1070
Maximum linear density (BPI) (FCI)	30760 23070	18600 12400	21400 14266	21400 14266	21400 14266
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3070	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	15	15	13	15
Average rotational delay (msec)	8.3	9.8	8.3	8.3	8.3
Average access time (msec)	24.3	24.8	23.3	21.3	23.3
Data transfer rate (KBytes/sec)	4800 synch. 1875 asynch.	1860	2460	2460	19600
FIRST CUSTOMER SHIPMENT	6/89	3Q84	9/87	9/88	1988
COMMENTS		Drive has 2 spindles	Drive has 2 spindles		N7767 uses 8 spindles in parallel array with 5 GB total capacity

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2363	D2367	D2373	D2377	D2463
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	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	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	IPI-2	SMD-E	IPI-2	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,132.4	U: 1,132.4	U: 1,415	U: 1,415	F: 1,044
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 51,200	U: 51,200	F: 37,888
Data surfaces per spindle	13.5	13.5	13.5	13.5	13.5
Heads per data surface	2/1	2/1	2/1	2/1	2/1
Tracks per surface	2048	2048	2048	2048	2048
Track density (TPI)	1290	1290	1290	1290	1290
Maximum linear density (BPI) (FCI)	21400 14266	21400 14266	26800 20100	26800 20100	21400 14266
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	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)	2460	2460	3070	3070	2460
FIRST CUSTOMER SHIPMENT	5/87	9/87	10/87	12/87	8/87
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5894	N7766	N7768	N7797	D2387
DISK/TREND GROUP	8	8	8	8	9
MARKET	OEM	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI-2	NEC	NEC	NEC	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,400.5	F: 1,301.1	F: 1,301.1	F: 1,536	U: 3,000.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 44,032	F: 47,476	F: 47,476	F: 47,552	U: 72,959
Data surfaces per spindle	19	13.5	13.5	15	15
Heads per data surface	1	2/1	2/1	1	2/1
Tracks per surface	1680	2030	2030	2154	2742
Track density (TPI)	1670	1290	1290	2400	1670
Maximum linear density (BPI) (FCI)	46900 35175	26800 20100	26800 20100	44660 33495	37800 28350
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	3600	3600	5400	3700
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	15	15	12	12
Average rotational delay (msec)	5.6	8.3	8.3	5.6	8.1
Average access time (msec)	16.6	23.3	23.3	17.6	20.1
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	3000	3000	4500	4500
FIRST CUSTOMER SHIPMENT	10/90	9/90	9/89	4/92	4/90
COMMENTS		Drive has 4 spindles	Drive has 8 spindles	Maximum 32 HDAs per drive	

MANUFACTURER	NEC	QUALITRON	QUALITRON	QUALITRON	QUALITRON
DRIVE	N7795	QW-521	QW-530	QW-540	QW-560
DISK/TREND GROUP	9	2	2	2	3
MARKET	Captive	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	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	NEC	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,855	U: 25.6	U: 38.4	U: 51.3	U: 76.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 69,416	U: 10,416	U: 15,624	U: 10,416	U: 15,624
Data surfaces per spindle	15	2	2	4	4
Heads per data surface	2/1	1	1	1	1
Tracks per surface	2742	615	615	820	820
Track density (TPI)	1670	588	588	777	777
Maximum linear density (BPI) (FCI)	37800 28350	9827	14791 9827	9935	14903 9935
Recording code	1,7 RLL	MFM	2,7 RLL	MFM	2,7 RLL
Rotational speed (RPM)	3700	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Servo type	Dedicated Surf.	Open Loop	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	12	40 (including settling)	40 (including settling)	40 (including settling)	40 (including settling)
Average rotational delay (msec)	8.1	8.3	8.3	8.3	8.3
Average access time (msec)	20.1	48.3	48.3	48.3	48.3
Data transfer rate (KBytes/sec)	4500	625	937.5	625	937.5
FIRST CUSTOMER SHIPMENT	6/91	1986	1986	1988	1988
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	40AT Go.Drive	40S Go.Drive	42AT ELS ProDrive	42S ELS ProDrive	52AT LPS ProDrive
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MIG	MIG	MIG
Interface	PC AT	SCSI	PC AT	SCSI, SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43	F: 43	F: 42	F: 42	F: 52
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	2	1	1	2
Heads per data surface	1	1	1	1	1
Tracks per surface	870	870	1536	1536	1219
Track density (TPI)	1700	1700	1800	1800	1330
Maximum linear density (BPI) (FCI)	48371 36278	48371 36278	38624 28968	38624 28968	29307 19538
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3663	3663	3662
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Optical Encoder
Average positioning time (msec)	19	19	19	19	17
Average rotational delay (msec)	8.3	8.3	8.2	8.2	8.2
Average access time (msec)	27.3	27.3	27.2	27.2	25.2
Data transfer rate (KBytes/sec)	4000 max.	4000 synch. 2000 asynch.	4000	3000 asynch.	4000 max.
FIRST CUSTOMER SHIPMENT	6/91	6/91	8/92	8/92	2/90
COMMENTS	15.6 mm high *Varies by zone	15.6 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	52S LPS ProDrive	EZ242 Hardcard	Hardcard 40 (Plus)	XL50 Hardcard II XL (Plus)	XL50 Passport
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM, PCM	OEM, PCM	PCM	OEM, PCM
MEDIA: Generic type	Fixed	Drive On Card	Drive On Card	Drive On Card	Removable Drive
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Ferrite	MIG	MIG
Interface	SCSI	IBM PC	IBM PC	PC AT	IBM PC/MAC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 52	F: 42	F: 42.26	F: 52	--
REMOVABLE	--	--	--	--	F: 52.2
Capacity per track (Bytes)	*	*	F: 14,336 and 17,408	*	*
Data surfaces per spindle	2	1	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1219	1536	612	1233	1219
Track density (TPI)	1330	1800	812	1330	1330
Maximum linear density (BPI) (FCI)	29307 19538	38624 28968	21524 22392	29307 19538	29307 19538
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3662	3663	3000	3662	3662
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Optical Encoder	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	17	19	40	17**	18
Average rotational delay (msec)	8.2	8.2	10	8.2	8.2
Average access time (msec)	25.2	27.2	50	25.2	26.2
Data transfer rate (KBytes/sec)	4000 synch. 2000 asynch.	4000	843.7/1031	4000	4000
FIRST CUSTOMER SHIPMENT	2/90	10/92	5/87	10/90	1/92
COMMENTS	25.4 mm high *Varies by zone	27.8 mm high *Varies by zone	25.4 mm high	23.5 mm high *Varies by zone **About 9 msec using cache	Drive with adapter mounts in half high 5.25" slot *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	60AT Go.Drive	80AT Go.Drive	80AT GRS Go.Drive	80AT ProDrive	80S Go.Drive
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Thin Film
Interface	PC AT	PC AT	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 64.7	F: 86	F: 84	F: 84	F: 86
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	4	2	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1097	870	1376	834	870
Track density (TPI)	2000	1700	2500	1000	1700
Maximum linear density (BPI) (FCI)	56688 42516	48371 36278	58878 44159	22050 14700	48371 36278
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3662	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Optical Encoder	Embedded
Average positioning time (msec)	17	19	17	19	19
Average rotational delay (msec)	8.3	8.3	8.3	8.2	8.3
Average access time (msec)	24.3	27.3	25.3	27.2	27.3
Data transfer rate (KBytes/sec)	4000	4000 max.	4000	4000 max.	4000 synch. 2000 asynch.
FIRST CUSTOMER SHIPMENT	1/92	8/91	3Q92	5/88	8/91
COMMENTS	19 mm high *Varies by zone	19 mm high *Varies by zone	15.6 mm high *Varies by zone	41.3 mm high *Varies by zone	19 mm high *Varies by zone

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MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	80S GRS Go.Drive	80S ProDrive	85AT ELS ProDrive	85S ELS ProDrive	EZ85 Hardcard
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Drive On Card
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	MIG	MIG	MIG
Interface	SCSI-2	SCSI	PC AT	SCSI, SCSI-2	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 84	F: 84	F: 85	F: 85	F: 85
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	6	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1376	834	1536	1536	1536
Track density (TPI)	2500	1000	1800	1800	1800
Maximum linear density (BPI) (FCI)	58878 44159	22050 14700	38624 28968	38624 28968	38624 28968
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3662	3663	3663	3663
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Optical Encoder	Embedded	Embedded	Embedded
Average positioning time (msec)	17	19	17	17	17
Average rotational delay (msec)	8.3	8.2	8.2	8.2	8.2
Average access time (msec)	25.3	27.2	25.2	25.2	27.2
Data transfer rate (KBytes/sec)	4000 synch. 2500 asynch.	4000 synch. 2000 asynch.	4000	3000 asynch.	4000
FIRST CUSTOMER SHIPMENT	3Q92	1/88	8/92	8/92	10/92
COMMENTS	15.6 mm high *Varies by zone	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	27.8 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	Hardcard II 80 (Plus)	105AT LPS ProDrive	105S LPS ProDrive	105S ProDrive	120AT Go.Drive
DISK/TREND GROUP	3	4	4	4	4
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Drive On Card	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	Thin Film
Interface	PC AT	PC AT	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80.5	F: 105	F: 105	F: 105	F: 130
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	*	*	*	*
Data surfaces per spindle	4	4	4	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	962	1219	1219	1019	1097
Track density (TPI)	1227	1330	1330	1225	2000
Maximum linear density (BPI) (FCI)	27225 18150	29307 19538	29307 19538	22055 14700	56688 42516
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	3662	3662	3662	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Optical Encoder	Optical Encoder	Optical Encoder	Embedded
Average positioning time (msec)	25	17	17	19	17
Average rotational delay (msec)	8.2	8.2	8.2	8.2	8.3
Average access time (msec)	33.2	25.2	25.2	27.2	24.3
Data transfer rate (KBytes/sec)	Up to 4000	4000 max.	4000 synch. 2000 asynch.	4000 synch. 2000 asynch.	4000
FIRST CUSTOMER SHIPMENT	1/90	--	2/90	--	1/92
COMMENTS	25.4 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone	19 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	120AT LPS ProDrive	120S Go.Drive	120S LPS ProDrive	127AT ELS ProDrive	127S ELS ProDrive
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	PC AT	SCSI	SCSI	PC AT	SCSI, SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 122	F: 130	F: 122	F: 127	F: 127
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	4	2	3	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1818	1097	1818	1536	1536
Track density (TPI)	1930	2000	1930	1800	1800
Maximum linear density (BPI) (FCI)	38600 29000	56688 42516	38600 29000	38624 28968	38624 28968
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4306	3600	4306	3663	3663
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Optical Encoder	Embedded	Optical Encoder	Embedded	Embedded
Average positioning time (msec)	16	17	16	17	17
Average rotational delay (msec)	7	8.3	7	8.2	8.2
Average access time (msec)	23	24.3	23	25.2	25.2
Data transfer rate (KBytes/sec)	5000	4000 synch. 2500 asynch.	10000 synch. 5000 asynch.	4000	3000 asynch.
FIRST CUSTOMER SHIPMENT	10/91	1/92	10/91	8/92	8/92
COMMENTS	25.4 mm high *Varies by zone	19 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	160AT GRS Go.Drive	160S GRS Go.Drive	170AT ELS ProDrive	170S ELS ProDrive	EZ127 Hardcard
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Drive On Card
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MIG	MIG	MIG
Interface	PC AT	SCSI-2	PC AT	SCSI, SCSI-2	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 169	F: 169	F: 170	F: 170	F: 127
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	4	4	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1376	1376	1536	1536	1536
Track density (TPI)	2500	2500	1800	1800	1800
Maximum linear density (BPI) (FCI)	58878 44159	58878 44159	38624 28968	38624 28968	38624 28968
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3663	3663	3663
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	17	17	17	17	17
Average rotational delay (msec)	8.3	8.3	8.2	8.2	8.2
Average access time (msec)	25.3	25.3	25.2	25.2	27.2
Data transfer rate (KBytes/sec)	4000	4000 synch. 2500 asynch.	4000	3000 asynch.	4000
FIRST CUSTOMER SHIPMENT	3Q92	3Q92	8/92	8/92	10/92
COMMENTS	19 mm high *Varies by zone	19 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	27.8 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	XL105 Hardcard II XL (Plus)	XL105 Passport	XL120 Passport	240AT LPS ProDrive	240S LPS ProDrive
DISK/TREND GROUP	4	4	4	5	5
MARKET	PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Generic type	Drive On Card	Removable Drive	Removable Drive	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	Thin Film
Interface	PC AT	IBM/MAC	IBM/MAC	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105	--	--	F: 245	F: 245
REMOVABLE	--	F: 105	F: 120	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1233	1219	1800	1818	1818
Track density (TPI)	1330	1330	1930	1930	1930
Maximum linear density (BPI) (FCI)	29307 19538	29307 19538	38600 29000	38600 29000	38600 29000
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	3662	4306	4306	4306
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Optical Encoder	Optical Encoder
Average positioning time (msec)	17**	18	17	16	16
Average rotational delay (msec)	8.2	8.2	7.0	7	7
Average access time (msec)	25.2	26.2	24.0	23	23
Data transfer rate (KBytes/sec)	4000	4000	10000	5000	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	10/90	1/92	3/92	10/91	10/91
COMMENTS	23.5 mm high *Varies by zone **About 9 msec using cache	Drive with adapter mounts in half high 5.25" slot *Varies by zone	Drive with adapter mounts in half high 5.25" slot *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	EZ240 Hardcard	XL240 Passport	425iAT ProDrive	425iS ProDrive	525AT LPS ProDrive
DISK/TREND GROUP	5	5	6	6	7
MARKET	PCM, OEM	OEM, PCM	OEM	OEM	OEM
MEDIA: Generic type	Drive On Card	Removable Drive	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM PC	IBM/MAC	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245	--	F: 426	F: 426	F: 525
REMOVABLE	--	F: 240	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	9	9	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1800	1800	1520	1520	2448
Track density (TPI)	1930	1930	1695	1695	2670
Maximum linear density (BPI) (FCI)	38600 29000	38600 29000	37146 27860	37146 27860	50500 37900
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4306	4306	3606	3606	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Optical Encoder	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	16	17	14**	14**	10 RD/11 WR
Average rotational delay (msec)	7.0	7.0	8.3	8.3	6.7
Average access time (msec)	23.0	24.0	22.3	22.3	16.7/17.7
Data transfer rate (KBytes/sec)	5000	10000	4000 max.	10000 synch. 4000 asynch.	5000
FIRST CUSTOMER SHIPMENT	8/92	3/92	5/91	1/91	9/92
COMMENTS	27.8 mm high *Varies by zone	Drive with adapter mounts in half high 5.25" slot *Varies by zone	41.3 mm high *Varies by zone **13 msec. average read positioning	41.3 mm high *Varies by zone **13 msec. average read positioning	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	RICOH
DRIVE	525S LPS ProDrive	700S ProDrive	1050S ProDrive	1225S ProDrive	RH5260 RH5261
DISK/TREND GROUP	7	7	8	8	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	5.25" Cartridge
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	ST506, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 525	F: 700	F: 1,050	F: 1,225	--
REMOVABLE	--	--	--	--	U: 25.5
Capacity per track (Bytes)	*	*	*	*	U: 10,416
Data surfaces per spindle	6	8	12	14	2
Heads per data surface	1	1	1	1	1
Tracks per surface	2448	2448	2448	2448	1224
Track density (TPI)	2670	2670	2670	2670	1222
Maximum linear density (BPI) (FCI)	50500 37900	50500 37900	50500 37900	50500 37900	10894
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	4500	4500	4500	4500	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10 RD/11 WR	10 RD/12 WR	10 RD/12 WR	10 RD/12 WR	98 (including settling)
Average rotational delay (msec)	6.7	6.7	6.7	6.7	8.6
Average access time (msec)	16.7/17.7	16.7/18.7	16.7/18.7	16.7/18.7	106.6
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	625
FIRST CUSTOMER SHIPMENT	9/92	9/92	9/92	9/92	1987
COMMENTS	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high RH5261 has SCSI interface

MANUFACTURER	RICOH	SAGEM	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	RH5500	MSA 252-200	SHD-2040N	SHD-2041B	SHD-2041N
DISK/TREND GROUP	1	5	2	2	2
MARKET	OEM	OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	5.25" Cartridge	Special	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	SCSI	SCSI	ST412	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	U: 51.2*	F: 47.0	F: 47.0
REMOVABLE	F: 50.0	F: 200	--	--	--
Capacity per track (Bytes)	F: 19,455	F: 23,040	U: 15,624*	F: 14,336	F: 14,336
Data surfaces per spindle	2	16	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1285	720	820	820	820
Track density (TPI)	1200	950	1065	1065	1065
Maximum linear density (BPI) (FCI)	25750 17166	19680 14760	20196 13464	22386 14924	22386 14924
Recording code	2,7 RLL	1,7 RLL	2,7 RLL*	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3183	3600	3568	3525	3525
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Servo type	Embedded	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	25	17	35 (including settling)	29 (including settling)	28 (including settling)
Average rotational delay (msec)	9.4	8.3	8.4	8.51	8.51
Average access time (msec)	34.4	25.3	43.4	37.51	36.51
Data transfer rate (KBytes/sec)	2000	1500	937.5*	937.5	937.5
FIRST CUSTOMER SHIPMENT	2Q89	10/90	4Q88	1Q90	1Q90
COMMENTS	41.3 mm high	Militarized Subsystem Removable Head/Disk Module	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	SHD-3061A	SHD-3062A	SHD-3101A	ST225	ST251
DISK/TREND GROUP	3	4	4	2	2
MARKET	Captive, OEM	OEM	Captive, OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads			MIG	Ferrite	Ferrite
Interface	PC AT	PC AT	PC AT	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 60.5	F: 120	U: 133.52 F: 105	U: 25.6	U: 51.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,480	F: 20,480	F: 20,480	U: 10,416	U: 10,416
Data surfaces per spindle	2	4	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1478	1478	1282	615	820
Track density (TPI)	1752	1752	1658	588	777
Maximum linear density (BPI) (FCI)	36139 27172	36139 27172	35161 26371	9827	9935
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	MFM	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Servo type	Embedded	Embedded	Embedded	Open Loop	Open Loop
Average positioning time (msec)	16	16	16	65 (including settling)	28 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	73.3	36.3
Data transfer rate (KBytes/sec)		1250	6000	625	625
FIRST CUSTOMER SHIPMENT	1992	1992	4Q91	10/84	3Q87
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST351A/X	ST9052A	ST3096A	ST4096	ST7075
DISK/TREND GROUP	2	2	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	48 mm OD 12 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Ferrite	Thin Film
Interface	PC AT/XT	PC AT	PC AT	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.8	F: 42.6	F: 89.2	U: 96	F: 65
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	U: 10,416	*
Data surfaces per spindle	2	2	3	9	4
Heads per data surface	1	1	1	1	1
Tracks per surface	820	1065	1024	1024	
Track density (TPI)	1290	2165	1760	1031	
Maximum linear density (BPI) (FCI)	28922 19281	40500 27000	34600 23000	9792	
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	MFM	
Rotational speed (RPM)	3048	3450	3528	3600	
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	28	16	16	28	16
Average rotational delay (msec)	9.8	8.7	8.5	8.3	
Average access time (msec)	37.8	24.7	24.5	36.3	
Data transfer rate (KBytes/sec)	1250-1750	4000	4000 max.	625	
FIRST CUSTOMER SHIPMENT	4Q90	4Q91	1Q90	1Q86	4Q92
COMMENTS	25.4 mm high *Varies by zone	12.5 mm high *Varies by zone	25.4 mm high *Varies by zone		12.5 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST9080A	ST9096A	ST2125N ST2125NM Wren 5 HH	ST2182E Wren 6 HH	ST2209N ST2209NM ST2209NV Wren 5 HH
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 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	Ferrite	Thin Film	Ferrite
Interface	PC AT	PC AT	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 64.0	F: 85.2	U: 125 F: 107	U: 182	U: 209 F: 183
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	U: 31,320	*
Data surfaces per spindle	2	4	3	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface		1065	1544	1453	1544
Track density (TPI)		2165	1280	1459	1280
Maximum linear density (BPI) (FCI)		40500 27000	19213 12808	31699 21132	19213 12808
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3450	3450	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	18	15	18
Average rotational delay (msec)	8.7	8.7	8.3	8.3	8.3
Average access time (msec)	24.7	24.7	26.3	23.3	26.3
Data transfer rate (KBytes/sec)	4000	4000	4700 synch.	1875	4700 synch.
FIRST CUSTOMER SHIPMENT	3Q92	4Q91	3Q88	1/89	3Q88
COMMENTS	12.5 mm high *Varies by zone	19 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST2274A Wren 6 HH	ST3120A	ST3144A	ST9144A	ST6344J FSD
DISK/TREND GROUP	4	4	4	4	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	65 mm OD 20 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	PC AT	PC AT	PC AT	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 193	F: 106.9	F: 130	F: 127.9	U: 344
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	*	*	*	U: 20,160
Data surfaces per spindle	5	3	3	6	12
Heads per data surface	1	1	1	1	2
Tracks per surface	1453	1024	1001	1065	1422
Track density (TPI)	1459	1760		2165	960
Maximum linear density (BPI) (FCI)	31699 21132	34600 23000	34600 23000	40500 27000	10000
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	MFM
Rotational speed (RPM)	3600	3528	3528	3450	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	16	16	16	16	18
Average rotational delay (msec)	8.3	8.5	8.5	8.7	8.3
Average access time (msec)	24.3	24.5	24.5	24.7	26.3
Data transfer rate (KBytes/sec)	1875	4000	4000	4000	1209
FIRST CUSTOMER SHIPMENT	4/89	1/91	3Q91	4Q91	4Q83
COMMENTS	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	19.05 mm high *Varies by zone	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1239A Swift	ST3243A	ST3283A	ST3283N	ST9235A
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	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	PC AT	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 210.7	F: 214	F: 245.38	F: 248.62	F: 209.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	*	*	*	*
Data surfaces per spindle	9	4	5	5	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1272		1672	1672	
Track density (TPI)	1543		1960	1960	
Maximum linear density (BPI) (FCI)	28103 18735		35000 26250	35000 26250	
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3811	4500	4500	3450
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	15	16	12	12	16
Average rotational delay (msec)	8.3	7.87	6.7	6.7	8.69
Average access time (msec)	23.3	23.87	18.7	18.7	24.69
Data transfer rate (KBytes/sec)	1250		3000	10000 synch. 3000 asynch.	4000
FIRST CUSTOMER SHIPMENT	3Q89	2Q92	1Q92	1Q92	3Q92
COMMENTS	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	19.05 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1400A	ST1400N	ST1401A	ST1401N	ST1480A
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads					
Interface	PC AT	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 383 F: 331	U: 383 F: 331	U: 390 F: 340	U: 390 F: 338	U: 492 F: 426
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	7	7	9	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1475	1476	1121	1100	1478
Track density (TPI)	1760	1760	1760	1760	1760
Maximum linear density (BPI) (FCI)	36000 27000	36000 27000	36000 27000	36000 27000	36000 27000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4412	4412	4412	4412	4412
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.		Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	14	12	12	14
Average rotational delay (msec)	6.8	6.8	6.8	6.8	6.8
Average access time (msec)	20.8	20.8	18.8	18.8	20.8
Data transfer rate (KBytes/sec)	8000	5000 synch. 4000 asynch.	8000	5000 synch. 4000 asynch.	1875-3125*
FIRST CUSTOMER SHIPMENT		1/91		1/91	1/91
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1480N	ST1481N	ST2383A Wren 6 HH	ST2383E Wren 6 HH	ST2383N ST2383ND ST2383NM Wren 6 HH
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads			Thin Film	Thin Film	Thin Film
Interface	SCSI, SCSI-2	SCSI-2	PC AT	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 492 F: 426	U: 492 F: 426	F: 338	U: 383	U: 383 F: 337
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 27,648	U: 31,320	*
Data surfaces per spindle	9	9	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1478	1476	1747	1747	1261
Track density (TPI)	1760	1760	1459	1459	1459
Maximum linear density (BPI) (FCI)	36000 27000	36000 27000	31699 21132	31699 21132	31674 21116
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4400	4412	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	14	16	16	14
Average rotational delay (msec)	6.8	6.8	8.3	8.3	8.3
Average access time (msec)	20.8	20.8	24.3	24.3	22.3
Data transfer rate (KBytes/sec)	5000 synch. 4000 asynch.	10000 synch. 4000 asynch.	1875	1875	4700 synch.
FIRST CUSTOMER SHIPMENT	1/91	3Q91	4/89	1/89	7/89
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high	41.3 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST2502N ST2502ND ST2502NM ST2502NV Wren 6 HH	ST3500A	ST3500N ST3500ND	ST4350N ST4350NM Wren 4	ST4376N ST4376NM ST4376NV Wren 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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	PC AT	SCSI-2	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 502 F: 442	F: 426	F: 426	U: 350 F: 307	U: 376 F: 330
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	7	7	7	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1755	1546	1546	1412	1549
Track density (TPI)	1459	2150	2150	1280	1280
Maximum linear density (BPI) (FCI)	31674 21116	46000 34500	46000 34500	19058 12705	19058 12705
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	4500	4500	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	9.9 RD/11.4 WR	9.9 RD/11.4 WR	16.5	17.5
Average rotational delay (msec)	8.3	6.7	6.7	8.3	8.3
Average access time (msec)	24.3	16.6/18.1	16.6/18.1	24.8	25.8
Data transfer rate (KBytes/sec)	4700 synch.	4000	10000 synch. 4000 asynch.	1500 synch.	4700 synch.
FIRST CUSTOMER SHIPMENT	9/89	1Q92	1Q92	3/87	10/87
COMMENTS	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	*Varies by zone	*Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4383E Wren 5	ST4384E Wren 5	ST4385N ST4385NM ST4385NV Wren Runner	ST4442E Wren 5	ST6515J ST6515K FSD
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	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	ESDI	SCSI	ESDI	Mod.SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 383	U: 383	U: 385 F: 357	U: 442	U: 516
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,880	U: 20,880	*	U: 20,880	U: 30,240
Data surfaces per spindle	13	15	15	15	12
Heads per data surface	1	1	1	1	2
Tracks per surface	1412	1224	791	1412	1422
Track density (TPI)	1280	1280	1280	1280	960
Maximum linear density (BPI) (FCI)	19600 13066	19600 13066	22000 14666	19600 13066	15159 10106
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	14.5	10.7	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	22.8	19	24.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	4700 synch.	1250	1825
FIRST CUSTOMER SHIPMENT	2/88	2/88	1Q89	2/88	4Q83
COMMENTS			*Varies by zone		

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1581N	ST1980N ST1980ND	ST3600A	ST3600N ST3600ND	ST41097J Elite 1
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium		Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	PC AT	SCSI-2	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 613 F: 525	U: 980 F: 860	U: 600 F: 525	U: 600 F: 525	U: 1,097
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	*	*	*	U: 30,800
Data surfaces per spindle	9	13	7	7	17
Heads per data surface	1	1	1	1	1
Tracks per surface	1476	1717	1877	1877	2101
Track density (TPI)			2150	2150	1801
Maximum linear density (BPI) (FCI)			49000 36750	49000 36750	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	4412	5400	4500	4500	5400
PERFORMANCE					
Actuator type		Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type		Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	9.9 RD/11.4 WR	10.5 RD/12 WR	10.5 RD/12 WR	11.5
Average rotational delay (msec)	6.8	5.56	6.7	6.7	5.56
Average access time (msec)	20.8	15.46/16.96	17.2/18.7	17.2/18.7	17.06
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	4000	10000 synch. 4000 asynch.	2750
FIRST CUSTOMER SHIPMENT		1Q92	1Q92	1Q92	2Q90
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4702N ST4702NM Wren 5	ST4766E Wren 6	ST4766N ST4766NM ST4766NV Wren 6	ST4767E Wren Runner-2	ST4767N ST4767ND ST4767NM ST4767NV Wren Runner-2
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	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	ESDI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 702 F: 613	U: 766	U: 766 F: 676	U: 788	U: 767 F: 676
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	U: 31,320	F: 28,672	U:	*
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1546	1632	1632	1399	1356
Track density (TPI)	1280	1459	1459	1600	1600
Maximum linear density (BPI) (FCI)	26000 17333	30500 20333	30500 20333	30600 22950	30600 22950
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4800	4800
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16.5	15.5	16.5	12.9	11.9
Average rotational delay (msec)	8.3	8.3	8.3	6.25	6.25
Average access time (msec)	24.8	23.8	24.8	19.15	18.15
Data transfer rate (KBytes/sec)	4700 synch.	1875	4700 synch.	3000	4800 synch.
FIRST CUSTOMER SHIPMENT	5/88	8/88	9/88	12/90	3/90
COMMENTS	*Varies by zone				*Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4769E Wren Runner-2	ST8851J ST8851K Sabre 4	ST8851N Sabre 4	ST11200N ST11200ND	ST41200N ST41200ND ST41200NM ST41200NV Wren 7
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	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SMD, IPI-2	SCSI	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 802	U: 851	U: 851 F: 727	U: 1,200 F: 1,050	U: 1,200 F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 34,450	U: 41,088	F: 34,816	*	*
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1552	1381	1381	1877	1931
Track density (TPI)	1600	1089	1089	2150	1600
Maximum linear density (BPI) (FCI)	29318 21988	19816 13210	19816 13210	46000 34500	32750 24562
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4800	3600	3600	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12.9	15	15	10.5 RD/12 WR	15
Average rotational delay (msec)	6.25	8.3	8.3	5.56	8.3
Average access time (msec)	19.15	23.3	23.3	16.06/17.56	23.3
Data transfer rate (KBytes/sec)	3000	2465	2465	10000 synch. 4000 asynch.	4800 synch.
FIRST CUSTOMER SHIPMENT	12/90	3Q87	3Q87	2Q92	5/89
COMMENTS				41.3 mm high *Varies by zone	*Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST41201J ST41201K Elite 1	ST41520N ST41520ND Elite 1	ST41600N ST41600ND ST41601N ST41601ND Elite 1	ST41650N ST41650ND Wren 8	ST41651N ST41651ND Wren 8
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	Mod. SMD, IPI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,200	U: 1,600 F: 1,370	U: 1,600 F: 1,370	U: 1,650 F: 1,420	U: 1,650 F: 1,420
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 33,600	*	*	*	*
Data surfaces per spindle	17	17	17	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2101	2101	2101	2110	2107
Track density (TPI)	1801	1801	1801	1760	1760
Maximum linear density (BPI) (FCI)	33344 22229	*	*		
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.5	11.5	11.5	15	15
Average rotational delay (msec)	5.56	5.56	5.56	8.3	8.3
Average access time (msec)	17.06	17.06	17.06	23.3	23.3
Data transfer rate (KBytes/sec)	3000	5000 synch.	5000 synch.	5000 synch.	10000 synch.
FIRST CUSTOMER SHIPMENT	1Q90	12/90	12/90	12/90	9/91
COMMENTS		*Varies by zone	*Varies by zone	*Varies by zone	*Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST41800K Elite 2	ST42100N Wren 9	ST81123J Sabre 5	ST81154K Sabre 5, 2HP	ST81236J ST81236K Sabre 5
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	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	IPI-2	SCSI-2	Mod. SMD	IPI-2	SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,986	U: 2,200 F: 1,900	U: 1,123	U: 1,154	U: 1,236
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 84,000	*	U: 45,792	U: 50,400	U: 50,400
Data surfaces per spindle	18	15	15	14	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2627	2574	1635	1635	1635
Track density (TPI)		2150	1289	1289	1289
Maximum linear density (BPI) (FCI)			22955 15303	25264 16842	25264 16842
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	12.9	15	15	15
Average rotational delay (msec)	5.56	8.3	8.3	8.3	8.3
Average access time (msec)	16.56	21.2	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	7500	10000 synch.	2747	6000	3000
FIRST CUSTOMER SHIPMENT	3Q91	3Q91	3Q88	4Q88	2Q88
COMMENTS		*Varies by zone	22 MHz version of Sabre 5	2 head parallel version of Sabre 5	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST81236N Sabre 5	ST82030J ST82030K Sabre 6	ST82038J Sabre 6	ST82105K 8 HP	ST42000N ST42000ND Elite 2
DISK/TREND GROUP	8	8	8	8	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	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	Mod. SMD, IPI-2	Modified SMD	IPI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,236 F: 1,056	U: 2,030	U: 2,038	U: 2,105	U: 2,000 F: 1,790
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 43,008	U: 50,400	U: 41,088	U: 50,400	*
Data surfaces per spindle	15	19	19	16	19
Heads per data surface	1	1	1	1	1
Tracks per surface	1635	2120	2611	2611	2627
Track density (TPI)	1289		1880	1880	
Maximum linear density (BPI) (FCI)	25264 16842				
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	11	12	12	11
Average rotational delay (msec)	8.3	8.3	8.3	8.3	5.56
Average access time (msec)	23.3	19.3	20.3	20.3	16.56
Data transfer rate (KBytes/sec)	3000	3000	2400	24000	10000 synch.
FIRST CUSTOMER SHIPMENT	2Q88	4Q90	3Q90	11/90	3Q92
COMMENTS			20 MHz version of Sabre 6	8 head parallel version of Sabre 6	*Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST42400N ST42400ND Elite 2	ST43200K Elite 3, 2HP	ST43400N ST43400ND Elite 3	ST43401N ST43401ND ST43402ND Elite 3	ST82272J Sabre 6
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IPI-2	SCSI-2	SCSI-2	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,500 F: 2,129	U: 3,338	U: 3,557 F: 2,904	U: 3,557 F: 2,904	U: 2,272
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	U: 45,792
Data surfaces per spindle	19	20	21	21	19
Heads per data surface	1	1	1	1	1
Tracks per surface	2627	2627	2627	2627	2611
Track density (TPI)					1880
Maximum linear density (BPI) (FCI)					21987 14658
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	11	11	11	12
Average rotational delay (msec)	5.56	5.56	5.56	5.56	8.3
Average access time (msec)	16.56	16.56	16.56	16.56	20.3
Data transfer rate (KBytes/sec)	5000 synch.	25000	10000 synch. 6000 asynch.	20000 synch.	2747
FIRST CUSTOMER SHIPMENT	3Q91	3/92	2/92	4/92	1Q90
COMMENTS	*Varies by zone	*Varies by zone 2 head parallel version of Elite 3	*Varies by zone	*Varies by zone Dual port optional	22 MHz version of Sabre 6

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST82368K Sabre PTD	ST82500J ST82500K Sabre 6	ST82500N Sabre 6	ST83050K Sabre 7 2HP	ST83220K Sabre 7
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IPI-2	SMD, IPI-2	SCSI	IPI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,368	U: 2,500	U: 2,500 F: 2,140	U: 3,050	U: 3,220
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 50,400	U: 50,400	F: 43,142	U: 127,680	U: 63,840
Data surfaces per spindle	18	19	19	18	19
Heads per data surface	1	1	1	1	1
Tracks per surface	2611	2611	2611	2655	2655
Track density (TPI)	1880	1880	1880	1912	1912
Maximum linear density (BPI) (FCI)	24200 16133	25409 16939	25409 16939	32202 24151	32202 24151
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4365	4365
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	12	12	12
Average rotational delay (msec)	8.3	8.3	8.3	6.87	6.87
Average access time (msec)	20.3	20.3	20.3	18.87	18.87
Data transfer rate (KBytes/sec)	27000	3000	3000	9340	4670
FIRST CUSTOMER SHIPMENT	3Q90	1Q90	2Q90	3/91	1/91
COMMENTS	9 head parallel version of Sabre 6			2 head parallel version of Sabre 7	

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-1085	806	XT-1120R	XT-1140	XT-1240R
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	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	Priam,SMD,SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.32	U: 227	U: 127.99*	U: 143.42	U: 239.98*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,160	U: 15,624*	U: 10,416	U: 15,624*
Data surfaces per spindle	8	11	8	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1023	1024	918	1024
Track density (TPI)	1070	1040	1070	1070	1070
Maximum linear density (BPI) (FCI)	9934	9167	14901 9934	9280	14901 9934
Recording code	MFM	MFM	2,7 RLL*	MFM	2,7 RLL*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	27	20	27	25.8	27
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	28.3	35.3	34.1	35.3
Data transfer rate (KBytes/sec)	625	1210	937.5*	625	937.5*
FIRST CUSTOMER SHIPMENT	2Q83	5/84	2Q87	2Q83	2Q87
COMMENTS			*With RLL controller		*With RLL controller

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-2190	XT-4170E	XT-4170S	XT-4230E	807
DISK/TREND GROUP	4	4	4	4	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	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Ferrite
Interface	ST412	ESDI	SCSI	ESDI	Priam,SMD,SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 191.23	U: 179.45	F: 157.93	U: 230.6	U: 344
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,940	F: 18,432	U: 20,940	U: 20,160
Data surfaces per spindle	15	7	7	9	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	1224	1224	1552
Track density (TPI)	1070	1070	1070	1070	1040
Maximum linear density (BPI) (FCI)	11155	21064 14043	21064 14043	21064 14042	12096
Recording code	MFM	2,7 RLL	2,7 RLL	2,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	28.9	14	14	16	25
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	33.3
Data transfer rate (KBytes/sec)	625	1250	4800 synch.	1250	1210
FIRST CUSTOMER SHIPMENT	3Q84	2Q87	2/86	3Q90	6/84
COMMENTS					

MANUFACTURER	SEQUEL	SEQUEL	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	SYQUEST TECHNOLOGY
DRIVE	XT-4380E	XT-4380S	8380-RXX	8380F	SQ555
DISK/TREND GROUP	6	6	9	9	1
MARKET	OEM	OEM	PCM	PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	SQ400
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	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	ESDI	SCSI	IBM	IBM	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 384.53	F: 338.41	Subsystem: 10,080 to 30,240 in 2.52 increments	F: 3,780	--
REMOVABLE	--	--	--	--	F: 44.39
Capacity per track (Bytes)	U: 20,940	F: 18,432	F: 47,476	F: 47,476	F: 17,408
Data surfaces per spindle	15	15	15/15/19	19	2
Heads per data surface	1	1	2	2	1
Tracks per surface	1224	1224	1770/3540/4192	4192	1275
Track density (TPI)	1070	1070	800/1400/1650	1650	1086
Maximum linear density (BPI) (FCI)	21064 14043	21064 14043	15240 10160	15240 10160	23642 15761
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3620	3620	3220
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	16	16	11/14/16	16	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	9.32
Average access time (msec)	24.3	24.3	19.3/22.3/24.3	24.3	29.32
Data transfer rate (KBytes/sec)	1250	4800 synch.	3000	3000	1250
FIRST CUSTOMER SHIPMENT	2Q87	4Q87	1988	1Q89	1Q88
COMMENTS			PCM 3380J,E,K Subsystem has 8 spindles 1X or 2X or 3X by pairs	PCM 3380K Drive has 2 spindles	41.3 mm high Removable data cartridge

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	SQ5110	SQ2542A	SQ3105A	SyDOS 44e SyDOS 44i	SyDOS 88e SyDOS 88i
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
MEDIA: Generic type	SQ800	SQ240	SQ310	SQ400	SQ800
Nominal disk diameter	130 mm OD 40 mm ID	65 mm OD 20 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	MIG	MIG	Ferrite	Ferrite
Interface	SCSI	PC AT	PC AT	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 88.8	F: 42.8	F: 105	F: 44.39	F: 88.8
Capacity per track (Bytes)	*	**	*	F: 17,408	*
Data surfaces per spindle	2	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1774	1936	2043	1275	1774
Track density (TPI)	1470	1598	2100	1086	1475
Maximum linear density (BPI) (FCI)	28546 19031	47055 35291	40000 30000	23642 15761	28546 19031
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3220	3247	3600	3220	3220
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	20	14.5/17*/23*	14.5	20	20
Average rotational delay (msec)	9.32	9.24	8.3	9.32	9.32
Average access time (msec)	29.32	23.7/26.2/32.2	22.8	29.32	29.32
Data transfer rate (KBytes/sec)	4000 synch. 1250 asynch.	4000	4000	4000 synch. 1250 asynch.	4000 synch. 1250 asynch.
FIRST CUSTOMER SHIPMENT	2/91	4Q92	3Q92	7/91	7/91
COMMENTS	41.3 mm high Removable data cartridge *Varies by zone	17.5 mm high. *Power save mode. Removable data cartridge. **Varies by zone	25.4 mm high Removable data cartridge *Varies by zone	41.3 mm high Removable data cartridge	41.3 mm high Removable data cartridge *Varies by zone

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TOSHIBA
DRIVE	SD-340H	SD-380H	SD-3105	SD-3210	MK-1022FC
DISK/TREND GROUP	2	3	4	5	2
MARKET	OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	
Interface	SCSI-2, PC AT	SCSI-2, PC AT	SCSI-2, PC AT	SCSI-2, PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43.01	F: 86.02	F: 105.02	F: 215	F: 22
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,480	F: 20,480	F: 20,480	F: 31,744	F: 17,920
Data surfaces per spindle	2	4	4	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1050	1050	1282	1695	615
Track density (TPI)	1500	1500	1814	2170	1450
Maximum linear density (BPI) (FCI)	33142 22095	33142 22095	33087 22058	56146 42110	39531 29648
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19	19	19	17	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	9.4
Average access time (msec)	27.3	27.3	27.3	25.3	32.4
Data transfer rate (KBytes/sec)	4000 synch. 2000 asynch.	4000 synch. 2000 asynch.	4000 synch. 2000 asynch.	4000 synch. 1500 asynch.	5000
FIRST CUSTOMER SHIPMENT	2Q90	2Q90	1/91	1/92	4/91
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	25.4 mm high	17 mm high

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-1032FB	MK-1122FC	MK-134FA	MK-232FB MK-232FBS	MK-232FC MK-232FCH
DISK/TREND GROUP	2	2	2	2	2
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads			Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	ST412	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 53	F: 43	U: 53.4	F: 45.4	F: 45.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,968	F: 22,016	U: 10,416	F: 17,920	F: 17,920
Data surfaces per spindle	2	2	7	3	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1339	977	733	845	845
Track density (TPI)	1850	2000	1000	1100	1100
Maximum linear density (BPI) (FCI)	36080 27060	51891 38918	13600	28443 18962	28443 18962
Recording code	1,7 RLL	1,7 RLL	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3402	3200	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	23	25	25	25
Average rotational delay (msec)	8.8	9.4	8.3	8.3	8.3
Average access time (msec)	24.8	32.4	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	5000 synch. 1500 asynch.	5000	625	1500	3750 (FC) 6250 (FCH)
FIRST CUSTOMER SHIPMENT	4/91	4/91	3Q87	1Q89	1Q89
COMMENTS	25.4 mm high	17 mm high	41.3 mm high	41.3 mm high MK-232FBS has 19 msec. average positioning time	41.3 mm high

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-2024FC	MK-1034FB	MK-1034FC	MK-2124FC	MK-234FB MK-234FBS
DISK/TREND GROUP	3	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	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads					Ferrite
Interface	PC AT	SCSI	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 86	F: 107	F: 107	F: 130.1	F: 106.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 22,016	F: 19,968	F: 19,968	F: 28,160	F: 17,920
Data surfaces per spindle	4	4	4	4	7
Heads per data surface	1	1	1	1	1
Tracks per surface	977	1339	1339	1155	845
Track density (TPI)	2000	1850	1850	2360	1100
Maximum linear density (BPI) (FCI)	51891 38918	36080 27060	36080 27060	65524 49620	28443 18962
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3200	3402	3402	3200	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	19	16	16	17	25
Average rotational delay (msec)	9.4	8.8	8.8	9.4	8.3
Average access time (msec)	28.4	24.8	24.8	26.4	33.3
Data transfer rate (KBytes/sec)	5000	5000 synch. 1500 asynch.	6000	6500	1500
FIRST CUSTOMER SHIPMENT	11/91	4/91	4/91	1Q92	1Q89
COMMENTS	19 mm high	25.4 mm high	25.4 mm high	19 mm high	41.3 mm high MK-234FBS has 19 msec. average positioning time

MANUFACTURER	TOSHIBA	TOSHIBA	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	MK-234FC MK-234FCH	MK-438FB	WDAC140 Caviar I	AL185 Caviar Lite	WDAC160 Caviar II
DISK/TREND GROUP	4	7	2	3	3
MARKET	Captive, OEM	Captive, OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Ferrite	Thin Film	Thin Film
Interface	PC AT	SCSI-2	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 106.0	F: 877	F: 42.5	F: 85.3	F: 62.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	*	F: 19,968	*	*
Data surfaces per spindle	7	15	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	845	1691	1079	1778	1349
Track density (TPI)	1100	1745	1401	2950	1712
Maximum linear density (BPI) (FCI)	28443 18962		31576 21057	54100 40575	33666 22444
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3598	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	25	12.5	18	16	15
Average rotational delay (msec)	8.3	8.3	8.2	8.3	8.3
Average access time (msec)	33.3	20.8	26.2	24.3	23.3
Data transfer rate (KBytes/sec)	4000 (FC) 6250 (FCH)	10000 synch. 5000 asynch.	4000	4500	4500
FIRST CUSTOMER SHIPMENT	1Q89	5/92	4/90	4Q92	6/91
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	25.4 mm high	15 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WDAC280 Caviar I	WDAH260 Tidbit	WDAH280 Tidbit II	AL2170 Caviar Lite	WDAC1170 Caviar IV
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	PC AT/XT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85.1	F: 62.8	F: 85.2	F: 170.6	F: 170.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,968	*	*	*	*
Data surfaces per spindle	4	4	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1079	1065	1405	1778	2233
Track density (TPI)	1401	1773	2463	2950	2481
Maximum linear density (BPI) (FCI)	31576 21057	35970 23980	36048 24032	54100 40575	55200 41400
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3598	3383	3383	3600	3322
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	18	19	16	16	13
Average rotational delay (msec)	8.2	8.8	8.8	8.3	9.0
Average access time (msec)	26.2	27.8	24.8	24.3	22.0
Data transfer rate (KBytes/sec)	4000	4500	4500	4500	5750
FIRST CUSTOMER SHIPMENT	4/90	1Q91	4Q91	4Q92	4Q92
COMMENTS	25.4 mm high	19 mm high *Varies by zone	19 mm high *Varies by zone	15 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WDAC2120 Caviar II	WDAC2170 Caviar III	WDAC2200 Caviar	WDAC2250 Caviar IV	WDAP4200 Piranha
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film		Thin Film	Thin Film
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 125	F: 170.6	F: 212.6	F: 255.9	F: 212.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	F: 20,480
Data surfaces per spindle	4	4	4	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1349	1584	1976	2233	1280
Track density (TPI)	1712	2400	2500	2481	1557
Maximum linear density (BPI) (FCI)	33666 22444	43000 28667	41250 27500	55200 41400	35574 23716
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3652	3652	3322	3610
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	15	14	14	13	15
Average rotational delay (msec)	8.3	8.2	8.21	9.0	8.3
Average access time (msec)	23.3	22.2	22.21	22.0	23.3
Data transfer rate (KBytes/sec)	4500	5000	5000	5750	5000 synch.
FIRST CUSTOMER SHIPMENT	6/91	8/92		4Q92	11/90
COMMENTS	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	41.3 mm high

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WINTEC TECNOLOGIA S.A.	XEBEC	XEBEC
DRIVE	WDSP4200 Piranha	WDAC2340 Caviar IV	WD-40/A	XE-3040	XE-3080
DISK/TREND GROUP	5	6	2	2	3
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	PC AT	PC AT	PC AT, IDE	PC AT, IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 209.8	F: 341.3	F: 43.24	F: 40	F: 80
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,480	*	F: 13,824	*	*
Data surfaces per spindle	8	4	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1280	2233	782	820	820
Track density (TPI)	1557	2481	1021		
Maximum linear density (BPI) (FCI)	35574 23716	55200 41400	22175 14783	33455 22303	33455 22303
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3610	3322	3329	3662	3662
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Servo type	Embedded	Embedded	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	15	13	28	19 (including settling)	19 (including settling)
Average rotational delay (msec)	8.3	9.0	9	8.2	8.2
Average access time (msec)	23.3	22.0	37	27.2	27.2
Data transfer rate (KBytes/sec)	5000 synch.	5750	640	4500	4500
FIRST CUSTOMER SHIPMENT	7/90	4Q92	1990	9/92	9/92
COMMENTS	41.3 mm high	25.4 mm high *Varies by zone	41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone

MANUFACTURER	XEBEC	XEBEC	ZENTEK	ZENTEK	ZENTEK
DRIVE	XE-3100	XE-3120	ZR 2040	ZH 3100	ZQ 2090
DISK/TREND GROUP	4	4	2	3	3
MARKET	OEM	OEM	OEM	OEM, PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Removable Drive	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	MIG	Thin Film
Interface	PC AT, IDE	PC AT, IDE	PC AT	PC AT, SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105.2	F: 120.6	--	F: 86	F: 84
REMOVABLE	--	--	F: 42	--	--
Capacity per track (Bytes)	*	*	*	F: 17,408	*
Data surfaces per spindle	6	6	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	1020	935	1020
Track density (TPI)			1850	1300	1850
Maximum linear density (BPI) (FCI)	29093 19395	33455 22303	41000 31000	27500 18333	39900 31000
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	3662	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Embedded	Embedded	Embedded
Average positioning time (msec)	19 (including settling)	19 (including settling)	20	20	18
Average rotational delay (msec)	8.1	8.2	8.3	8.3	8.3
Average access time (msec)	27.1	27.2	28.3	28.3	26.3
Data transfer rate (KBytes/sec)	1800	4500	4000	4000	4500
FIRST CUSTOMER SHIPMENT	2Q91	4Q91	1Q93	3Q91	3Q92
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	19 mm high *Varies by zone	41.3 mm high	19 mm high *Varies by zone

MANUFACTURER	ZENTEK	ZENTEK	ZENTEK	ZENTEK	ZENTEK
DRIVE	ZH 3140	ZM 3140	ZH 3270	ZH 3380	ZH 3490
DISK/TREND GROUP	4	4	5	6	6
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	Thin Film
Interface	PC AT	PC AT	PC AT	PC AT, SCSI	PC AT, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 121	F: 124.56	F: 239.03	F: 332	F: 427
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 17,920	*	F: 31,586	F: 31,586
Data surfaces per spindle	4	7	5	7	9
Heads per data surface	1	1	1	1	1
Tracks per surface	935	1553	1585	1495	1495
Track density (TPI)	1300	1850	1800	1750	1750
Maximum linear density (BPI) (FCI)	27500 18333	36000 24000	37400 28050	38880 29160	38880 29160
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	20	19	12	12	12
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	27.3	20.3	20.3	20.3
Data transfer rate (KBytes/sec)	4000	6000	4000	5000 synch. 1500 asynch.	5000 synch. 1500 asynch.
FIRST CUSTOMER SHIPMENT	3Q91	2Q92	2Q92	10/91	10/91
COMMENTS	41.3 mm high	25.4 mm high	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high

MANUFACTURER PROFILES

1992 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing moving head rigid magnetic disk drives, or which have indicated specific plans to enter the market, are listed in this section. The heading "1991 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. "1991 total net sales" covers the fiscal year ending December 31, 1991, for each firm unless noted otherwise, or for the parent company if the disk drive manufacturer is a subsidiary that does not report financial data separately.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars is given below. The average exchange rates for 1991 are used, as reported by the U.S. Federal Reserve Bulletin, and rounded to three significant figures, except that the exchange rate for the Brazilian Cruzeiro which fluctuates widely and which is not covered by the Federal Reserve Bulletin, has been averaged from several published sources.

Country	Currency	Currency units per U.S. dollar
Brazil	Cruzeiro	437.0
France	Franc	5.65
Germany	Deutschmark	1.66
Italy	Lira	1241.0
Japan	Yen	135.0
South Korea	Won	737.0
Taiwan	Dollar	26.8
United Kingdom	Pound	0.580

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

U.S. Manufacturers

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

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

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

Areal Technology was founded in February, 1988 by Jack Swartz, an industry veteran and co-founder of Maxtor. The initial target was development of a 3.5" single disk 105 megabyte drive for production start in the fourth quarter of 1989. A 2.5" 50 megabyte drive was also announced. The drives were to be among the first to use glass substrates. Nippon Sheet Glass is one of Areal's major investors. In 1990, management reorganizations resulted in Swartz leaving the company, along with the 3.5" development effort. Areal is now concentrating on 2.5" drives and moved into a new facility in mid-1990. The firm has entered into an agreement with Sanyo Electric to produce Areal's drives in Japan at its Tottori facility, and Sanyo has acquired an equity position in Areal. Production of a 2.5" single disk 62 megabyte drive began at Areal's factory and at Sanyo in 1991. 120 and 180 megabyte two platter drives started production in early 1992.

ATASI TECHNOLOGY INC.
2323-B Owen Street
Santa Clara, CA 95054

Atasi Technology (no relation to the original Atasi Corporation except for a few employees in common) followed an end-of-life strategy, acquiring the rights to manufacture older disk drive designs and manufacture them as long as demand holds up. Atasi Technology started by purchasing rights to manufacture Priam's 5.25" 190 and 380 megabyte drives and the original Atasi 85 megabyte drive in 1989. Production ended in 1991.

AURA ASSOCIATES
12930 Saratoga Avenue
Saratoga, CA 95070

Aura Associates, founded by industry veterans in mid-1986, initially planned

to develop a 2.5" drive using multiple actuators and offering very fast access time and transfer rate. An early model of the drive was demonstrated at the 1988 Fall Comdex, but was never produced. More recently, Aura designed 1.8" drives which are now in production by NEC, but for which Aura also retains manufacturing and sales rights. The company has recently announced an agreement with DZU, the Bulgarian state-owned disk drive manufacturing organization, under which DZU will produce 1.8" drive head/disk assemblies for Aura on a contract basis.

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 ceased production of 5.25" drives. The company began production of several models of 3.5" drives in the 170 to 226 megabyte range in mid-1990, and is now concentrating on models in the 200 to 800 megabyte range.

CERPLEX TECHNOLOGIES
3332 La Palma
Anaheim, CA 92806

Cerplex is the renamed successor of Century Data, Inc. After several years of flat sales, Century Data Systems was sold in mid-1986 by Xerox, and in a complicated restructuring involving Cybernex, the previous thin film head manufacturer, evolved into Century Data, Inc., combining the operations of Century Data Systems, Cybernex Advanced Storage Technology (CAST), Amcodyne, Tecstor, and Ford-Higgins, a subsystem producer. The Century product line had been in transition for years, as newer fixed disk drives gradually replaced products in production before the acquisition by Xerox in 1979. Century pinned its hopes on higher capacity 8" drives 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. The change of company name in 1990 reflects another corporate reorganization and a new emphasis on drive refurbishment as a primary line of business. Only a few 8" disk drives were produced in 1991 and production ceased at year end.

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

1991 disk sales: $1,567,600,000
1991 Total net sales: $1,598,984,000 Net income: $92,492,000

By any measure, the rapid growth of Conner Peripherals remains one of the industry's outstanding success stories. The firm is headed by Finis Conner, co-founder of Seagate Technology, and the first product was designed by a development company organized by John Squires, who was a key member of the Miniscribe technical staff until early 1985. Shortly after its founding, the company attracted a minority investment by Compaq Computer and built a production facility to make 3.5" 40 megabyte drives. By mid-1987, shipments, mostly to Compaq, had reached high levels, and facilities were rapidly expanded. In addition to adding another facility at the original site, Conner established high volume production in Singapore, and in 1989 moved into a new headquarters building. Conner also entered into a joint venture with Olivetti, resulting in construction of a new manufacturing facility in Italy which makes a portion of the Conner product line for captive use by Olivetti and for OEM sales in Europe. Conner increased its share of ownership from 51% to 81% in 1990. Conner also established an additional wholly owned factory in Scotland in 1990. Sales to Compaq have declined to about 11% of the Conner total in recent quarters, reflecting continued success in attracting new OEM business. In 1992, Conner established a subsidiary, Conner Technology, Inc., to manufacture small tape drives using technology obtained from 3M. At the same time, Conner created business units to market drives and drive subsystems through VAR and other distribution channels. In September, 1992, the firm announced it would begin manufacturing drives in China via a joint venture with Shenzen CPC, a subsidiary of China Electronics Corporation.

Because of the firm's early entrance into the 2.5" market, combined with the ability to deliver large quantities of drives, Conner has achieved a major share of the market for hard disk drives in the notebook computer market. A 32 megabyte 1.8" drive was announced in 1992. On the high end, Conner has extended its 3.5" family to 1.3 gigabytes.

While Conner Peripherals has indicated its desire to concentrate upon drive assembly rather than become vertically integrated, the firm has made acquisitions of what it believes are key technologies, including the sputtered disk production facilities of bankrupt Domain Technology and the 1991 purchase of VISqUS Corporation, a development firm working on a method of near-contact recording using a continuous lubrication technique. Conner has sold off its head stack assembly operation, suggesting that vertical integration will be limited to what Conner considers critical strategic component technologies.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1991 disk sales: $776,400,000
1992 total net sales: $13,930,872,000 (FY ending 6/27/92) Net income: ($2,795,507,000)

Digital has maintained internal disk drive manufacturing programs for more than 20 years, initially with disk cartridge drives, but did not venture into designing high end drives until 10 years ago. The RA80 series of 14" drives, now out of production, was followed in 1988 by the 9" RA90 series, now approaching end-of-life. The RA70 series of 5.25" drives, also first produced in 1988, have become Digital's highest volume disk drives. In recent years Digital has also been a major customer for OEM 5.25" and 3.5" SCSI drives for use with its engineering workstation systems.

In a major departure from its previous policy of limiting its disk drive activities to captive programs, Digital announced an OEM marketing program for new high end 5.25" and 3.5" drives in late 1991. The new 2.0 gigabyte 5.25" drive is produced at Digital's manufacturing facility in Kaufbeuren, Germany. The high-end 3.5" and 2.5" drives are manufactured at Colorado Springs, using Digital's internally manufactured thin film heads. The new drives represent a renewed Digital effort to stay with the industry leaders in 5.25", 3.5" and 2.5", with reorganized management and manufacturing organizations, and utilizing vertical integration in production of critical components. While there has been skepticism concerning Digital's viability as an OEM supplier, by mid-1992, Digital had established a position as the leading OEM supplier of 1 gigabyte 3.5" drives.

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. By mid-1986, the bank had been paid off and the firm restarted operations as DMA Technologies. A 25.5 megabyte half high drive with removable media was announced in mid-1988.

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

1991 disk sales: $280,700,000
1991 total net sales: $14,494,000,000 Net income: $755,000,000
(FY ending 10/31/91)

Hewlett-Packard has an extensive manufacturing operation for disk drives at Boise, Idaho, established in 1977, supplemented in mid-1983 with a facility in Bristol, England. H-P has made disk cartridge, disk pack, and fixed Winchester disk drives at Boise, which is also the firm's development and manufacturing facility for sputtered disks. During 1987, H-P introduced 5.25" drives with capacities up to 389 megabytes and 8" drives with up to 571 megabytes. Also during 1987, the company launched an OEM sales program for rigid disk drives, spearheaded by the new 5.25" models. The OEM disk drive 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 2 gigabytes. As of mid-1992, the 3.5" line extended to a gigabyte. In 1989, H-P startled the industry by announcing 150,000 hour MTBF and a five year warranty for its 5.25" drives, an action which substantially improved H-P's visibility in the OEM market. The MTBF specification on the newest high end 5.25" drives has been extended to 300,000 hours. H-P's credentials as an OEM disk drive producer were significantly enhanced with its announcement of the first 1.3" drive in 1992. The 21 megabyte "Kittyhawk" drive will be in production by late 1992, and will be initially targeted at a wide variety of nontraditional applications.

INTEGRAL PERIPHERALS
5775 Flatiron Parkway
Boulder, CO 80301

Integral Peripherals was founded in September, 1990, by engineering and management personnel who previously pioneered in early 2.5" drives at Prairie-Tek. The company was the first to design and manufacture 1.8" disk drives. Its initial product was a 20 megabyte drive, first produced in the second half of 1991, and for which the available market was minimal. Integral has had somewhat better luck with a 42 megabyte model, in production since early 1992, and a 64 megabyte model, available since early summer. The 1.8" drives use ramp loaded MIG heads, and are designed to high operating shock and vibration specifications, with low power requirements, in anticipation of wide usage in subnotebook computers and other portable computer applications. Integral began its high volume manufacturing in Singapore in mid-1992.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1991 disk sales: $11,313,900,000
1991 total net sales: $64,792,000,000 Net income: ($2,827,000,000)

In July, 1990, IBM created the new Storage Systems Products Division, encompassing the previous General Products Division, which held responsibility for more than twenty years for disk and tape drives for mainframe applications, and Low End Disk Operations, established during the 1980's to coordinate IBM's worldwide development and manufacturing operations for disk drives used in personal computers and mid-range systems. In early 1992, SSPD became Adstar, one of IBM's new wholly owned subsidiary companies. IBM manufactures 10.8", 5.25", 3.5" and 2.5" fixed disk drives at several factories in the United States, Europe and Japan. The revenue leader is clearly high-end drives for mainframe computers, now primarily the 3390, supplemented by 5.25" models.

After a flurry of activity during the first half of the 1980's resulted in various 14", 8", 5.25" and 3.5" drives without much distinction, IBM in the last three years introduced several drives which place it in the first tier of mid-range and low-end disk drive manufacturers. These include the 1 gigabyte and up 3.5" "Corsair" series, 5.25" 857 megabyte "Redwing" and 1/1.5 gigabyte "Sutter/Sawmill", 1" high 3.5" "Kai" 100 and 200 megabyte drives, and the "Tanba" 2.5" drive series, including a 12.7 millimeter high single disk model introduced in 1991. 1.8" drives have appeared in trade show exhibits, but have not yet been formally introduced. Other new drives are also expected soon, including high-end Tanba models with capacities over 200 megabytes, the 2 gigabyte 3.5" Corsair-4, and the "Spitfire" series of high-end 1" high 3.5" drives. The venerable 14" 3380 series was superseded by the 10.8" 3390-1/2 in December of 1989 and in turn by the 3390-3 in September, 1991, with capacity per spindle of 5,676 megabytes. IBM is expected to offer one more "mid-life kicker" for the 3390 next year, boosting capacity to the range of 17 gigabytes.

IBM's first significant OEM sales of disk drives were made in 1984, when the firm began selling the 3380 to both Siemens and Honeywell. Some low-end 3.5" drives with Microchannel interfaces have been sold to European system manufacturers who chose to offer personal computer models with the Microchannel bus. For disk drives broadly sold on an OEM basis, it has been more difficult for IBM to establish significant sales, due to tough competition. Despite the difficulties, IBM has had gradually increasing success in marketing 3.5" drives in the personal computer aftermarket through distribution, and in sales to other system manufacturers of both 2.5" and 3.5" drives offered early in their life cycles. Currently, IBM has offered the 2 gigabyte Corsair-4 to numerous system manufacturers on an OEM basis, even before it has been announced. The most important OEM disk drive sale so far for IBM has apparently been a by-product of the newly inspired spirit of cooperation between IBM and Apple Computer -- the purchase of 160 megabyte 3.5" drives for the Macintosh.

KALOK CORPORATION
1287 Anvilwood Avenue
Sunnyvale, CA 94089

1991 disk sales: $81,300,000

Kalok was founded in 1987 by Wayne Lockhart and Steve Kaczeus, a well-known designer of low-end disk drives, to participate in the market for 20 and 40 megabyte 3.5" drives, designed for very low manufacturing cost. Unable to obtain adequate funding from U.S. venture capital sources, the firm negotiated a manufacturing and inventory financing arrangement with Oriental Precision Company of South Korea. OPC started manufacturing Kalok drives in mid-1988 with substantial shipment levels. In order to broaden its production base, Kalok in 1989 also established a plant in the Philippines, the first hard disk drive producer to do so. In late 1991, Kalok sold its Philippines factory to Xebec Co. Ltd, a Japanese firm based in Tokyo, and announced a contract manufacturing relationship with Xebec. Subsequently, Kalok sold its entire stepping motor drive product line to Xebec, retaining only the design for a .5 inch high 200 megabyte 3.5" drive which the firm is currently attempting to put into production.

MAXTOR CORPORATION
150 River Oaks Parkway
San Jose, CA 95134

1991 disk sales: $928,500,000
1991 total net sales: $1,037,481,000 (FY ending 3/28/92) Net income: $7,149,000

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

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

extending from 40 to 130 megabytes and a 2.5" 85 megabyte drive that was announced in the third quarter of 1991.

After the departure of several key employees in mid-1987, new management was unable to move a procession of announced new products rapidly into manufacturing, with a severe negative financial impact, resulting in new management shuffles. The newest management team has apparently succeeded in reestablishing the leading edge product development programs that created its original success and as of mid-1992 had experienced several quarters of improving financial performance. The older drive models in the 5.25" product line have been sold to Sequel, which now produces them, and Maxtor is now concentrating on 3.5" and smaller drives. Maxtor's product line now includes 2.5" drives with capacities to 128 megabytes, several mid-range 3.5" drives, and a 1.2 gigabyte 3.5" model operating at 6,300 RPM, the fastest production drive so far.

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

The pioneer magnetic media and plug compatible disk drive producer originally known as Memorex Corporation was acquired by Burroughs in late 1981, and Burroughs placed all disk drive development and manufacturing responsibility for the entire company in the Memorex organization. In late 1986, however, Burroughs sold the disk drive sales and service operations of Memorex to a group of Memorex executives, retaining only the rigid disk development and manufacturing operations. Telex was acquired by Memorex in early 1988 and the firm adopted its new name. Plug compatible disk drive subsystems now sold and serviced by Memorex Telex use various drive mechanisms manufactured by Fujitsu and Seagate. Memorex, now headquartered in Europe, includes PCM marketing operations, the Memorex Communications Division, and the flexible media operations. The firm is under financial stress, and in mid-1991 announced that it would enter a "pre-packaged bankruptcy" arrangement in the Fall of 1991. The associated restructuring was completed in February, 1992.

MFM TECHNOLOGY, INC.
North Andover, MA 01845

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

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1991 disk sales: $346,600,000
1991 total net sales: $350,875,000 Net income: $4,343,000

Known as the originator of what were then considered high capacity 5.25" flexible disk drives, Micropolis started production of 8" Winchester disk drives in 1979 and became a factor in the marketplace, after the usual Winchester early production problems. Micropolis has been the 5.25" industry leader at 85 megabytes and 170 megabytes, and a close contender for leadership at 380 megabytes, 760 megabytes, and the 1-2 gigabyte range. A 3 gigabyte 5.25" drive was announced in 1992. Heavy price competition in lower capacity "cash cow" products and delays in getting newer products into volume production hurt Micropolis' financial results during the late 1980's, and the firm had to cancel its 3.5" development program in order to concentrate on 5.25" drives. After returning to profitability in 1990, Micropolis reentered the 3.5" drive market in 1991 with the first announced 1 gigabyte 3.5" drive. Although an earlier effort had been aborted, Micropolis succeeded in entering the disk drive array market in late 1991, creating a separate division to market a modular array in the subsystem market.

MICROSCIENCE INTERNATIONAL CORPORATION
1015 East Brokaw Road
San Jose, CA 95131

Microscience International, incorporated in 1982, started shipments in mid-1983 for its half high 5.25" drive using plated disks. A shift in customer demand from 5.25" drives to 3.5" drives hampered growth in 1989, but newer 3.5" drives with capacities to 420 megabytes have been introduced. In 1990, Microscience also expanded its product line by purchasing the rights to manufacture and market the Siemens 5.25" 777 megabyte and 1.2 gigabyte drives. A 1.6 gigabyte drive is scheduled for late 1992 production.

Microscience has established a joint venture, Microscience Shenzen, in the People's Republic of China. Operations began in October of 1990. The firm also joined with Wearnes Brothers, Ltd., to establish a manufacturing facility in Singapore, now in production, and started its own production in Taiwan in 1987 for voice coil drives. Wearnes Brothers is a major investor in Microscience, owning 20% of the U.S. based parent and 59% of Microscience International (Singapore) Ltd. Microscience weathered a management change in 1987, and in 1990 became a publicly owned company. Additional management changes in early 1991 were followed by transfer of all manufacturing to the overseas facilities. Production in Taiwan ceased in 1991.

MILTOPE CORPORATION
1770 Walt Whitman Road
Melville, NY 11747

Miltope has manufactured both flexible and rigid disk drives for use in its line of militarized peripherals, which include disk, tape and bubble memory subsystems. In 1988, Miltope acquired the disk drive product line of Vermont Research. Miltope's internally manufactured Winchester drives included 5.25" models incorporating heads and media in removable cartridges, but internal manufacturing of drive mechanisms has been halted. The firm now buys drives from others and modifies them for militarized applications.

MINISTOR PERIPHERALS CORPORATION
2801 Orchard Parkway
San Jose, CA 95134

Founded in 1991 by former Maxtor executives and funded by seed money from venture capitalists, Ministor is developing 1.8" diameter drives. Despite management changes and a skeptical venture capital market, the firm has managed to acquire the necessary resources to continue its program and plans to start production of 32 and 64 megabyte drives in 1992.

ORCA TECHNOLOGY
1751 Fox Drive
San Jose, CA 95131

Formed in July, 1990, Orca purchased rights to manufacture the 3.5" "Shrike" 400 megabyte drive that had been under development by Priam before Priam's demise, as well as rights to the Priam 5.25" 760 megabyte "Falcon" drive, and a considerable amount of Priam's tooling, inventory and fixtures. The firm arranged for manufacture of the 5.25" drives starting in 1991 by Magtron in Taiwan, with sales by both Orca and Magtron, and for production of 3.5" drives by Zentek, with first production scheduled in late 1991. Efforts to start up production facilities in Eastern Europe were frustrated by exhaustion of funds, and the firm was dissolved in bankruptcy in 1992.

PLUS DEVELOPMENT CORPORATION (See Quantum Corporation)

QUANTUM CORPORATION
1804 McCarthy Boulevard
Milpitas, CA 95035

1991 disk sales: $1,072,400,000 (including Plus Development)
1992 total net sales: $1,127,733,000 Net income: $46,844,000
(FY ending 3/31/92)

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

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

Quantum was able to reestablish growth in OEM drive shipments in 1987, through successful implementation of an emergency plan to quickly develop an OEM 3.5" drive using the Hardcard design and tooling, with manufacturing by Matsushita-Kotobuki Electronics. While Quantum has designed all of its 3.5" drives, manufacturing of low-end models is done in Japan by MKE. MKE has rights to distribute the drives it manufactures within Japan, under a Quantum license. High-end 3.5" drives are manufactured in a new, highly automated facility in California. MKE is establishing a factory in Dundalk, Ireland, to manufacture Quantum drives for the European market. Production is scheduled for October, 1992. The Quantum-MKE relationship is considered successful and has contributed to the higher than industry average margins typically enjoyed by Quantum.

Quantum's OEM products now include 3.5" drives from 42 megabytes to 1.2 gigabytes capacity. 2.5" 42 and 86 megabyte drives began shipping in mid-1991, and the 2.5" product line has since been extended to 169 megabytes. Quantum has emphasized drive intelligence, including such features as self-testing and cache.

In 1991, Quantum further strengthened its efforts to increase sales through distribution, folding Plus Development and its industrial distribution activities into a business unit named Quantum Commercial Products. Quantum also operates a direct marketing subsidiary, LaCie Ltd., which has been attached to the new business unit. About 30% of Quantum's revenue comes from distribution.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1991 disk sales: $2,614,700,000
1992 total net sales: $2,875,273,000 Net income: $63,183,000
(FY ending 6/30/92)

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

After 1985, a major part of Seagate's growth came from the personal computer aftermarket. IBM cut back purchases of Seagate drives in favor of internal captive production, but Seagate launched a successful campaign to take the business away from IBM at the dealer level, with phenomenal success. But the company was vulnerable to IBM's "bundling" hard disk drives with systems at the factory instead of giving dealers an easy opportunity to upgrade with independent disk drives. The effect of this bundling, plus Seagate's late arrival in the 3.5" marketplace, cut into Seagate's shipment rate. The firm overestimated the market in early 1988, causing excess inventory accumulation and disappointing financial results. However, Seagate demonstrated the resiliency likely to be necessary for future survival, and after an unprofitable 1988 winter quarter, returned to profitability in 1989. However, the economic recession of 1990-91 and Seagate's aging product line for the personal computer market again resulted in flattening revenues and the expectation of further losses.

In October, 1989, Seagate completed an agreement with Control Data to acquire Imprimis Technology in a deal valued at $450 million. There was little overlap between the product lines of Seagate and Imprimis, or between Seagate's predominantly aftermarket distribution and Imprimis' predominantly OEM sales. The Imprimis headquarters function has been completely integrated into Seagate's, and operational control of products and manufacturing has now been divided into "California" and "Oklahoma" operations.

The new Seagate has maintained an aggressive pace of product development and market leadership with the high end 5.25" and 3.5" drives developed at the Oklahoma operations. But because its older 5.25" drives were fading fast, and in order to improve penetration of the OEM market for its small diameter products, Seagate has undertaken a "time to market strategy" in an attempt to catch up with the industry leaders in the 2.5" and low end 3.5" markets. In late 1991, the company made key changes in executive management in an attempt to reassert product leadership and appears to be successful in establishing its planned aggressive product development program.

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

Sequel was created in November, 1989, as the result of a management buyout of the Unisys rigid disk drive and media production facilities. Sequel supplies new drives to other companies on a contract manufacturing basis, as well as refurbishing older drives. The firm also supplies some media on an OEM basis. Shortly after its establishment, Sequel acquired the rights to manufacture several of Priam's product lines, and has since acquired rights to Maxtor's older 5.25" drives, including the XT1000, XT2000 and XT4000 series.

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

1991 total net sales: $1,584,904,000 Net income: $93,074,000

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. After a series of complex negotiations with creditors, the firm emerged from bankruptcy in mid-1987.

Orders for STC's innovative 1/2" tape cartridge library system have been strong, and have been instrumental in restoring STC's position in the storage products industry. However, shipments of drives equivalent to IBM's 3380K did not start until 1989, and the firm has never regained its earlier share of the IBM plug compatible market. In 1990, the firm began discussing new products incorporating disk drive arrays to be sold into the PCM marketplace. The low-end of the array product line will incorporate array hardware and software from Array Technology, which will be resold by Storage Technology. The high-end "Iceberg" array project, which uses purchased 5.25" drives, was to be available in the first half of 1992, but had slipped at least two quarters as of mid-1992.

SYQUEST TECHNOLOGY
47071 Bayside Parkway
Fremont, CA 94538

1991 disk dales: $63,300,000
1991 total net sales: $115,137,000 Net income: $6,007,000

SyQuest was started in early 1982 to make disk drives using 3.9" (100 mm) plated disks, in both fixed and removable disk configurations. After initial early emphasis on the personal computer aftermarket, SyQuest established significant OEM sales, with major shipments to the segment of the PC market controlled by governmental security requirements. SyQuest also manufactures the disk cartridges for the drives, and cartridges accounted for 51% of 1991 revenue. The firm went public in December, 1991. The firm began shipping removable 5.25" drives with formatted capacity of 44 megabytes and embedded SCSI controllers in 1988, achieving significant success in the Macintosh add-on market. In 1989, Syquest began operations in Singapore. In early 1991, Syquest began shipping an 88 megabyte 5.25" removable drive.

A 3.5" drive development was started in 1990 in the company's newly formed SyCo division, resulting in a 105 megabyte drive announcement in 1991. A subsidiary corporation, Iota Memories, was also formed in 1991 to develop a 2.5" drive and cartridge. A 42 megabyte 2.5" drive was announced in late 1991. The firm hopes to begin shipments of both 3.5" and 2.5" drives by the end of 1992. The firm also established a subsidiary, SyDOS, in 1991 to sell subsystems containing its drives in the IBM PC compatible marketplace.

WESTERN DIGITAL CORPORATION
2445 McCabe Way
Irvine, CA 92714

1991 disk sales: $540,000,000
1992 total net sales: $938,332,000 Net income: ($72,860,000)
(FY ending 6/30/92)

Western Digital, a major supplier of controllers and specialized semiconductor components, entered the rigid disk drive market by purchasing the rigid disk drive operations of Tandon at the end of 1987. The product line now consists of 3.5" and 2.5" drives in the 30 to 341 megabyte range. 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. The two disk, 341 megabyte "Caviar IV" model is scheduled for shipment in late 1992.

The company has passed through a difficult period of several losing quarters and has undergone significant structural and management changes, but returned to profitability in mid-1992.

Asian Manufacturers

(All fiscal years end in March, 1991, unless otherwise noted. All companies are in Japan unless otherwise noted.)

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

1991 total net sales: $3,423,874,000 Net income: $61,185,000

Alps Electric, founded in 1948, is a manufacturer of electronic components and subassemblies for television, audio, instruments and computer applications. The firm builds floppy disk drives on an OEM basis, and started production in the U.S. in 1987. In 1988, a facility to make various computer peripherals was established in Ireland. About 15% of Alps' shipments are computer peripherals, mostly disk drives and printers. In 1985, Alps introduced a line of 5.25" half high and 3.5" rigid disk drives and in 1986, Alps became the first manufacturer to announce a 30 mm high 3.5" drive. The company has continued the development of its rigid disk drives, and the 3.5" product line extended to 211 megabytes in mid-1992.

Alps entered into an agreement with PrairieTek to produce the PrairieTek 2.5" drives on a contract basis, and production under this contract began in 1990. Alps continues to produce the drives, even though PrairieTek has ceased manufacturing operations. The current 2.5" products include 85 and 135 megabyte drives.

CHC TECHNOLOGY (MAGTRON, INC.)
57 Section 3, Ming-Shen East Road
Taipei, Taiwan

The company was founded in September, 1988, as Damax, but was subsequently renamed Magtron. In early 1992, the firm was renamed CHC Technology as a result of a major investment from Cheng Hong Chemical company. Magtron will be retained as a brand name for marketing purposes.

The firm licensed the CAST 5.25" 115, 140, and 170 megabyte half high drives for its initial products. In 1989, a subsidiary, Pacific/Magtron, was established in the U.S. to market the Magtron products and to serve as a design center for new 40 and 80 megabyte 3.5" drives announced in 1991. However, the firm withdrew these products when it determined that production volumes would not be large enough to permit competitive pricing.

Magtron agreed to make Orca's high capacity 5.25" drives, planned for capacities from 400 megabytes to 1 gigabyte. Production of 400 and 760 megabyte models began in mid-1991, and a 1 gigabyte drive was announced for delivery in late 1991, but Orca's bankruptcy has seriously hampered this effort.

EPSON (See Seiko Epson)

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

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

Peripheral Technology was founded in 1985 to develop a 3.5" drive first shipped in 1986, with founders who had worked together at Dataproducts. 70% of PTI was owned by Haitai International, a Korean consumer products company, but in mid-1987, this interest was sold to Live Systems, a Japanese company serving the medical market and production moved to Korea. In early 1989, control of PTI was assumed by Tongil Machinery Co., a manufacturer of machine tools and auto parts, as a diversification move. In February, 1990, the company was renamed EsPerT. A further change in status occurred in 1991 when the firm was purchased by Daeyoung, following a financially disastrous year of technical problems with the EsPerT 41 megabyte 3.5" drive. Daeyoung undertook to redesign the drive and expects to resume shipments of improved drives in 1992.

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

1991 disk sales: $45,200,000
1991 total net sales: $6,209,333,000 Net income: $1,697,548,000

Fuji Electric was established in 1923 and is the firm from which Fujitsu was born in 1935. Fuji Electric still owns about 13.5% of Fujitsu (which owns 7% of Fuji Electric). The firm manufactures power generating equipment, electrical equipment for the transportation sector, vending machines and instrumentation. Data storage products include sputtered media (of which Fuji Electric is a significant supplier) and 3.5" disk drives. The firm began selling 3.5" drives under its own name in 1985, but cut back on export sales in 1988, squeezed by exchange rates and low priced competition. 1 inch high 91 megabyte drives were introduced in 1990 and a 43 megabyte 19 millimeter high 2.5" model became available in 1991. As of mid-1992, the 3.5" drive family was up to 249 megabytes and a 2.5" family with capacities to 105 megabytes had been announced. 40 megabyte 2.5" drives began shipping in late 1991. In mid-1992, Fuji Electric entered into a contract manufacturing agreement with Integral Peripherals, in which Fuji Electric will manufacture 1.8" drives intended for the Japanese market.

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

1991 disk sales: $1,861,300,000
1991 total net sales: $22,010,830,000 Net income: $612,393,000

Fujitsu derives about 70% of its sales from the computer industry and is known as the leading manufacturer of computers for the Japanese domestic market. Fujitsu is also a major exporter to the worldwide computer market. Since 1982, the company has been among the leaders in worldwide disk drive revenues, and skillfully managed a transition from older removable disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters. Fujitsu is manufacturing some of its high performance drives at a major facility near Portland, Oregon, which is now in full operation. Some low end 3.5" drives are produced in Thailand. Intellistor, located in Longmont, Colorado, is a Fujitsu subsidiary developing small diameter disk drives and drive arrays. Fujitsu also has 44% ownership in Amdahl.

Fujitsu has marketed most of its captive drives in OEM versions, using industry standard OEM interfaces, and is a leader in the U.S. market for OEM rigid disk drives. Fujitsu is also a major factor in the IBM plug compatible disk drive market with sales first of 10.5" drives, and later 8" models, through Amdahl. Particularly effective in the OEM market has been the series of high performance 8" 48/84/168/337/690/824/1000/2000/2600 megabyte drives. Fujitsu's 5.25" product line was extended to 2 gigabytes in 1991, and an extensive 3.5" line ranges from 25 to 1 gigabyte (formatted). A 90 megabyte 2.5" drive was announced in September, 1991. Fujitsu has joined the "reliability wars" by specifying its high capacity 5.25" and 3.5" drives at 200,000 hours MTBF.

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

Greenery initially produced 3.5" 60 megabyte drives based upon technology developed by ITRI, a government research organization. Production started in late 1990. Additional 3.5" drives with capacities to 105 megabytes were also announced, but production never ramped up and the firm subsequently shut down operations.

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

1991 disk sales: $1,187,300,000
1991 total net sales: $57,310,822,000 Net income: $1,705,074,000

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 for both captive and noncaptive markets. In addition to significant OEM sales of smaller capacity fixed disk drives, Hitachi also sells IBM compatible 3380 equivalent drives through Hitachi Data Systems (formerly National Advanced Systems, before acquisition by Hitachi), and in 1983 started selling 3380 equivalent drives for distribution in the European PCM market through BASF, and currently through Comparex. 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. Current IBM plug compatible drive subsystems utilize Hitachi's 9.5" drives, including a 3390-3 equivalent version announced within a week after IBM's 3390-3 announcement. In the spring of 1987, Hitachi began shipping rigid disk drives from a manufacturing facility in Norman, Oklahoma, which makes high-end rigid drives and a line of 5.25" optical disk drives. Hitachi has announced plans to make large disk drives in France beginning in 1992.

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

Hyosung was formed in 1979 to help its parent diversify into the computer industry. The firm produces a variety of small systems and specialized terminals. The computers are sold in the U.S. under the Maxar brand. In 1987, Hyosung made a minority investment in Brand Technologies and started production of the Brand full size 5.25" drives, for sale by Hyosung. The firm ceased production of disk drives in mid-1991.

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

1991 disk sales: $127,600,000
1991 total net sales: $6,861,156,000 Net income $118,593,000

JVC's revenues are generated mostly by consumer electronics products. The firm has been the beneficiary of sharp growth in the home video recorder market and consumer electronics now account for 88% of total revenues.

Matsushita Electric Industrial holds 52.4% ownership. JVC is now expanding into software and computer peripherals, starting in 1984 with 5.25" floppy disk drives, a program since dropped due to small market share and unfavorable exchange rates. 3.5" rigid drives were first shipped in 1985, and the present 3.5" product line includes 25.4 mm high and 20.8 mm high drives aimed at the laptop computer market, with the largest capacity drive an 85 megabyte model. JVC was an early producer of 20 megabyte 2.5" drives and began shipping 40 megabyte 19 mm high drives in late 1990 and began shipping a 12.7 millimeter high 64 megabyte drive in mid-1992. JVC and Rodime explored having JVC produce a 120 megabyte drive for Rodime, but the project was dropped.

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

1991 total net sales: $3,416,541,000 Net income: $238,889,000

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. LaPine's operations were subsequently halted, and Kyocera produced the drives under its own name. In 1990, the firm introduced 40 and 80 megabyte (formatted) 3.5" drives. Kyocera was unable to generate adequate volume and halted all rigid disk drive production in mid-1991.

KYUSHU MATSUSHITA ELECTRIC CO., LTD.
4-1-62 Minoshima
Hakata-ku
Fukuoka

1991 total net sales: $2,231,074,000 Net income: $81,637,000

Kyushu Matsushita Electric (KME), a subsidiary of Matsushita Electric Industrial Co. (MEI), was founded in 1951 to supply electrical components for MEI. Its first products were electric transformers and pumps, but the firm has since diversified into factory automation, telecommunication, audio, video and other electric equipment. MEI owns 50.4% of KME.

Perhaps best known in the disk drive industry as one of the world's largest magnetic head suppliers, KME surprised the industry in 1991 when the company introduced a 1" high 210 megabyte 3.5" drive using negative pressure sliders to control head flying height. The drive was originally scheduled for shipment in the Fall of 1992, but KME decided not to put it into production.

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

1991 total net sales: $2,027,400,000 Net income: $75,622,000

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 57.6% of MKE.

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

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

1991 total net sales: $24,564,763,000 Net income: $590,815,000

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. After many years of producing a variety of removable disk drives, plus a later manufacturing program for small diameter fixed disk drives at a highly automated facility near Osaka, most disk drive operations have been discontinued. Captive shipments were the major portion of Mitsubishi's disk drive shipments, and an attempt to garner OEM business in small diameter Winchester drives was not successful. 9" drives with capacities to 630 megabytes for Mitsubishi Electric captive applications are the only rigid disk drives still in production.

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

1991 total net sales: $1,174,874,000 (FY ending 1/31/91) Net income: $11,341,000

Mitsumi is primarily a component manufacturer, but also manufactures floppy drives (about 9% of 1990 sales) and has manufactured 3.5" rigid disk drives. Mitsumi has had a rigid drive development program in place for some time, but so far has had some difficulties in having products ready to catch the start of the newest product cycles.

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

In late 1991, a group of Taiwanese investors purchased the corporate shell of Myrica Trading Company and subsequently acquired Rodime's Singapore production facilities and some Rodime R&D facilities in Scotland. The firm is planning to produce several of Rodime's 3.5" disk drive designs and is currently in production of models in the 100 to 200 megabyte range. 540 megabyte drives are planned for introduction by late 1992.

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

1991 disk sales: $1,307,200,000
1991 total net sales: $27,398,504,000 Net income: $402,837,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 49% of the firm's total revenues. Current disk drive production involves fixed disk drives, from large to small configurations, for both captive and OEM markets. Fixed disk drives include 14", 9", 8", 5.25", 3.5" and 1.8" disk diameters. The 1.8" model was designed by Aura Associates, which also has manufacturing rights. 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. 3.5" drives have now reached 426 megabytes, the 5.25" product line has attained 1.5 gigabytes, and the 9" line has reached 3 gigabytes. NEC was the first of the major Japanese drive producers to produce small form factor rigid disk drives offshore, with the establishment of a factory in the Philippines.

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

OPC, founded in 1953, was one of Korea's pioneering firms in the electronics industry, a major supplier of telecommunications equipment, broadcasting equipment, and a volume producer of small computers and peripherals. In the past, OPC produced a 3.9" cartridge disk drive on a contract manufacturing basis for SyQuest, as well as 3.5" drives for Peripheral Technology. Most recently, OPC made a minority investment in Kalok, and since mid-1988 manufactured Kalok's 3.5" drives in substantial quantities on a contract basis for sale by Kalok. In 1991, OPC was purchased by Jade Insurance, part of the Korea Chemical group, which is, in turn, a Hyundai group affiliate. The new owners withdrew from disk drive manufacturing, and production ceased in 1991.

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

1991 total net sales: $7,431,578,000 Net income: $100,422,000

Copiers, sensitized papers and photographic equipment provide the major portion of Ricoh's revenues, but the firm has invested in a growing line of data processing equipment since 1979. About 29% of revenues are from information processing products. Its first disk drives were 8" floppy drives made under a license from Calcomp.

In 1985, Ricoh obtained a license to make the DMA 5.25" cartridge disk drive design, and production began in 1986. 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 introduced a 50 megabyte removable cartridge drive.

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

1991 total net sales: $7,092,442,300 Net income: $93,118,000

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 manufactured Comport's 3.5" line of disk drives until Comport went out of business. As of mid-1991, Samsung's production of disk drives was entirely in 3.5" models ranging from 50 to 245 megabytes. Samsung maintains an R&D center for disk drive design in San Jose, California.

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

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

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

1991 total net sales: $27,339,081,000 Net income: $866,111,000

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

The firm's first entry into the rigid disk drive market came in 1987, with half high 5.25" SCSI drives offering up to 40 megabytes formatted, but Sony decided to withdraw the product due to late market entry. Undiscouraged, Sony introduced a 42 megabyte 3.5" drive in 1989. Sony produced the drive, since discontinued, for Apple Computer, and continues development activities for rigid disk drives.

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

1991 total net sales: $943,370,000 Net income: $32,800,000

TEAC has expanded into computer peripherals, in recognition of slow growth in the worldwide market for quality audio tape decks, its previous major product area. Computer peripherals now account for about 73% of sales, mostly in

floppy disk drives, with TEAC now the worldwide leader in total shipments of 5.25" and 3.5" floppy drives. In 1982, TEAC acquired a manufacturing license from Seagate Technology for its 5.25" Winchester disk drives, with rights to market the drives in Japan and the Far East. After limited success with 5.25" rigid disk drives, the firm began manufacturing 3.5" drives with capacities in the 43 megabyte to 86 megabyte (formatted) range in late 1989, and has since extended 3.5" drive capacity to 215 megabytes. 40 and 60 megabyte 2.5" drives with 15 mm height were planned for 1992 production, but TEAC elected to remain out of the 2.5" market for the time being. Shinano Tokki, a subsidiary producing motors for disk drives, was sold in 1989.

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

1991 total net sales: $1,006,689,000 Net income: $21,437,000

Tokico, a member of the Hitachi group (Hitachi has 21.0% ownership), is a manufacturer of automotive equipment, including shock absorbers, brakes and air compressors. Factory automation is a newly developed product area. The company began disk drive manufacturing with a 5.25" fixed disk drive design derived from the discontinued Nippon Peripherals Ltd. joint venture with Fujitsu, with versions of the Tokico drive sold separately by Hitachi and by the Hitachi group trading company, Nissei Sangyo. A half high version went into production in late 1983. More recently, the 5.25" product line was discontinued. Tokico began to market its disk drive products under its own name in 1987 and began concentrating on its 3.5" drive product line. However, limited volume and decreasing profitability led to a decision to cease rigid drive production in 1992.

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

1991 disk sales: $175,400,000
1991 total net sales: $1,006,689,000 Net income: $21,437,000

Toshiba is a major factor in consumer electric and electronic products, plus a wide range of industrial electronic products and heavy electric power equipment. The company also has a leading position in the Japanese office computer market. Disk drives supplied by Toshiba include rigid, floppy and optical drives. Rigid disk drive production is concentrated in newer Winchester technology fixed disk drives in low and mid-range capacities, in 8", 5.25", and 3.5" disk diameters, plus a recently announced 2.5" series with drives up to 86 megabyte capacity. The 1991 5.25" product line extended to 765 megabytes, but Toshiba has dropped most of its 5.25" drives in order to concentrate on 3.5" and smaller form factors. 1992 capacities for 3.5" drives ranged from 45 to 877 megabytes.

Toshiba's presence in the U.S. OEM rigid disk drive market was strongly enhanced when it acquired the OEM disk drive operations of Memorex from Burroughs, and Toshiba has continued to expand its U.S. operations, establishing a design center in Southern California and, in 1992, opening a factory to make high-end 3.5" disk drives in San Jose.

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

Xebec, founded in 1974, is primarily a producer of hybrid ICs and printed circuit boards. It has no relationship to Xebec Corporation, a onetime U.S. manufacturer of PC boards, drive controllers, and 5.25" disk drives. After purchasing Kalok's factory in the Philippines and agreeing to produce the Kalok drives on a contract basis, in April of 1992 Xebec purchased the rights to manufacture and market all of Kalok's stepping motor disk drives. The drives are now marketed worldwide under Xebec's name.

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

Zentek, which is a joint venture between Universal Scientific Industrial Co., Ltd., and Longshine Electronics, was established in September, 1989. Much of the original engineering team came from Longshine and Priam. USI is a manufacturer of film hybrid integrated circuits. Zentek is manufacturing 60 megabyte and 100 megabyte 3.5" drives based on designs developed by ITRI, a government research agency. Production started in early 1992. Zentek also makes the Orca 332 and 427 megabyte 3.5" drives. The original design for these drives was done as a joint effort between Priam and Matsushita Communication Industrial. Orca obtained rights to the drive when Priam ceased operations and enlisted Zentek as a manufacturing source. Zentek also plans to produce several 2.5" models beginning in late 1992.

European Manufacturers

CALLUNA TECHNOLOGY LIMITED
Blackwood Road, Eastfield
Glenrothes, Fife KY7 4NP
Scotland

Calluna Technology is a disk drive manufacturing start up which intends to design and manufacture 1.8" drives in Glenrothes. The founders are all veterans of Rodime, and many were previously with the Burroughs disk drive manufacturing facility in Glenrothes. Calluna occupied a new industrial building early in 1992 and hopes to be in production by early 1993.

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

Comparex became operational at the beginning of January, 1987, as a joint venture operation comprising the former BASF and Siemens PCM businesses, marketing systems and peripherals made by Fujitsu and Hitachi. In late 1991, the owners announced BASF's assumption of complete ownership. Current disk drive activities involve PCM 3380/3390 equivalent drives produced by Hitachi, plus an optical drive produced by LMSI and integrated with a Cygnet jukebox. Semiconductor and cartridge tape systems, both made by third parties, are also offered.

DZU
6000 Stara Zagora
Bulgaria

DZU is the current name for the Bulgarian organization known for many years as ISOT, following a series of reorganizations in 1989 of the governmental structure which manages Bulgarian technology industries. Under the previous Eastern Bloc Comecon system, disk drives were manufactured since the 1960's by DZU, the Bulgarian state computer organization, and exported throughout Eastern Bloc countries by Isotimpex, the foreign trade organization for Bulgarian computer equipment and other electronic products. DZU, which operates factories with perhaps the highest level of vertical integration to be found anywhere in the disk drive industry, began production of 14", 8" and 5.25" Winchester drives in late 1985. The disintegration of the Eastern Bloc and the movement of all of its old Comecon trading partners to hard currencies as a basis for international trade has left DZU's older products exposed to competition from newer disk drives, and as a result DZU's business has declined severely. DZU is actively trying to secure contracts to make components, subassemblies and complete

drives, in order to keep its factories busy. The organization recently announced a program to manufacture head/disk assemblies for 1.8" drives on a contract basis for Aura Associates.

EZI GMBH
Schmidthuette 9
D-6342 Haiger
Germany

EZI, whose business is primarily in disk drive repair, acquired the rights to manufacture and market Siemens 382 and 310 megabyte 5.25" disk drives, when Siemens discontinued its own disk drive manufacturing activities in 1990. The firm continues to manufacture these drives for the European market, and plans to maintain the program as long as demand remains alive.

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

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

Rodime surprised the industry by obtaining patent coverage on the form factor of a 3.5" drive -- claiming no new technology, only a reduction in size. The firm then sued Miniscribe and Conner Peripherals for patent infringement. When IBM announced the PS/2 family, which uses 3.5" drives, it sued Rodime to invalidate the patent, and Rodime bravely met the challenge by countersuing IBM for patent infringement. Miniscribe opted out of the legal proceedings by taking a license. In the meantime, after extensive patent office preliminaries, the affair began a long tour of the U.S. federal court system which ended when IBM and Conner took licenses. Several other companies have also signed up for Rodime licenses, and others are in negotiation.

In early 1989, top management was completely overhauled as Rodime came perilously near bankruptcy. Rodime obtained refinancing, and its new management hoped to be able to return Rodime to profitability. The retail disk drive subsystem division, Rodime Systems, was sold to Profit Technology, Inc., in May, 1990. Rodime pursued joint ventures with JVC and companies in Taiwan and Korea for design and manufacturing of new products. However, in mid-1991 Rodime announced that these ventures were unlikely to come to fruition and that it would file for bankruptcy and cease manufacturing of drives after using up its

current inventory of materials. Rodime continues to actively pursue licensing of its 3.5" disk drive patents.

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

SAGEM is active in the fields of military electronics, telecommunications, office systems, industrial and military equipment and computer peripherals. The firm's earliest disk drives were head-per-track designs. In 1986, SAGEM introduced a unique 5.25" Winchester drive with multiple heads per slider, sold as a military subsystem. The firm's more recent products have focused upon a line of militarized removable disk drives ranging in capacity from 100 to 200 megabytes.

SIEMENS AG
Communications Group
St. Martinstrasse 76
D-8000 Munchen 80
West Germany

1991 total net sales: $43,980,723,000 (FY ending 9/30/91) Net income: $1,079,518,000

After many years of producing 14" rigid disk drives of its own design in Munich for captive use with Siemens mainframe systems, Siemens developed a 5.25" Winchester disk drive with capacities up to 300 megabytes, and started deliveries in early 1986. 380 and 770 megabyte models were added in 1988 and a 1.2 gigabyte model in 1989. Siemens sold the drives in noncaptive markets as well as in captive systems. Siemens never was able to achieve a production volume permitting profitable operation of its disk drive product line, and in 1990 announced it would withdraw from the 5.25" rigid disk drive business, selling its disk drive product lines to Microscience International and to EZI.

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, and in late 1991 Siemens sold its share of Comparex to BASF.

South American Manufacturers

DIGIREDE INFORMATICA LTDA.
Av. Angelica, 2582
01228 Sao Paulo SP
Brazil

1991 total net sales: $52,000,000 Net income: $2,500,000

Digirede manufactures rigid disk drives, multiuser microcomputers, banking automation equipment, POS systems and industrial automation equipment. The company, which is privately held, was founded in 1977 and has been manufacturing rigid disk drives under an agreement with Maxtor initiated in November of 1985. The product line includes Maxtor 5.25" designs up to 240 megabytes, using ST506 and RLL controllers. Higher capacity models will be produced in the future. Much of the drive content is locally produced, although media, heads and motors are still imported, as are some drive models not manufactured by Digirede.

EDISA INFORMATICA S/A
BR 290 Km 75
Distrito Industrial Gravatai
94000 Gravatai RS
Brazil

Edisa Informatica was created in 1989 as a joint venture between Hewlett-Packard and Ioschpe, a large Brazilian firm with interests in construction equipment, pharmaceuticals, paper and electronics. Edisa is best known as a supplier of automated banking equipment, but in 1990 began producing the Hewlett-Packard 380 megabyte 5.25" drive in its own facility. Production of a 664 megabyte drive began in 1991. Key components are purchased from Hewlett-Packard, which also supplied much of the manufacturing equipment used by Edisa.

ELEBRA INFORMATICA
Rua Geraldo Flausino Gomes, 78
04575 Sao Paulo SP
Brazil

1991 Total Net Sales: $81,374,000

Founded in 1978, Elebra is a producer of minicomputers, defense electronics, industrial control electronics, data communications and peripheral equipment. Minicomputers are made under license from Digital Equipment. The peripheral equipment product line includes rigid and floppy disk drives, printers, and tape drives. All of the floppy drives are 5.25" half height types. Manufacturing of rigid disk drives began in 1985. About 14% of 1991 sales were disk drives,

but as a result of the opening of the Brazilian computer market, Elebra, like other Brazilian disk drive manufacturers, has scaled back production of disk drives, and now manufactures only 5.25" drives in the 60 to 100 megabyte range.

FLEXDISC TECNOLOGIA S.A.
Rua Dom Aguirre, 176
04671 Santo Amaro
Sao Paulo SP
Brazil

Flexdisc, a privately held company, was founded in 1979. Floppy disk drives for Apple II computers were the firm's original products, but streamer tape drives, IBM compatible 500 kilobyte and 1.6 megabyte floppy drives, and rigid disk drives were produced. Rigid drives were first made under license from Seagate in 1983 and then Vertex in 1985. A new 3.5" 20 megabyte stepping motor drive designed by Flexdisc was scheduled for production in 1990 but because of poor economic conditions the drive was never produced, and Flexdisc halted operations in 1991.

ITAUTEC INFORMATICA S.A.
Rua Odorico Mendes, 540
03106 Mooca
Sao Paulo SP
Brazil

Itautec is part of the Itau group, Brazil's second largest bank. Itautec was formed in 1979 to automate the banking systems of its parent organization and went into the computer systems business in 1984. The firm began production of floppy disk drives in 1986 and a 20 megabyte half high rigid drive in 1988. A 96 megabyte version was added in 1990. Both rigid drives were made under license from BASF, which also supplied production equipment for the drives to Itautec. As a result of the opening of the Brazilian computer market, Itautec found it more economical to purchase drives than to manufacture them, and production was halted in 1991.

MICROLAB S/A
Av. Nova York, 381
21041 Bonsucesso
Rio de Janeiro RJ
Brazil

Founded in 1961, Microlab started as a defense contractor for the Brazilian Navy and then diversified into products for the oil industry. Since 1970, the firm has produced military radar and communications equipment as well as process control and power distribution equipment. Rigid disk drive production began in

1985 with a 300 megabyte pack drive licensed from Ampex. The firm also produced the Megavault 8" drive and an Atasi 5.25" 50 megabyte drive under license. The Atasi drive went out of production in 1989, while the Ampex and Megavault designs had their last production year in 1988. Current products are licensed from Seagate and include 5.25" drives up to 144 megabyte capacity. 3.5" drives were introduced in 1991.

Due to a weak economy, Microlab was forced into the Brazilian equivalent of Chapter 11 status, but has since resumed normal operations. Disk drive manufacturing is at a low level as a result of the opening of the Brazilian computer market.

MULTIDIGIT S. A.
BR 290 Km 22
Distrito Industrial Gravatai
94000 Gravatai RS
Brazil

Multidigit was founded in 1979. The firm's first 5.25" drive, a 5 megabyte model, was manufactured in 1983. Multidigit currently manufactures 5.25" flexible disk drives and 5.25" stepper motor rigid disk drives with capacities of 25 to 178 megabytes. The firm also distributed an 8" 330 megabyte drive from Pertec in the early 1980's. In addition to rigid disk drives, Multidigit also produces small quantities of 5.25" flexible disk drives. Like other Brazilian firms, Multidigit has been impacted by the removal of computing equipment import restrictions and is scaling down production of disk drives.

PROLOGICA INDUSTRIA E COMERCIO DE MICROCOMPUTADORES LTDA.
Rua Fidencio Ramos, 302
04551 Villa Olimpia
Sao Paulo SP
Brazil

Prologica began as a retail store for electronic components, but soon moved into sales of kits for radios and, eventually, sales of microcomputer kits. The company decided to produce floppy drives in 1982 and started production of an IBM compatible 500 kilobyte drive in 1983. In 1984, the firm established a related company, Microperifericos, to manufacture drives for OEM customers and to do contract manufacturing. Rigid drive production began in 1983 with a 5.25" 5 megabyte CMI look-alike. 3.5" 12 and 25 megabyte drives were produced in mid-1987 and an improved performance version was introduced in 1988. In 1990, the 3.5" family was extended to 105 megabytes capacity. The new drives use voice coil positioning mechanisms rather than the rack and pinion mechanism employed in the older drives. Production of these drives ceased in 1991.

QUALITRON TECNOLOGIA S.A.
Rua Anhembi, 228, Santa Amaro
CEP 04728 Sao Paulo SP
Brazil

Qualitron, founded in 1986, currently produces 5.25" half high drives ranging from 25 to 77 megabytes capacity. The firm is considering a line of 3.5" disk drives which it plans to provide on an OEM basis to Brazilian system manufacturers.

WINTEC TECNOLOGIA S.A.
Rua Caminho do Engenho, 605
05524 Bairro Ferreira
Sao Paulo SP
Brazil

Founded in 1986, Wintec has specialized in small rigid disk drives. The firm's first product was a 5.25" 20 megabyte drive. Current production consists of 40 megabyte 3.5" drives, mostly sold to Microtec, a major Brazilian microcomputer manufacturer which has an ownership position in Wintec. Wintec has a relatively well developed distribution network as a result of its association with Microtec.

1992 DISK/TREND REPORT

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 on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. A system with a hard disk is highly recommended, but a system with two floppy disks can be used if necessary. All DISK/TREND ON DISK files contain data only -- manipulation of data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended.

A file translation program, AutoImport, is available from DISK/TREND to assist in converting the data supplied to the formats of several popular spreadsheet programs.

Two types of diskette files are supplied for each DISK/TREND disk drive report. The first type contains the statistical tables in ASCII format. File names are keyed to the table numbers in the report for easy identification. The second type contains the specification section in a Lotus 1-2-3 data base format. Multiple disks of each type are provided where the files are too numerous or too large to fit on a single floppy disk. The color used on the label of each floppy disk is similar to the color used on the cover of the corresponding report for ease in identification.

Because the statistical tables are provided in ASCII format, they can be used with any spreadsheet program that can import ASCII text files. However, the specification tables have been prepared specifically in Lotus 1-2-3 format to allow them to be searchable using Lotus 1-2-3 data base commands. If you are using a spreadsheet program other than Lotus 1-2-3 that can translate Lotus WK1 formatted files to its own format, it may be able to import the specification tables.

The authors of this manual assume that you are familiar with personal computers, Lotus 1-2-3 or other spreadsheets, and MS-DOS, and do not cover their operation in this manual. This manual deals specifically with how to load and use the files supplied on the floppy disks.

One copy of AutoImport is provided automatically at no extra charge to

DISK/TREND subscribers who have purchased an original copy of DISK/TREND ON DISK but is provided only in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any time. If you have not purchased DISK/TREND ON DISK, but would find AutoImport useful with other file translation tasks, it may be purchased independently from DISK/TREND or White Crane Systems, Inc.

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

DISK/TREND ON DISK

Information License

DISK/TREND supplies diskettes containing selected information from the 1992 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1992 DISK/TREND Report volume.

YOU MAY:

1. Install and use the information on a single computer system, provided that you or the organization by which you are employed has purchased at least one copy of the DISK/TREND report volume associated with the information.
2. Make backup copies of the information for your own use. Such backup copies may be used only on the computer on which the information is installed. You must reproduce the copyright notice on any copies.
3. Reproduce the information, but not the associated programs or documentation, contained in the Product for use within internal documents distributed within the organization by which you are employed.

YOU MAY NOT:

1. Install, or allow the use of, the information on more than a single computer system.
2. Transfer the information through or within a computer network.
3. Distribute the information or any portion thereof in any form outside the organization by which you are employed or modify the information for purposes of distribution.
4. Transfer this license to another party.

AUTOIMPORT

Use of AutoImport is subject to the terms and conditions provided by White Crane Systems, Inc.

Trademarks

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

1992 DISK/TREND REPORT

Getting started

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

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

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

DISK/TREND on Disk for the Rigid Disk Drive Report is normally shipped on 5.25" 1.2 megabyte diskettes. There will be two diskettes in a set, one containing statistical tables and one containing specification tables. You may also request shipment on 3.5" 1.44 megabyte diskettes or 5.25" 360 kilobyte diskettes. If you request the 5.25" 360 kilobyte diskettes, there will be two diskettes containing statistical tables and two diskettes with specification tables. In each case, diskette #1 contains data for product groups one through five. The remainder is on diskette #2. Otherwise, there will be one diskette for statistical tables and one for specification tables.

STATISTICAL TABLES

Loading and Installation

1. Place the floppy disk marked 'Tables' in a floppy disk drive able to read 5.25" disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the Lotus 1-2-3 system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the 'Tables' disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which Lotus 1-2-3 normally stores worksheet files. Using the DOS 'COPY' command, copy all the statistical table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?T*.*

   Several utility files should also be copied. The commands are:

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

   The utility file names of the form FORMLIN?.PRN are specific to use with Lotus 1-2-3 data parsing and are needed only if you prefer not to use AutoImport for file translation.

   Installing AutoImport: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place AutoImport disk 1 in drive A and type: A:INSTALL C:\AIMP and then ENTER. Follow any instructions appearing on the screen until installation is complete. To make AutoImport accessible from any directory, place C:\AIMP in your AUTOEXEC.BAT file's "PATH" statement. See your MS-DOS instruction manual for information about this step.

   If you are using a floppy-only system, copy the AutoImport disks and use only the copies in following steps. In a floppy-only system, AutoImport disk 1 should be in drive A when AutoImport is in use for file translation.

3. If you are using AutoImport (highly recommended) for translation of files to spreadsheet format, do the translation at this point. See the following section on using AutoImport for details.

4. Now you are ready to start your spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the spreadsheet system disk in drive A. If you are using a rigid disk system, place a copy of the spreadsheet system disk in floppy drive A if required by the security provisions of your spreadsheet program. Now start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the appropriate file retrieval command to select a file. An example of a Lotus 1-2-3 command is:

   /FR<filename>

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

   X= Type of data
   F (Flexible disk drive data)
   R (Rigid disk drive data)
   O (Optical disk drive data)

   YY= Table number, as shown in the appropriate report volume

   Examples:
   File RT11.WK1 is Rigid Disk Drive Report Table 11
   File FT2.WK1 is Flexible Disk Drive Report Table 2
   File OT1.WK1 is Optical Disk Drive Report Table 1

   The file selected will be loaded as a worksheet. If this is the first time the file has been loaded, you may want to create your own formulas linking the cells of the spreadsheet. See your spreadsheet reference manual for details on numerical manipulations and graphics.

If you don't use AutoImport

If you don't use AutoImport but still want to translate ASCII files to your spreadsheet format, you will have to use spreadsheet tools such as the Lotus 1-2-3 Data Parse commands. They allow the user to convert a table which has been imported in the form of a block of text to a form in which the individual numbers and labels can be manipulated as spreadsheet elements or used to prepare graphics. Let's take Lotus 1-2-3 as an example. Before proceeding, it would be useful to read the Lotus reference manual on this subject if you are not a regular user of the Data Parse commands.

The trickiest and most time-consuming part of using the Data Parse com-

mands is setting up the format line. Several utility files have been provided on the tables disk to make this process easier. These are used with various table formats encountered in the DISK/TREND Reports and correspond with the precomputed masks provided for use with AutoImport:

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

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

After you have used spreadsheet tools to translate a file, you will understand why we recommend AutoImport for this function.

Using AutoImport

Using AutoImport is a two-step process. Step one is creation of a translation mask for each format used in files to be converted. The typical DISK/TREND Report uses 5 to 7 standard mask designs (which have been precomputed and included on your Statistical Tables disk as files with .MSK file name suffixes) plus additional masks that are dependent upon table content, as some table types have variable numbers of columns. You will have to create your own masks for such tables, but this can be done easily as shown below.

Step two is the translation process. Once the mask has been created, it can be used with any table matching the mask format. See the table below which relates table types to specific masks.

MASK TABLE

Mask File Name	Rigid Report	Flexible Report	Optical Report
MASKA	<-------- Table 1--------->		Tables 1,2
	<------------ Product Group Revenue ---------->		
	<------------ Product Group Shipment ---------->		
MASKB	<-------- Table 2 -------->		Tables 3,4
MASKC	Tables 3,4,6,9, 10,11	Tables 3,4	Tables 5 to 12
MASKD	<----- All Product Group Application Tables ------->		
MASKE	N/A	Drive Height, Track Density, Drive Capacity	Write-Once/ Erasable Analysis
MASKF	N/A	Applications Summary	N/A
MASKG	*	Product Group Market Share	*
MASKH	Tables 7,8	N/A	N/A
MASKI	Product Group Price/Megabyte	N/A	N/A

N/A = Not applicable to this report

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

TABLE NUMBER TO MASK CROSS-REFERENCE

Table Number	1992 Rigid Report	1991 Flexible Report	1992 Optical Report
1	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA
3	MASKC	MASKC	MASKB
4	MASKC	MASKC	MASKB
5	--	--	MASKC
6	MASKC	--	MASKC
7	MASKH	MASKF	MASKC
8	MASKH	MASKA	MASKC
9	MASKC	MASKA	MASKC
10	MASKC	MASKE	MASKC
11	MASKC	MASKD	MASKC
12	--	MASKG	MASKC
13	--	MASKA	--
14	MASKA	MASKA	--
15	MASKA	MASKE	--
16	--	MASKE	--
17	--	MASKD	MASKA
18	MASKD	MASKG	MASKA
19	MASKI	MASKA	--
20	--	MASKA	--
21	MASKA	--	MASKD
22	MASKA	--	--
23	--	MASKE	MASKA
24	--	MASKE	MASKA
25	MASKD	MASKD	--
26	MASKI	MASKG	--
27	--	MASKA	--
28	MASKA	MASKA	--
29	MASKA	--	MASKE
30	--	--	MASKD
31	--	MASKD	--
32	MASKD	MASKG	MASKA
33	MASKI		MASKA
34	--		MASKD
35	MASKA		MASKA
36	MASKA		MASKA
37	--		MASKA
38	--		MASKA
39	MASKD		--
40	MASKI		--
41	--		MASKE
42	MASKA		MASKA
43	MASKA		MASKA
44	--		--
45	--		--
46	MASKD		MASKE
47	MASKI		MASKA

Cross reference (continued)

Mask File Name	1992 Rigid Report	1991 Flexible Report	1992 Optical Report
48	--		MASKA
49	MASKA		--
50	MASKA		--
51	--		MASKE
52	--		
53	MASKD		
54	MASKI		
55	--		
56	MASKA		
57	MASKA		
58	--		
59	--		
60	MASKD		
61	MASKI		
62	--		
63	MASKA		
64	MASKA		
65	--		
66	--		
67	MASKD		
68	MASKI		
69	--		
70	MASKA		
71	MASKA		
72	--		
73	--		
74	--		
75	MASKD		
76	MASKI		
77	--		

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

Translation using precomputed masks

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

   COPY A:?T*.*
   COPY A:*.MSK

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

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

2. Now start AutoImport. When the opening screen appears, select the 'TRANSLATE' menu item using the arrow keys or just type 'T'. (The AutoImport menu system works just like the menus in Lotus 1-2-3.)

3. When the next screen appears, enter the name of the mask to use on the top line where the highlighted space is. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. Press 'ENTER'.

4. Select the output file name. Type /OFT (Output:File:Type-in)

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

   Examples: RT4 FT12 OT14

5. Enter the input file name using the same file naming convention as above. Type /IT (Input:Type-in)

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

   Examples: RT4.92R FT12.92F OT14.92O

6. The default spreadsheet type to which the translation is made is Lotus 1-2-3 version 2.x. If you wish to translate to a different spreadsheet format you may choose it by typing /TS (Type:Spreadsheet) and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Type 'G' for 'GO' or select 'GO' using the arrow keys. You will see the file being translated scroll by as the translation proceeds. If it does not scroll during translation, you may have a damaged mask file. See the next section for details on mask file creation.

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

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

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select 'Mask' using the arrow keys or type 'M'.

2. Name the file you will use as the template to create the mask. The file name will be of the form ?Tnn.yy?, where ? is the type of report (R, F, or O), nn is the table number and yy is the report year.

   Example: RT50.92R

   To name the file, type /FIT (File:Input:Type-in). When the highlighted blank space appears, fill it in with the file name and press 'Enter'. The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the left top of the report table. Now type /LH (Line:Header). Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press 'Enter'. If there are any footnotes at the bottom, the lines in which they appear can be treated the same way by locating the header at the left margin of the first footnote line, typing /LH, extending the highlight area over the note and pressing 'Enter'.

4. Next, locate the longest left margin label (excluding the header lines) in the table. Position the cursor so that it is at the left margin of the line containing the longest label. Type /AY (Auto:Yes). This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

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

   Another unusual case can occur in which the right-hand part of a label is somehow included in a value occurring in the next column to the right. Deal with this rare case as follows:

   o Place cursor in left margin of offending line. Type /CW to adjust width and then use arrow keys to move right column margin clear of the column of values.

   o Set cursor on last position of column to the right of the left margin labels. Type /DCO to delete this one column from the mask.

   o Now place cursor in first space to the right of the left margin label col-

umn. Type /C and then adjust the column width to encompass all places in the values column you have been working with. This will restore the mask column, also.

5. Save the mask in a mask file. Type /FMS (File:Mask:Save). Fill in the name of the mask file.

   Example: RT50MSK

6. Save the output file. Type /FOT (File:Output:Type-in). Now enter the file name.

   Example: RT50. You don't need to enter the file extender.

7. To make more masks, repeat from step 2. To quit the mask function, type /Q (quit). This returns you to the AutoImport main menu. To leave AutoImport, type /E.

Other AutoImport Functions

AutoImport can do much more than the functions described above, which are those concerned with a basic understanding of how to create spreadsheets from DISK/TREND ON DISK files. See the separate AutoImport manual provided for details of these other functions.

SPECIFICATION TABLES

The rigid disk drive specifications are supplied on two diskettes if 5.25" 360 kilobyte diskettes were supplied to you or one diskette if otherwise. If you are using two diskettes, specification diskette 1 contains the specifications for DISK/TREND product groups one through five. The other diskette contains specifications for groups six through nine. If your computer has enough memory (it may require expanded memory in some cases) you can load the two data bases sequentially into one large data base for ease of data manipulation. See the comments in the Operating Tips section.

Loading

1. Place the floppy disk marked 'Specifications' in a floppy disk drive able to read 5.25" disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the spreadsheet system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the 'Tables' disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which your spreadsheet normally stores worksheet files. Using the DOS 'COPY' command, copy all the specification table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?S*.*

3. Now you are ready to start Lotus 1-2-3 or other spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus spreadsheet system disk in drive A. If you are using a rigid disk system, place the spreadsheet system disk in floppy drive A. If your spreadsheet is not Lotus 1-2-3, you will have to translate the data from Lotus 1-2-3 to your format. Almost all spreadsheet packages of recent vintage are able to do this translation. After translation, if needed, start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the spreadsheet File Retrieve command to select a file. The equivalent Lotus 1-2-3 command is: /FR<filename>.

The file names are in the format XSYZZ.WK1 or XSYZZ.WKS, depending upon which version of Lotus 1-2-3 you are using. X,Y, and Z are:

X= F (Flexible disk drive data)
O (Optical disk drive data)
R (Rigid disk drive data)

Y= Table number. Usually, there is only one table, but if the specification file is so large as to need multiple disks to hold it, there may be several.

ZZ= Year of report.

Example: RS192 Rigid disk specification table, Groups 1 to 5
RS292 Rigid disk specification table, Groups 6 to 9
RS392 Complete specification table: supplied on 1.2 megabyte 5.25" or 1.44 megabyte 3.5" diskettes only

Note that the specification tables load directly as a data base. You can use the various data base functions of Lotus 1-2-3 to sort, count or otherwise manipulate the data for purposes of special analysis. Other spreadsheets may have similar capabilities.

Using the specification data base

Introduction: If you have not used the Lotus 1-2-3 /DATA QUERY commands, it will be helpful for you to review the sections of the Lotus 1-2-3 reference manual that pertain to their use before proceeding further.

The specification data base fits into a worksheet format of 25 to 30 columns, depending upon whether rigid, optical or floppy drives are involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a single column in the Specifications section of the DISK/TREND report. Each column represents a specific specification parameter, and is equivalent to one row of the DISK/TREND report.

The data base has been set up for data extraction using Lotus 1-2-3 commands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the

database is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

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

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

- o There are other 'pop-up' programs resident in the memory of your computer. These should be removed.

- o You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.

- o If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You may have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have 640K memory, you will probably get this message.

Combining specification data bases: Lotus 1-2-3 allows you to combine worksheets into a larger worksheet. If you think your computer has enough memory, you can combine the specification data bases by doing the following:

1. Load the worksheet RS192 from the specification diskette (specification diskette 1 if you have 360 kilobyte diskettes) into a new worksheet. Now move the worksheet cursor to column A and the row just under the last manufacturer's name.

2. Load the worksheet from RS292 from the specification diskette (or specification diskette 2) using the Lotus command /FCC.

3. Edit the worksheet to remove the header and criteria range areas that were loaded with the second worksheet.

4. Using the data query (/DQ) command, select the new input range so that it covers the entire worksheet area in which there is data. Remember, the column header row must be included in the input range. Quit the DQ menu.

5. Copy the column header row using the /C command to a row 5 to 10 lines below the input range. Using the /DQ command, select the output range. It should include the header row you just established plus as many rows as you would like, and should extend to the last column of data.

6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it to a new file name first so that you can easily reload if you make an unrecoverable alteration.

Saving time

The specification data base is large and takes significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups you are interested in into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

Another way to save time is to use the SORT capabilities of your spreadsheet to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, and so on.

Make sure that when you save a worksheet using the FILE SAVE command that you save it in a new file name. If you save it in the file name from which it was loaded, the original copy will be overwritten. If a file is overwritten unintentionally, it can take a long time to recreate.

If you are interested in a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and use the second file for analysis. The smaller file will take less time to process.

Special data: The specification database contains one category of information not present in the hard copy report. This is the country code field, representing the continental region in which the headquarters of the drive producer is located. A key is located at the top of the adjacent column to the right.

All specification files have been prepared as Lotus 1-2-3 spreadsheets set up for data extraction. Criterion, input, and output ranges are predefined.

File RS192.WK1 contains DISK/TREND Product Groups 1 through 5. File RS292.WK1 contains Product Groups 6 through 9. File RS392.WK1 contains the entire specification data base, but the amount of memory required is large and may not allow enough room for large data extractions.

If file RS392.WK1 is present, you are using a 1.2 or 1.44 megabyte diskette, and should have a computer equipped with expanded memory capability.

In order to make it easier to do sorting or extraction analysis on the data, the contents of certain fields have been modified and are not exactly the same as in the printed report tables. The affected fields have been converted to purely numeric fields as described below. Where multiple values existed, the value representing the highest level of performance or capability has been retained.

Comments and asterisks in the affected fields have been eliminated. A '0' means that no data was available. Asterisks are retained in the comment field so that you will have an indication that one or more characteristics of the drive was referenced to a comment. Check the printed report table for details.

The affected fields are:

Group:	Numeric conversion: Now you can extract a range of groups.
Surfaces per spindle	Numeric conversion: You can now extract a range of values.
Heads per surface	Will be a single numeric value: 1 or 2.
TPI	Will be a single numeric value, 0 if data not available. If a drive model has several configurations, the highest TPI is used.
RPM	Numeric conversion: You can now extract a range of values.

Tracks per surface	Will be a single numeric value, 0 if data not available. If a drive model has several configurations, the largest value of tracks per surface is used.
Average positioning time	Will be a single numeric value, 0 if data not available. If a drive model is specified as having more than one positioning time, the shortest will be used. Settling time is always included.
Average rotational delay	Numeric conversion: You can now extract a range of values.
Average access time	Same as for average positioning time.

A country code field has been added in the last column of the data base. The code explanation is:

1 = U.S. manufacturer
2 = Asian manufacturer
3 = European manufacturer
4 = South American or other manufacturer

Codes are based upon the location of the manufacturer's headquarters.

First ship date has been modified so that the last two characters will always represent the year of shipment. An entry of ??89 in the criterion field for the First Ship Date column will cause all drives first shipped in 1989 to be extracted.

Technical support

Just about all of your questions regarding the use of DISK/TREND ON DISK should be answered in this manual or in the Lotus 1-2-3 reference manual. However, if you need to contact us to resolve any points of confusion, report errors, or otherwise receive comfort:

Call us at: **415-961-6209**
Fax us at: **415-969-2560**

Ask for technical support for DISK/TREND on Disk.

In order to make this process efficient, when you call--

1. Tell us what is on the diskette label.

2. Have your computer up and displaying the data or operation that is the subject of your call.

3. Have this manual and the Lotus 1-2-3 reference manual handy.

If you have questions about AutoImport as it is used with DISK/TREND ON DISK, contact DISK/TREND at the number above. Questions about other functions of AutoImport should be referred to White Crane Systems.

Apple Macintosh compatibility: While DISK/TREND on DISK has been prepared for use on IBM PC compatible computers, users have reported that they are able to translate files into Macintosh format using Apple Computer software. The specific software reported used is Apple File Exchange.