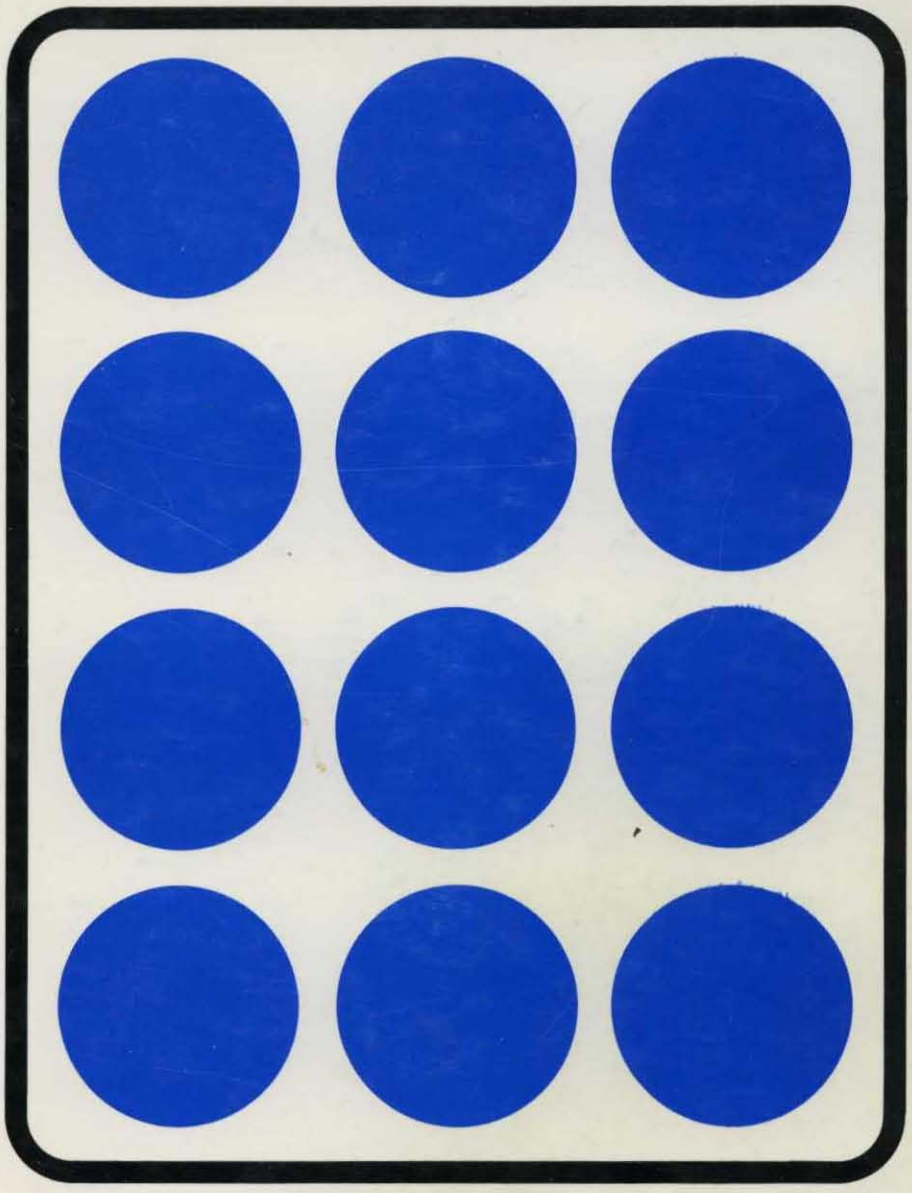
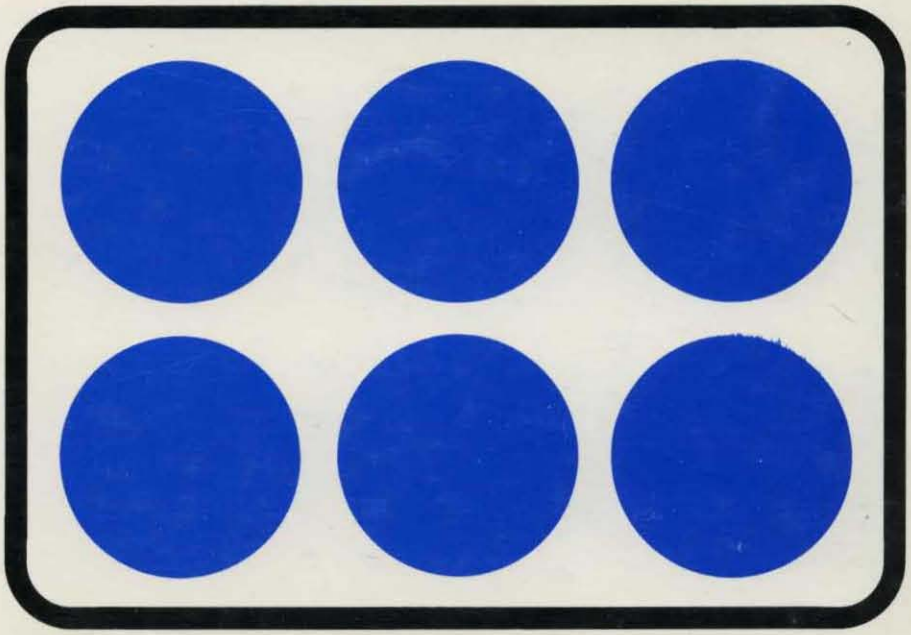


1993 DISK/TREND® REPORT



RIGID DISK DRIVES

1993 DISK/TREND® REPORT

RIGID DISK DRIVES

October, 1993

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

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

FOREWORD

In a year of outstanding growth in unit shipments, the disk drive industry has managed to cut prices fast enough to reduce total sales revenues and cut profitability to the bone. But we've always known this was not a normal industry. It's filled with very bright people with high energy levels, who have done an amazing job in rapidly evolving a difficult technology, in producing products with very tight tolerances by the tens of millions, and in developing markets with a missionary's zeal. Perhaps all that's needed now is to add a few key executives with experience in selling horses or used cars -- someone who will sell the products for more than they cost.

The DISK/TREND Report is now in its seventeenth year, few of which have been as demanding as this one. However, we're ready to try again next year. This year the DISK/TREND Report is being published in four volumes for the first time. A new report on disk drive arrays was released in April, the industry's first market study with complete coverage of the emerging disk drive array business. It was followed in July with the 1993 report on optical disk drives, 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.

DISK/TREND ON DISK, statistical and specification tables on floppy disks, is again available to subscribers to the DISK/TREND Report. Instructions for using the disks are included at the end of this report.

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

James N. Porter

Robert H. Katzive

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INTRODUCTION

Something new: No format changes in this year's DISK/TREND Report

For the first time in years we haven't made any changes in the way the DISK/TREND Report on rigid disk drives is organized. In each of the last several years we've either added new tables with breakdowns for disk diameter or price per megabyte, or redefined marketing channels to reflect industry changes or transitioned, with the industry, to formatted capacities for all product groups. In several years, we've also split product groups to reflect new clusters of product activity and combined old product groups as shipments decreased. But the lack of change affects only the report's format. This DISK/TREND Report reflects one of the industry's most difficult years -- an odd combination of poor profitability, rapid transitions to higher capacities and major growth in shipments.

Look for a few changes in product groups next year

The rapid evolution of the industry's product mix will make it wise to revise some product groups next year, and we plan to make those changes. Because of the rapid decline in total shipments of lower capacity drives, all drives with capacities less than 100 megabytes will be combined into a single group. And since the high growth for drives with capacities more than 2 gigabytes has created the opposite situation, the existing product group will be split in two: One product group will cover drives in the 2-3 gigabyte range and another group will cover drives with capacities more than 3 gigabytes.

Some people are still confused

We still receive questions on these points by new users of the DISK/TREND Report (and occasionally from experienced ones!), so here are a few reminders:

* We report all disk drive revenues at the level of the product's first public sale, at the estimated transaction price, whether the sale occurs at the captive, PCM/Reseller or OEM/Integrator levels.

* All unit totals are given in spindles in the DISK/TREND Report. A disk drive enclosure containing two spindles is counted as two spindles, except for some plug compatible drives for mainframes which are counted in units equivalent to corresponding IBM drive models.

SUMMARY: RIGID MAGNETIC DISK DRIVES

Industry size

Despite a major increase in unit shipments, worldwide sales revenues declined slightly in 1992, the second year of reduced total revenues for the industry. 1992 captive disk drive revenues were down 18.1%, at $12 billion. The 25.7% increase in noncaptive disk drive revenues was not enough to offset the captive drive shortfall, and the overall industry was off by .3%. In 1993 captive revenues continue to decline, while noncaptive drives are expected to generate only a slight increase in revenues, resulting in a 3.9% drop in total industry revenues.

Underlying the fall in captive drive revenues is IBM's replacement of older, larger diameter drives with new, smaller diameter drives for low-end through mid-range systems, plus continued weakness in the market for disk drives used with mainframes. Competitive price pressures on computer systems continue to force producers of captive disk drives to make severe price reductions for new 3.5" drives which are already much lower in price than the larger drives they replace. Other U.S. and non-U.S. producers of captive drives are experiencing the same problems, although usually on a later time scale because of IBM's early lead in development of higher density recording. As a result worldwide captive revenues for all types of disk drives are expected to continue declining through 1995, then increase 10.7% in 1996.

Noncaptive drive unit shipments increased a remarkable 37.2% in 1992, boosted by vigorous shipments of lower cost personal computers and an expanding aftermarket, growing rapidly to upgrade installed personal computers with the additional disk capacity needed for new software. However, 1992 noncaptive sales revenues increased only 25.7%, and the 1993 rate of revenue increase is also much lower than the rate of increase in unit shipments. The collapse of disk drive price levels, especially for drives sold to the personal computer market, is the problem. For example, the noncaptive average price per megabyte for 100-200 megabyte drives, currently the largest product group, fell from $1.99 in 1992 to an estimated $1.24 in 1993.

Market demand for more capacity is projected to increase industry shipments to 67.2 million drives in 1996, with revenue growth gradually recovering, due to higher average capacities and somewhat slower price reductions.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

RIGID MAGNETIC DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	6,079.9	8,952.2	5,443.6	8,003.0	5,170.8	7,637.4	5,187.0	7,644.8	5,859.3	8,533.9
Other U.S. Captive	569.5	1,179.5	765.2	1,264.4	489.9	853.4	530.1	907.0	593.9	999.8
TOTAL U.S. CAPTIVE	6,649.4	10,131.7	6,208.8	9,267.4	5,660.7	8,490.8	5,717.1	8,551.8	6,453.2	9,533.7
PCM/Reseller	2,072.9	3,579.2	2,016.4	3,595.7	2,322.5	3,724.2	2,307.7	3,569.6	2,210.6	3,519.5
OEM/Integrator	3,980.1	6,519.6	4,439.7	7,255.7	4,953.9	8,004.7	5,836.5	9,261.2	6,692.6	10,526.5
TOTAL U.S. NONCAPTIVE	6,053.0	10,098.8	6,456.1	10,851.4	7,276.4	11,728.9	8,144.2	12,830.8	8,903.2	14,046.0
TOTAL U.S. REVENUES	12,702.4	20,230.5	12,664.9	20,118.8	12,937.1	20,219.7	13,861.3	21,382.6	15,356.4	23,579.7
Non-U.S. Manufacturers										
Captive	51.2	1,885.0	74.8	1,481.5	98.1	1,083.7	96.7	695.7	100.9	704.2
PCM/Reseller	511.7	1,155.3	426.2	889.6	427.7	840.8	579.9	1,029.3	476.6	871.6
OEM/Integrator	515.2	1,278.7	483.5	1,111.3	755.6	1,520.3	967.9	1,968.1	1,323.7	2,540.7
TOTAL NON-U.S. REVENUES	1,078.1	4,319.0	984.5	3,482.4	1,281.4	3,444.8	1,644.5	3,693.1	1,901.2	4,116.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	13,780.5	24,549.5	13,649.4	23,601.2	14,218.5	23,664.5	15,505.8	25,075.7	17,257.6	27,696.2

Marketing channels

The list of companies producing rigid disk drives became smaller again last year. The total has shrunk from last year's 47 companies to the current list of 40 disk drive manufacturers. Most of the dropouts during the past year had small market shares and were not able to compete efficiently as total shipment levels rose sharply and prices fell with equal sharpness. Only three new manufacturers joined the list: Avatar Systems (U.S.), with a 2.5" disk cartridge drive; Gigastorage Technology (U.S.), with a reborn, higher capacity 5.25" drive derived from an earlier Priam effort; and Calluna Technology (Scotland), with 1.8" drives in PCMCIA Type III format. All of these companies were organized by managers with extensive industry experience and are producing drives which were difficult to design.

The noncaptive marketing channels for rigid disk drives are currently evolving into new patterns. During the last few years the PCM/Reseller channel, including the drives sold through distributors, mass merchandisers and storage subsystem builders, grew to almost 20% of the industry's total revenues, as the result of extensive upgrading of disk storage on existing personal computers, driven by growing use of Microsoft's Windows and related applications software. However, most personal computer system manufacturers are now installing much larger disk drives at the originating factory, and the outlook is for a gradual decline in the PC disk drive aftermarket. DISK/TREND forecasts indicate that PCM/Reseller revenues will fall to 15.9% of the industry total in 1996, while OEM/Integrator revenues will rise from 31.8% of 1992's total to 47.1% in 1996.

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. The price used for each drive is the estimated value at the first time it is sold to a nonaffiliated buyer, at captive end user, PCM/Reseller or OEM/Integrator levels. For example, captive drive revenues for 1992 totaled $12 billion, 48.9% of the overall revenue worldwide total. But 1992 captive drive shipments totaled 5.6 million units, only 12.7% 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	1992 Revenues $M	1992 Revenues %	1993 Forecast $M	1993 Forecast %	1994 Forecast $M	1994 Forecast %	1995 Forecast $M	1995 Forecast %	1996 Forecast $M	1996 Forecast %
U.S. Manufacturers										
IBM Captive	8,952.2 -19.6%	36.4%	8,003.0 -10.6%	33.9%	7,637.4 -4.6%	32.2%	7,644.8 --	30.4%	8,533.9 +11.6%	30.8%
Other U.S. Captive	1,179.5 +19.4%	4.8%	1,264.4 +7.2%	5.3%	853.4 -32.5%	3.6%	907.0 +6.3%	3.6%	999.8 +10.2%	3.6%
PCM/Reseller	3,579.2 +36.9%	14.5%	3,595.7 +.5%	15.2%	3,724.2 +3.6%	15.7%	3,569.6 -4.2%	14.2%	3,519.5 -1.4%	12.7%
OEM/Integrator	6,519.6 +32.2%	26.5%	7,255.7 +11.3%	30.7%	8,004.7 +10.3%	33.8%	9,261.2 +15.7%	36.9%	10,526.5 +13.7%	38.0%
Total U.S. Manufacturers	20,230.5 +2.8%	82.2%	20,118.8 -.6%	85.1%	20,219.7 +.5%	85.3%	21,382.6 +5.8%	85.1%	23,579.7 +10.3%	85.1%
Non-U.S. Manufacturers										
Captive	1,885.0 -25.7%	7.6%	1,481.5 -21.4%	6.2%	1,083.7 -26.9%	4.5%	695.7 -35.8%	2.7%	704.2 +1.2%	2.5%
PCM/Reseller	1,155.3 +17.8%	4.7%	889.6 -23.0%	3.7%	840.8 -5.5%	3.5%	1,029.3 +22.4%	4.1%	871.6 -15.3%	3.1%
OEM/Integrator	1,278.7 -11.2%	5.5%	1,111.3 -13.1%	5.0%	1,520.3 +36.8%	6.7%	1,968.1 +29.5%	8.1%	2,540.7 +29.1%	9.3%
Total Non-U.S. Manufacturers	4,319.0 -12.9%	17.8%	3,482.4 -19.4%	14.9%	3,444.8 -1.1%	14.7%	3,693.1 +7.2%	14.9%	4,116.5 +11.5%	14.9%
Worldwide Recap										
Captive	12,016.7 -18.1%	48.9%	10,748.9 -10.6%	45.5%	9,574.5 -10.9%	40.5%	9,247.5 -3.4%	36.9%	10,237.9 +10.7%	37.0%
PCM/Reseller	4,734.5 +31.7%	19.3%	4,485.3 -5.3%	19.0%	4,565.0 +1.8%	19.3%	4,598.9 +.7%	18.3%	4,391.1 -4.5%	15.9%
OEM/Integrator	7,798.3 +22.4%	31.8%	8,367.0 +7.3%	35.5%	9,525.0 +13.8%	40.2%	11,229.3 +17.9%	44.8%	13,067.2 +16.4%	47.1%
Total All Manufacturers	24,549.5 -.3%	100.0%	23,601.2 -3.9%	100.0%	23,664.5 +.3%	100.0%	25,075.7 +6.0%	100.0%	27,696.2 +10.5%	100.0%

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

Product mix

The industry continues to move to higher capacities and to ship in larger quantities much faster than expected -- even though the expectations have been high. The popularity of Microsoft's Windows and numerous related application programs have driven these rapid changes during the last few years, and the advent of Windows NT and other advanced software will maintain a similar pace for at least several years in the future.

In 1992, shipment rates collapsed for all fixed media drives with capacities less than 100 megabytes, and 100-200 megabyte drives almost tripled in sales, becoming the largest DISK/TREND product group, with 17.5 million drives. But this group is expected to grow less than 5% in 1993, and by 1996 is projected to decline to only 2.8 million drives. In 1993, 200-300 megabyte drives are expected to become the largest product group with 19.8 million drives and continuing to grow through 1996, which will probably be the group's peak year. Coming up rapidly behind that product group will be 300-500 megabyte drives, which shipped only 1.8 million units in 1992, but which is projected to ship 15.8 million drives in 1996. The disk capacities offered by each of these product groups is now considered a basic part of the mainstream personal computer industry.

Even though the quantities are smaller for higher capacity disk drives, the rates of growth are comparable to those of drives sold in the personal computer market, and sometimes higher. For example, 1993's estimated shipments of drives with more than 2 gigabyte capacity are 230.9% higher than last year, due to booming shipments of both 5.25" and 3.5" drives, predominantly for noncaptive markets. The outlook for this group and the other high capacity product groups through 1996 is excellent, with the expected shipment increases in most years above the 50% mark.

3.5" drives provided the largest boost to 1992's worldwide unit shipments, with an increase of more than 10 million drives, bringing the year's total to 36.3 million. Continued growth for the 3.5" drive configuration is forecasted through 1996, although at a lower rate of annual increase. On the other hand, shipments of 5.25" drives continue to drop, and are expected to constitute only .3% of 1996's overall unit shipments. The last shipments of drives in the 8" to 14" sizes are expected in 1995.

The long-term problem for the 3.5" drive format, and for the larger drives which preceded it, is the industry's 36 year old trend to continually improved areal density -- which eventually will make it possible for 2.5" and smaller disk drives to provide cost-effective competition for 3.5" drives. For example, during 1994 IBM is expected to introduce a 1 gigabyte 2.5" drive using 4 disks, or 250 megabytes per disk, at a probable areal density of about 500 megabits per square inch. Such a drive will constitute leading edge technology in 1994, at a level not really suitable for highly competitive mainstream personal computer markets. But a year or so later it should be possible to produce a single disk 2.5" drive with 250 megabytes capacity in very high volumes at low cost -- and thus provide effective competition with 3.5" drives of the same capacity. At that point, we can expect to see a repetition of the classic disk drive phenomenon: The smaller disk drive starts to replace the older one, in its basic markets.

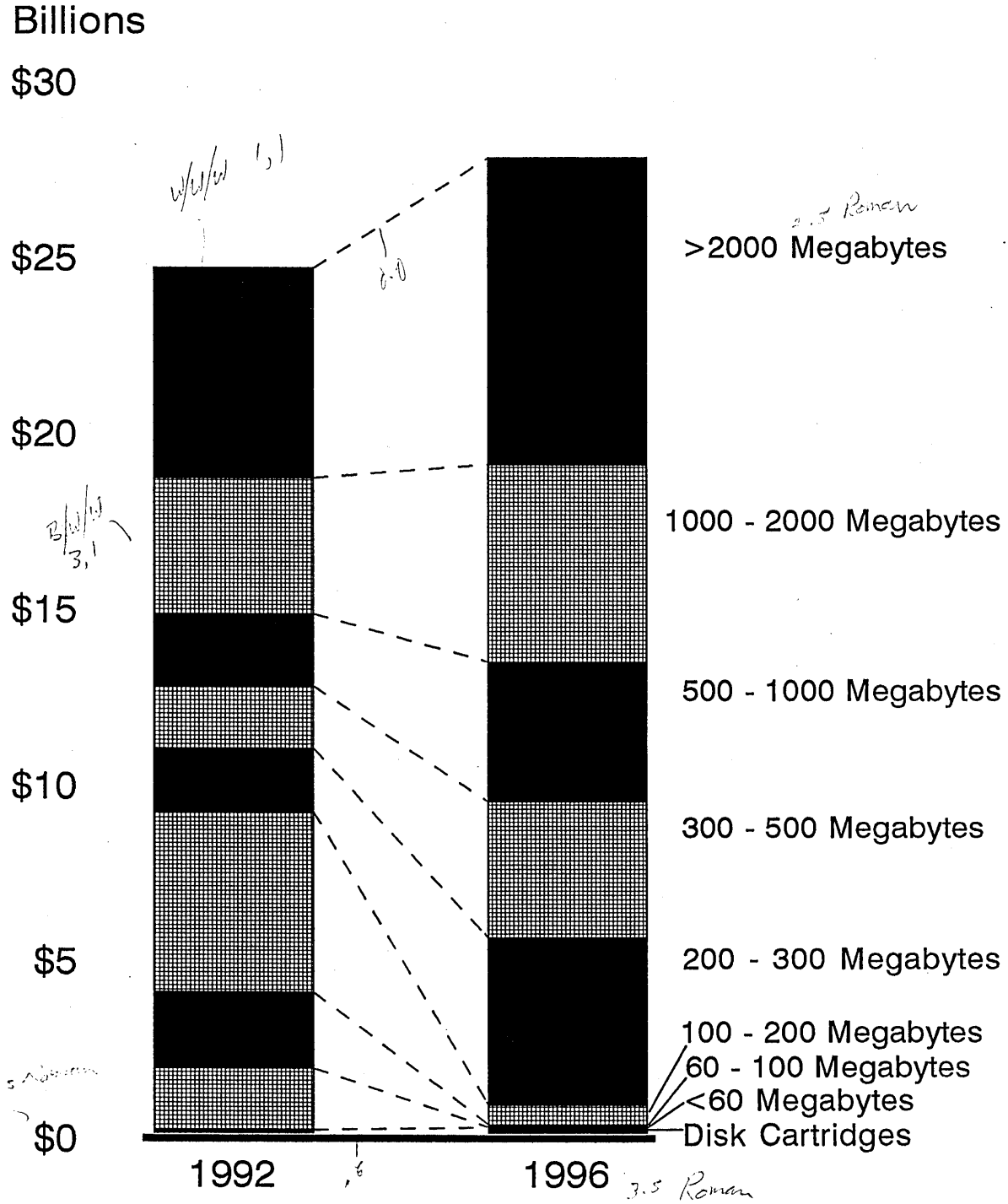
The currently available 2.5" drives have been an essential part of the success story for notebook computers in the four to seven pound range, providing small size, low power requirements and continually increasing storage capacity. 2.5" drives now cover the capacity range up to 520 megabytes and are expected to maintain continuous growth in shipments through 1996, reaching 13.2 million drives in that year. Expansion of the notebook computer market will be responsible for most of the expected growth in 2.5" drives through 1996, but penetration of selected desktop personal computer markets is also anticipated. One of the earliest entry points for 2.5" drives may be the widespread development activity for "green machines", the expected wave of personal computers designed to minimize power consumption. 2.5" drives have already been designed for minimum power in order to lengthen battery life in notebook systems, and thus have a natural advantage for this application.

Manufacturers of 1.8" drives have been struggling to increase capacities and to solve the packaging problems of PCMCIA card configurations, while waiting for the subnotebook computer market to actually materialize. 1994 is now thought to be the year when these factors will finally come together and 1.8" shipments start into high volume. 1.3" drive shipments may also start a significant upward ramp in 1994 if the various personal digital assistant, personal communicator, etc., markets hit their stride.

Figure 1

CHANGING PRODUCT MIX

Worldwide Rigid Disk Drive Revenue



1993 DISK/TREND REPORT

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1992 Revenues $M	1992 Revenues %	1993 Forecast $M	1993 Forecast %	1994 Forecast $M	1994 Forecast %	1995 Forecast $M	1995 Forecast %	1996 Forecast $M	1996 Forecast %
DISK CARTRIDGE DRIVES	82.2 +17.3%	.3%	101.9 +24.0%	.4%	122.8 +20.5%	.5%	140.5 +14.4%	.6%	152.1 +8.3%	.5%
FIXED DISK DRIVES less than 60 Megabytes	1,726.9 -50.2%	7.0%	282.9 -83.6%	1.2%	111.4 -60.6%	.5%	25.0 -77.6%	.1%	6.8 -72.8%	--
FIXED DISK DRIVES 60 - 100 Megabytes	2,156.0 +10.5%	8.8%	1,176.8 -45.4%	5.0%	273.0 -76.8%	1.2%	154.4 -43.4%	.6%	76.2 -50.6%	.3%
FIXED DISK DRIVES 100 - 200 Megabytes	5,158.9 +59.2%	21.0%	3,982.5 -22.8%	16.9%	2,507.3 -37.0%	10.6%	1,361.3 -45.7%	5.4%	550.0 -59.6%	2.0%
FIXED DISK DRIVES 200 - 300 Megabytes	1,801.3 +82.2%	7.3%	3,551.0 +97.1%	15.0%	4,608.5 +29.8%	19.5%	4,877.5 +5.8%	19.5%	4,744.5 -2.7%	17.1%
FIXED DISK DRIVES 300 - 500 Megabytes	1,751.9 -36.5%	7.1%	1,970.2 +12.5%	8.3%	3,015.1 +53.0%	12.7%	3,446.2 +14.3%	13.7%	3,875.1 +12.4%	14.0%
FIXED DISK DRIVES 500 Megabytes to 1 GB	2,044.5 -34.7%	8.3%	1,837.5 -10.1%	7.8%	2,514.4 +36.8%	10.6%	3,332.6 +32.5%	13.3%	3,962.8 +18.9%	14.3%
FIXED DISK DRIVES 1 - 2 Gigabytes	3,873.2 +45.0%	15.8%	3,608.8 -6.8%	15.3%	3,589.9 -.5%	15.2%	4,371.5 +21.8%	17.4%	5,616.3 +28.5%	20.3%
FIXED DISK DRIVES more than 2 Gigabytes	5,954.6 -6.2%	24.3%	7,089.6 +19.1%	30.0%	6,922.1 -2.4%	29.2%	7,366.7 +6.4%	29.4%	8,712.4 +18.3%	31.5%
Total Worldwide Revenue	24,549.5 -.3%	100.0%	23,601.2 -3.9%	100.0%	23,664.5 +.3%	100.0%	25,075.7 +6.0%	100.0%	27,696.2 +10.5%	100.0%

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

Figure 2

UNIT SHIPMENT SUMMARY

Worldwide Shipments in Millions of Units

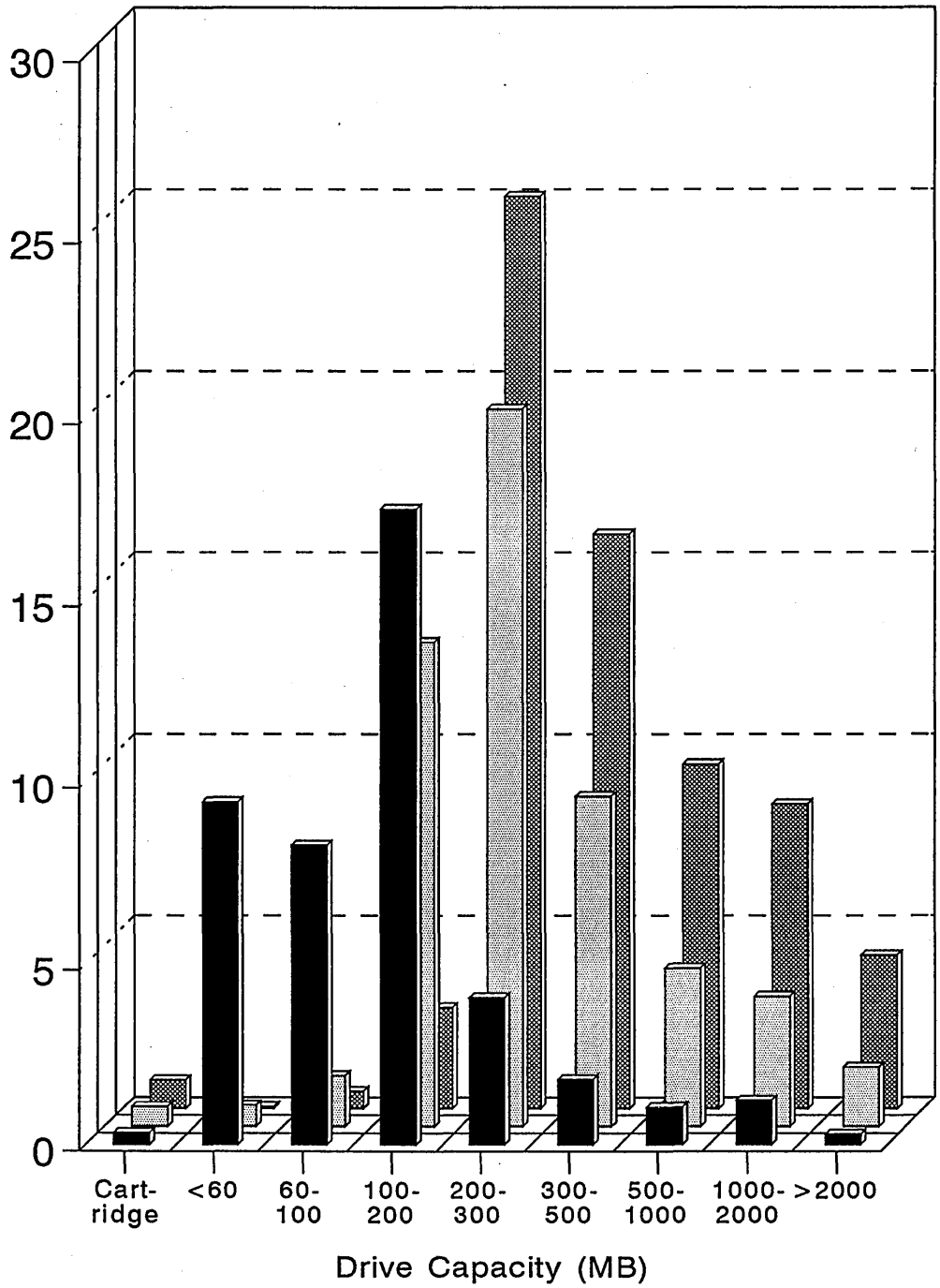


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1992 Shipments Units	1992 Shipments %	1993 Forecast Units	1993 Forecast %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %
DISK CARTRIDGE DRIVES	317.9	.7%	421.4	.9%	550.0	1.0%	675.0	1.1%	790.0	1.2%
	+31.1%		+32.6%		+30.5%		+22.7%		+17.0%	
FIXED DISK DRIVES less than 60 Megabytes	9,431.2	21.5%	1,655.5	3.4%	587.0	1.1%	180.0	.3%	60.0	.1%
	-42.1%		-82.4%		-64.5%		-69.3%		-66.7%	
FIXED DISK DRIVES 60 - 100 Megabytes	8,234.2	18.8%	5,807.8	11.9%	1,411.0	2.6%	865.0	1.4%	480.0	.7%
	+54.5%		-29.5%		-75.7%		-38.7%		-44.5%	
FIXED DISK DRIVES 100 - 200 Megabytes	17,501.2	39.9%	18,306.9	37.6%	13,350.0	24.6%	7,350.0	12.1%	2,790.0	4.2%
	+194.0%		+4.6%		-27.1%		-44.9%		-62.0%	
FIXED DISK DRIVES 200 - 300 Megabytes	4,066.8	9.3%	12,571.9	25.8%	19,750.0	36.3%	23,930.0	39.5%	25,120.0	37.4%
	+113.3%		+209.1%		+57.1%		+21.2%		+5.0%	
FIXED DISK DRIVES 300 - 500 Megabytes	1,808.4	4.1%	4,686.6	9.6%	9,090.0	16.7%	12,360.0	20.4%	15,820.0	23.6%
	+33.1%		+159.2%		+94.0%		+36.0%		+28.0%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	1,031.1	2.3%	2,167.2	4.4%	4,380.0	8.1%	6,830.0	11.3%	9,490.0	14.1%
	+25.2%		+110.2%		+102.1%		+55.9%		+38.9%	
FIXED DISK DRIVES 1 - 2 Gigabytes	1,228.0	2.8%	2,161.8	4.4%	3,610.0	6.6%	5,705.0	9.4%	8,380.0	12.5%
	+174.5%		+76.0%		+67.0%		+58.0%		+46.9%	
FIXED DISK DRIVES more than 2 Gigabytes	288.3	.6%	954.0	2.0%	1,644.5	3.0%	2,726.0	4.5%	4,245.0	6.2%
	+19.4%		+230.9%		+72.4%		+65.8%		+55.7%	
Total Worldwide Shipments	43,907.1	100.0%	48,733.1	100.0%	54,372.5	100.0%	60,621.0	100.0%	67,175.0	100.0%
	+34.7%		+11.0%		+11.6%		+11.5%		+10.8%	
% U.S. Manufacturers	89.6%		90.5%		89.7%		87.0%		84.9%	
Total Capacity (Terabytes)	8,180.4		14,441.1		21,030.6		30,610.1		43,720.0	

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

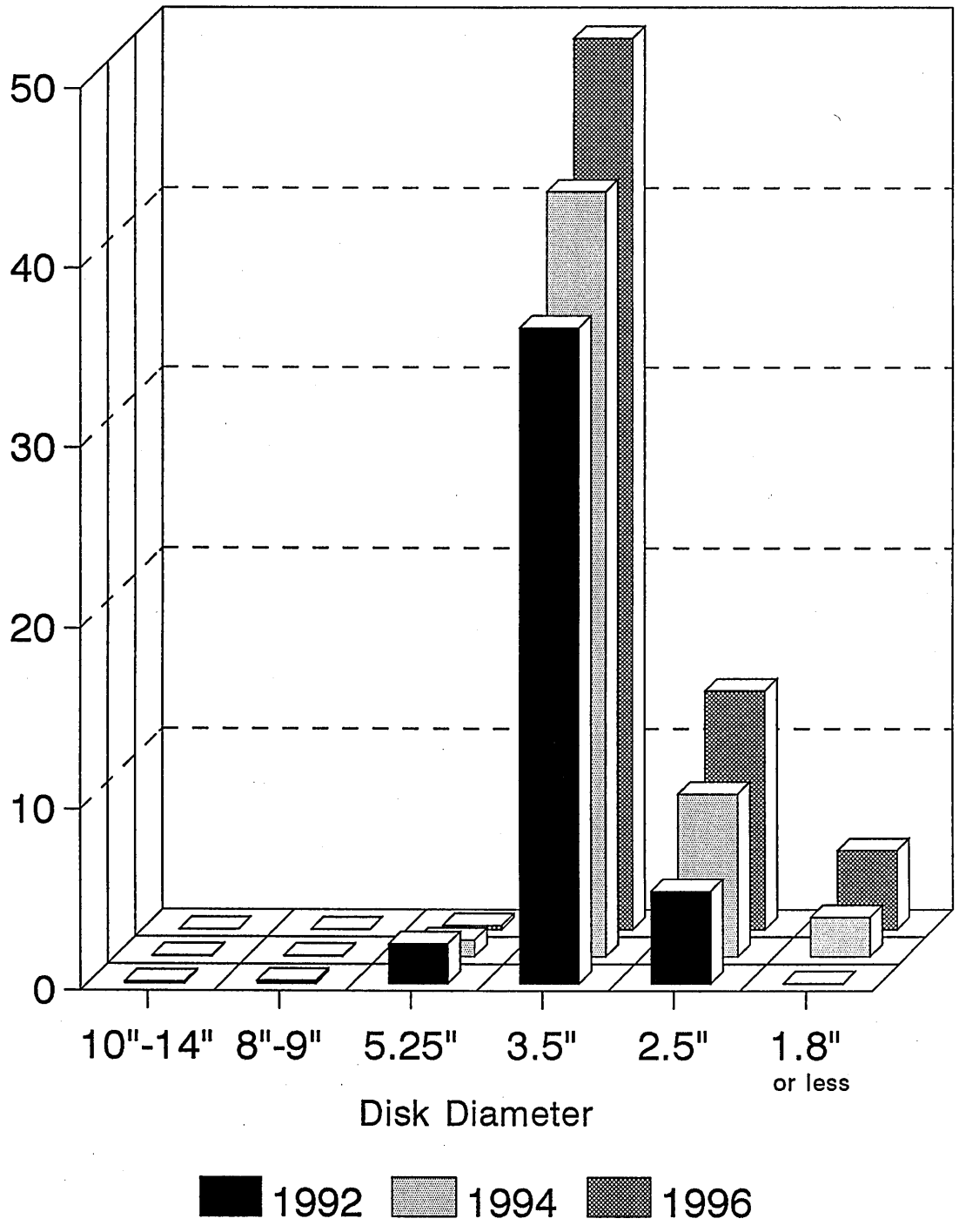


TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
SUMMARY BY DISK DIAMETER

UNIT SHIPMENTS IN THOUSANDS	1992 Shipments Units	1992 Shipments %	1993 Forecast Units	1993 Forecast %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %
10 - 14 INCH	98.3	.2%	83.3	.2%	52.0	.1%	6.0	--	--	--
	-37.8%		-15.3%		-37.6%		-88.5%		--	
8 - 9 INCH	155.0	.4%	94.8	.2%	54.0	.1%	10.0	--	--	--
	-42.0%		-38.8%		-43.0%		-81.5%		--	
5.25 INCH	2,202.5	5.0%	1,368.9	2.8%	913.5	1.7%	535.0	.9%	225.0	.3%
	-27.7%		-37.9%		-33.3%		-41.4%		-57.9%	
3.5 INCH	36,313.7	82.7%	40,452.2	83.0%	42,485.0	78.1%	45,765.0	75.5%	49,375.0	73.5%
	+39.5%		+11.4%		+5.0%		+7.7%		+7.9%	
2.5 INCH	5,115.9	11.7%	6,385.2	13.1%	8,992.0	16.5%	11,280.0	18.6%	13,210.0	19.7%
	+65.8%		+24.8%		+40.8%		+25.4%		+17.1%	
1.8 INCH OR LESS	21.7	--	348.7	.7%	1,876.0	3.5%	3,025.0	5.0%	4,365.0	6.5%
	+2,070.0%		+1,506.9%		+438.0%		+61.3%		+44.3%	
Total Worldwide Shipments	43,907.1	100.0%	48,733.1	100.0%	54,372.5	100.0%	60,621.0	100.0%	67,175.0	100.0%
	+34.7%		+11.0%		+11.6%		+11.5%		+10.8%	

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

Figure 4

CAPACITY SHIPMENT SUMMARY

Worldwide Shipments in Terabytes

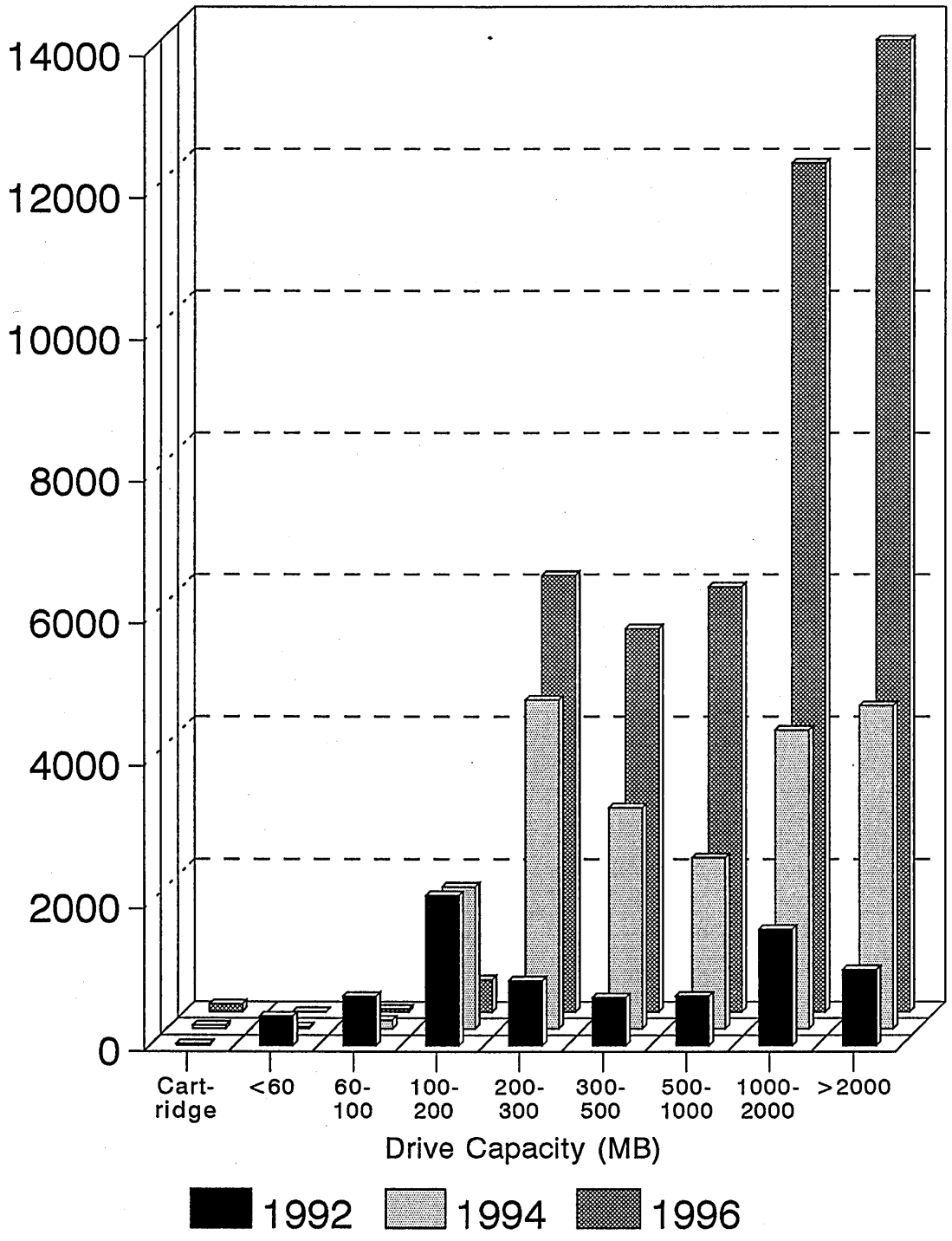


TABLE 6

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	1992 Shipments Tbytes	1992 Shipments %	1993 Forecast Tbytes	1993 Forecast %	1994 Forecast Tbytes	1994 Forecast %	1995 Forecast Tbytes	1995 Forecast %	1996 Forecast Tbytes	1996 Forecast %
DISK CARTRIDGE DRIVES	20.4	.2%	34.2	.2%	46.7	.2%	77.2	.3%	114.1	.3%
	+70.0%		+67.6%		+36.5%		+65.4%		+47.8%	
FIXED DISK DRIVES less than 60 Megabytes	407.4	5.0%	72.2	.5%	23.4	.1%	8.4	--	3.0	--
	-38.1%		-82.3%		-67.5%		-64.1%		-64.4%	
FIXED DISK DRIVES 60 - 100 Megabytes	689.4	8.4%	486.1	3.4%	119.4	.6%	73.1	.2%	40.4	.1%
	+68.4%		-29.5%		-75.4%		-38.8%		-44.8%	
FIXED DISK DRIVES 100 - 200 Megabytes	2,101.9	25.7%	2,692.7	18.6%	1,992.0	9.5%	1,213.0	4.0%	460.9	1.1%
	+188.3%		+28.1%		-26.0%		-39.1%		-62.0%	
FIXED DISK DRIVES 200 - 300 Megabytes	909.9	11.1%	2,887.3	20.0%	4,617.2	22.0%	5,686.3	18.6%	6,129.9	14.0%
	+122.0%		+217.3%		+59.9%		+23.2%		+7.8%	
FIXED DISK DRIVES 300 - 500 Megabytes	670.5	8.2%	1,634.3	11.3%	3,105.6	14.8%	4,203.2	13.7%	5,378.8	12.3%
	+38.3%		+143.7%		+90.0%		+35.3%		+28.0%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	693.3	8.5%	1,270.6	8.8%	2,400.1	11.4%	4,334.8	14.2%	5,971.8	13.7%
	+22.2%		+83.3%		+88.9%		+80.6%		+37.8%	
FIXED DISK DRIVES 1 - 2 Gigabytes	1,625.8	19.9%	2,663.4	18.4%	4,191.0	19.9%	7,230.1	23.6%	11,944.0	27.3%
	+169.5%		+63.8%		+57.4%		+72.5%		+65.2%	
FIXED DISK DRIVES more than 2 Gigabytes	1,061.8	13.0%	2,700.3	18.7%	4,534.8	21.5%	7,783.9	25.4%	13,677.0	31.2%
	+27.8%		+154.3%		+67.9%		+71.6%		+75.7%	
Total Capacity (Terabytes)	8,180.4	100.0%	14,441.1	100.0%	21,030.6	100.0%	30,610.1	100.0%	43,720.0	100.0%
	+73.9%		+76.5%		+45.6%		+45.6%		+42.8%	
% U.S. Manufacturers	84.6%		88.5%		87.2%		85.3%		83.6%	

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

Price per megabyte

For anyone who doubts the severity of the industry's 1993 price wars, Tables 7 and 8, which display the worldwide captive and noncaptive average price per megabyte for each DISK/TREND product group, should be an eye-opener.

Noncaptive drives are undergoing their sharpest price reductions in memory during 1993 for all product groups with capacities over 100 megabytes. While the average price per megabyte for each of these product groups is expected to fall almost 30% or more in 1993, a few groups are being hit even harder. The drop for 300-500 megabyte drives is put at 44.1%, as low cost two platter drives in this capacity range overwhelm older configurations. Drives with more than 2 gigabytes will see a reduction of 55.7%, with high volume shipments of 5.25" and 3.5" drives become dominant, displacing drives with larger disks.

The disk drive industry normally expects prices to fall each year, responding to the lower unit costs associated with continuous parts count reduction, improved manufacturing systems and higher production quantities. But the 1993 reductions in noncaptive prices display the desperate attempts by some disk drive manufacturers to gain market share through overaggressive pricing, in order to load excess factory capacity.

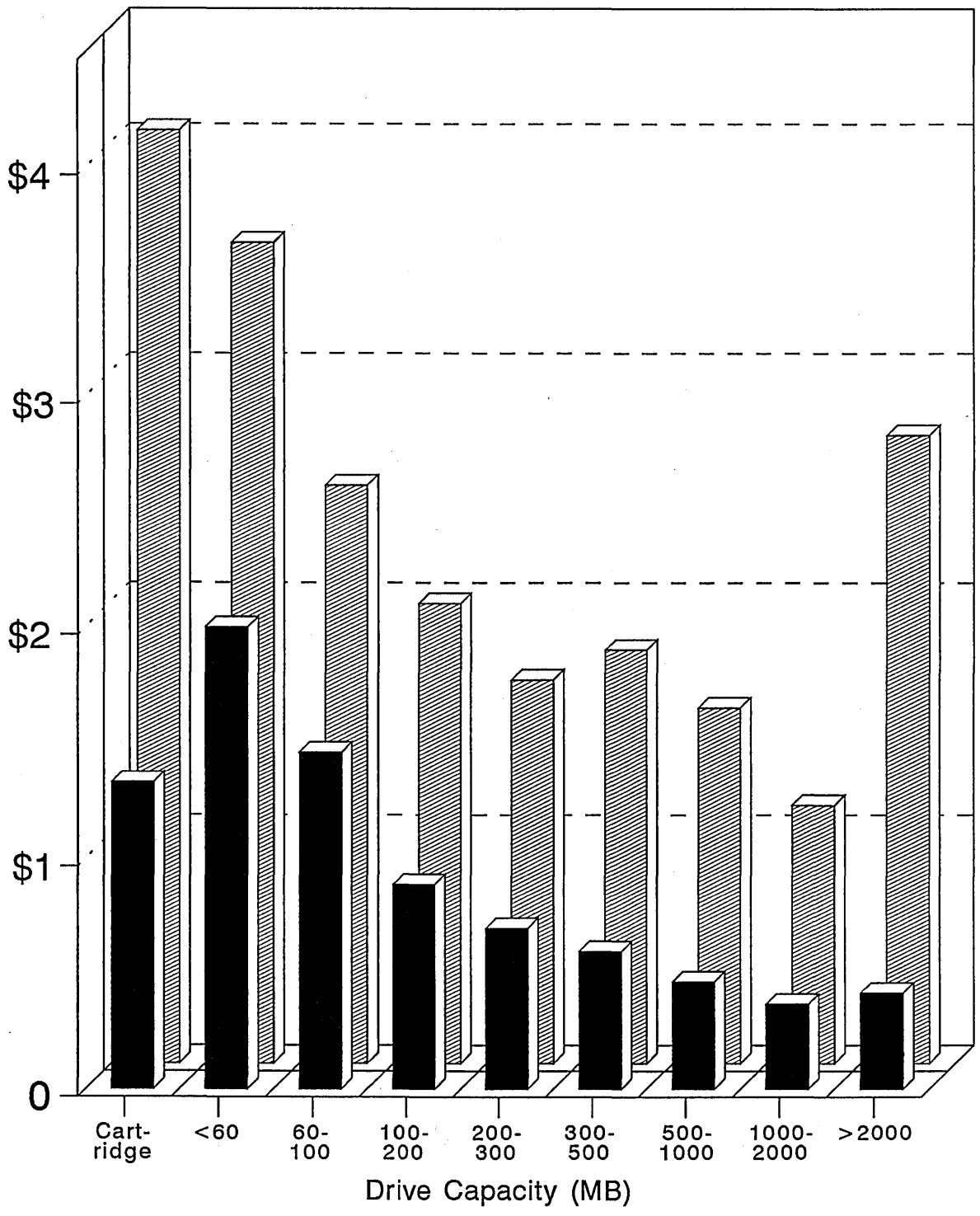
Captive drives have even steeper 1993 declines in average price per megabyte for most product groups with capacities over 100 megabytes. The captive drive producers must respond to prices in the noncaptive market, as the drives are resold by competitive system manufacturers. IBM is easily the largest participant in captive disk drive markets and has aggressively lowered its pricing structures to stay competitive. Also affecting IBM and other captive manufacturers is their continuing movement to new, smaller drives, at significantly lower prices.

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.

Figure 5

PRICE PER MEGABYTE SUMMARY

Noncaptive Worldwide Shipments ($/MB)



1993 DISK/TREND REPORT

TABLE 7

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1992	1993	1994	1995	1996
DISK CARTRIDGE DRIVES	3.75 -35.8%	3.09 -17.6%	2.63 -14.9%	1.82 -30.8%	1.33 -26.8%
FIXED DISK DRIVES less than 60 Megabytes	3.56 -20.9%	3.50 -1.6%	4.19 +19.5%	2.43 -42.0%	2.00 -17.6%
FIXED DISK DRIVES 60 - 100 Megabytes	2.50 -32.9%	1.87 -25.0%	2.11 +12.4%	1.81 -13.9%	1.46 -19.6%
FIXED DISK DRIVES 100 - 200 Megabytes	1.99 -27.9%	1.24 -37.6%	1.07 -14.1%	.93 -12.8%	.89 -3.9%
FIXED DISK DRIVES 200 - 300 Megabytes	1.66 -24.7%	1.03 -37.7%	.86 -17.2%	.76 -11.5%	.70 -7.6%
FIXED DISK DRIVES 300 - 500 Megabytes	1.79 -23.5%	1.00 -44.1%	.82 -18.1%	.69 -16.1%	.60 -12.9%
FIXED DISK DRIVES 500 Megabytes to 1 GB	1.54 -25.4%	1.09 -29.5%	.75 -30.5%	.58 -23.2%	.47 -18.6%
FIXED DISK DRIVES 1 - 2 Gigabytes	1.12 -24.2%	.81 -28.0%	.66 -18.6%	.48 -26.6%	.37 -23.8%
FIXED DISK DRIVES more than 2 Gigabytes	2.72 -27.5%	1.21 -55.7%	.80 -33.6%	.61 -24.4%	.42 -30.8%

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

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

TABLE 8

CAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1992	1993	1994	1995	1996
DISK CARTRIDGE DRIVES	--	--	--	--	--
	--	--	--	--	--
FIXED DISK DRIVES	9.41	7.73	8.72	5.63	3.60
less than 60 Megabytes	-26.5%	-17.9%	+12.7%	-35.4%	-36.1%
FIXED DISK DRIVES	6.31	5.03	4.62	3.70	2.86
60 - 100 Megabytes	-32.5%	-20.3%	-8.1%	-19.9%	-22.9%
FIXED DISK DRIVES	6.99	3.42	2.61	2.40	2.20
100 - 200 Megabytes	-34.7%	-51.1%	-23.6%	-8.2%	-8.2%
FIXED DISK DRIVES	4.96	2.40	1.80	1.55	1.42
200 - 300 Megabytes	-77.2%	-51.5%	-25.3%	-13.5%	-8.7%
FIXED DISK DRIVES	6.31	3.44	1.94	1.55	1.32
300 - 500 Megabytes	-45.7%	-45.5%	-43.6%	-20.3%	-14.5%
FIXED DISK DRIVES	8.34	6.65	2.73	1.83	1.42
500 Megabytes to 1 GB	-35.3%	-20.2%	-59.0%	-32.8%	-22.8%
FIXED DISK DRIVES	6.03	2.81	1.64	1.22	1.09
1 - 2 Gigabytes	-50.3%	-53.4%	-41.5%	-25.9%	-10.3%
FIXED DISK DRIVES	8.26	4.55	3.09	1.75	1.35
more than 2 Gigabytes	-21.4%	-45.0%	-31.9%	-43.3%	-23.0%

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

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

Noncaptive market

Noncaptive drives constituted 87.3% of total worldwide unit shipments of rigid disk drives in 1992, a share which is destined to decline slightly through 1996, to 84.5%, even though the actual total will continually increase. The total in that year is forecasted at 56.8 million drives. However, noncaptive worldwide revenues are expected to continue the growth trend started at the beginning of the 1990's, expanding from 51.1% of total revenues in 1992 to 63% in 1996. The increasing share of revenues for noncaptive drives is rooted in the continually growing share of higher capacity drives, at relatively higher prices, which are sold through noncaptive channels, plus the fact that the difference between captive drive prices and noncaptive prices is gradually being reduced.

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.

The market for noncaptive disk drives is dominated by 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.

The noncaptive drive leaders now face new challenges, as they try to cope with the conflicting demands of overaggressive price leaders and the development of ever-increasing recording densities and higher performance. In the higher capacity ranges, the independent firms face new levels of competition from traditional captive producers, such as IBM, Digital Equipment and Hewlett-Packard. Presumably, the best managers will win.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1992 Revenues $M	1992 Revenues %	1993 $M	1993 %	1994 $M	1994 %	Forecast 1995 $M	Forecast 1995 %	Forecast 1996 $M	Forecast 1996 %
DISK CARTRIDGE DRIVES	82.2 +17.3%	.7%	101.9 +24.0%	.8%	122.8 +20.5%	.9%	140.5 +14.4%	.9%	152.1 +8.3%	.9%
FIXED DISK DRIVES less than 60 Megabytes	1,280.7 -52.3%	10.2%	228.0 -82.2%	1.8%	85.9 -62.3%	.6%	17.0 -80.2%	.1%	5.0 -70.6%	--
FIXED DISK DRIVES 60 - 100 Megabytes	1,437.7 +15.7%	11.5%	753.1 -47.6%	5.8%	233.7 -69.0%	1.6%	111.7 -52.2%	.7%	40.9 -63.4%	.2%
FIXED DISK DRIVES 100 - 200 Megabytes	3,794.8 +139.5%	30.3%	2,979.6 -21.5%	23.3%	1,861.9 -37.5%	13.4%	981.2 -47.3%	6.2%	317.8 -67.6%	1.9%
FIXED DISK DRIVES 200 - 300 Megabytes	1,364.0 +52.7%	10.9%	2,557.0 +87.5%	19.9%	3,351.5 +31.1%	23.7%	3,761.6 +12.2%	23.9%	3,845.3 +2.2%	22.1%
FIXED DISK DRIVES 300 - 500 Megabytes	981.6 +35.6%	7.8%	1,496.9 +52.5%	11.7%	2,198.6 +46.9%	15.6%	2,443.4 +11.1%	15.4%	2,676.8 +9.6%	15.3%
FIXED DISK DRIVES 500 Megabytes to 1 GB	846.6 +6.1%	6.8%	1,290.2 +52.4%	10.0%	1,541.5 +19.5%	11.0%	2,131.1 +38.2%	13.5%	2,244.2 +5.3%	12.9%
FIXED DISK DRIVES 1 - 2 Gigabytes	1,360.2 +110.1%	10.8%	1,570.6 +15.5%	12.2%	2,210.9 +40.8%	15.7%	2,928.0 +32.4%	18.5%	3,789.8 +29.4%	21.7%
FIXED DISK DRIVES more than 2 Gigabytes	1,385.0 +4.6%	11.0%	1,875.0 +35.4%	14.5%	2,483.2 +32.4%	17.5%	3,313.7 +33.4%	20.8%	4,386.4 +32.4%	25.0%
Total Worldwide Revenues	12,532.8 +25.7%	100.0%	12,852.3 +2.5%	100.0%	14,090.0 +9.6%	100.0%	15,828.2 +12.3%	100.0%	17,458.3 +10.3%	100.0%

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

TABLE 10

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1992 Shipments Units	1992 Shipments %	1993 Forecast Units	1993 Forecast %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %
DISK CARTRIDGE DRIVES	317.9 +31.1%	.8%	421.4 +32.6%	1.0%	550.0 +30.5%	1.2%	675.0 +22.7%	1.3%	790.0 +17.0%	1.4%
FIXED DISK DRIVES less than 60 Megabytes	8,269.9 -44.1%	21.7%	1,484.1 -82.1%	3.5%	507.0 -65.8%	1.1%	145.0 -71.4%	.3%	50.0 -65.5%	.1%
FIXED DISK DRIVES 60 - 100 Megabytes	6,813.6 +56.3%	17.8%	4,750.7 -30.3%	11.4%	1,311.0 -72.4%	2.8%	725.0 -44.7%	1.4%	330.0 -54.5%	.6%
FIXED DISK DRIVES 100 - 200 Megabytes	15,893.5 +233.8%	41.5%	16,294.5 +2.5%	38.5%	11,811.0 -27.5%	25.3%	6,365.0 -46.1%	12.4%	2,090.0 -67.2%	3.6%
FIXED DISK DRIVES 200 - 300 Megabytes	3,648.8 +93.2%	9.5%	10,795.4 +195.9%	25.6%	17,038.0 +57.8%	36.3%	21,150.0 +24.1%	40.7%	22,680.0 +7.2%	40.1%
FIXED DISK DRIVES 300 - 500 Megabytes	1,463.4 +72.8%	3.8%	4,292.1 +193.3%	10.2%	7,860.0 +83.1%	16.8%	10,455.0 +33.0%	20.2%	13,155.0 +25.8%	23.2%
FIXED DISK DRIVES 500 Megabytes to 1 GB	847.0 +45.1%	2.2%	2,047.2 +141.7%	4.8%	3,729.0 +82.2%	8.0%	5,675.0 +52.2%	10.9%	7,365.0 +29.8%	12.9%
FIXED DISK DRIVES 1 - 2 Gigabytes	880.6 +176.8%	2.3%	1,529.6 +73.7%	3.6%	2,847.0 +86.1%	6.1%	4,642.0 +63.0%	9.0%	6,925.0 +49.2%	12.2%
FIXED DISK DRIVES more than 2 Gigabytes	174.3 +34.2%	.4%	618.8 +255.0%	1.4%	1,189.5 +92.2%	2.4%	2,024.0 +70.2%	3.8%	3,395.0 +67.7%	5.9%
Total Worldwide Shipments	38,309.0 +37.2%	100.0%	42,233.8 +10.2%	100.0%	46,842.5 +10.9%	100.0%	51,856.0 +10.7%	100.0%	56,780.0 +9.5%	100.0%
% U.S. Manufacturers	90.0%		90.8%		90.0%		86.6%		84.0%	
Total Capacity (Terabytes)	6,500.3	100.0%	11,550.9	100.0%	17,021.0	100.0%	24,920.8	100.0%	35,973.4	100.0%

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

TABLE 11

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPPED IN TERABYTES	1992 Capacity Units	1992 Capacity %	1993 Forecast Units	1993 Forecast %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %
DISK CARTRIDGE DRIVES	20.4	.3%	34.2	.3%	46.7	.3%	77.2	.3%	114.1	.3%
	+70.0%		+67.6%		+36.5%		+65.4%		+47.8%	
FIXED DISK DRIVES less than 60 Megabytes	360.0	5.6%	65.1	.6%	20.5	.1%	7.0	--	2.5	--
	-39.6%		-81.9%		-68.5%		-65.9%		-64.3%	
FIXED DISK DRIVES 60 - 100 Megabytes	575.6	8.8%	401.9	3.4%	110.9	.6%	61.6	.3%	28.0	.1%
	+72.4%		-30.2%		-72.4%		-44.5%		-54.5%	
FIXED DISK DRIVES 100 - 200 Megabytes	1,906.7	29.4%	2,399.3	20.9%	1,744.8	10.3%	1,054.3	4.2%	355.3	1.0%
	+232.0%		+25.8%		-27.3%		-39.6%		-66.3%	
FIXED DISK DRIVES 200 - 300 Megabytes	821.7	12.7%	2,473.9	21.4%	3,916.9	23.1%	4,967.9	20.1%	5,495.6	15.4%
	+102.7%		+201.1%		+58.3%		+26.8%		+10.6%	
FIXED DISK DRIVES 300 - 500 Megabytes	548.5	8.4%	1,496.7	13.0%	2,684.8	15.8%	3,554.7	14.2%	4,472.7	12.4%
	+77.2%		+172.9%		+79.4%		+32.4%		+25.8%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	549.6	8.5%	1,188.3	10.3%	2,043.6	12.0%	3,679.7	14.8%	4,757.5	13.2%
	+42.3%		+116.2%		+72.0%		+80.1%		+29.3%	
FIXED DISK DRIVES 1 - 2 Gigabytes	1,209.2	18.6%	1,938.1	16.8%	3,351.9	19.7%	6,045.1	24.2%	10,272.5	28.6%
	+177.0%		+60.3%		+73.0%		+80.3%		+69.9%	
FIXED DISK DRIVES more than 2 Gigabytes	508.6	7.7%	1,553.4	13.3%	3,100.5	18.1%	5,473.2	21.9%	10,475.0	29.0%
	+44.2%		+205.4%		+99.6%		+76.5%		+91.4%	
Total Capacity (Terabytes)	6,500.3	100.0%	11,550.9	100.0%	17,021.0	100.0%	24,920.8	100.0%	35,973.4	100.0%
	+90.8%		+77.7%		+47.4%		+46.4%		+44.4%	
% U.S. Manufacturers	83.4%		87.3%		85.6%		83.1%		81.3%	

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

TABLE 12

1992 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1992 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Conner Peripherals	--	--	640.4	13.5	1,593.8	20.4	2,234.2	9.1
Digital Equipment	824.7	6.9	28.7	.6	33.5	.4	886.9	3.6
Hewlett-Packard	354.7	3.0	68.4	1.4	96.3	1.2	519.4	2.1
IBM	8,952.2	74.5	63.0	1.3	358.5	4.6	9,373.7	38.2
Maxtor	--	--	723.5	15.3	576.4	7.4	1,299.9	5.3
Micropolis	--	--	167.5	3.5	214.6	2.8	382.1	1.6
Quantum	--	--	386.6	8.2	1,142.5	14.7	1,529.1	6.2
Seagate Technology	--	--	1,124.0	23.7	1,792.6	23.0	2,916.6	11.9
SyQuest Technology	--	--	74.8	1.6	.3	--	75.1	.3
Western Digital	--	--	274.1	5.8	667.2	8.6	941.3	3.8
Other U.S.	--	--	28.2	.6	43.9	.6	72.2	.3
U.S. Total	10,131.7	84.3	3,579.2	75.6	6,519.6	83.6	20,230.5	82.4
NON-U.S. MANUFACTURERS								
Alps Electric	--	--	89.8	1.9	56.0	.7	145.8	.6
Fujitsu	738.5	6.1	156.5	3.3	693.7	8.9	1,588.7	6.5
Hitachi	383.3	3.2	715.0	15.1	149.5	1.9	1,247.8	5.1
NEC	548.2	4.6	--	--	66.6	.9	614.8	2.5
Samsung Electronics	30.0	.2	45.0	1.0	33.0	.4	108.0	.4
Toshiba	177.5	1.5	71.0	1.5	123.4	1.6	371.9	1.5
Other Non-U.S.	7.5	.1	78.0	1.6	156.5	2.0	242.0	1.0
Non-U.S. Total	1,885.0	15.7	1,155.3	24.4	1,278.7	16.4	4,319.0	17.6
WORLDWIDE TOTAL	12,016.7	100.0	4,734.5	100.0	7,798.3	100.0	24,549.5	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"-6.5"
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 (20)	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	2				
Aura Associates	P,O		1.8	1.8	1.8	3				
Avatar Systems	O	2								
Conner Peripherals	P,O			3	2,3	2,3	2,3	3	3	3
Digital Equipment	C,O						3	3,5	3,5	3,5
DMA Technologies	O	5								
Gigastorage Technology	O								5	5
Hewlett-Packard	C,P,O		1,3					3,5	3,5	3,5
IBM	C,P,O				2,3	2,3	2,3,5	3,5	3,5,10	3,10
Integral Peripherals	P,O		1.8	1.8	1.8					
Kalok	P,O					3	3	3		
Maxtor	P,O				1.8,2,3	2,3	3	3	3	
MFM Technology	O	5								
Micropolis	P,O							3	3	5
MiniStor Peripherals	O		1.8	1.8	1.8					
Quantum	P,O		2,3	2,3	2,3	2,3	3	3	3	
Seagate Technology	P,O		2,3	2,3	2,3	2,3	2,3	3	3,5	3,5,8
Sequel	O			5	5,8	8	5	5		
SyQuest Technology	P,O	2,3,5								
Western Digital	P,O		1.8		2,3	3	3	3		
Asian Manufacturers (13)										
Alps Electric	O		3	2	2,3	3	3			
Daeyoung	O				3					
Fuji Electric	O		3	2,3	2,3	3				
Fujitsu	C,P,O		2,3	2,3	2,3	2,3,5	3,5,8	3,5,8,10	3,5,8,10	5,8
Hitachi	C,P,O			5	5	3	3,5,8	3,5,8	3,5,8,14	5,8
Myrica	O					3				
NEC	C,O		1.8,3	1.8	1.8,3,5	3	3,5,8	5,8	3,5,8	8
Ricoh	O	5								
Samsung Electronics	C,P,O				3	3		3		
Teac	P,O					3				
Toshiba	C,O		2,3	2	2	2	2	2	3	
Xebec	P,O					3				
Zentek	O				2,3	3				
European Manufacturers (3)										
Calluna Technology	O			1.8						
EZI	O						5			
Sagem	O					5				
South American Manufacturers (4)										
Digiredo	O			5	5					
Elebra	P,O			5						
Qualitron	O		5	5						
Wintec Tecnologia	P,O		3							

TECHNICAL REVIEW

Competing technologies

Fast paced technological improvement in the rigid disk drive industry continues unabated, and since IBM's 1989 demonstration of 1 gigabit per square inch recording, the rate of change has increased. Each year manufacturers consistently provide smaller, faster, more reliable, higher capacity, less expensive disk drives. The magnetic storage industry infrastructure has made the rapid rate of change possible 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. If all of the projected improvements occur, a thirty to fifty-fold expansion of capacity within existing form factors by the end of the decade appears credible.

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.

Those few technologies which do provide competition to magnetic disk drives in applications where characteristics such as speed, removability, or environmental tolerance give them unique advantages, are discussed in the following sections.

* Semiconductor memory -- applications and trends: Semiconductor memory offers fast response time and high reliability, characteristics that have won it a secondary storage role in both large and small systems. When very fast access to data or programs is required, semiconductor memory can serve as an effective, though expensive, substitute for rigid drives. Larger systems frequently have large auxiliary semiconductor storage units performing as virtual disk drives or as cache between the host processor and disk storage. Personal computer operating systems allow part of main memory to be designated for use as a fast virtual disk.

Fast semiconductor memory is expensive, ranging from a few hundred to a few thousand dollars per megabyte, which limits its use to situations where its high speed or lack of moving parts are vitally necessary to meet system requirements. The least expensive semiconductor memories are volatile, and require the continuous availability of power to avoid loss of data. Nonvolatile semiconductor memory is more expensive, usually slower, and does not yet match the capacity per chip of DRAM, the most common form of volatile semiconductor memory. Some companies package semiconductor memory in disk drive form factors, typically using 4 megabit chips as the active storage elements. For instance, Hitachi offers 320 megabytes in a full height 5.25" form factor.

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

The packaging of memory modules is evolving rapidly, especially memories used with portable systems. The Personal Computer Memory Card International Association (PCMCIA) has standardized the interface for plug-in cards used to expand system memory, emulate a disk drive, or provide other peripheral functions. 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 be in the form of PCMCIA cards and will have the capability to be plugged into a PCMCIA Type III card slot. Some issues regarding software support of the PCMCIA interface are not yet fully worked out, and the use of the PCMCIA interface does not yet fully guarantee functional interchange among devices that are electrically and physically PCMCIA compliant.

Specialized portable computers can use removable semiconductor memory packaged in a flat "credit card" format with PCMCIA interfaces. Pin interconnect and packaging standards have been worked out, with the final result being a 68 pin connector and a family of package heights 3.3 millimeters (Type I), 5 millimeters (Type II) and 10.5 millimeters (Type III). The cards are available with a variety of memory forms, including disk drives, PROM, ROM, SRAM, DRAM, and flash memory.

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 diame-

ter wafers are available. 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.

Can semiconductor memory technology 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 have inspired 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 readily available in 4 megabit configurations and production of 16 megabit configurations has started. Large quantity production of 64 megabit DRAM chips is not expected until after 1995.

  SRAM memory chips are in volume production in 1 megabit and 4 megabit configurations. 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. SRAM is sometimes used in removable memory cards that contain a small battery that provides the power needed by SRAM memories to retain data. However, SRAM is more expensive than DRAM.

* Nonvolatile semiconductor memories: Flash memory, a form of EEPROM in which a block of memory cells can be erased by an electrical signal, is nonvolatile and can be used as fixed or removable storage. Flash memory can provide adequate mass storage where capacity need be only a few megabytes, power limitations are severe, a hostile environment exists, and product price is not a paramount factor.

  Flash memory is often discussed as a major competitor to rotating memory, but its more significant applications will be for program storage

and as a reprogrammable BIOS in computer systems. In this role, flash memory can provide obsolescence protection by allowing periodic code updates, and provide functionality changes in printers, fax machines, and other electronic equipment.

While flash memories are rugged, portable, reliable and use little power, they have some functional disadvantages. When rewriting, it is not possible to change only a few bits; an entire block must be erased and rewritten, and this can take from 10 milliseconds to as long as half a second for the equivalent of a disk sector in some flash memories. Whatever is in the cell block must be saved to RAM and restored after the erase/write cycle on the flash memory chip. As a result, read operations can be very fast compared to a magnetic drive, but writing may be slower. There is also a limit to the number of times the memory device can be rewritten. At present, most flash memory devices are specified for 100,000 write/erase cycles. Some chips are specified at only 10,000 cycles. Some flash memories still require 12 volt power, but more recent products operate on 5 volts and development on 3.3 volt chips is under way at several companies. A 512K 3.3 volt chip became available from Atmel in 1993.

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 remained at about $40 to $60 per megabyte in 1992 and 1993 due to production roadblocks expected to clear by late 1993. 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. Some disk drive producers, including Seagate, Conner and Quantum, have formed alliances with flash memory producers with the expectation of bringing flash memory modules organized as low capacity disk drives to market. These alliances also provide drive manufacturers with an early opportunity to assess and react to flash memory as a competitor to magnetic storage and to profit in either case.

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. Ramtron's effort will produce 64 kilobit chips in 1993 and may produce 256 kilobit chips in 1994 and 4 megabit chips in 1995. 4 kilobit chips are currently being sold for a variety of applications, including electronic games, where they can provide a "save game" function.

Supporters of ferroelectric memories project that in the 1995-1996 time frame, chips with 1 to 4 megabit capacity could be available selling at $30 to $60 per megabyte. 16 megabit chips, possibly available in 1996, could sell in the $15 to $25 per megabyte range. Additional packaging and system costs will be incurred to fabricate the equivalent of a disk drive.

Ferroelectric and flash memories will contend for acceptance in portable computers, "smart cards" and in 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. Among the supporters of the MCC effort have been DEC, NCR, Eastman Kodak, General Dynamics and E-Systems. MCC demonstrated working prototypes of holographic memories in a 5.25" form factor in 1992 and established a subsidiary corporation, Tamarack Storage Devices, to commercialize the technology. MCC's devices had targeted capacities in the range of 200 megabytes to 10 gigabytes, average access times in the 1 to 10 microsecond range and data transfer rates in the gigabyte per second range. The storage medium, once written, can be read billions of times without significant degradation. However, the storage medium is a write-once medium. The specifications of Tamarack's first product will not be quite so impressive: It will include a jukebox holding up to 30 memory "tiles", with each tile containing 914 megabytes of storage. Once loaded, a tile is mechanically moved to center the appropriate area under a read/write head. Because of the positioning required, average access time is likely to be in the 30 to 50 millisecond range plus exchange time, if necessary. Data transfer rate is likely to be in the 1 to 1.5 megabyte per second range.

Tamarack has projected the cost per megabyte of its holographic storage at 2 to 4 times the cost of magnetic storage of equivalent unit capacity. Pilot line production of a 30-50 gigabyte device occupying a 5.25" form factor is expected in early 1994.

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

* Optical disk drives: Optical drives range from 3.5" units with 128 megabyte capacity to 14" drives with several gigabytes of capacity. With track densities of 18,000 tracks per inch and linear bit densities of 30,000 bits per inch or more, optical disk drives are capable of higher areal densities than magnetic disk drives now in use, although magnetic disk drives now exceeding 350 megabits per square inch areal density are closing the gap. 2.5" optical drives are expected to be available in 1994.

  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. (IBM has projected availability of magnetic disk drives operating at a gigabit per square inch in 1996.) However, slightly shorter wavelength lasers are 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 current magnetic disk technology, nor can optical drives yet compete on a product cost basis. Therefore, optical disk drives are preferred only where removability of the media is an advantage, such as use in an automated library or for security concerns. Even in some removable applications, 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 1994 due to the expected displacement of 5.25" write-once drives by multifunction optical disk drives. Because individual manufacturers have championed their own approaches, 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 megabytes per side, 512 megabytes per side, or 652 megabyte per side capacity. An advance to over 1 gigabyte per side is anticipated in late 1994. IBM, Sony, Maxoptix, Hewlett-Packard and others have begun production of the 652 megabyte version, and Hitachi expects to have a 970 megabyte per side drive in production by late 1993. The 1.3 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 230 megabytes per side is anticipated in the late 1993 time frame, and 3.5" drives with 512 megabytes per side are being actively considered by a number of firms. Sony has indicated it intends to produce and license a 140 megabyte 2.5" drive. Production is expected in the second half of 1994.

  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 stymied its development effort.

Rewritable magneto-optic storage is well into the manufacturing stage. Almost 380,000 5.25" and 3.5" drives were shipped in 1992. About 90% of these were magneto-optic rewritable drives. 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 eventually become 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.

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

* Magnetic bubbles: Bubble memories continue to serve markets requiring specialized packaging or operation under environmental stress. Once 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. Hitachi remains the largest producer, with most production used by Nippon Telephone and Telegraph for 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 University, 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 began commercial development of VBL memory technology in conjunction with Jet Propulsion Laboratories and Boston University, but this effort ceased after Magnesys was purchased by Group Technologies Corp., which used other Magnesys bubble memories in military equipment.

  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 150 megabytes in capacity and compete with removable 5.25" rigid cartridge 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 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 produced by Insite Peripherals and Iomega (licensed by Insite) have achieved a degree of acceptance. Several Japanese floppy drive producers have jointly proposed a standard for a family of high capacity drives including 10, 20 and 40 megabyte models.

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. The 3.5" drives produced by Insite and Iomega use Barium Ferrite magnetic media with an optical servo pattern on the disk surface, combined with optical tracking methods. Brier Technology offers a 20 megabyte model that 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 with metal particle media.

Disk drive enhancements

The first moving head rigid magnetic disk drive was introduced by IBM in 1956, giving birth to a highly competitive industry whose hallmark is continuous and rapid improvement in product technology. IBM provided disk drive technology leadership until the late 1970s at which time IBM was displaced from its leading position by aggressive competitors manufacturing small diameter drives. IBM reemerged as a technology leader in the late 1980s, especially in packaging. Leading products included 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. As of mid-1993, IBM continues to reinforce its position, with the 1" high, 3.5" 1 gigabyte "Spitfire" disk drive, a leader in high-end drive packaging. Other manufacturers are expected to follow IBM's lead and move to higher areal densities based on magnetoresistive heads and improved data channels. The critical technologies being addressed by IBM and others are discussed below.

* Head flying height: Because head flying height determines the achievable areal density, reductions are of critical importance. Head flying height is 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 or other alternative substrates may be necessary to obtain the required smoothness and flatness for the lowest flying and glide heights. Determining reliable processes for manufacturing, coating, texturing and testing disk media using alternative substrates are major challenges, especially as glide heights decrease below 2 microinches in coming years. A few drive manufacturers have begun using glass substrates even where not absolutely required in order to gain experience and prepare for more exacting future demands.

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, developed a "water skiing" technique in which the friction of head/disk contact is controlled by floating a head on a continually refreshed liquid bearing surface. Lubricant that spins off the disk due to centrifugal force is filtered and recirculated back to the disk surface. IBM has publicly discussed a "tail dragging" approach that suspends a small head from a larger flying head. The large area of the flying head keeps the head at a stable height and orientation while positioning the smaller active head at the surface of the disk. 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 (minisliders) designed to compete against IBM's 3370, 3375, 3380, and other new drives with ferrite heads became common. The avalanche of small diameter disk drives from multiple OEM sources since the early 1980's has required smaller head contours and continues to drive the demand for higher performance smaller heads. These pressures have driven the development of composite, metal-in-gap ferrite heads, inductive thin film heads, and magnetoresistive thin film heads.

  Sliders have continued to decline in size under the pressure to make ever smaller HDAs. The 70% form factor microslider (70% of the volume of a minislider) is being used in thin 3.5" and 2.5" diameter drives and the 50% form factor nanoslider 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 during 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. Drive manufacturers often perform a disk drive product launch using thin film heads to insure performance, and then retrofit the drive with highly customized MIG heads to reduce cost. Still, thin film heads are probably the technology of choice for most 3.5" drives with capacities of 500 megabytes and above.

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.

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 acquired Dastek.

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 capabilities now exceed demand.

Now making their debut are magnetoresistive heads, which have appeared in both high performance and small form factor drives. IBM introduced the first disk drives using MR heads in 1991 and uses them in 3.5" and 2.5" disk drives, as well as in the 3390-9. Other drive manufacturers are expected to introduce drives with MR heads for production in 1994.

Magnetoresistive thin film heads will be 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 a 1 gigabyte 3.5" drive that began production in late 1991. The first 2.5" drive with MR heads followed in 1993. In August, 1993, IBM published information suggesting that advanced MR heads using "giant magnetoresistance", which enhances head sensitivity, will be a key factor in moving beyond 1 gigabit per square inch in 1996, to 10 gigabits per square inch areal density by the end of the decade. Giant magnetoresistance is still in the laboratory stage at IBM and other firms. Utilization in a production disk drive is probably at least three years away. There appear to be several possible methods of constructing multilayer heads exhibiting enhanced magnetoresistance, with the more promising designated as the multilayer granular alloy approach and the spin valve, also a multilayer structure. The challenge is to fabricate a structure highly responsive to the lower field strengths typically seen by read heads.

MR heads are usually fabricated in an assembly including an inductive thin film head for writing and the MR head for readback of data. The width of the write head is usually 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. Fluorocarbon based lubricants are typically used in current drive designs. Carbon and silicon dioxide overcoatings have been getting thinner to reduce head-recording layer separation. The thinnest are now down to about .2 microinch. Carbon is the most favored material.

  Substrate smoothness has been a critical issue for several years as flying heights have diminished. Aluminum substrates require a layer, usually plated, of very smooth material to serve as a surface for the deposition of the magnetic recording layer. A typical layer is 300 to 400 microinches thick, and is textured to provide protection against stiction. The depth of the texturing is decreasing as flying heights decrease, but the texturing patterns are becoming more complex, increasing the sophistication and

expense of texturing equipment. Zoned recording (requiring zoned texturing) and the expansion of the active recording area closer to the outer edge of the disk are also increasing the complexity of the texturing process. The increasing complexity of the processes required to create good aluminum substrates are encouraging the use of glass and glass/ceramic hybrid materials as substrates, as the surface is inherently smooth and texturing can be obtained in the process of making the basic substrate.

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, has abandoned oxide coated media in all drives introduced since 1989. While barium ferrite might be able to extend the areal density capabilities of coated disks, the surface roughness of barium ferrite is too great for reliable operation at today's lowering flying heights. If barium ferrite is used, it will probably occupy only a few product niches.

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 remain in production, most drive producers believe plated media practically tops out at 1,200 oersteds and prefer sputtered media above that value of coercivity.

Media producers find the sputtering process easier to control and capable of substantially higher yields than the plating process. Sputtering is also less subject to water contamination. Sputtered disk producers are concentrating on 5.25", 3.5", and 2.5" media because the bulk of the near term demand is in those sizes, and some are manufacturing 1.8" media. Production of 1.3" media is limited, because there is currently only one major customer. Media with coercivity in the 1,400 to 1,800 oersted range is routinely produced, and some companies have demonstrated fabrication of media up to 2,300 oersted coercivity on production quality sputtering systems. Media with coercivities exceeding 1,800 oersteds is expected to increasingly appear in new high end 2.5" and 1.8" drive designs in 1994 and after.

While most thin film media production has been from independent producers, some drive manufacturers, such as IBM, Conner, Western Digital and Seagate also produce some of their media needs, and appear to be in the process of substantially upgrading internal production capabilities. The effect is to reduce external disk purchases by these drive manufacturers, although the effect on the independent disk media manufacturers has been mitigated by the very strong demand for 3.5" and 2.5" drives. However, it is possible that an overcapacity situation may be developing in the thin film media industry.

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. 1.8" glass media has yet to become widely available. Glass substrates are potentially smoother and flatter (especially in very thin substrates) than aluminum, have fewer impurities that can cause defects, and can be made very thin. These characteristics allow for lower flying heights and the inclusion of more disks in a stack, both highly desirable features. However, because of low production volume, glass disks currently cost significantly more than aluminum substrates and industry production capacity is limited at present. In 1993, Seagate Technology and Corning announced that Seagate has agreed to use Corning's canasite glass/ceramic substrates in volume production, and the company is adding substantial disk substrate production capacity. Other alternative substrate materials have been proposed, including carbon, plastic, titanium and silicon carbide, but none of these have yet won acceptance.

As flying heights decline below 4 microinches, it is possible 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. Alternative substrates offer other advantages as well: They are typically harder than aluminum and less vulnerable to shock induced head slap damage. Texturing may also be easier to control in alternative substrates.

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 in drives appearing in 1993 and 1994. 2.5" drive substrates, now at 35 mils, are also migrating to 25 mils and will probably have begun a further migration to 15 mil substrates by mid-decade. The 1.3" Kittyhawk drive currently uses 15 mil thick substrates. Some disk drive designers believe that 7 mil glass substrates will be in use within a few years.

* Areal density: Many drives currently in production have areal densities exceeding 150 million bits per square inch and areal density continues to rapidly increase. Drives using MR heads and having areal densities exceeding 350 million bits per square inch went into production in the first half of 1993. Areal density is expected to increase to 1 gigabit per square inch in 1996, and 10 gigabits per square inch might be reached by the end of the decade. The effect of increasing areal density is to reduce the

number of disks and heads needed to achieve a given capacity in a specific form factor, which in turn lowers production costs for that configuration.

TPI in excess of 2,000 is common and some small drives operate at over 4,000 TPI. The industry still has plenty of room for innovation in this area. IBM's "Wakasa" 2.5" drive operates at 4,300 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 1 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. New materials and designs being developed to improve vibration suppression damping in head gimbal assemblies and positioning mechanisms should assist in reaching higher track densities.

IBM's 1 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 often operate with bit density between 50,000 and 70,000 BPI, and a few have BPI in excess of 80,000. This figure is expected to eventually exceed 200,000 BPI as MR heads and contact recording become widely used.

* 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 Independent Disks) denotes multiple drive configurations generically, with specific configurations ranging from multiple, uncoordinated disk drives to striped, synchronized drives defined within the RAID designation as RAID-0, RAID-1, RAID-2, etc., through RAID-5. The RAID nomenclature, which derives from papers published by the University of California, has been formally defined only up to the RAID-5 level, but various firms offer advanced redundant architectures informally defined as RAID-6 or RAID-7. The RAID Advisory Board, an industry association, is attempting to develop a standardized nomenclature.

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

  Disk array markets have grown to a significant size. While product complexity and proliferation, lack of standardization, customer confusion and

ignorance of array capabilities would be expected to suppress market development, the array market is actually on a healthy growth pattern and has already passed the billion dollar level.

* Performance: Significant improvements in data transfer rates and average access times are expected during the next few years. 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 technique may be the use of multiple heads per surface and/or multiple heads per slider to permit parallel access to large amounts of data without head movement. Conner Peripherals, borrowing from the mainframe world, offered a multiple actuator 3.5" drive, but the product was not successful in the market.

  After many years of 3,600 RPM specifications, drive rotation rates leaped in 1989 when Imprimis announced a family of high capacity 5.25" drives operating at 5,400 RPM. Most of the 1 gigabyte 3.5" drives announced to date offer 4,300 RPM or faster spin rates, and Seagate's Barracuda series, introduced in late 1992, rotates at 7,200 RPM. 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 heat, power consumption and bearing wear problems generated by these higher spin rates present a challenge to drive and system designers.

  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.

  The requirements of digital audio and digital video based systems require a different view of performance. While data processing systems can specify performance in terms of average response times and throughput, multimedia oriented systems require specification of the maximum sustained performance in terms of throughput and response times so that system

designers can obtain the smooth flow of audio/video content required by end users. The continuity of output requirement has implications on how intelligent drive controllers manage potentially disruptive operations such as periodic recalibration, head degaussing, and other internal, and usually invisible, housekeeping functions.

* Form factor: Sub-3.5" drives are an increasingly significant part of the market as manufacturers of notebook computers require small footprint, low height, low power drive designs. Drive height has steadily declined, and competition in providing higher capacity and thinner sub-3.5" disk diameter drives is keen. 15 to 19 millimeter heights are available for new low-end drives for desktop computers, so that half of an existing "half high" disk drive bay can be free for other peripheral devices. 2.5" drives are already in the 10 to 12.7 millimeter high range, to allow maximum volume for batteries in notebook computers, and 1.8" and 1.3" drives conforming to the 10.5 millimeter PCMCIA Type III height requirement are in production. As of mid-1993, Maxtor's 105 megabyte 1.8" drive offered the highest 1.8" capacity in the PCMCIA form factor, but other firms are preparing even higher capacity designs and even thinner packages. Several drive manufacturers intend to offer 1.8" drives in the 5 millimeter high PCMCIA Type II card format in 1994 if critical components are available.

  Technologically, form factor reduction is being driven by improvements in areal density, smaller heads, thinner media, greater IC functionality, and higher energy magnetic materials that permit fabrication of smaller motors and actuators without reducing performance. One of the most critical factors is the reduction in the surface area required to mount electronics needed by the drive. An increasing degree of functional integration in chips is needed and is being provided. In some drive designs, fewer than 7 chips are needed and some drive designers anticipate being able to design with a 5 chip (or less) set in the near future.

  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 the size related patents.

* Power reduction: Another aspect of form factor reduction is the need to operate the drive at low power to conserve battery life in portable systems or to meet the requirements of energy efficient desktop systems. Smaller form factor drives typically need less power to rotate the disks and move the heads. Portable systems require the drive to have several operating modes to conserve power when not in use. Typically, the drive does not spin when data is not being transferred and other power consuming functions may also be shut down when the drive is inactive. A related need is

for the drive to quickly come up to operating speed when needed. A few designs incorporate ramp loading of heads, enabling removal of the heads from disk contact when the drive spins down. The removal of head drag on the disk enables the drive to spin up faster with less power demand and lessens the danger of a stiction caused malfunction.

The voltage required by the drive is also a factor. 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. While concerns exist about the performance of drives operating at 3 volt levels, the performance requirements of the portable computers most likely to employ 3 volt drives may not demand the highest levels of disk drive performance. 3 volt chips and chip sets are gradually becoming available, with various functions such as controllers and read/write channels available from Cirrus Logic, IMP, Allegro, Zilog and others.

* Interfaces and controllers: 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, servers and equivalent applications. SCSI is also used as an interface to other types of peripheral products, including tape drives, optical drives, libraries, scanners and others. While most drives with IDE interfaces have capacities well under 500 megabytes, a few recently announced IDE drives have capacities in excess of 500 megabytes.

  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 1993. SCSI interfaces are most frequently encountered in workstations, file servers (especially those using disk drive arrays) and Apple Macintosh and IBM personal computers. PC/AT interfaces far outnumber SCSI interfaces in the IBM compatible personal computer market, though most IBM PS/2 models use SCSI drives. For 1.8" and smaller drives, the standards for pin connections used for ATA (AT Attachment) cards that fit physically into PCMCIA sized slots and connectors exist but various manufacturers have implemented them in ways leading to incompatibility between cards. However, some companies have agreed to informal interchange standards: In September of 1993 IBM, Maxtor, Seagate, SunDisk and Toshiba announced that mass storage cards using the PCMCIA interface and supplied by those companies would be interchangeable and would also comply with the ATA standard.

  The SCSI interface continues to evolve, with the SCSI-2 command set now in general use. SCSI-3, the next version, is currently being discussed in various standards groups. However, SCSI is implemented in different

ways by different peripheral manufacturers, and is not the ironclad standard that many would prefer.

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 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 and appropriate chips are available from independent semiconductor vendors. Cirrus Logic has already announced a PRML chip set. Companies understood to be working on digital read channels include GEC Plessey, Silicon Systems, Philips Semiconductor and others.

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

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

DEFINITIONS

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

Market classification

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

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

Examples:

* Drives sold by Hewlett-Packard, IBM or Hitachi 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 Maxtor or Seagate Technology are noncaptive.

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

Examples:

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

* Disk drives sold by Storage Technology through distributors to end users of IBM personal computers.

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

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

Examples:

* Drives produced by Western Digital or Conner Peripherals for sale to system manufacturers.

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

Geographic classification

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

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

Examples:

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

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

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

Example:

* Seagate is considered a U.S. manufacturer, even though the firm manufactures 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 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/Reseller or OEM/Integrator levels. All prices are in 1993 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, Hitachi HITFILE.

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 and the Tandy Sensation, are also included in this category.

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

DISK CARTRIDGE DRIVES

1993 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	RH5500
SyQuest Technology	SQ555, SQ5110, SyDOS 88e

3.5" disk diameter

SyQuest Technology	SQ3105A/S, SyDOS 105e

2.5" disk diameter

Avatar Systems	ASR-80

1.8" disk diameter

SyQuest Technology	SQ1080

This product group includes all drives using a removable rigid disk cartridge. 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 shipments of SyQuest's 3.5" drives under way since 1992, followed in 1993 by Avatar Systems' 2.5" drives. In addition, SyQuest has recently developed a drive in a PCMCIA Type III card format, which uses 1.8" disks in a removable cartridge.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	77.2	99.9	121.6	140.5	152.1
All manufacturers	82.2	101.9	122.8	140.5	152.1

Disk cartridge drives had another strong growth year in 1992, and the trend is continuing in 1993. The 317,900 units shipped worldwide in 1992 represented a 31.1% increase, and the 421,400 disk cartridge drives forecasted for 1993 will boost shipments another 32.6%. Total revenues for disk cartridge drives increased 17.3% in 1992, to $82.2 million, and are expected to reach $101.9 million in 1993, up another 24%.

Although SyQuest's initial growth in disk cartridge drive shipments was built on the company's original 3.9" drives, the 5.25" model introduced in 1987 became the dominant "prepress" standard for interchange of graphics and desktop publishing projects between designers and printing industry suppliers. But despite the active upgrading from 44 megabyte to 88 megabyte drives which has been under way during the last year, the overall market for 5.25" disk cartridge drives appears to have peaked. After several years of complete dominance by 5.25" disk cartridge drives, the product mix in this group is now starting the expected transition to smaller diameters.

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 most aggressive competition for SyQuest is not currently provided by other manufacturers of rigid disk cartridge drives or optical disk drives, but by Iomega, maker of the high capacity Bernoulli floppy disk drive. Iomega's 44 megabyte 5.25" drive was supplemented in 1991 with a 90 megabyte model and in 1992 with a new 150 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 long since been phased out, accounting for the absence of captive revenues. The growth expectations of several years ago for 14" and 8" drives were largely unfulfilled, due to the arrival in the market of more cost-effective smaller drives.

SyQuest's first shipments of its 105 megabyte 3.5" drives began in 1992, and expected shipments of 3.5" drives in 1993 will provide more than 20% of the total disk cartridge drive shipments. In addition to extensive shipments through PCM/Reseller channels for usage as add-on drives with Macintosh and IBM

compatible personal computers, the 3.5" drives are also expected to capture significant OEM sales to system manufacturers -- a market in which 5.25" disk cartridge drives had only a minor role in recent years.

The first 2.5" disk cartridge drive shipments are underway in 1993. SyQuest's previously announced 2.5" drive has been dropped, but Avatar Systems has introduced an 85 megabyte 2.5" disk cartridge drive intended for a variety of personal computer and specialized applications. In the meantime, SyQuest's 1.8" drive in the PCMCIA Type III form factor is one of the most unusual disk drive designs to date. It uses a disk cartridge which can be removed from the drive, which, like all drives in a PCMCIA card format, is removable from the host system. This drive has an interesting potential future market, since the removable disk cartridge will have a much lower cost than the complete drive unit. The relatively low media cost will be important in applications requiring multiple media units, and may make it possible for SyQuest to gradually migrate the "prepress" disk cartridge interchange market from its 5.25" drives to its new 1.8" drives.

SyQuest Technology captured 96.3% of the worldwide unit shipments of disk cartridge drives in 1992, with 306,000 drives. In 1992 all disk cartridge drives were shipped in noncaptive market channels.

Marketing trends

Although 5.25" drives provided 99.8% of 1992's worldwide unit shipment total, continuing decline for 5.25" disk cartridge drives is forecasted. The total of 125,000 drives expected for 1996 is only 15.8% of worldwide shipments. The PCM/Reseller sales channel will continue to dominate 5.25" disk cartridge drive shipments, and the few remaining OEM shipments are expected to die off.

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" drive and the Avatar Systems 2.5" model have an interesting opportunity 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 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 98.0% of all disk cartridge drive 1992 unit shipments were sold through PCM/Reseller channels, but forecasts a drop to 74.6% in 1996, with the balance sold to OEM/Integrators.

SyQuest's 1.8" "removable/removable" drive may have even greater potential, in both PCM/Reseller and OEM/Integrator channels. The PCMCIA standards for removable devices in the card format is clearly destined for very wide usage in the computer industry, for desktop personal computers, notebook and subnotebook computers and for a variety of mobile computing devices intended for individual use. Since it is not yet clear which applications will survive the market introduction phase, forecasting the specific usage patterns for the storage devices which will be available is still very speculative. However, it is now obvious that there will be innumerable PCMCIA slots offered with new notebook and desktop PCs -- and this market alone will provide a major sales opportunity for 1.8" drives offering the added feature of removable media.

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 now going into quantity production 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 available, plus the 1.8" drives soon to be in production, may be expected to increase continually in capacity during the coming years, following closely the rapid improvements in areal density expected with higher capacity fixed disk drives.

Forecasting assumptions

1. Significant shipments of 3.5" and 2.5" disk cartridge drives will start in early 1993, with successful sales to both system manufacturers and the after-market.
2. Production for 5.25" disk cartridge drives with capacities over 40 megabytes has peaked, to be followed 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)									
	1992 Revenues		Forecast							
			1993		1994		1995		1996	
	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	49.1	74.8	51.8	86.6	62.7	100.2	70.4	107.9	70.9	112.8
OEM/Integrator	.8	2.4	9.4	13.3	14.4	21.4	24.2	32.6	27.5	39.3
TOTAL U.S. NONCAPTIVE	49.9	77.2	61.2	99.9	77.1	121.6	94.6	140.5	98.4	152.1
TOTAL U.S. REVENUES	49.9	77.2	61.2	99.9	77.1	121.6	94.6	140.5	98.4	152.1
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	2.0	3.0	.8	1.2	.4	.8	--	--	--	--
OEM/Integrator	1.5	2.0	.4	.8	.4	.4	--	--	--	--
TOTAL NON-U.S. REVENUES	3.5	5.0	1.2	2.0	.8	1.2	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	53.4	82.2	62.4	101.9	77.9	122.8	94.6	140.5	98.4	152.1
OEM Average Price ($000)		.656		.324		.250		.210		.196

TABLE 15

DISK CARTRIDGE DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	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	200.2	305.2	225.0	375.0	286.0	461.0	335.0	520.0	370.0	590.0
OEM/Integrator	1.4	2.7	30.6	41.4	60.2	86.0	115.0	155.0	140.0	200.0
TOTAL U.S. NONCAPTIVE	201.6	307.9	255.6	416.4	346.2	547.0	450.0	675.0	510.0	790.0
TOTAL U.S. SHIPMENTS	201.6	307.9	255.6	416.4	346.2	547.0	450.0	675.0	510.0	790.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	4.0	6.0	2.0	3.0	1.0	2.0	--	--	--	--
OEM/Integrator	3.0	4.0	1.0	2.0	1.0	1.0	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	7.0	10.0	3.0	5.0	2.0	3.0	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	208.6	317.9	258.6	421.4	348.2	550.0	450.0	675.0	510.0	790.0
Total Capacity (Terabytes)	13.4	20.4	21.2	34.2	29.7	46.7	51.7	77.2	73.4	114.1
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	1,639.0	2,608.0	1,897.6	3,029.4	2,245.8	3,579.4	2,695.8	4,254.4	3,205.8	5,044.4
WORLDWIDE TOTAL	1,692.3	2,687.0	1,950.9	3,108.4	2,299.1	3,658.4	2,749.1	4,333.4	3,259.1	5,123.4

TABLE 16

DISK CARTRIDGE DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues		Forecast											
			1993			1994			1995			1996		
	5.25"	3.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"
U.S. MANUFACTURERS														
PCM/Reseller	74.7	.1	65.6	21.0	--	58.0	29.9	12.3	38.8	34.0	35.1	21.3	30.5	61.0
OEM/Integrator	2.2	.2	1.5	9.0	2.8	1.2	12.7	7.5	--	15.0	17.6	--	13.3	26.0
TOTAL U.S. REVENUES	76.9	.3	67.1	30.0	2.8	59.2	42.6	19.8	38.8	49.0	52.7	21.3	43.8	87.0
NON-U.S. MANUFACTURERS														
PCM/Reseller	3.0	--	1.2	--	--	.8	--	--	--	--	--	--	--	--
OEM/Integrator	2.0	--	.8	--	--	.4	--	--	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	5.0	--	2.0	--	--	1.2	--	--	--	--	--	--	--	--
WORLDWIDE RECAP														
PCM/Reseller	77.7	.1	66.8	21.0	--	58.8	29.9	12.3	38.8	34.0	35.1	21.3	30.5	61.0
	+17.2%	--	-14.0%	--	--	-12.0%	+42.4%	--	-34.0%	+13.7%	+185.4%	-45.1%	-10.3%	+73.8%
OEM/Integrator	4.2	.2	2.3	9.0	2.8	1.6	12.7	7.5	--	15.0	17.6	--	13.3	26.0
	+10.5%	--	-45.2%	--	--	-30.4%	+41.1%	+167.9%	--	+18.1%	+134.7%	--	-11.3%	+47.7%
Total Revenues	81.9	.3	69.1	30.0	2.8	60.4	42.6	19.8	38.8	49.0	52.7	21.3	43.8	87.0
	+16.8%	--	-15.6%	--	--	-12.6%	+42.0%	+607.1%	-35.8%	+15.0%	+166.2%	-45.1%	-10.6%	+65.1%
ANNUAL SHARE, BY DIAMETER	99.7%	.3%	67.9%	29.4%	2.7%	49.3%	34.7%	16.0%	27.6%	35.0%	37.4%	14.0%	28.8%	57.2%

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

TABLE 17

DISK CARTRIDGE DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments		Forecast											
			1993			1994			1995			1996		
	5.25"	3.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"
U.S. MANUFACTURERS														
PCM/Reseller	305.0	.2	305.0	70.0	--	290.0	130.0	41.0	210.0	170.0	140.0	125.0	160.0	305.0
OEM/Integrator	1.9	.8	1.4	30.0	10.0	1.0	55.0	30.0	--	75.0	80.0	--	70.0	130.0
TOTAL U.S. SHIPMENTS	306.9	1.0	306.4	100.0	10.0	291.0	185.0	71.0	210.0	245.0	220.0	125.0	230.0	435.0
NON-U.S. MANUFACTURERS														
PCM/Reseller	6.0	--	3.0	--	--	2.0	--	--	--	--	--	--	--	--
OEM/Integrator	4.0	--	2.0	--	--	1.0	--	--	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	10.0	--	5.0	--	--	3.0	--	--	--	--	--	--	--	--
WORLDWIDE RECAP														
PCM/Reseller	311.0	.2	308.0	70.0	--	292.0	130.0	41.0	210.0	170.0	140.0	125.0	160.0	305.0
	+34.3%	--	-1.0%	--	--	-5.2%	+85.7%	--	-28.1%	+30.8%	+241.5%	-40.5%	-5.9%	+117.9%
OEM/Integrator	5.9	.8	3.4	30.0	10.0	2.0	55.0	30.0	--	75.0	80.0	--	70.0	130.0
	-45.4%	--	-42.4%	--	--	-41.2%	+83.3%	+200.0%	--	+36.4%	+166.7%	--	-6.7%	+62.5%
Total Shipments	316.9	1.0	311.4	100.0	10.0	294.0	185.0	71.0	210.0	245.0	220.0	125.0	230.0	435.0
	+30.7%	--	-1.7%	--	--	-5.6%	+85.0%	+610.0%	-28.6%	+32.4%	+209.9%	-40.5%	-6.1%	+97.7%
ANNUAL SHARE, BY DIAMETER	99.8%	.2%	74.0%	23.7%	2.3%	53.6%	33.6%	12.8%	31.1%	36.4%	32.5%	15.8%	29.1%	55.1%
TOTAL CAPACITY (Terabytes)	20.3	.1	23.0	10.4	.8	20.5	20.4	5.9	16.8	36.8	23.7	11.3	46.0	56.9

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

TABLE 18

DISK CARTRIDGE DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	303.0	95.3	774.2	98.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application and electronic typewriters	--	--	--	--
NONOFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	14.9	4.7	15.8	2.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	317.8	100.0	790.0	100.0

TABLE 19

DISK CARTRIDGE DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1992	Forecast 1993	1994	1995	1996
Captive					
5.25"	--	--	--	--	--
3.5"	--	--	--	--	--
2.5" or less	--	--	--	--	--
Captive Average	--	--	--	--	--
PCM/Reseller					
5.25"	3.60	3.10	2.87	2.31	1.88
3.5"	3.33	2.86	2.09	1.33	.95
2.5" or less	--	--	3.75	2.08	1.33
PCM/Reseller Average	3.59	3.04	2.65	1.82	1.26
OEM/Integrator					
5.25"	22.42	23.98	16.31	--	--
3.5"	3.33	2.86	2.09	1.33	.95
2.5" or less	--	3.26	2.90	2.55	2.32
OEM/Integrator Average	16.52	3.45	2.48	1.79	1.56

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

TABLE 20

DISK CARTRIDGE DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	5.25"	3.5"	Total		5.25"	3.5"	Total	
SyQuest Technology	200.0	.9	200.9	96.3	305.0	1.0	306.0	96.3
Ricoh	7.0	--	7.0	3.4	10.0	--	10.0	3.1
Other U.S.	.7	--	.7	.3	1.9	--	1.9	.6
Other Non-U.S.	--	--	--	--	--	--	--	--
TOTAL	207.7	.9	208.6	100.0	316.9	1.0	317.9	100.0

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

1993 DISK/TREND REPORT

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Qualitron	QW-540*

3.5" disk diameter

Alps Electric	DRR040D**
Fuji Electric	FK316A-45R**
Fujitsu	M2227D2*, M2611S**
NEC	D3841*, D3835**
Quantum	42AT/S ELS**
Seagate Technology	ST151A/X**
Toshiba	MK-1032FB**
Wintec Tecnologia	WD-40/A*

2.5" disk diameter

Fujitsu	M2631S***
Quantum	40AT Go.Drive***
Toshiba	MK-1122FC***

1.8" disk diameter

Aura Associates	AU43****
Integral Peripherals	1842***, 1841PA*****
Ministor Peripherals	Miniport 32P****, Miniport 42P*****
NEC	D1711****
Seagate Technology	ST7050P*****
Western Digital	CU140*****

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.
*****PCMCIA Type III (10.5 mm height)

In recognition of the declining shipments of lower capacity drives during the last few years, the previously separate product groups covering fixed disk drives with less than 30 megabytes and 30-60 megabytes were combined into a single

group last year. 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.

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 drive 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, the remaining 2.5" drives in this product group with 30 and 40 megabyte capacities now use only one disk, with drive height limited to 3/4 inch. 1.8" drives are also limited to one disk in this capacity range. Integral Peripheral initiated 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 and nature of the market available to 21 and 42 megabyte 1.3" drives.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	1,517.4	220.7	82.6	21.4	6.8
All manufacturers	1,726.9	282.9	111.4	25.0	6.8

As recently as 1991, shipments of drives with capacities less than 60 megabytes were larger than for any other DISK/TREND product group. However, the storage demands of new software and user operating practices have moved the typical capacities required by personal computers out of this product group's range for most applications.

Following a modest decline in 1991, worldwide unit shipments dropped 42.1% in 1992, and the total for 1993 is expected to be down a resounding 82.4%. Sales revenue has also fallen sharply, with the 1993 worldwide total forecasted at only $1.7 billion. Shipments of 5.25", 3.5" and 2.5" drives are all in decline, with only 1.8" drive shipments still currently increasing.

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, to cope with new software programs and ever-increasing file storage requirements. 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 sales winner. 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, estimated at 94.2% of the 1992 worldwide total.

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 late 1991, due to excess inventories and the temporary market saturation for many types of notebook computers. Although demand for notebook computers recovered in 1992, the minimum disk capacity required for the 1992 notebook computer market had increased to levels above those offered by the 2.5" drives in this product group. Shipments of 2.5" drives with capacities below 60 megabytes fell 40.2% in 1992 and are expected to drop another 84.3% in 1993, down to only 174,000 drives.

Seagate continued to hold the lead in noncaptive unit shipments for 1992, with 34.8% of the worldwide total. Conner Peripherals was close behind with 34.6% of total shipments, boosted by relatively strong 2.5" drive shipments. Quantum was in third place with 21.7% of the total.

Single user personal computer applications dominate applications for drives with less than 60 megabytes, increasing to 98.1% of the worldwide market for drives in this group in 1992. However, that application's share is expected to decline to 78% of the 1996 market, due to growth expected for consumer and hobby computers, as well as for nonoffice systems and workstations.

Marketing trends

With the disappearance of the traditional desktop computer notebook computer markets for 3.5" and 2.5" drives in this product group, only 1.8" and 1.3" drives are expected to be in demand for requirements below 60 megabytes after 1994. Furthermore, it is expected that shipments of even 1.8" and smaller drives will also decline after 1994, as capacity requirements for most applications move upward.

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
5.25" full size	6.5	.5	--	--	--
	.1%	--	--	--	--
5.25" half high	151.0	.1	--	--	--
	1.6%	--	--	--	--
3.5" 1.625" high	353.7	49.3	20.0	--	--
	3.8%	3.0%	3.4%	--	--
3.5" 1" high or less	7,795.5	1,227.6	75.0	--	--
	82.6%	74.2%	12.8%	--	--
2.5"	1,107.2	174.0	12.0	--	--
	11.7%	10.5%	2.0%	--	--
1.8" or less	17.8	204.0	480.0	180.0	60.0
	.2%	12.3%	81.8%	100.0%	100.0%
	9,431.2	1,655.5	587.0	180.0	60.0

By 1996, worldwide shipments for all drives in this product group are projected to drop to only 60,000 units, an average annual decline of 66.8% for the 1994-96 period. Revenues for 1996 are expected to be only $6.8 million.

In this edition of the DISK/TREND Report, 1.3" drives have been combined in a group of 1.8" and smaller drives for forecasting purposes. The currently available capacities of 1.3" drives preclude usage in most of the recognized keyboard 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.

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.

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, many drives offer embedded controllers, with the choice of either SCSI or PC/AT (IDE) interfaces.

A different set of requirements has guided the development work on new 1.3" (and smaller) drives in this capacity range. The objective has been to increase capacity significantly without increasing the parts count, and cost. In order to open the widest market opportunity, rapid jumps in areal density are needed, which will 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. Shipments of 1.8" and smaller drives in this product group will continue to grow through 1994, but movement to high capacity drives will cause shipments to decline starting in 1995.

TABLE 21

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	216.9	336.0	15.3	23.6	--	--	--	--	--	--
Other U.S. Captive	--	--	1.2	1.2	9.0	12.0	4.0	5.5	1.1	1.8
TOTAL U.S. CAPTIVE	216.9	336.0	16.5	24.8	9.0	12.0	4.0	5.5	1.1	1.8
PCM/Reseller	245.3	442.6	33.2	68.2	28.1	32.8	10.2	12.6	3.5	5.0
OEM/Integrator	435.6	738.8	77.6	127.7	27.4	37.8	2.2	3.3	--	--
TOTAL U.S. NONCAPTIVE	680.9	1,181.4	110.8	195.9	55.5	70.6	12.4	15.9	3.5	5.0
TOTAL U.S. REVENUES	897.8	1,517.4	127.3	220.7	64.5	82.6	16.4	21.4	4.6	6.8
Non-U.S. Manufacturers										
Captive	3.5	110.2	--	30.1	1.5	13.5	--	2.5	--	--
PCM/Reseller	1.3	11.5	--	.4	--	--	--	--	--	--
OEM/Integrator	4.4	87.8	1.4	31.7	3.5	15.3	.3	1.1	--	--
TOTAL NON-U.S. REVENUES	9.2	209.5	1.4	62.2	5.0	28.8	.3	3.6	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	907.0	1,726.9	128.7	282.9	69.5	111.4	16.7	25.0	4.6	6.8
OEM Average Price ($000)		.157		.162		.167		.110		--

TABLE 22

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	605.6	941.0	65.3	100.5	--	--	--	--	--	--
Other U.S. Captive	--	--	4.0	4.0	30.0	40.0	18.0	25.0	6.0	10.0
TOTAL U.S. CAPTIVE	605.6	941.0	69.3	104.5	30.0	40.0	18.0	25.0	6.0	10.0
PCM/Reseller	1,644.3	2,946.2	236.0	497.0	160.0	190.0	85.0	105.0	35.0	50.0
OEM/Integrator	2,807.7	4,797.6	483.0	826.0	168.0	232.0	20.0	30.0	--	--
TOTAL U.S. NONCAPTIVE	4,452.0	7,743.8	719.0	1,323.0	328.0	422.0	105.0	135.0	35.0	50.0
TOTAL U.S. SHIPMENTS	5,057.6	8,684.8	788.3	1,427.5	358.0	462.0	123.0	160.0	41.0	60.0
Non-U.S. Manufacturers										
Captive	7.0	220.3	--	66.9	5.0	40.0	--	10.0	--	--
PCM/Reseller	10.0	74.7	--	3.0	--	--	--	--	--	--
OEM/Integrator	22.3	451.4	5.5	158.1	20.0	85.0	3.0	10.0	--	--
TOTAL NON-U.S. SHIPMENTS	39.3	746.4	5.5	228.0	25.0	125.0	3.0	20.0	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	5,096.9	9,431.2	793.8	1,655.5	383.0	587.0	126.0	180.0	41.0	60.0
Total Capacity (Terabytes)	219.5	407.4	34.2	72.2	15.1	23.4	5.9	8.4	2.0	3.0
Cumulative Shipments (Units in millions)										
IBM	5.6	8.4	5.7	8.5	5.7	8.5	5.7	8.5	5.7	8.5
Non-IBM	49.2	91.8	49.9	93.3	50.3	93.9	50.4	94.1	50.4	94.2
WORLDWIDE TOTAL	54.8	100.2	55.6	101.8	56.0	102.4	56.1	102.6	56.2	102.7

TABLE 23

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues				Forecast								
					1993				1994			1995	1996
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	<=1.8"	<=1.8"
U.S. MANUFACTURERS													
IBM Captive	1.0	315.0	20.0	--	.5	23.1	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	1.2	--	--	12.0	5.5	1.8
PCM/Reseller	16.8	417.0	8.8	--	--	64.6	.9	2.7	4.0	--	28.8	12.6	5.0
OEM/Integrator	4.2	604.0	126.5	4.1	--	75.4	14.7	37.6	4.4	1.6	31.8	3.3	--
TOTAL U.S. REVENUES	22.0	1,336.0	155.3	4.1	.5	163.1	15.6	41.5	8.4	1.6	72.6	21.4	6.8
NON-U.S. MANUFACTURERS													
Captive	.1	83.4	26.6	.1	--	29.2	.9	--	6.0	--	7.5	2.5	--
PCM/Reseller	.1	4.4	7.0	--	--	--	.4	--	--	--	--	--	--
OEM/Integrator	1.4	56.3	29.8	.3	--	11.7	8.7	11.3	3.0	--	12.3	1.1	--
TOTAL NON-U.S. REVENUES	1.6	144.1	63.4	.4	--	40.9	10.0	11.3	9.0	--	19.8	3.6	--
WORLDWIDE RECAP													
Captive	1.1	398.4	46.6	.1	.5	52.3	.9	1.2	6.0	--	19.5	8.0	1.8
	-92.7%	-44.9%	-2.9%	--	-54.5%	-86.9%	-98.1%	--	-88.5%	--	--	-59.0%	-77.5%
PCM/Reseller	16.9	421.4	15.8	--	--	64.6	1.3	2.7	4.0	--	28.8	12.6	5.0
	-78.4%	-48.7%	-27.2%	--	--	-84.7%	-91.8%	--	-93.8%	--	+966.7%	-56.2%	-60.3%
OEM/Integrator	5.6	660.3	156.3	4.4	--	87.1	23.4	48.9	7.4	1.6	44.1	4.4	--
	-87.6%	-50.5%	-59.4%	--	--	-86.8%	-85.0%	--	-91.5%	-93.2%	-9.8%	-90.0%	--
Total Revenues	23.6	1,480.1	218.7	4.5	.5	204.0	25.6	52.8	17.4	1.6	92.4	25.0	6.8
	-82.9%	-48.6%	-51.9%	--	-97.9%	-86.2%	-88.3%	--	-91.5%	-93.7%	+75.0%	-72.9%	-72.8%
ANNUAL SHARE, BY DIAMETER	1.4%	85.8%	12.7%	.1%	.2%	72.2%	9.0%	18.6%	15.6%	1.4%	83.0%	100.0%	100.0%

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

TABLE 24

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments				Forecast 1993				1994			1995	1996
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	<=1.8"	<=1.8"
U.S. MANUFACTURERS													
IBM Captive	1.0	900.0	40.0	--	.5	100.0	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	4.0	--	--	40.0	25.0	10.0
PCM/Reseller	120.0	2,774.2	52.0	--	--	482.0	6.0	9.0	30.0	--	160.0	105.0	50.0
OEM/Integrator	30.0	4,005.0	746.0	16.6	--	576.0	104.0	146.0	35.0	12.0	185.0	30.0	--
TOTAL U.S. SHIPMENTS	151.0	7,679.2	838.0	16.6	.5	1,158.0	110.0	159.0	65.0	12.0	385.0	160.0	60.0
NON-U.S. MANUFACTURERS													
Captive	.3	166.7	53.1	.2	--	64.9	2.0	--	15.0	--	25.0	10.0	--
PCM/Reseller	.2	33.5	41.0	--	--	--	3.0	--	--	--	--	--	--
OEM/Integrator	5.5	269.8	175.1	1.0	.1	54.0	59.0	45.0	15.0	--	70.0	10.0	--
TOTAL NON-U.S. SHIPMENTS	6.0	470.0	269.2	1.2	.1	118.9	64.0	45.0	30.0	--	95.0	20.0	--
WORLDWIDE RECAP													
Captive	1.3	1,066.7	93.1	.2	.5	164.9	2.0	4.0	15.0	--	65.0	35.0	10.0
	-92.4%	-23.2%	+3.4%	--	-61.5%	-84.5%	-97.9%	--	-90.9%	--	--	-46.2%	-71.4%
PCM/Reseller	120.2	2,807.7	93.0	--	--	482.0	9.0	9.0	30.0	--	160.0	105.0	50.0
	-78.3%	-43.0%	-2.1%	--	--	-82.8%	-90.3%	--	-93.8%	--	--	-34.4%	-52.4%
OEM/Integrator	35.5	4,274.8	921.1	17.6	.1	630.0	163.0	191.0	50.0	12.0	255.0	40.0	--
	-84.4%	-41.6%	-44.7%	--	-99.7%	-85.3%	-82.3%	+985.2%	-92.1%	-92.6%	+33.5%	-84.3%	--
Total Shipments	157.0	8,149.2	1,107.2	17.8	.6	1,276.9	174.0	204.0	95.0	12.0	480.0	180.0	60.0
	-80.3%	-40.2%	-40.2%	--	-99.6%	-84.3%	-84.3%	--	-92.6%	-93.1%	+135.3%	-62.5%	-66.7%
ANNUAL SHARE, BY DIAMETER	1.7%	86.5%	11.7%	.1%	--	77.2%	10.5%	12.3%	16.2%	2.0%	81.8%	100.0%	100.0%
TOTAL CAPACITY (Terabytes)	6.8	354.4	45.5	.7	--	57.1	7.4	7.7	4.1	.5	18.9	8.4	3.0

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

TABLE 25

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	6.6	.1	--	--
PERSONAL COMPUTERS Business and professional, single user	9,252.0	98.1	468.0	78.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application and electronic typewriters	45.3	.5	--	--
NONOFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	29.2	.3	60.0	10.0
CONSUMER AND HOBBY COMPUTERS	96.2	1.0	72.0	12.0
OTHER APPLICATIONS	1.9	--	--	--
Total	9,431.2	100.0	600.0	100.0

TABLE 26

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1992	Forecast 1993	1994	1995	1996
Captive					
5.25"	--	--	--	--	--
3.5"	9.15	7.56	8.88	--	--
2.5"	11.93	8.50	--	--	--
1.8" or less	--	12.00	8.66	5.63	3.60
Captive Average	9.41	7.71	8.71	5.63	3.60
PCM/Reseller					
5.25"	3.12	--	--	--	--
3.5"	3.45	3.02	3.09	--	--
2.5"	4.04	3.15	--	--	--
1.8" or less	--	9.02	4.50	2.40	2.00
PCM/Reseller Average	3.45	3.10	4.26	2.40	2.00
OEM/Integrator					
5.25"	3.95	--	--	--	--
3.5"	3.49	3.02	3.45	--	--
2.5"	4.14	3.38	3.21	--	--
1.8" or less	6.22	6.69	4.30	2.54	--
OEM/Integrator Average	3.61	3.70	4.12	2.54	--

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

TABLE 27

FIXED DISK DRIVES, LESS THAN 60 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 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	100.0	1690.0	117.0	--	1907.0	42.5	150.0	2571.0	160.0	--	2881.0	34.8
Conner Peripherals	--	1283.0	355.0	--	1638.0	36.5	--	2354.0	506.0	--	2860.0	34.6
Quantum	--	738.7	57.6	--	796.3	17.8	--	1679.2	117.0	--	1796.2	21.7
Other U.S.	--	93.0	15.0	2.7	110.7	2.5	--	175.0	15.0	16.6	206.6	2.5
Other Non-U.S.	--	25.3	7.0	--	32.3	.7	5.7	303.3	216.1	1.0	526.1	6.4
TOTAL	100.0	3830.0	551.6	2.7	4484.3	100.0	155.7	7082.5	1014.1	17.6	8269.9	100.0

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

FIXED DISK DRIVES, 60 - 100 MEGABYTES

1993 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*
Qualitron	QW-560*
Sequel	XT-1085

3.5" disk diameter

Conner Peripherals	CP-30080E**, CP-30084E**
Fuji Electric	FK314S-90R**
Fujitsu	M2612ES*
Quantum	85AT ELS**
Seagate Technology	ST3096A**
Xebec	XE-3080*

2.5" disk diameter

Alps Electric	DR232N2***
Areal Technology	A-85****
Fuji Electric	FK202S-80R***
Fujitsu	M2633S/T***
Quantum	80S/AT Go.Drive***
Seagate Technology	ST9080A****, ST9100A****
Toshiba	MK-14224FCv****

1.8" disk diameter

Aura Associates	AU85***, AU63-III*****
Calluna Technology	CT-80MC*****
Integral Peripherals	1885***, 1882PA****
MiniStor Peripherals	MiniPORT 64P***,MiniPORT 85A****
NEC	D1721****, D1731****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****PCMCIA Type III (10.5 mm height).

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. Most of the remaining 3.5" drives are 1" high models, but shipments have started to decline as the desktop personal computer market moves to higher capacities. 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, joined in 1991 by 80 megabyte models. Most of the 2.5" drives in the group have 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, followed during the past year by 85 megabyte models from several manufacturers.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	2,006.1	1,076.9	197.8	99.0	53.1
All manufacturers	2,156.0	1,176.8	273.0	154.4	76.2

As the capacity requirements for desktop and notebook personal computers have moved rapidly upward, unit shipments in the 60-100 megabyte product group have peaked earlier than expected. Although 8.2 million drives were shipped in 1992, a 54.5% increase over 1991, 1993's shipments are expected to drop to 5.8 million drives, down 29.5%. 1993 revenues are forecasted to shrink even faster, declining 45.4%, to $1.2 billion, under pressure from rapidly falling average unit prices.

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 disk drives than they would have desired, due to the

scarcity of drives with higher capacities. However, by late 1992 there was more than adequate production capacity available to the disk drive industry, and the movement to higher disk drive capacities severely limited the market available for all types of drives in this product group except those with disk diameters of 1.8" or less.

The personal computer market has absorbed most of the worldwide production of 60-100 megabyte drives in recent years, taking 98.6% of 1992's shipments. However, with the projected future dominance of 1.8" and smaller drives in this product group, a significant diversion to other applications is expected. Personal computers are expected to account for 77.0% of 1996 worldwide shipments, but nonoffice systems and workstations are forecasted to grow to 15% in 1996, and consumer and hobby computers are expected to reach 8% of the total.

Conner Peripherals continued to lead in noncaptive shipments in 1992 for 60-100 megabyte drives with 2.8 million units, 41.8% of the worldwide total. More than one million of the drives Conner Peripherals shipped in this product group were 2.5" models. Western Digital rose to 24.8% of the worldwide total, and Seagate Technology was third, with 8.4%.

Marketing trends

Although shipments of 1.8" and smaller drives are not expected to peak until 1995, the overall shipment level for this product group is already declining, with a sharp drop forecasted for 1994 as shipments of 3.5" drives dry up. The expected average annual decline in worldwide shipments for all drives in this product group during 1994-96 is 53%. The average annual decline for revenues in the same period is projected at 56.9%.

In the face of declining shipments for older drive formats, 1.8" drives are expected to assume leadership in unit shipments for the product group in 1994. Although 1.8" drives in this product group are expected to have a higher price per megabyte than 2.5" drives, 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 47.1% of 1994 unit shipments,

growing to 97.7% in 1995. 1.8" drives are forecasted to provide 100% of 1996 shipments for the product group, but by then the total is expected to be declining, in the face of relentless pressure to move to higher capacities.

Shipments of 3.5" drives are expected to drop more than 3.5 million units in 1994, as the desktop computer market moves to capacities well above those offered by this product group:

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
5.25" full size	15.7	1.5	1.0	--	--
	.2%	--	.1%	--	--
5.25" half high	49.2	1.3	--	--	--
	.6%	--	--	--	--
3.5" 1.625" high	94.3	39.1	--	--	--
	1.1%	.7%	--	--	--
3.5" 1" high or less	5,326.3	4,078.5	570.0	--	--
	64.7%	70.2%	40.4%	--	--
2.5"	2,744.8	1,565.2	175.0	20.0	--
	33.3%	27.0%	12.4%	2.3%	--
1.8" or less	3.9	122.2	665.0	845.0	480.0
	.1%	2.1%	47.1%	97.7%	100.0%
	8,234.2	5,807.8	1,411.0	865.0	480.0

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 high areal densities achieved in 3.5" drives with capacities above 100 megabytes are now employed with drives in this product group, using heads, disks and other components made available through the pioneering at higher capacities.

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 will cease production of all drives with capacities below 100 megabytes in 1993.

2. Shipments of 3.5" and 2.5" 60-100 megabyte drives peaked in 1992, and the last shipments of 3.5" drives will be in 1994, with the last 2.5" drives in 1995.

3. Shipments of 1.8" and smaller drives will lead this product group starting in 1994.

TABLE 28

FIXED DISK DRIVES, 60 - 100 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	458.3	691.4	260.4	400.7	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	5.6	7.0	12.7	18.5
TOTAL U.S. CAPTIVE	458.3	691.4	260.4	400.7	--	--	5.6	7.0	12.7	18.5
PCM/Reseller	168.7	340.7	75.1	156.0	54.4	76.5	42.6	60.4	18.1	26.2
OEM/Integrator	542.5	974.0	315.9	520.2	77.1	121.3	18.8	31.6	4.8	8.4
TOTAL U.S. NONCAPTIVE	711.2	1,314.7	391.0	676.2	131.5	197.8	61.4	92.0	22.9	34.6
TOTAL U.S. REVENUES	1,169.5	2,006.1	651.4	1,076.9	131.5	197.8	67.0	99.0	35.6	53.1
Non-U.S. Manufacturers										
Captive	4.5	26.9	4.0	23.0	9.8	39.3	7.8	35.7	4.8	16.8
PCM/Reseller	8.8	36.3	6.0	18.3	5.1	11.8	4.8	9.6	1.3	3.3
OEM/Integrator	38.5	86.7	18.3	58.6	5.9	24.1	2.4	10.1	.6	3.0
TOTAL NON-U.S. REVENUES	51.8	149.9	28.3	99.9	20.8	75.2	15.0	55.4	6.7	23.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,221.3	2,156.0	679.7	1,176.8	152.3	273.0	82.0	154.4	42.3	76.2
OEM Average Price ($000)		.211		.160		.168		.151		.120

TABLE 29

FIXED DISK DRIVES, 60 - 100 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	915.6	1,381.0	650.3	1,000.5	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	20.0	25.0	55.0	80.0
TOTAL U.S. CAPTIVE	915.6	1,381.0	650.3	1,000.5	--	--	20.0	25.0	55.0	80.0
PCM/Reseller	801.3	1,639.6	487.6	1,037.7	265.0	390.0	275.0	390.0	145.0	210.0
OEM/Integrator	2,618.8	4,674.1	2,059.1	3,327.1	466.0	741.0	125.0	210.0	40.0	70.0
TOTAL U.S. NONCAPTIVE	3,420.1	6,313.7	2,546.7	4,364.8	731.0	1,131.0	400.0	600.0	185.0	280.0
TOTAL U.S. SHIPMENTS	4,335.7	7,694.7	3,197.0	5,365.3	731.0	1,131.0	420.0	625.0	240.0	360.0
Non-U.S. Manufacturers										
Captive	7.8	39.6	10.0	56.6	25.0	100.0	25.0	115.0	20.0	70.0
PCM/Reseller	41.5	152.5	32.0	100.0	25.0	60.0	30.0	60.0	10.0	25.0
OEM/Integrator	155.0	347.4	93.0	285.9	30.0	120.0	15.0	65.0	5.0	25.0
TOTAL NON-U.S. SHIPMENTS	204.3	539.5	135.0	442.5	80.0	280.0	70.0	240.0	35.0	120.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	4,540.0	8,234.2	3,332.0	5,807.8	811.0	1,411.0	490.0	865.0	275.0	480.0
Total Capacity (Terabytes)	379.5	689.4	279.1	486.1	68.6	119.4	41.3	73.1	23.1	40.4
Cumulative Shipments (Units in millions)										
IBM	3.4	5.0	4.1	6.0	4.1	6.0	4.1	6.0	4.1	6.0
Non-IBM	11.1	18.9	13.8	23.7	14.6	25.1	15.1	25.9	15.4	26.4
WORLDWIDE TOTAL	14.5	23.9	17.9	29.7	18.7	31.1	19.2	32.0	19.5	32.5

TABLE 30

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues				Forecast										
					1993				1994				1995		1996
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	2.5"	<=1.8"	<=1.8"
U.S. MANUFACTURERS															
IBM Captive	1.4	325.0	365.0	--	.7	180.0	220.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--	--	--	--	7.0	18.5
PCM/Reseller	7.7	315.7	17.3	--	--	149.4	5.7	.9	--	18.0	--	58.5	--	60.4	26.2
OEM/Integrator	5.9	630.1	336.7	1.3	.6	371.9	126.0	21.7	.6	59.5	12.8	48.4	--	31.6	8.4
TOTAL U.S. REVENUES	15.0	1,270.8	719.0	1.3	1.3	701.3	351.7	22.6	.6	77.5	12.8	106.9	--	99.0	53.1
NON-U.S. MANUFACTURERS															
Captive	4.9	4.6	17.4	--	1.2	7.6	14.1	.1	--	--	5.3	34.0	1.5	34.2	16.8
PCM/Reseller	2.0	16.1	18.2	--	--	10.2	8.1	--	--	--	4.8	7.0	--	9.6	3.3
OEM/Integrator	3.2	14.2	69.3	--	.2	4.9	41.0	12.5	--	--	8.3	15.8	2.3	7.8	3.0
TOTAL NON-U.S. REVENUES	10.1	34.9	104.9	--	1.4	22.7	63.2	12.6	--	--	18.4	56.8	3.8	51.6	23.1
WORLDWIDE RECAP															
Captive	6.3	329.6	382.4	--	1.9	187.6	234.1	.1	--	--	5.3	34.0	1.5	41.2	35.3
	-78.9%	-46.2%	+492.0%	--	-69.8%	-43.1%	-38.8%	--	--	--	-97.7%	--	-71.7%	+21.2%	-14.3%
PCM/Reseller	9.7	331.8	35.5	--	--	159.6	13.8	.9	--	18.0	4.8	65.5	--	70.0	29.5
	-70.8%	+3.8%	+123.3%	--	--	-51.9%	-61.1%	--	--	-88.7%	-65.2%	--	--	+6.9%	-57.9%
OEM/Integrator	9.1	644.3	406.0	1.3	.8	376.8	167.0	34.2	.6	59.5	21.1	64.2	2.3	39.4	11.4
	-74.7%	+43.3%	+4.4%	--	-91.2%	-41.5%	-58.9%	--	-25.0%	-84.2%	-87.4%	+87.7%	-89.1%	-38.6%	-71.1%
Total Revenues	25.1	1,305.7	823.9	1.3	2.7	724.0	414.9	35.2	.6	77.5	31.2	163.7	3.8	150.6	76.2
	-74.6%	-5.5%	+75.6%	--	-89.2%	-44.6%	-49.6%	--	-77.8%	-89.3%	-92.5%	+365.1%	-87.8%	-8.0%	-49.4%
ANNUAL SHARE, BY DIAMETER	1.2%	60.7%	38.1%	--	.2%	61.6%	35.3%	2.9%	.2%	28.5%	11.4%	59.9%	2.5%	97.5%	100.0%

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

TABLE 31

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments				Forecast 1993				1994				1995		1996
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	2.5"	<=1.8"	<=1.8"
U.S. MANUFACTURERS															
IBM Captive	1.0	650.0	730.0	--	.5	450.0	550.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--	--	--	--	25.0	80.0
PCM/Reseller	28.2	1,530.4	81.0	--	.2	1,003.5	31.0	3.0	--	130.0	--	260.0	--	390.0	210.0
OEM/Integrator	19.2	3,097.2	1,553.9	3.8	1.1	2,565.0	692.0	69.0	1.0	440.0	80.0	220.0	--	210.0	70.0
TOTAL U.S. SHIPMENTS	48.4	5,277.6	2,364.9	3.8	1.8	4,018.5	1,273.0	72.0	1.0	570.0	80.0	480.0	--	625.0	360.0
NON-U.S. MANUFACTURERS															
Captive	2.4	5.6	31.6	--	.6	20.6	35.2	.2	--	--	15.0	85.0	5.0	110.0	70.0
PCM/Reseller	6.1	76.4	70.0	--	--	55.0	45.0	--	--	--	30.0	30.0	--	60.0	25.0
OEM/Integrator	8.0	61.0	278.3	.1	.4	23.5	212.0	50.0	--	--	50.0	70.0	15.0	50.0	25.0
TOTAL NON-U.S. SHIPMENTS	16.5	143.0	379.9	.1	1.0	99.1	292.2	50.2	--	--	95.0	185.0	20.0	220.0	120.0
WORLDWIDE RECAP															
Captive	3.4	655.6	761.6	--	1.1	470.6	585.2	.2	--	--	15.0	85.0	5.0	135.0	150.0
	-77.3%	-24.1%	+727.8%	--	-67.6%	-28.2%	-23.2%	--	--	--	-97.4%	--	-66.7%	+58.8%	+11.1%
PCM/Reseller	34.3	1,606.8	151.0	--	.2	1,058.5	76.0	3.0	--	130.0	30.0	290.0	--	450.0	235.0
	-64.1%	+25.1%	+228.3%	--	-99.4%	-34.1%	-49.7%	--	--	-87.7%	-60.5%	--	--	+55.2%	-47.8%
OEM/Integrator	27.2	3,158.2	1,832.2	3.9	1.5	2,588.5	904.0	119.0	1.0	440.0	130.0	290.0	15.0	260.0	95.0
	-62.4%	+78.7%	+67.3%	--	-94.5%	-18.0%	-50.7%	--	-33.3%	-83.0%	-85.6%	+143.7%	-88.5%	-10.3%	-63.5%
Total Shipments	64.9	5,420.6	2,744.8	3.9	2.8	4,117.6	1,565.2	122.2	1.0	570.0	175.0	665.0	20.0	845.0	480.0
	-64.5%	+38.5%	+122.6%	--	-95.7%	-24.0%	-43.0%	--	-64.3%	-86.2%	-88.8%	+444.2%	-88.6%	+27.1%	-43.2%
ANNUAL SHARE, BY DIAMETER	.8%	65.9%	33.3%	--	--	71.0%	26.9%	2.1%	.1%	40.5%	12.4%	47.0%	2.3%	97.7%	100.0%
TOTAL CAPACITY (Terabytes)	4.3	456.2	228.6	.3	.1	346.3	129.4	10.3	.1	48.0	14.9	56.5	1.7	71.5	40.4

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

TABLE 32

FIXED DISK DRIVES, 60 - 100 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	5.8	.1	--	--
PERSONAL COMPUTERS Business and professional, single user	8,118.9	98.6	3,696.0	77.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application and electronic typewriters	3.3	--	--	--
NONOFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	34.6	.4	720.0	15.0
CONSUMER AND HOBBY COMPUTERS	71.6	.9	384.0	8.0
OTHER APPLICATIONS	--	--	--	--
Total	8,234.2	100.0	4,800.0	100.0

TABLE 33

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1992	Forecast 1993	1994	1995	1996
Captive					
5.25"	31.90	--	--	--	--
3.5"	6.27	5.02	--	--	--
2.5"	6.25	4.99	4.11	3.52	--
1.8" or less	--	--	4.70	3.70	2.85
Captive Average	6.31	5.03	4.61	3.69	2.85
PCM/Reseller					
5.25"	4.23	--	--	--	--
3.5"	2.44	1.78	1.62	--	--
2.5"	2.77	2.20	1.85	--	--
1.8" or less	--	3.08	2.65	1.83	1.47
PCM/Reseller Average	2.50	1.81	2.30	1.83	1.47
OEM/Integrator					
5.25"	5.08	7.74	8.57	--	--
3.5"	2.40	1.71	1.60	--	--
2.5"	2.62	2.19	1.90	1.76	--
1.8" or less	4.52	3.41	2.60	1.77	1.41
OEM/Integrator Average	2.49	1.89	1.99	1.77	1.41

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

TABLE 34

FIXED DISK DRIVES, 60 - 100 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 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	
Conner Peripherals	--	1033.0	485.0	--	1518.0	42.0	--	1833.0	1017.0	--	2850.0	41.8
Western Digital	--	773.0	100.0	--	873.0	24.1	--	1546.0	145.0	--	1691.0	24.8
Seagate Technology	21.1	188.0	108.0	--	317.1	8.8	34.9	300.0	235.0	--	569.9	8.4
Maxtor	4.9	314.0	15.0	--	333.9	9.2	7.0	525.0	35.0	--	567.0	8.3
Quantum	--	284.6	56.0	--	340.6	9.4	--	405.6	141.0	--	546.6	8.0
Toshiba	--	--	75.0	--	75.0	2.1	1.0	--	191.0	--	192.0	2.8
Other U.S.	4.5	8.0	24.5	.5	37.5	1.0	5.5	18.0	61.9	3.8	89.2	1.3
Other Non-U.S.	--	41.5	80.0	--	121.5	3.4	13.1	137.4	157.3	.1	307.9	4.6
TOTAL	30.5	2642.1	943.5	.5	3616.6	100.0	61.5	4765.0	1983.2	3.9	6813.6	100.0

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

FIXED DISK DRIVES, 100 - 200 MEGABYTES

1993 DISK/TREND REPORT

FIXED DISK DRIVES, 100 - 200 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Digirede	W525/190
Hitachi	DK512-17, DK524C-20*
NEC	D5655*, D5852
Sequel	XT-2190, XT-4230E

3.5" disk diameter

Alps Electric	DR311C91**
Conner Peripherals	CP-30170**
Daeyoung	DX-3120A**
Fuji Electric	FK316S-105R**
Fujitsu	M2614ES*, M2617S**
IBM	H3171-A2**
Maxtor	7131A**
NEC	D3661*, D3765**
Quantum	105S LPS**, 170AT LPS**
Samsung Electronics	SHD3062S**
Seagate Technology	ST3144A**
Western Digital	WDAC1170**
Xebec	XE-3120*
Zentek	ZM 3140**

2.5" disk diameter

Alps Electric	DR232N8***
Areal Technology	A130****, A170***
Conner Peripherals	CP-2124***, CFN-170S/A***
Fuji Electric	FK205A-105Z***
IBM	H2171***
Maxtor	25128A***
Quantum	120AT Go.Drive***, 160S GRS***
Seagate Technology	ST9144A***, ST9190AG****
Toshiba	MK-2124FC***, MK-1522FCV****
Western Digital	AL2170***
Zentek	ZQ 2140***

1.8" disk diameter

Aura Associates	AU126****
Integral Peripherals	8105PA*****, 8170PA*****
Maxtor	MXL-105-III*****
MiniStor	MiniPORT 128A****
NEC	D1741****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****PCMCIA Type III (10.5 mm height)

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" models, more than 90% of the total. However, substantial shipments of 2.5" drives started in 1992, and the first drives with 1.8" disks are expected in 1993.

Market forces created one of the greatest surges in shipments in the history of the disk drive industry during 1992 for 3.5" drives in the 100-200 megabyte product group. Combined with continually improving areal density, the very large 3.5" drive shipments resulted in an aggressive effort by most disk drive manufacturers to reduce parts count, resulting in lower costs. 120 megabyte drives using a single disk have become common, and 1993 has seen the broad-scale introduction of single platter drives with 170 megabytes capacity. Growth in 2.5" shipments has had the same effect, and the first 126 megabyte 2.5 inch drive using a single disk has been introduced.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	4,316.9	3,412.7	2,211.8	1,169.5	407.9
All manufacturers	5,158.9	3,982.5	2,507.3	1,361.3	550.0

1992 growth in shipments of 100-200 megabyte disk drives was much larger than expected, up 194% over the 1991 level. The 1992 total was 17.5 million drives, easily making this product group the largest in unit shipments. The extraordinary growth during 1992 was driven by the surge in demand for new, low cost personal computers, combined with availability of new and improved software. Although many personal computer system manufacturers and end users would have preferred drives with higher capacities than those offered by this product group, the disk drive industry did not have enough capacity to satisfy the demand for most of 1992, and higher capacity drives were in shorter supply than 100-200 megabyte drives, resulting in higher demand for drives in this

product group. It is a different situation in 1993, since the industry entered the year with more than enough additional capacity to handle demand for higher capacities. Only 4.6% overall growth is expected for shipments in the product group, and shipments are expected to peak this year, at 18.3 million drives.

Due to falling prices, the rate of revenue growth failed to achieve the same level as shipments. While unit shipments were increasing by a factor almost three in 1992, revenues climbed only 59.2%, to $5.2 billion, and revenues are expected to decline 22.8% in 1993. It is clear that the major problem with sales revenues, and with the subsequent profitability of most of the participating drive manufacturers, is the faster than normal drop in selling prices. For example, the worldwide OEM/Integrator average selling price per megabyte for 3.5" drives in this product group was $2.74 in 1991, dropping to $1.93 in 1992, with a further drop to $1.18 forecasted for 1993. Similar price reductions are occurring with 2.5" drives, for which volume shipments started in 1992.

Seagate Technology's shipments in this product group increased rapidly in 1992, and Seagate held 25.4% of worldwide noncaptive unit shipments, with more than 4 million drives. Conner Peripherals held second place with 21%. Quantum doubled its unit shipments of 100-200 megabyte drives compared to the previous year, but ended the year in third place, with 17.7% of the worldwide total.

Marketing trends

Due to the unstoppable trend to higher capacities, shipments of drives in this product group are forecasted to decline starting in 1994. By 1996, shipments are expected to be only 2.8 million drives, an average annual decline of 44.7% during 1994-96. Sales revenues are forecasted to drop slightly faster, down an average of 47.4% per year in the 1994-96 period.

The growing disk storage requirements of new PC systems have boosted shipments of 3.5" drives in the 100-200 megabyte range to the existing high levels, but the continuing appetite for even higher capacities has already started to cause the decline of 3.5" drives in this product group. Worldwide 3.5" drive shipments peaked in 1992 at 16.2 million drives and are forecasted to sink to 420,000 drives in 1996.

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 as they try to meet proposed requirements for lower total power consumption by personal computers and will greatly broaden the market available to higher capacity 2.5" drives during the next few years. The shipment peak for 2.5" drives is not expected until 1994, but the movement to higher capacities will depress shipments in subsequent years.

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
8"	.1	--	--	--	--
	--	--	--	--	--
5.25" full size	53.3	7.6	3.0	--	--
	.3%	--	--	--	--
5.25" half high	23.2	6.1	1.0	--	--
	.1%	--	--	--	--
3.5" 1.625" high	414.9	83.7	5.0	--	--
	2.4%	.5%	--	--	--
3.5" 1" high or less	15,802.2	15,090.0	8,211.0	4,050.0	420.0
	90.3%	82.5%	61.5%	55.1%	15.1%
2.5"	1,207.5	3,097.0	4,605.0	2,090.0	515.0
	6.9%	16.9%	34.5%	28.4%	18.4%
1.8" or less	--	22.5	525.0	1,210.0	1,855.0
	--	.1%	4.0%	16.5%	66.5%
	17,501.2	18,306.9	13,350.0	7,350.0	2,790.0

For the last few years, there has been a general expectation in the industry that 1.8" drives would enjoy a large market when drives with adequate capacity for general notebook computer applications became available. In 1994 a combination of developments will favor growth for 1.8" drives: Drive capacities over 100 megabytes in PCMCIA Type III format, increasing shipments of subnotebook computers and the availability of numerous systems with PCMCIA slots. The first

high volume shipments of 1.8" drives in this product group are expected in 1994, with rapid growth through 1996. By that year, 1.8" drives are forecasted to account for 66.5% of the total 100-200 megabyte unit shipments.

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 very high areal densities. There will be 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 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 initially meet the 10.5 millimeter height requirement of the PCMCIA Type III standard and will eventually meet the 5 millimeter height limit for Type II drives.

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 personal computer market, but will continue to decline in shipments.
3. 2.5" drives used for notebook computer applications will increase in shipment volume through 1994, for both notebook computer and desktop PC markets, but the 1.8" drives becoming available in 1993 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)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	692.2	1,022.0	483.6	731.0	304.5	470.0	169.1	267.8	82.9	139.2
Other U.S. Captive	--	--	--	--	--	--	--	--	9.0	12.0
TOTAL U.S. CAPTIVE	692.2	1,022.0	483.6	731.0	304.5	470.0	169.1	267.8	91.9	151.2
PCM/Reseller	723.5	1,251.9	432.1	820.9	226.1	399.5	153.9	251.4	78.7	116.1
OEM/Integrator	1,266.7	2,043.0	1,123.5	1,860.8	743.5	1,342.3	360.4	650.3	69.4	140.6
TOTAL U.S. NONCAPTIVE	1,990.2	3,294.9	1,555.6	2,681.7	969.6	1,741.8	514.3	901.7	148.1	256.7
TOTAL U.S. REVENUES	2,682.4	4,316.9	2,039.2	3,412.7	1,274.1	2,211.8	683.4	1,169.5	240.0	407.9
Non-U.S. Manufacturers										
Captive	43.2	342.1	42.3	271.9	35.0	175.4	32.3	112.3	23.5	81.0
PCM/Reseller	63.0	185.1	37.6	128.7	10.7	26.6	13.7	26.0	16.8	31.0
OEM/Integrator	91.6	314.8	47.1	169.2	28.4	93.5	16.8	53.5	9.3	30.1
TOTAL NON-U.S. REVENUES	197.8	842.0	127.0	569.8	74.1	295.5	62.8	191.8	49.6	142.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,880.2	5,158.9	2,166.2	3,982.5	1,348.2	2,507.3	746.2	1,361.3	289.6	550.0
OEM Average Price ($000)		.239		.185		.158		.153		.149

TABLE 36

FIXED DISK DRIVES, 100 - 200 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	880.6	1,301.0	1,095.3	1,650.5	780.6	1,201.0	455.0	720.0	250.0	420.0
Other U.S. Captive	--	--	--	--	--	--	--	--	30.0	40.0
TOTAL U.S. CAPTIVE	880.6	1,301.0	1,095.3	1,650.5	780.6	1,201.0	455.0	720.0	280.0	460.0
PCM/Reseller	3,019.9	5,305.5	2,486.0	4,745.0	1,455.0	2,606.0	980.0	1,625.0	510.0	755.0
OEM/Integrator	5,425.7	8,716.1	6,147.1	10,109.4	4,795.0	8,520.0	2,405.0	4,275.0	470.0	945.0
TOTAL U.S. NONCAPTIVE	8,445.6	14,021.6	8,633.1	14,854.4	6,250.0	11,126.0	3,385.0	5,900.0	980.0	1,700.0
TOTAL U.S. SHIPMENTS	9,326.2	15,322.6	9,728.4	16,504.9	7,030.6	12,327.0	3,840.0	6,620.0	1,260.0	2,160.0
Non-U.S. Manufacturers										
Captive	41.3	306.7	57.0	361.9	70.0	338.0	75.0	265.0	70.0	240.0
PCM/Reseller	267.1	744.9	195.0	619.0	55.0	140.0	75.0	145.0	105.0	195.0
OEM/Integrator	344.2	1,127.0	226.0	821.1	165.0	545.0	100.0	320.0	60.0	195.0
TOTAL NON-U.S. SHIPMENTS	652.6	2,178.6	478.0	1,802.0	290.0	1,023.0	250.0	730.0	235.0	630.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	9,978.8	17,501.2	10,206.4	18,306.9	7,320.6	13,350.0	4,090.0	7,350.0	1,495.0	2,790.0
Total Capacity (Terabytes)	1,200.3	2,101.9	1,513.1	2,692.7	1,100.7	1,992.0	677.2	1,213.0	246.1	460.9
Cumulative Shipments (Units in millions)										
IBM	2.5	3.6	3.6	5.2	4.4	6.4	4.8	7.2	5.1	7.6
Non-IBM	15.2	26.9	24.3	43.5	30.8	55.7	34.5	62.3	35.7	64.7
WORLDWIDE TOTAL	17.8	30.5	28.0	48.8	35.3	62.2	39.4	69.5	40.9	72.3

TABLE 37

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues				Forecast													
	1993				1994				1995			1996		
	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	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	--	2.0	880.0	140.0	1.0	520.0	210.0	--	2.0	288.0	180.0	--	140.1	102.5	25.2	34.0	37.0	68.2
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12.0
PCM/Reseller	--	13.3	1,228.5	10.1	--	805.1	15.8	--	--	345.6	21.3	32.6	156.6	11.6	83.2	11.7	3.0	101.4
OEM/Integrator	.2	20.1	1,860.3	162.4	5.8	1,410.9	443.3	.8	--	693.1	579.6	69.6	343.4	233.1	73.8	29.2	39.3	72.1
TOTAL U.S. REVENUES	.2	35.4	3,968.8	312.5	6.8	2,736.0	669.1	.8	2.0	1,326.7	780.9	102.2	640.1	347.2	182.2	74.9	79.3	253.7
NON-U.S. MANUFACTURERS																		
Captive	--	25.2	231.1	85.8	10.4	189.5	72.0	--	5.4	85.0	75.0	10.0	28.0	56.3	28.0	8.0	28.0	45.0
PCM/Reseller	--	--	162.7	22.4	--	112.3	16.4	--	--	--	18.8	7.8	--	10.8	15.2	--	3.8	27.2
OEM/Integrator	--	10.6	220.4	83.8	.8	72.7	90.1	5.6	--	18.1	62.2	13.2	7.4	24.5	21.6	--	5.2	24.9
TOTAL NON-U.S. REVENUES	--	35.8	614.2	192.0	11.2	374.5	178.5	5.6	5.4	103.1	156.0	31.0	35.4	91.6	64.8	8.0	37.0	97.1
WORLDWIDE RECAP																		
Captive	--	27.2	1,111.1	225.8	11.4	709.5	282.0	--	7.4	373.0	255.0	10.0	168.1	158.8	53.2	42.0	65.0	125.2
	--	-63.3%	-29.0%	--	-58.1%	-36.1%	+24.9%	--	-35.1%	-47.4%	-9.6%	--	-54.9%	-37.7%	+432.0%	-75.0%	-59.1%	+135.3%
PCM/Reseller	--	13.3	1,391.2	32.5	--	917.4	32.2	--	--	345.6	40.1	40.4	156.6	22.4	98.4	11.7	6.8	128.6
	--	-84.0%	+226.6%	--	--	-34.1%	-.9%	--	--	-62.3%	+24.5%	--	-54.7%	-44.1%	+143.6%	-92.5%	-69.6%	+30.7%
OEM/Integrator	.2	30.7	2,080.7	246.2	6.6	1,483.6	533.4	6.4	--	711.2	641.8	82.8	350.8	257.6	95.4	29.2	44.5	97.0
	-86.7%	-48.7%	+105.2%	--	-78.5%	-28.7%	+116.7%	--	--	-52.1%	+20.3%	--	-50.7%	-59.9%	+15.2%	-91.7%	-82.7%	+1.7%
Total Revenues	.2	71.2	4,583.0	504.5	18.0	3,110.5	847.6	6.4	7.4	1,429.8	936.9	133.2	675.5	438.8	247.0	82.9	116.3	350.8
	-98.9%	-67.2%	+52.5%	--	-74.7%	-32.1%	+68.0%	--	-58.9%	-54.0%	+10.5%	--	-52.8%	-53.2%	+85.4%	-87.7%	-73.5%	+42.0%
ANNUAL SHARE, BY DIAMETER	--	1.4%	88.9%	9.7%	.5%	78.2%	21.3%	--	.3%	57.1%	37.4%	5.2%	49.7%	32.2%	18.1%	15.1%	21.2%	63.7%

TABLE 38

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments				Forecast													
					1993				1994				1995			1996		
	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	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	--	1.0	1,100.0	200.0	.5	1,300.0	350.0	--	1.0	800.0	400.0	--	400.0	250.0	70.0	100.0	100.0	220.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40.0
PCM/Reseller	--	18.1	5,253.4	34.0	--	4,669.0	76.0	--	--	2,351.0	125.0	130.0	1,095.0	70.0	460.0	85.0	20.0	650.0
OEM/Integrator	.1	30.8	8,122.7	562.5	6.9	8,010.0	2,090.0	2.5	--	4,780.0	3,450.0	290.0	2,435.0	1,430.0	410.0	215.0	265.0	465.0
TOTAL U.S. SHIPMENTS	.1	49.9	14,476.1	796.5	7.4	13,979.0	2,516.0	2.5	1.0	7,931.0	3,975.0	420.0	3,930.0	1,750.0	940.0	400.0	385.0	1,375.0
NON-U.S. MANUFACTURERS																		
Captive	--	10.1	218.6	78.0	5.2	266.7	90.0	--	3.0	165.0	150.0	20.0	70.0	125.0	70.0	20.0	70.0	150.0
PCM/Reseller	--	--	674.9	70.0	--	541.0	78.0	--	--	--	110.0	30.0	--	65.0	80.0	--	25.0	170.0
OEM/Integrator	--	16.5	847.5	263.0	1.1	387.0	413.0	20.0	--	120.0	370.0	55.0	50.0	150.0	120.0	--	35.0	160.0
TOTAL NON-U.S. SHIPMENTS	--	26.6	1,741.0	411.0	6.3	1,194.7	581.0	20.0	3.0	285.0	630.0	105.0	120.0	340.0	270.0	20.0	130.0	480.0
WORLDWIDE RECAP																		
Captive	--	11.1	1,318.6	278.0	5.7	1,566.7	440.0	--	4.0	965.0	550.0	20.0	470.0	375.0	140.0	120.0	170.0	410.0
	--	-57.5%	+13.3%	--	-48.6%	+18.8%	+58.3%	--	-29.8%	-38.4%	+25.0%	--	-51.3%	-31.8%	+600.0%	-74.5%	-54.7%	+192.9%
PCM/Reseller	--	18.1	5,928.3	104.0	--	5,210.0	154.0	--	--	2,351.0	235.0	160.0	1,095.0	135.0	540.0	85.0	45.0	820.0
	--	-85.6%	+313.3%	--	--	-12.1%	+48.1%	--	--	-54.9%	+52.6%	--	-53.4%	-42.6%	+237.5%	-92.2%	-66.7%	+51.9%
OEM/Integrator	.1	47.3	8,970.2	825.5	8.0	8,397.0	2,503.0	22.5	--	4,900.0	3,820.0	345.0	2,485.0	1,580.0	530.0	215.0	300.0	625.0
	-85.7%	-46.9%	+188.2%	--	-83.1%	-6.4%	+203.2%	--	--	-41.6%	+52.6%	--	-49.3%	-58.6%	+53.6%	-91.3%	-81.0%	+17.9%
Total Shipments	.1	76.5	16,217.1	1,207.5	13.7	15,173.7	3,097.0	22.5	4.0	8,216.0	4,605.0	525.0	4,050.0	2,090.0	1,210.0	420.0	515.0	1,855.0
	-95.7%	-68.2%	+184.0%	--	-82.1%	-6.4%	+156.5%	--	-70.8%	-45.9%	+48.7%	--	-50.7%	-54.6%	+130.5%	-89.6%	-75.4%	+53.3%
ANNUAL SHARE, BY DIAMETER	--	.4%	92.8%	6.8%	.1%	83.0%	16.9%	--	--	61.6%	34.5%	3.9%	55.2%	28.4%	16.4%	15.1%	18.5%	66.4%
TOTAL CAPACITY (Terabytes)	--	11.8	1,935.2	154.9	2.0	2,248.6	439.2	2.9	.6	1,242.6	683.2	65.6	685.1	348.5	179.4	71.0	87.5	302.3

TABLE 39

FIXED DISK DRIVES, 100 - 200 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI				
General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	52.5	.3	--	--
PERSONAL COMPUTERS				
Business and professional, single user	16,821.9	96.1	2,594.7	93.0
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	194.5	1.1	27.9	1.0
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	325.5	1.9	111.6	4.0
CONSUMER AND HOBBY COMPUTERS	105.0	.6	53.0	1.9
OTHER APPLICATIONS	1.8	--	2.8	.1
Total	17,501.2	100.0	2,790.0	100.0

TABLE 40

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1992	Forecast 1993	1994	1995	1996
Captive					
5.25"	17.00	14.25	13.30	--	--
3.5"	7.01	3.10	2.37	2.14	2.10
2.5"	6.39	4.39	2.93	2.59	2.24
1.8"	--	--	4.00	2.81	2.20
Captive Average	6.98	3.41	2.61	2.39	2.19
PCM/Reseller					
5.25"	4.44	--	--	--	--
3.5"	1.98	1.19	.98	.84	.81
2.5"	2.44	1.62	1.23	1.03	.88
1.8"	--	--	2.01	1.21	.92
PCM/Reseller Average	2.00	1.20	1.05	.96	.91
OEM/Integrator					
5.25"	4.26	5.57	--	--	--
3.5"	1.93	1.18	.97	.83	.80
2.5"	2.31	1.50	1.13	.97	.87
1.8"	--	2.21	1.92	1.20	.91
OEM/Integrator Average	1.98	1.26	1.07	.91	.88

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

TABLE 41

FIXED DISK DRIVES, 100 - 200 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	8"	5.25"	3.5"	2.5"	Total		8"	5.25"	3.5"	2.5"	Total	
Seagate Technology	--	10.3	2765.0	98.0	2873.3	31.7	--	16.0	3820.0	196.0	4032.0	25.4
Conner Peripherals	--	--	1573.0	155.0	1728.0	19.1	--	--	3086.0	246.0	3332.0	21.0
Quantum	--	--	1611.8	33.0	1644.8	18.2	--	--	2721.4	94.0	2815.4	17.7
Maxtor	--	6.0	1147.7	15.0	1168.7	12.9	--	15.0	1886.7	35.5	1937.2	12.2
Western Digital	--	--	796.0	5.0	801.0	8.8	--	--	1592.0	5.0	1597.0	10.0
Alps Electric	--	--	45.0	--	45.0	.5	--	--	370.0	8.0	378.0	2.4
Samsung Electronics	--	--	170.0	--	170.0	1.9	--	--	345.0	--	345.0	2.2
Toshiba	--	--	--	119.0	119.0	1.3	--	8.0	35.0	265.0	308.0	1.9
Fujitsu	--	--	3.7	--	3.7	--	--	--	248.9	--	248.9	1.6
NEC	--	5.5	86.0	--	91.5	1.0	--	6.5	203.6	--	210.1	1.3
Other U.S.	.1	14.3	199.0	16.4	229.8	2.6	.1	17.9	270.0	20.0	308.0	1.9
Other Non-U.S.	--	--	152.1	30.0	182.1	2.0	--	2.0	319.9	60.0	381.9	2.4
TOTAL	.1	36.1	8549.3	471.4	9056.9	100.0	.1	65.4	14898.5	929.5	15983.5	100.0

FIXED DISK DRIVES, 200 - 300 MEGABYTES

1993 DISK/TREND REPORT

FIXED DISK DRIVES, 200 - 300 MEGABYTES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Sequel	807

5.25" disk diameter

Fujitsu	M2248E/S
Sagem	MSA 252-200

3.5" disk diameter

Alps Electric	DR112C-90**
Aura Associates	AU245A/S**
Conner Peripherals	CP-30254**, CFS-210A**
Fuji Electric	FK317S-240R**
Fujitsu	M2618T**
Hitachi	DK312C-25*, DK-324C-21A**
IBM	H3256-A3**
Kalok	Kalok P3250****
Maxtor	7213S/A**, 7245S/A**
Myrica	3259AP*
Quantum	240AT LPS**, 270AT LPS**
Samsung Electronics	SHD-3122A**
Seagate Technology	ST3283A**, ST3290A-**
Teac	SD-3250N****
Western Digital	WDAC2250**
Xebec	XE-3245A/S**
Zentek	ZM 3260**

2.5" disk diameter

Areal Technology	A260***
Conner Peripherals	CFN-250S/A***
Fujitsu	M2637S/T***
IBM	H2258***
Maxtor	25252A/S***
Quantum	256S/AT Go.Drive***
Seagate Technology	ST9235A***
Toshiba	MK-2224FC***, MK-1624FCV****

*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.

The separate product group for 200-300 megabyte drives was established only last year. During most of the 1980's, there was little activity in this capacity range, with most 14", 8" and 5.25" drive capacities jumping to higher levels when the pace of the technology allowed. However, the personal computer market's continually increasing requirements for higher storage capacities created a new market for 200-300 megabyte drives at the beginning of the 1990's. This market is served by 3.5" drives, while the notebook computer market stimulated the introduction of 2.5" drives in this capacity range in 1992.

Although 8" and 5.25" 200-300 megabyte drives are expected to be out of production after this year, the increasing demand for 3.5" and 2.5" drives is inspiring continual refinements in product design for small form factor drives. One inch height has become the standard for 3.5" drives, and the improved areal density developed initially for drives in higher capacity ranges is making possible regular reductions in the parts count for mainstream 200-300 megabyte 3.5" drives. Most major drive manufacturers offered 3.5" drives using two disks in this capacity range during the past year, and the newest introductions use a single disk for up to 270 megabytes. The many 2.5" drives introduced in this capacity range during the past year use two or three disks, but the first single platter 2.5" drive in this product group could appear during the coming year.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	1,695.6	3,206.6	4,105.2	4,173.1	3,900.1
All manufacturers	1,801.3	3,551.0	4,608.5	4,877.5	4,744.5

As lower capacity drives lose shipment momentum due to the changing capacity demands of the personal computer market, the 200-300 megabyte product group is now achieving a higher growth rate than any other group. Unit shipments topped 4 million drives in 1992, a 113.3% increase over 1991, and a startling 209.1% jump in shipments is forecasted for 1993, boosting worldwide unit shipments for the year to 12.6 million drives. Although falling average unit prices dampen the rate of revenue increases, the expected 97.1% increase in sales revenue will bring the 1993 total to $3.6 billion.

Most of the growing prosperity for this product group has been generated by increasing shipments of 3.5" drives, especially 1" high models. 3.5" drives produced 98.6% of 1992's total shipments, as a result of the evolving software requirements of desktop personal computers. During 1993, the increasing software demands of notebook computers have generated significant shipments of 2.5" drives, accounting for more than 10% of unit shipments for the product group for the year, an estimated 1.3 million 2.5" drives.

The personal computer market produced 91.1% of 1992's worldwide unit shipments, trailed by 5.3% for nonoffice systems and workstations, with small usage levels in other applications. The personal computer market, including portable system applications, is expected to consume 95% of 1996's shipments.

Quantum's early product emphasis in this product group enabled the firm to capture 29.1% of the 1992 worldwide noncaptive shipments, for 1 million units, all 3.5" drives. Maxtor held second place with 21.6%, followed closely by Conner Peripherals with 21.2% of the total.

Marketing trends

200-300 megabyte drives are expected to become the largest DISK/TREND product group in 1994, and to hold that position through 1996. The 1996 worldwide unit shipment total is projected at 25.1 million drives. However, by that year, unit shipment growth is expected to be only 5%, as the inevitable demand for more capacity per disk drive continues upward. Nor is the downward pressure on average unit prices expected to cease. Declining prices are projected to depress 1996 total sales by 2.7%, with worldwide revenue forecasted at $4.7 billion.

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 has turned 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 associated applications software will continue to require greater disk capacity, acceler-

ating 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, with shipments forecasted to exceed 6.5 million drives in 1996. 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 and lower parts count make it possible for 2.5" drives to compete with 3.5" drives for some desktop applications. 2.5" drives offer the advantages of lower power requirements, less heat generation and quieter operation, which will help them penetrate part of the expected market for personal computers designed for lower power and reduced environmental impact.

The industry's continual improvements in areal densities are expected to make possible the production of 1.8" drives in this capacity range starting in 1994. 1.7 million 1.8" drives are forecasted for 1996, with markets expected mostly in subnotebook computer applications. But despite growth in shipments by smaller diameter drives, 3.5" drives will continue to dominate this product group through 1996:

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
8"	1.9	.8	--	--	--
	--	--	--	--	--
5.25"	1.7	.5	--	--	--
	--	--	--	--	--
3.5" 1.625" high	807.3	83.3	12.0	--	--
	19.9%	.7%	.1%	--	--
3.5" 1" high or less	3,199.5	11,192.3	16,923.0	17,655.0	16,930.0
	78.7%	89.0%	85.7%	73.8%	67.4%
2.5"	56.4	1,295.0	2,650.0	5,625.0	6,525.0
	1.4%	10.3%	13.4%	23.5%	26.0%
1.8"	--	--	165.0	650.0	1,665.0
	--	--	.8%	2.7%	6.6%
	4,066.8	12,571.9	19,750.0	23,930.0	25,120.0

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.

Single disk 3.5" drives in the 200-300 megabyte capacity range have been introduced, and single disk 2.5" drives are expected next year. 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.

The initial shipments of 1.8" drives with 200-300 megabyte capacities expected in 1994 will require high areal densities, but in a range thought to be attainable in high volume production. It is expected that the PCMCIA Type III drives already being designed for lower capacities will smooth out most of the mechanical and packaging difficulties by then.

Forecasting assumptions

1. Shipments of IBM's 3.5" drives in this capacity group, started in 1992, and 2.5" drives, starting in 1993, are expected to grow until a decline commences in the 1995-96 period. IBM is forecasted to start 1.8" drive shipments in 1995.
2. 3.5" drives will continue to dominate noncaptive drive shipments through 1996 due to their wide acceptance in the desktop personal computer market.
3. 2.5" drives for other captive and noncaptive applications will continue to grow in shipment volume through 1996, and 1.8" drives will be in volume production for noncaptive markets in 1994.

TABLE 42

FIXED DISK DRIVES, 200 - 300 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast							
			1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	277.8	404.0	577.2	867.0	699.6	1,073.0	604.7	943.4	448.9	707.0
Other U.S. Captive	3.4	8.5	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	281.2	412.5	577.2	867.0	699.6	1,073.0	604.7	943.4	448.9	707.0
PCM/Reseller	281.4	486.2	500.4	876.3	687.4	1,141.6	570.5	942.5	511.4	838.0
OEM/Integrator	492.6	796.9	862.3	1,463.3	1,093.8	1,890.6	1,302.2	2,287.2	1,338.2	2,355.1
TOTAL U.S. NONCAPTIVE	774.0	1,283.1	1,362.7	2,339.6	1,781.2	3,032.2	1,872.7	3,229.7	1,849.6	3,193.1
TOTAL U.S. REVENUES	1,055.2	1,695.6	1,939.9	3,206.6	2,480.8	4,105.2	2,477.4	4,173.1	2,298.5	3,900.1
Non-U.S. Manufacturers										
Captive	--	24.8	21.0	127.0	42.0	184.0	45.5	172.5	53.2	192.2
PCM/Reseller	6.3	29.4	14.3	56.3	25.7	72.3	45.7	109.5	63.9	137.4
OEM/Integrator	11.8	51.5	47.0	161.1	86.4	247.0	148.0	422.4	191.1	514.8
TOTAL NON-U.S. REVENUES	18.1	105.7	82.3	344.4	154.1	503.3	239.2	704.4	308.2	844.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,073.3	1,801.3	2,022.2	3,551.0	2,634.9	4,608.5	2,716.6	4,877.5	2,606.7	4,744.5
OEM Average Price ($000)		.363		.241		.198		.180		.172

TABLE 43

FIXED DISK DRIVES, 200 - 300 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	275.7	401.0	1,100.3	1,650.5	1,600.0	2,450.0	1,555.0	2,420.0	1,240.0	1,950.0
Other U.S. Captive	1.1	2.1	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	276.8	403.1	1,100.3	1,650.5	1,600.0	2,450.0	1,555.0	2,420.0	1,240.0	1,950.0
PCM/Reseller	715.3	1,247.4	2,210.0	3,858.3	3,560.0	5,925.0	3,370.0	5,590.0	3,200.0	5,275.0
OEM/Integrator	1,359.0	2,200.4	3,639.1	6,115.2	5,565.0	9,563.0	7,330.0	12,750.0	7,890.0	13,730.0
TOTAL U.S. NONCAPTIVE	2,074.3	3,447.8	5,849.1	9,973.5	9,125.0	15,488.0	10,700.0	18,340.0	11,090.0	19,005.0
TOTAL U.S. SHIPMENTS	2,351.1	3,850.9	6,949.4	11,624.0	10,725.0	17,938.0	12,255.0	20,760.0	12,330.0	20,955.0
Non-U.S. Manufacturers										
Captive	--	14.9	20.0	126.0	60.0	262.0	95.0	360.0	135.0	490.0
PCM/Reseller	15.0	70.0	53.0	198.0	125.0	350.0	245.0	585.0	370.0	790.0
OEM/Integrator	28.8	131.0	185.4	623.9	420.0	1,200.0	780.0	2,225.0	1,085.0	2,885.0
TOTAL NON-U.S. SHIPMENTS	43.8	215.9	258.4	947.9	605.0	1,812.0	1,120.0	3,170.0	1,590.0	4,165.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,394.9	4,066.8	7,207.8	12,571.9	11,330.0	19,750.0	13,375.0	23,930.0	13,920.0	25,120.0
Total Capacity (Terabytes)	535.9	909.9	1,658.8	2,887.3	2,653.5	4,617.2	3,174.4	5,686.3	3,383.6	6,129.9
Cumulative Shipments (Units in millions)										
IBM	.3	.5	1.4	2.1	3.0	4.6	4.6	7.0	5.8	9.0
Non-IBM	4.0	6.3	10.1	17.2	19.8	34.5	31.6	56.1	44.3	79.2
WORLDWIDE TOTAL	4.3	6.9	11.5	19.4	22.9	39.2	36.2	63.1	50.2	88.2

TABLE 44

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues				Forecast													
					1993				1994			1995			1996			
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	
U.S. MANUFACTURERS																		
IBM Captive	4.0	--	400.0	--	2.0	--	725.0	140.0	798.0	275.0	--	648.0	285.1	10.3	455.0	207.0	45.0	
Other U.S. Captive	--	7.7	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
PCM/Reseller	--	--	485.3	.9	--	--	870.4	5.9	1,108.8	13.8	19.0	849.3	28.2	65.0	660.8	32.3	144.9	
OEM/Integrator	2.8	--	779.9	14.2	.9	--	1,252.4	210.0	1,530.5	335.2	24.9	1,447.5	791.2	48.5	1,281.8	956.3	117.0	
TOTAL U.S. REVENUES	6.8	7.7	1,666.0	15.1	2.9	--	2,847.8	355.9	3,437.3	624.0	43.9	2,944.8	1,104.5	123.8	2,397.6	1,195.6	306.9	
NON-U.S. MANUFACTURERS																		
Captive	--	--	17.6	7.2	--	--	66.5	60.5	107.0	77.0	--	85.0	67.5	20.0	78.0	64.7	49.5	
PCM/Reseller	--	--	26.5	2.9	--	--	39.5	16.8	50.7	18.4	3.2	66.8	27.1	15.6	79.5	28.0	29.9	
OEM/Integrator	--	.5	47.6	3.4	--	.4	93.0	67.7	155.6	86.7	4.7	197.2	202.2	23.0	236.9	238.5	39.4	
TOTAL NON-U.S. REVENUES	--	.5	91.7	13.5	--	.4	199.0	145.0	313.3	182.1	7.9	349.0	296.8	58.6	394.4	331.2	118.8	
WORLDWIDE RECAP																		
Captive	4.0	7.7	418.4	7.2	2.0	--	791.5	200.5	905.0	352.0	--	733.0	352.6	30.3	533.0	271.7	94.5	
	-71.4%	-89.7%	--	--	-50.0%	--	+89.2%	--	+14.3%	+75.6%	--	-19.0%	+.2%	--	-27.3%	-22.9%	+211.9%	
PCM/Reseller	--	--	511.8	3.8	--	--	909.9	22.7	1,159.5	32.2	22.2	916.1	55.3	80.6	740.3	60.3	174.8	
	--	--	+53.8%	--	--	--	+77.8%	+497.4%	+27.4%	+41.9%	--	-21.0%	+71.7%	+263.1%	-19.2%	+9.0%	+116.9%	
OEM/Integrator	2.8	.5	827.5	17.6	.9	.4	1,345.4	277.7	1,686.1	421.9	29.6	1,644.7	993.4	71.5	1,518.7	1,194.8	156.4	
	-61.1%	-84.4%	+50.5%	--	-67.9%	-20.0%	+62.6%	--	+25.3%	+51.9%	--	-2.5%	+135.5%	+141.6%	-7.7%	+20.3%	+118.7%	
Total Revenues	6.8	8.2	1,757.7	28.6	2.9	.4	3,046.8	500.9	3,750.6	806.1	51.8	3,293.8	1,401.3	182.4	2,792.0	1,526.8	425.7	
	-67.9%	-89.5%	+97.5%	--	-57.4%	-95.1%	+73.3%	--	+23.1%	+60.9%	--	-12.2%	+73.8%	+252.1%	-15.2%	+9.0%	+133.4%	
ANNUAL SHARE, BY DIAMETER	.4%	.5%	97.7%	1.4%	.1%	--	85.9%	14.0%	81.5%	17.5%	1.0%	67.6%	28.7%	3.7%	58.9%	32.2%	8.9%	

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

TABLE 45

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments				Forecast: 1993				1994			1995			1996		
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"	3.5"	2.5"	<=1.8"
U.S. MANUFACTURERS																	
IBM Captive	1.0	--	400.0	--	.5	--	1,450.0	200.0	1,900.0	550.0	--	1,800.0	600.0	20.0	1,400.0	450.0	100.0
Other U.S. Captive	--	1.1	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	1,245.4	2.0	--	--	3,838.3	20.0	5,805.0	60.0	60.0	5,210.0	130.0	250.0	4,495.0	150.0	630.0
OEM/Integrator	.9	--	2,166.5	33.0	.3	--	5,394.9	720.0	8,013.0	1,470.0	80.0	8,880.0	3,680.0	190.0	8,720.0	4,490.0	520.0
TOTAL U.S. SHIPMENTS	1.9	1.1	3,812.9	35.0	.8	--	10,683.2	940.0	15,718.0	2,080.0	140.0	15,890.0	4,410.0	460.0	14,615.0	5,090.0	1,250.0
NON-U.S. MANUFACTURERS																	
Captive	--	--	8.9	6.0	--	--	71.0	55.0	152.0	110.0	--	170.0	150.0	40.0	195.0	185.0	110.0
PCM/Reseller	--	--	63.0	7.0	--	--	138.0	60.0	260.0	80.0	10.0	400.0	125.0	60.0	530.0	130.0	130.0
OEM/Integrator	--	.6	122.0	8.4	--	.5	383.4	240.0	805.0	380.0	15.0	1,195.0	940.0	90.0	1,590.0	1,120.0	175.0
TOTAL NON-U.S. SHIPMENTS	--	.6	193.9	21.4	--	.5	592.4	355.0	1,217.0	570.0	25.0	1,765.0	1,215.0	190.0	2,315.0	1,435.0	415.0
WORLDWIDE RECAP																	
Captive	1.0	1.1	409.9	6.0	.5	--	1,521.0	255.0	2,052.0	660.0	--	1,970.0	750.0	60.0	1,595.0	635.0	210.0
	-60.0%	-91.3%	--	--	-50.0%	--	+271.1%	--	+34.9%	+158.8%	--	-4.0%	+13.6%	--	-19.0%	-15.3%	+250.0%
PCM/Reseller	--	--	1,308.4	9.0	--	--	3,976.3	80.0	6,065.0	140.0	70.0	5,610.0	255.0	310.0	5,025.0	280.0	760.0
	--	--	+92.8%	--	--	--	+203.9%	+788.9%	+52.5%	+75.0%	--	-7.5%	+82.1%	+342.9%	-10.4%	+9.8%	+145.2%
OEM/Integrator	.9	.6	2,288.5	41.4	.3	.5	5,778.3	960.0	8,818.0	1,850.0	95.0	10,075.0	4,620.0	280.0	10,310.0	5,610.0	695.0
	-66.7%	-83.3%	+90.2%	--	-66.7%	-16.7%	+152.5%	--	+52.6%	+92.7%	--	+14.3%	+149.7%	+194.7%	+2.3%	+21.4%	+148.2%
Total Shipments	1.9	1.7	4,006.8	56.4	.8	.5	11,275.6	1,295.0	16,935.0	2,650.0	165.0	17,655.0	5,625.0	650.0	16,930.0	6,525.0	1,665.0
	-63.5%	-89.5%	+112.5%	--	-57.9%	-70.6%	+181.4%	--	+50.2%	+104.6%	--	+4.3%	+112.3%	+293.9%	-4.1%	+16.0%	+156.2%
ANNUAL SHARE, BY DIAMETER	--	--	98.6%	1.4%	--	--	89.8%	10.2%	85.8%	13.4%	.8%	73.9%	23.5%	2.6%	67.5%	26.0%	6.5%
TOTAL CAPACITY (Terabytes)	.5	.4	897.1	11.9	.1	.1	2,593.3	293.8	3,954.9	626.0	36.3	4,118.0	1,412.3	156.0	3,939.8	1,757.3	432.9

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

TABLE 46

FIXED DISK DRIVES, 200 - 300 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	76.9	1.9	--	--
PERSONAL COMPUTERS Business and professional, single user	3,704.4	91.1	23,864.0	95.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application and electronic typewriters	52.9	1.3	100.5	.4
NONOFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	215.5	5.3	879.2	3.5
CONSUMER AND HOBBY COMPUTERS	17.1	.4	251.2	1.0
OTHER APPLICATIONS	--	--	25.1	.1
Total	4,066.8	100.0	25,120.0	100.0

TABLE 47

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1992	1993	1994	1995	1996
Captive					
8"	20.00	20.00	--	--	--
5.25"	25.66	--	--	--	--
3.5"	4.84	2.25	1.70	1.43	1.29
2.5"	5.53	3.21	2.09	1.82	1.62
1.8" or less	--	--	--	2.09	1.73
Captive Average	4.95	2.40	1.79	1.55	1.41
PCM/Reseller					
8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	1.74	.99	.83	.71	.64
2.5"	1.96	1.33	1.00	.86	.79
1.8" or less	--	--	1.43	1.08	.88
PCM/Reseller Average	1.74	1.00	.84	.73	.68
OEM/Integrator					
8"	9.13	--	--	--	--
5.25"	4.80	3.50	--	--	--
3.5"	1.60	1.01	.83	.71	.64
2.5"	2.02	1.29	.99	.86	.78
1.8" or less	--	--	1.41	1.06	.86
OEM/Integrator Average	1.61	1.05	.86	.76	.70

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

TABLE 48

FIXED DISK DRIVES, 200 - 300 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 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	--	--	594.4	--	594.4	28.1	--	--	1060.1	--	1060.1	29.1
Maxtor	--	--	485.0	--	485.0	22.9	--	--	789.0	--	789.0	21.6
Conner Peripherals	--	--	465.0	--	465.0	22.0	--	--	772.0	--	772.0	21.2
Seagate Technology	.3	--	352.0	17.0	369.3	17.4	.7	--	475.0	35.0	510.7	14.0
Western Digital	--	--	145.0	--	145.0	6.8	--	--	285.0	--	285.0	7.8
Other U.S.	.2	--	15.4	--	15.6	.7	.2	--	30.8	--	31.0	.8
Other Non-U.S.	--	--	35.5	8.3	43.8	2.1	--	.6	185.0	15.4	201.0	5.5
TOTAL	.5	--	2092.3	25.3	2118.1	100.0	.9	.6	3596.9	50.4	3648.8	100.0

FIXED DISK DRIVES, 300 - 500 MEGABYTES

1993 DISK/TREND REPORT

FIXED DISK DRIVES, 300 - 500 MEGABYTES

Coverage

Examples of disk drives in this group include:

9" disk diameter

Hitachi	DK815-5
NEC	N7756

8" disk diameter

Fujitsu	M2343K, M2381K

5.25" disk diameter

EZI	4410
Fujitsu	M2249E/S
Hitachi	DK514-38
IBM	9336-10
NEC	D5662
Sequel	XT-4380E/S

3.5" disk diameter

Alps Electric	DR322C**
Conner Peripherals	CP-3360*, CFS-420A**
Digital Equipment	RF31T*
Fujitsu	M2622S*
Hitachi	DK314C-41*
IBM	0661-467*, H3342-A4
Kalok	P3360****
Maxtor	7345A/S**
NEC	D3872*, D3881*
Quantum	425iS/AT ProDrive*, 340S/AT LPS**
Seagate Technology	ST3550A/N**
Teac	SD-3360N****
Western Digital	WDAC2340**, WDAC2420**

2.5" disk diameter

Conner Peripherals	CFN-340S/A***
IBM	H2344***
Seagate Technology	ST9385AG***
Toshiba	MK-2326FC/FB***

*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.

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 Micropolis and Digital Equipment, but all half high 5.25" drive shipments have now ceased.

In 1989, IBM became the first company to announce and ship 3.5" drives in this capacity range, but numerous other drive manufacturers also introduced 3.5" drives in 1990. In 1991, Seagate announced 426 megabyte models only 1" high, and in late 1992 Western Digital started shipments of a 1" high 340 megabyte 3.5" drive using only two disks, followed by a 425 megabyte model in early 1993. The higher areal densities now practical for high volume production subsequently made it possible for several other disk drive manufacturers to follow the Western Digital initiative, and two disk configurations have become standard for all new 3.5" drives in this product group.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	1,440.6	1,723.3	2,676.2	3,053.1	3,466.9
All manufacturers	1,751.9	1,970.2	3,015.1	3,446.2	3,875.1

During the last few years this product group has been undergoing a transition from disk drive product lines intended primarily for workstations and mid-range computer systems to new low cost drives for use with personal computers. In the process, emphasis has been placed on reducing drive parts count to the minimum in order to achieve minimum cost, with the result that two platter 3.5" drives are now the norm, along with 3 or 4 disk 2.5" drives.

Following a 33.1% increase in unit shipments in 1992, this year's total of 300-500 megabyte drives is expected to climb 159.2%, to 4.7 million units. Total sales revenues declined 36.5% in 1992, mostly as the result of IBM's reduced shipments of Lightning and Turbo 3.5" drives, which were displaced by 1 gigabyte Corsair 3.5" drives in several applications. However, overall revenues for 1993 are expected to be up 12.5%, due to rapid growth of noncaptive shipments by U.S. disk drive manufacturers.

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 and 56.1% in 1992, with a further decline of 80.5% expected in 1993, dropping shipments to a nominal 46,000 units.

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, and 1992 shipments fell to 230,000 drives. The Lightning and Turbo are expected to be out of production within the next year, replaced by new IBM drives using only 2 disks.

The 1989 Lightning introduction represented an interesting change in IBM sales strategy for the noncaptive disk drive 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 personal computer 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 more than 1.3 million drives were shipped by the other 12 manufacturers which remain in the field, followed by an estimated 4.2 million

drives in 1993. OEM/Integrator shipments are expected to be up 224% in 1993 and PCM/Reseller shipments will climb 247.6%.

Both IBM and Toshiba announced 2.5" drives with 340 megabyte capacity in 1993, with IBM's drive becoming the first 2.5" drive to utilize magnetoresistive heads. Shipments of 244,000 drives are estimated for 1993, but the final total for the year will depend on the companies' ability to successfully initiate high volume production.

Personal computer applications increased their shipment leadership in this product group in 1992 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 61.1% of 1992 unit shipments, and further growth to 70% in 1996 is expected. Minicomputer and multiuser micro applications, including network file servers, fell to 17.7% of 1992 shipments, and will decline further to 16% in 1996. The share for technical workstations will also fall, as will the share for dedicated application office systems, as older drives are replaced with higher capacity models.

Seagate again dominated 1992 noncaptive shipments in this product group, with 593,500 drives, 40.6% of the worldwide total, by combining leadership in both 5.25" and 3.5" drive shipments. Maxtor was second with 16.4%, and Fujitsu held third place with 11% of worldwide shipments.

Marketing trends

Aggressive growth is expected to continue for this product group, with a 52.7% annual average increase in unit shipments for the 1994-96 period. The changing product mix and continually declining prices will hold the annual average increase in sales revenues to half that figure, at 26.6%.

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 peaked in 1992 at 1.4 million drives and are expected to be produced for the last time in 1995. In the meantime, 1" high models, shipped for the first time in 1992, are expected to account for 3.6 million drives in 1993, with the total for 1996 rising to more than 11.2 million drives.

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 popular with designers of arrays used in PC network file servers.

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 also forecasted to end in 1994, leaving the 300-500 megabyte capacity range to 3.5" and 2.5" drives:

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
14"	.2	.2	--	--	--
	--	--	--	--	--
8"	7.4	1.7	.5	--	--
	.4%	--	--	--	--
5.25"	235.9	46.0	10.5	--	--
	13.0%	1.0%	.1%	--	--
3.5" 1.625" high	1,438.5	771.8	295.0	20.0	--
	79.6%	16.5%	3.3%	.2%	--
3.5" 1" high	126.4%	3,622.9	7,464.0	9,490.0	11,240.0
	7.0%	77.3%	82.1%	76.8%	71.0%
2.5"	--	244.0	1,320.0	2,850.0	4,580.0
	--	5.2%	14.5%	23.0%	29.0%
	1,808.4	4,686.6	9,090.0	12,360.0	15,820.0

As expected, the first 2.5" drives in this capacity group were shipped in 1993, and shipments are projected to grow to 4.6 million drives in 1996. 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 $1.69 in 1992, and down to an estimated 95 cents in 1993. By 1996, it's expected to decline to 57 cents. The average OEM/Integrator price per megabyte for 2.5" drives is estimated at $1.17 for the first year of shipments in 1993, dropping to 64 cents in 1996.

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 smaller semiconductor chip sets. 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, newer drives are using only 2 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's two disk 1" high 3.5" drive delivered in late 1992 with a capacity of 340 megabytes, was the pathfinder for the rest of the industry in moving to two platter 3.5" drives in the 300-500 megabyte range. 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 were busy readying comparable two disk units for the market, the advance planners have been looking ahead to the day they will be offering capacities in the 300-500 megabyte range with only

one disk. Such drives will require higher areal densities, but densities in this range are likely to be available in drives for high production levels within a year or two. The highest capacity 3.5" drives now in production already utilize capacities per disk in this range. 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 most of today's chips.

Forecasting assumptions

1. Shipments of 14" drives will end in 1993, and both 8" drives and 5.25" drives will be shipped for the last time 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. Initial volume 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)									
	1992		Forecast							
	Revenues		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	367.9	522.0	198.1	291.2	466.7	685.0	613.2	927.6	730.7	1,143.1
Other U.S. Captive	39.7	69.3	24.6	36.2	8.4	12.0	--	--	--	--
TOTAL U.S. CAPTIVE	407.6	591.3	222.7	327.4	475.1	697.0	613.2	927.6	730.7	1,143.1
PCM/Reseller	155.5	295.6	273.0	479.5	359.7	568.4	341.6	520.7	319.7	488.9
OEM/Integrator	321.9	553.7	503.1	916.4	819.8	1,410.8	971.7	1,604.8	1,191.8	1,834.9
TOTAL U.S. NONCAPTIVE	477.4	849.3	776.1	1,395.9	1,179.5	1,979.2	1,313.3	2,125.5	1,511.5	2,323.8
TOTAL U.S. REVENUES	885.0	1,440.6	998.8	1,723.3	1,654.6	2,676.2	1,926.5	3,053.1	2,242.2	3,466.9
Non-U.S. Manufacturers										
Captive	--	179.0	7.5	145.9	9.8	119.5	11.1	75.2	14.4	55.2
PCM/Reseller	--	--	3.6	11.6	7.5	21.0	10.2	33.2	12.1	39.6
OEM/Integrator	43.9	132.3	20.2	89.4	64.9	198.4	94.1	284.7	101.4	313.4
TOTAL NON-U.S. REVENUES	43.9	311.3	31.3	246.9	82.2	338.9	115.4	393.1	127.9	408.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	928.9	1,751.9	1,030.1	1,970.2	1,736.8	3,015.1	2,041.9	3,446.2	2,370.1	3,875.1
OEM Average Price ($000)		.675		.340		.278		.234		.203

TABLE 50

FIXED DISK DRIVES, 300 - 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	170.0	238.0	201.5	293.0	757.6	1,111.0	1,190.0	1,800.0	1,630.0	2,550.0
Other U.S. Captive	23.2	36.4	18.4	25.4	7.0	10.0	--	--	--	--
TOTAL U.S. CAPTIVE	193.2	274.4	219.9	318.4	764.6	1,121.0	1,190.0	1,800.0	1,630.0	2,550.0
PCM/Reseller	234.5	447.7	771.3	1,308.6	1,285.3	2,005.5	1,475.0	2,250.0	1,585.0	2,425.0
OEM/Integrator	478.5	832.6	1,517.9	2,766.9	2,972.0	5,098.5	4,195.0	6,890.0	5,865.0	9,030.0
TOTAL U.S. NONCAPTIVE	713.0	1,280.3	2,289.2	4,075.5	4,257.3	7,104.0	5,670.0	9,140.0	7,450.0	11,455.0
TOTAL U.S. SHIPMENTS	906.2	1,554.7	2,509.1	4,393.9	5,021.9	8,225.0	6,860.0	10,940.0	9,080.0	14,005.0
Non-U.S. Manufacturers										
Captive	--	70.6	5.0	76.1	15.0	109.0	20.0	105.0	30.0	115.0
PCM/Reseller	--	--	9.0	29.0	25.0	70.0	40.0	130.0	55.0	180.0
OEM/Integrator	61.7	183.1	44.6	187.6	225.0	686.0	390.0	1,185.0	490.0	1,520.0
TOTAL NON-U.S. SHIPMENTS	61.7	253.7	58.6	292.7	265.0	865.0	450.0	1,420.0	575.0	1,815.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	967.9	1,808.4	2,567.7	4,686.6	5,286.9	9,090.0	7,310.0	12,360.0	9,655.0	15,820.0
Total Capacity (Terabytes)	354.1	670.5	891.2	1,634.3	1,803.9	3,105.6	2,485.4	4,203.2	3,282.7	5,378.8
Cumulative Shipments (Units in millions)										
IBM	1.0	1.4	1.2	1.7	2.0	2.8	3.2	4.6	4.8	7.2
Non-IBM	3.0	5.1	5.4	9.5	9.9	17.5	16.0	28.0	24.0	41.3
WORLDWIDE TOTAL	4.1	6.5	6.6	11.2	11.9	20.3	19.2	32.7	28.9	48.5

TABLE 51

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues				Forecast											
					1993					1994				1995		1996	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	51.5	10.5	460.0	--	10.2	7.0	186.0	88.0	5.0	1.8	483.1	195.1	650.0	277.6	783.1	360.0
Other U.S. Captive	--	--	32.7	36.6	--	--	.6	35.6	--	--	--	12.0	--	--	--	--	--
PCM/Reseller	--	--	56.5	239.1	--	--	6.0	473.5	--	--	.5	555.9	12.0	490.0	30.7	446.0	42.9
OEM/Integrator	--	4.8	102.4	446.5	--	2.4	20.5	893.5	--	--	3.5	1,256.8	150.5	1,249.5	355.3	1,252.9	582.0
TOTAL U.S. REVENUES	--	56.3	202.1	1,182.2	--	12.6	34.1	1,588.6	88.0	5.0	5.8	2,307.8	357.6	2,389.5	663.6	2,482.0	984.9
NON-U.S. MANUFACTURERS																	
Captive	3.6	15.4	44.2	115.8	3.2	1.2	22.8	88.7	30.0	--	13.2	64.0	42.3	28.0	47.2	--	55.2
PCM/Reseller	--	--	--	--	--	--	--	--	11.6	--	--	--	21.0	--	33.2	--	39.6
OEM/Integrator	--	.4	15.2	116.7	--	--	7.7	47.7	34.0	--	1.4	98.2	98.8	132.2	152.5	167.4	146.0
TOTAL NON-U.S. REVENUES	3.6	15.8	59.4	232.5	3.2	1.2	30.5	136.4	75.6	--	14.6	162.2	162.1	160.2	232.9	167.4	240.8
WORLDWIDE RECAP																	
Captive	3.6	66.9	87.4	612.4	3.2	11.4	30.4	310.3	118.0	5.0	15.0	559.1	237.4	678.0	324.8	783.1	415.2
	-72.9%	-38.2%	-62.4%	-63.6%	-11.1%	-83.0%	-65.2%	-49.3%	--	-56.1%	-50.7%	+80.2%	+101.2%	+21.3%	+36.8%	+15.5%	+27.8%
PCM/Reseller	--	--	56.5	239.1	--	--	6.0	473.5	11.6	--	.5	555.9	33.0	490.0	63.9	446.0	82.5
	--	--	-52.2%	+368.8%	--	--	-89.4%	+98.0%	--	--	-91.7%	+17.4%	+184.5%	-11.9%	+93.6%	-9.0%	+29.1%
OEM/Integrator	--	5.2	117.6	563.2	--	2.4	28.2	941.2	34.0	--	4.9	1,355.0	249.3	1,381.7	507.8	1,420.3	728.0
	--	-14.8%	-57.8%	+112.5%	--	-53.8%	-76.0%	+67.1%	--	--	-82.6%	+44.0%	+633.2%	+2.0%	+103.7%	+2.8%	+43.4%
Total Revenues	3.6	72.1	261.5	1,414.7	3.2	13.8	64.6	1,725.0	163.6	5.0	20.4	2,470.0	519.7	2,549.7	896.5	2,649.4	1,225.7
	-79.7%	-36.9%	-58.5%	-29.2%	-11.1%	-80.9%	-75.3%	+21.9%	--	-63.8%	-68.4%	+43.2%	+217.7%	+3.2%	+72.5%	+3.9%	+36.7%
ANNUAL SHARE, BY DIAMETER	.2%	4.1%	14.9%	80.8%	.2%	.7%	3.3%	87.7%	8.1%	.2%	.7%	82.0%	17.1%	74.1%	25.9%	68.5%	31.5%

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

	1992 Shipments				Forecast 1993					1994				1995		1996	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	5.0	3.0	230.0	--	1.0	2.0	180.0	110.0	.5	.5	810.0	300.0	1,300.0	500.0	1,800.0	750.0
Other U.S. Captive	--	--	9.9	26.5	--	--	.4	25.0	--	--	--	10.0	--	--	--	--	--
PCM/Reseller	--	--	73.2	374.5	--	--	6.7	1,301.9	--	--	.5	1,965.0	40.0	2,130.0	120.0	2,230.0	195.0
OEM/Integrator	--	1.2	122.1	709.3	--	.6	21.3	2,745.0	--	--	3.5	4,585.0	510.0	5,480.0	1,410.0	6,360.0	2,670.0
TOTAL U.S. SHIPMENTS	--	6.2	208.2	1,340.3	--	1.6	30.4	4,251.9	110.0	.5	4.5	7,370.0	850.0	8,910.0	2,030.0	10,390.0	3,615.0
NON-U.S. MANUFACTURERS																	
Captive	.2	1.1	11.4	57.9	.2	.1	6.5	49.3	20.0	--	4.0	40.0	65.0	20.0	85.0	--	115.0
PCM/Reseller	--	--	--	--	--	--	--	--	29.0	--	--	--	70.0	--	130.0	--	180.0
OEM/Integrator	--	.1	16.3	166.7	--	--	9.1	93.5	85.0	--	2.0	349.0	335.0	580.0	605.0	850.0	670.0
TOTAL NON-U.S. SHIPMENTS	.2	1.2	27.7	224.6	.2	.1	15.6	142.8	134.0	--	6.0	389.0	470.0	600.0	820.0	850.0	965.0
WORLDWIDE RECAP																	
Captive	.2	6.1	24.3	314.4	.2	1.1	8.9	254.3	130.0	.5	4.5	860.0	365.0	1,320.0	585.0	1,800.0	865.0
	-71.4%	-33.0%	-57.7%	-29.3%	--	-82.0%	-63.4%	-19.1%	--	-54.5%	-49.4%	+238.2%	+180.8%	+53.5%	+60.3%	+36.4%	+47.9%
PCM/Reseller	--	--	73.2	374.5	--	--	6.7	1,301.9	29.0	--	.5	1,965.0	110.0	2,130.0	250.0	2,230.0	375.0
	--	--	-44.5%	+541.3%	--	--	-90.8%	+247.6%	--	--	-92.5%	+50.9%	+279.3%	+8.4%	+127.3%	+4.7%	+50.0%
OEM/Integrator	--	1.3	138.4	876.0	--	.6	30.4	2,838.5	85.0	--	5.5	4,934.0	845.0	6,060.0	2,015.0	7,210.0	3,340.0
	--	-7.1%	-60.2%	+185.3%	--	-53.8%	-78.0%	+224.0%	--	--	-81.9%	+73.8%	+894.1%	+22.8%	+138.5%	+19.0%	+65.8%
Total Shipments	.2	7.4	235.9	1,564.9	.2	1.7	46.0	4,394.7	244.0	.5	10.5	7,759.0	1,320.0	9,510.0	2,850.0	11,240.0	4,580.0
	-84.6%	-29.5%	-56.1%	+93.2%	--	-77.0%	-80.5%	+180.8%	--	-70.6%	-77.2%	+76.6%	+441.0%	+22.6%	+115.9%	+18.2%	+60.7%
ANNUAL SHARE, BY DIAMETER	--	.4%	13.0%	86.6%	--	--	1.0%	93.9%	5.1%	--	.1%	85.5%	14.4%	77.0%	23.0%	71.1%	28.9%
TOTAL CAPACITY (Terabytes)	.1	3.0	82.5	584.9	.1	.6	15.4	1,535.2	83.0	.2	3.5	2,653.1	448.8	3,234.2	969.0	3,821.6	1,557.2

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

	1992 Estimate		1996 Projection	
APPLICATION	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI				
General purpose	2.2	.1	--	--
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	319.9	17.7	2,531.2	16.0
PERSONAL COMPUTERS				
Business and professional, single user	1,105.1	61.1	11,074.0	70.0
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	136.0	7.5	316.4	2.0
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	245.2	13.6	1,819.3	11.5
CONSUMER AND HOBBY COMPUTERS	--	--	79.1	.5
OTHER APPLICATIONS	--	--	--	--
Total	1,808.4	100.0	15,820.0	100.0

TABLE 54

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1992	1993	1994	1995	1996
Captive					
14"	36.00	32.00	--	--	--
8"	27.87	28.25	25.00	--	--
5.25"	10.51	10.85	10.26	--	--
3.5"	5.50	3.44	1.89	1.50	1.27
2.5"	--	2.67	1.91	1.63	1.41
Captive Average	6.31	3.43	1.94	1.54	1.32
PCM/Reseller					
14"	--	--	--	--	--
8"	--	--	--	--	--
5.25"	2.17	2.72	2.77	--	--
3.5"	1.69	1.03	.82	.67	.58
2.5"	--	1.17	.88	.75	.64
PCM/Reseller Average	1.77	1.04	.82	.68	.59
OEM/Integrator					
14"	--	--	--	--	--
8"	8.55	11.95	--	--	--
5.25"	2.43	2.70	2.59	--	--
3.5"	1.69	.95	.80	.67	.57
2.5"	--	1.17	.86	.74	.64
OEM/Integrator Average	1.79	.97	.81	.68	.59

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

14 inch totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

TABLE 55

FIXED DISK DRIVES, 300 - 500 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 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	.6	50.2	229.3	280.1	36.2	1.2	81.4	510.9	593.5	40.6
Maxtor	--	22.0	145.0	167.0	21.6	--	36.4	203.0	239.4	16.4
Fujitsu	--	--	60.0	60.0	7.7	--	4.5	156.0	160.5	11.0
Quantum	--	--	64.0	64.0	8.2	--	--	120.0	120.0	8.2
Western Digital	--	--	60.0	60.0	7.7	--	--	118.0	118.0	8.1
Conner Peripherals	--	--	86.0	86.0	11.1	--	--	107.0	107.0	7.3
Micropolis	--	32.6	--	32.6	4.2	--	62.8	--	62.8	4.3
Other U.S.	--	10.9	12.4	23.3	3.0	--	14.7	24.9	39.6	2.7
Other Non-U.S.	--	1.5	.2	1.7	.2	.1	11.8	10.7	22.6	1.5
TOTAL	.6	117.2	656.9	774.7	100.0	1.3	211.6	1250.5	1463.4	100.0

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

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

1993 DISK/TREND REPORT

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

10.5" disk diameter

Fujitsu	F6425G, M2361A

9-9.5" disk diameter

Hitachi	DK815-10, DKU-86I
NEC	N7757

8" disk diameter

Fujitsu	M2344K/KS, M2382K/P

5.25" disk diameter

Digital Equipment	RA71
Fujitsu	M2263E
Hewlett-Packard	97548D
Hitachi	DK711S-60D, DK515-78
IBM	9336-20
NEC	D5682
Sequel	XT-8760SH

3.5" disk diameter

Conner Peripherals	CP-3540*, CFA-540S/A**
Digital Equipment	RF35*, DSP3053L**
Fujitsu	M2624S*, M2693H*
Hewlett-Packard	C2244*
Hitachi	DK325C-57**
IBM	0662-508**
Kalok	P3500****
Maxtor	MXT-540SL**
Micropolis	2205S*, 4105D**
Quantum	700S ProDrive*, 525AT LPS**
Samsung Electronics	SHD-3252S**
Seagate Technology	ST1980N*, ST3600A/N**

2.5" disk diameter

Toshiba	MK-2428FC***

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

Maxtor's introduction of a 768 megabyte 5.25" drive precipitated a flurry of announcements from many of the same companies already competing for the 380 megabyte 5.25" market. In 1990, Maxtor was also the first company to announce a 3.5" drive in this product group, but the firm was quickly followed by several major competitors. Twelve drive manufacturers have announced or are shipping 3.5" drives in this capacity range. Several of the leading drive manufacturers also added 1" high models in 1992, which have already assumed market leadership for the product group.

Toshiba, which has provided much of the product leadership in 2.5" drives during the last two years, has announced 520 megabyte 2.5" models for deliveries scheduled by year-end 1993.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	1,298.3	1,362.8	2,169.6	3,025.7	3,609.7
All manufacturers	2,044.5	1,837.5	2,514.4	3,332.6	3,962.8

Shipments of 14", 8" and 5.25" drives in this capacity range continue to fall rapidly. Although the larger drives are making a smaller contribution to the shipment statistics, 3.5" drives are more than making up the difference. Overall shipments for the product group grew 25.2% in 1992 and are expected to be up 110.2% in 1993. Total sales revenues for the product group are down in 1992 and 1993, however, due mostly to dropping shipments of captive 5.25" and larger drives by both U.S. and non-U.S. manufacturers. The forecasted sales revenue total for 1993 is $1.8 billion, the lowest level since this DISK/TREND product group was established in 1987.

Even though the first shipments of 1" high 3.5" drives with more than 500 megabytes capacity did not occur until 1992, with a modest 42,500 units, 1" high

models are overwhelming the market for 3.5" drives. The 1993 shipment total for 1" high drives is estimated at 1.5 million, almost 70% of unit shipments for the product group. The scramble for lower prices underlies the rapid development of the 1" high drive market -- with all of the new drives utilizing a lower parts count than the full size 3.5" drives. The overall OEM/Integrator average selling price for 3.5" drives in this group is $1.00 in 1993, with 1" models obviously lower than the average.

Minicomputers and multiuser microcomputers, including file server applications, held the largest share of applications in 1992 with 44.8% of shipments, but are projected to drop to 16% in 1996. Personal computers held only 19.2% of the market in 1992, but are expected to rise rapidly through 1996, to 69%. Nonoffice systems and workstations held 25% of 1992 shipments, but are destined to decline to 14% in 1996, as personal computer applications continue to increase in storage requirements.

Based on strong shipments of 3.5" drives, Fujitsu rose to first place in 1992 worldwide noncaptive shipments for the product group with 27.5% of the total. Conner Peripherals held second place with 21.5%, with all 3.5" drives, and Maxtor was third, at 16.2%, with a mixture of 5.25" and 3.5" drives.

Marketing trends

As the result of continuing demand for drives in this capacity range from the engineering workstation and network file server markets, plus the emerging appetite for more disk capacity by the high end personal computer market, this product group is expected to have excellent growth in both shipments and sales revenue through 1996. Unit shipments are expected to increase an average of 65.6% per year in the 1994-96 period, reaching 9.5 million units. Despite the continual reductions in average unit price expected for all growing disk drive groups, total sales for drives in this group are expected to increase at an annual average of 29.4% during the same period.

The current outlook for this product group is set at much higher levels than previously projected, due mostly to the rapidly growing requirement for storage with high end personal computers, as the result of the emergence of software such as Microsoft's Windows NT, continuing growth in graphics applications, and

the expected utilization of larger drives on systems heavily used for multimedia activities. The 1" high 3.5" drives which already dominate shipments for this product group make possible easy upgrades to existing personal computers, but will be used primarily by system manufacturers with systems offering the latest processors and software.

Increasing software demands and new applications will also affect the disk storage market for notebook computers. The first 2.5" drive with capacity over 500 megabytes has already been announced, and significant shipments are expected in 1994, with growth to a projected 920,000 drives in 1996:

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
14"	3.5	1.0	--	--	--
	.3%	--	--	--	--
8"	28.3	12.2	4.0	--	--
	2.8%	.6%	.1%	--	--
5.25"	465.3	119.5	20.0	--	--
	45.1%	5.5%	.5%	--	--
3.5" 1.625" high	491.5	530.9	240.0	50.0	--
	47.7%	24.5%	5.5%	.7%	--
3.5" 1" high	42.5	1,503.6	3,966.0	6,380.0	8,570.0
	4.1%	69.4%	90.5%	93.4%	90.3%
2.5"	--	--	150.0	400.0	920.0
	--	--	3.4%	5.9%	9.7%
	1,031.1	2,167.2	4,380.0	6,830.0	9,490.0

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. Most of those drives utilized 8 disks in their initial versions, for

capacities in the range of 1 gigabyte or more. It's a fact that most of the heads, disks, and semiconductors for those drives, plus many of the mechanical components, are also be appropriate for usage in 1" high 3.5" drives designed for fewer 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 costly to design for drives in the 500 megabyte - 1 gigabyte range have already been developed for other drives, and can be utilized immediately. Most major drive manufacturers are working on 2 platter 3.5" drives with 540/550 megabytes for production in 1994, and IBM is planning a single platter 3.5" drive with a capacity of 550 megabytes for production in early 1994.

The technology which will be used in the 2.5" disk drives currently forecasted for first shipment in 1994 is probably similar to that developed for the 3.5" drive programs, and will borrow heavily from it. Toshiba's already announced 520 megabyte 2.5" drive uses inductive thin film heads and four sputtered disks, but some of the drives which will follow from other companies may utilize magnetoresistive heads. 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 by the end of this forecast period, using close-to-contact recording. PRML encoding, or a variation, is likely.

Forecasting assumptions

1. IBM will stop production of 5.25" drives in this product group by 1993, followed by 8" drives in 1994. The existing Spitfire 1" high 3.5" drives will be superseded by new 1" high 3.5" drives in 1994.
2. Shipments of 3.5" drives by other noncaptive and captive drive manufacturers will continue to increase through 1996.
3. First shipments of 2.5" drives in this product group will commence at the end of 1993.

TABLE 56

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	374.8	571.8	111.5	167.0	547.2	796.4	704.0	1,050.0	982.8	1,502.6
Other U.S. Captive	101.6	193.5	64.0	139.3	38.5	72.5	78.0	135.0	89.5	159.5
TOTAL U.S. CAPTIVE	476.4	765.3	175.5	306.3	585.7	868.9	782.0	1,185.0	1,072.3	1,662.1
PCM/Reseller	112.8	203.8	198.7	390.8	258.9	431.8	336.3	560.5	346.3	577.5
OEM/Integrator	230.1	329.2	437.4	665.7	565.0	868.9	838.1	1,280.2	898.2	1,370.1
TOTAL U.S. NONCAPTIVE	342.9	533.0	636.1	1,056.5	823.9	1,300.7	1,174.4	1,840.7	1,244.5	1,947.6
TOTAL U.S. REVENUES	819.3	1,298.3	811.6	1,362.8	1,409.6	2,169.6	1,956.4	3,025.7	2,316.8	3,609.7
Non-U.S. Manufacturers										
Captive	--	432.6	--	241.0	--	104.0	--	16.5	5.0	56.5
PCM/Reseller	29.8	30.5	28.4	29.0	28.5	38.8	32.3	51.3	32.8	51.7
OEM/Integrator	131.5	283.1	85.0	204.7	83.7	202.0	94.9	239.1	98.9	244.9
TOTAL NON-U.S. REVENUES	161.3	746.2	113.4	474.7	112.2	344.8	127.2	306.9	136.7	353.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	980.6	2,044.5	925.0	1,837.5	1,521.8	2,514.4	2,083.6	3,332.6	2,453.5	3,962.8
OEM Average Price ($000)		1.033		.632		.410		.373		.302

TABLE 57

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	63.5	96.0	37.0	52.0	400.5	581.0	670.0	1,000.0	1,210.0	1,850.0
Other U.S. Captive	32.4	57.1	23.3	49.0	33.0	61.0	80.0	140.0	120.0	215.0
TOTAL U.S. CAPTIVE	95.9	153.1	60.3	101.0	433.5	642.0	750.0	1,140.0	1,330.0	2,065.0
PCM/Reseller	115.1	212.3	309.5	616.9	615.5	1,027.0	885.0	1,475.0	1,115.0	1,860.0
OEM/Integrator	262.1	365.8	704.3	1,085.3	1,395.0	2,146.0	2,245.0	3,435.0	2,970.0	4,535.0
TOTAL U.S. NONCAPTIVE	377.2	578.1	1,013.8	1,702.2	2,010.5	3,173.0	3,130.0	4,910.0	4,085.0	6,395.0
TOTAL U.S. SHIPMENTS	473.1	731.2	1,074.1	1,803.2	2,444.0	3,815.0	3,880.0	6,050.0	5,415.0	8,460.0
Non-U.S. Manufacturers										
Captive	--	31.0	--	19.0	--	9.0	--	15.0	5.0	60.0
PCM/Reseller	41.0	42.0	52.0	53.0	65.0	90.0	85.0	135.0	105.0	165.0
OEM/Integrator	109.7	226.9	129.0	292.0	196.0	466.0	250.0	630.0	325.0	805.0
TOTAL NON-U.S. SHIPMENTS	150.7	299.9	181.0	364.0	261.0	565.0	335.0	780.0	435.0	1,030.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	623.8	1,031.1	1,255.1	2,167.2	2,705.0	4,380.0	4,215.0	6,830.0	5,850.0	9,490.0
Total Capacity (Terabytes)	416.2	693.3	735.8	1,270.6	1,478.8	2,400.1	2,671.2	4,334.8	3,676.7	5,971.8
Cumulative Shipments (Units in millions)										
IBM	.3	.6	.4	.7	.8	1.3	1.4	2.3	2.7	4.1
Non-IBM	1.8	3.1	3.1	5.2	5.4	9.0	8.9	14.9	13.6	22.5
WORLDWIDE TOTAL	2.2	3.8	3.5	5.9	6.2	10.3	10.4	17.2	16.3	26.6

TABLE 58

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues				Forecast 1993				1994				1995		1996	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	--	76.8	495.0	--	--	25.0	50.0	92.0	12.4	--	559.0	225.0	750.0	300.0	1,120.0	382.6
Other U.S. Captive	--	1.5	92.0	100.0	--	--	19.0	120.3	--	2.5	70.0	--	85.5	49.5	87.5	72.0
PCM/Reseller	--	--	132.4	71.4	--	--	29.9	360.9	--	1.4	430.4	--	560.5	--	570.4	7.1
OEM/Integrator	--	4.5	167.7	157.0	--	2.0	39.6	624.1	--	5.4	863.5	--	1,241.4	38.8	1,288.5	81.6
TOTAL U.S. REVENUES	--	82.8	887.1	328.4	--	27.0	138.5	1,197.3	12.4	9.3	1,922.9	225.0	2,637.4	388.3	3,066.4	543.3
NON-U.S. MANUFACTURERS																
Captive	72.1	105.0	250.0	5.5	20.1	61.3	157.2	2.4	27.0	77.0	--	--	16.5	--	31.5	25.0
PCM/Reseller	--	--	--	30.5	--	--	--	29.0	--	--	38.8	--	51.3	--	48.1	3.6
OEM/Integrator	--	117.2	39.4	126.5	--	40.3	15.0	149.4	3.5	4.0	194.5	--	226.9	12.2	216.0	28.9
TOTAL NON-U.S. REVENUES	72.1	222.2	289.4	162.5	20.1	101.6	172.2	180.8	30.5	81.0	233.3	--	294.7	12.2	295.6	57.5
WORLDWIDE RECAP																
Captive	72.1	183.3	837.0	105.5	20.1	86.3	226.2	214.7	39.4	79.5	629.0	225.0	852.0	349.5	1,239.0	479.6
	-42.4%	-70.5%	-47.2%	--	-72.1%	-52.9%	-73.0%	+103.5%	-54.3%	-64.9%	+193.0%	--	+35.5%	+55.3%	+45.4%	+37.2%
PCM/Reseller	--	--	132.4	101.9	--	--	29.9	389.9	--	1.4	469.2	--	611.8	--	618.5	10.7
	--	--	-27.3%	+506.5%	--	--	-77.4%	+282.6%	--	-95.3%	+20.3%	--	+30.4%	--	+1.1%	--
OEM/Integrator	--	121.7	207.1	283.5	--	42.3	54.6	773.5	3.5	9.4	1,058.0	--	1,468.3	51.0	1,504.5	110.5
	--	-29.1%	-41.0%	+327.0%	--	-65.2%	-73.6%	+172.8%	-91.7%	-82.8%	+36.8%	--	+38.8%	--	+2.5%	+116.7%
Total Revenues	72.1	305.0	1,176.5	490.9	20.1	128.6	310.7	1,378.1	42.9	90.3	2,156.2	225.0	2,932.1	400.5	3,362.0	600.8
	-46.6%	-61.6%	-44.4%	+473.5%	-72.1%	-57.8%	-73.6%	+180.7%	-66.6%	-70.9%	+56.5%	--	+36.0%	+78.0%	+14.7%	+50.0%
ANNUAL SHARE, BY DIAMETER	3.5%	14.9%	57.6%	24.0%	1.1%	7.0%	16.9%	75.0%	1.7%	3.6%	85.9%	8.8%	88.1%	11.9%	84.9%	15.1%

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

	1992 Shipments				Forecast											
					1993				1994				1995		1996	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	--	6.0	90.0	--	--	2.0	10.0	40.0	1.0	--	430.0	150.0	750.0	250.0	1,400.0	450.0
Other U.S. Captive	--	.6	36.5	20.0	--	--	7.0	42.0	--	1.0	60.0	--	95.0	45.0	125.0	90.0
PCM/Reseller	--	--	121.5	90.8	--	--	32.7	584.2	--	1.0	1,026.0	--	1,475.0	--	1,840.0	20.0
OEM/Integrator	--	1.4	158.7	205.7	--	.6	40.2	1,044.5	--	6.0	2,140.0	--	3,355.0	80.0	4,295.0	240.0
TOTAL U.S. SHIPMENTS	--	8.0	406.7	316.5	--	2.6	89.9	1,710.7	1.0	8.0	3,656.0	150.0	5,675.0	375.0	7,660.0	800.0
NON-U.S. MANUFACTURERS																
Captive	3.5	6.7	19.4	1.4	1.0	4.2	13.1	.7	2.0	7.0	--	--	15.0	--	35.0	25.0
PCM/Reseller	--	--	--	42.0	--	--	--	53.0	--	--	90.0	--	135.0	--	155.0	10.0
OEM/Integrator	--	13.6	39.2	174.1	--	5.4	16.5	270.1	1.0	5.0	460.0	--	605.0	25.0	720.0	85.0
TOTAL NON-U.S. SHIPMENTS	3.5	20.3	58.6	217.5	1.0	9.6	29.6	323.8	3.0	12.0	550.0	--	755.0	25.0	910.0	120.0
WORLDWIDE RECAP																
Captive	3.5	13.3	145.9	21.4	1.0	6.2	30.1	82.7	3.0	8.0	490.0	150.0	860.0	295.0	1,560.0	565.0
	-47.0%	-69.6%	-22.9%	--	-71.4%	-53.4%	-79.4%	+286.4%	-51.6%	-73.4%	+492.5%	--	+75.5%	+96.7%	+81.4%	+91.5%
PCM/Reseller	--	--	121.5	132.8	--	--	32.7	637.2	--	1.0	1,116.0	--	1,610.0	--	1,995.0	30.0
	--	--	-22.3%	+740.5%	--	--	-73.1%	+379.8%	--	-96.9%	+75.1%	--	+44.3%	--	+23.9%	--
OEM/Integrator	--	15.0	197.9	379.8	--	6.0	56.7	1,314.6	1.0	11.0	2,600.0	--	3,960.0	105.0	5,015.0	325.0
	--	-62.3%	-36.1%	+520.6%	--	-60.0%	-71.3%	+246.1%	-83.3%	-80.6%	+97.8%	--	+52.3%	--	+26.6%	+209.5%
Total Shipments	3.5	28.3	465.3	534.0	1.0	12.2	119.5	2,034.5	4.0	20.0	4,206.0	150.0	6,430.0	400.0	8,570.0	920.0
	-52.7%	-66.1%	-29.0%	+588.1%	-71.4%	-56.9%	-74.3%	+281.0%	-67.2%	-83.3%	+106.7%	--	+52.9%	+166.7%	+33.3%	+130.0%
ANNUAL SHARE, BY DIAMETER	.3%	2.7%	45.2%	51.8%	--	.6%	5.5%	93.9%	.1%	.5%	96.1%	3.3%	94.2%	5.8%	90.4%	9.6%
TOTAL CAPACITY (Terabytes)	2.3	18.9	330.6	341.5	.7	8.3	82.3	1,179.3	2.6	13.4	2,303.2	81.0	4,091.3	243.5	5,406.3	565.5

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

	1992 Estimate		1996 Projection	
APPLICATION	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI				
General purpose	53.6	5.2	--	--
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	461.6	44.8	1,518.4	16.0
PERSONAL COMPUTERS				
Business and professional, single user	198.4	19.2	6,548.1	69.0
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	60.1	5.8	94.9	1.0
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	257.4	25.0	1,328.6	14.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	1,031.1	100.0	9,490.0	100.0

TABLE 61

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1992	Forecast 1993	1994	1995	1996
Captive					
14"	31.34	28.71	--	--	--
8"	21.06	20.07	18.71	--	--
5.25"	7.30	10.28	14.83	--	--
3.5"	5.82	3.88	2.34	1.81	1.45
2.5"	--	--	2.77	1.87	1.31
Captive Average	8.33	6.65	2.72	1.83	1.41
PCM/Reseller					
14"	--	--	--	--	--
8"	--	--	--	--	--
5.25"	1.58	1.34	1.94	--	--
3.5"	1.23	1.09	.77	.58	.47
2.5"	--	--	--	--	.64
PCM/Reseller Average	1.41	1.10	.77	.58	.47
OEM/Integrator					
14"	--	--	--	--	--
8"	11.92	10.57	7.00	--	--
5.25"	1.56	1.43	1.27	--	--
3.5"	1.17	1.00	.74	.57	.46
2.5"	--	--	--	.89	.59
OEM/Integrator Average	1.59	1.07	.74	.57	.46

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

14" totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

TABLE 62

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 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	
Fujitsu	4.8	6.9	120.0	131.7	24.9	9.5	20.1	203.0	232.6	27.5
Conner Peripherals	--	--	136.0	136.0	25.8	--	--	182.0	182.0	21.5
Maxtor	--	51.2	38.0	89.2	16.9	--	78.1	58.7	136.8	16.2
Seagate Technology	.4	56.1	16.9	73.4	13.9	1.4	97.3	31.1	129.8	15.3
Micropolis	--	46.6	.9	47.5	9.0	--	77.7	1.4	79.1	9.3
Hewlett-Packard	--	16.3	.3	16.6	3.1	--	25.1	.3	25.4	3.0
Hitachi	--	7.0	--	7.0	1.3	3.8	18.5	.1	22.4	2.6
Other U.S.	--	1.0	13.5	14.5	2.8	--	2.0	23.0	25.0	3.0
Other Non-U.S.	--	--	12.0	12.0	2.3	.3	.6	13.0	13.9	1.6
TOTAL	5.2	185.1	337.6	527.9	100.0	15.0	319.4	512.6	847.0	100.0

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

FIXED DISK DRIVES, 1 - 2 GIGABYTES

1993 DISK/TREND REPORT

FIXED DISK DRIVES, 1 - 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Hitachi	DKU-85I

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

NEC	N7766

8" disk diameter

Fujitsu	M2392K

5.25" disk diameter

Digital Equipment	RF72
Fujitsu	M2266H, M2652P
Gigastorage Technology	Phoenix 1.2
Hewlett-Packard	97560, C3009
Hitachi	DK516C-16
IBM	9333-3110, 9345-1/2
NEC	N7797
Seagate Technology	ST41600N, ST41800N

3.5" disk diameter

Conner Peripherals	CP-31370*, CFP-1060S/D**
Digital Equipment	RZ26*, DSP3133L**
Fujitsu	M2694H*
Hewlett-Packard	C2247*, C3323A**
Hitachi	DK315C-11*, DK315C-14*
IBM	0662-S12**, O663-E15*
Maxtor	MXT-1240S*
Micropolis	2112D*, 4110D**
NEC	D3892*

3.5" disk diameter (continued)

Quantum	1225S ProDrive*, 1080S Empire**
Seagate Technology	ST11200N*, ST31200N**
Toshiba	MK-538FB*

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

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 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, which are still currently available from 8 companies, became the major products in the 1-2 gigabyte range. Joining them since 1991 were 3.5" drives, now available from 12 firms, with the first shipments of 1" high 3.5" drives under way in 1993. The first 2.5" drives with capacity over 1 gigabyte are expected to be in production in 1994.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	3,113.9	2,929.8	2,849.3	3,612.6	4,665.7
All manufacturers	3,873.2	3,608.8	3,589.9	4,371.5	5,616.3

Following the pattern of other product groups, drives in the 1-2 gigabyte capacity range are undergoing rapid changes in product mix. Previously the domain of drives designed for mainframes, the 1-2 gigabyte product group by 1991 had become an area of rapid growth for 5.25" OEM drives, with declining captive shipments of high-end drives. By 1992, 14" and 8"/9" drives provided

less than 5% of the shipment total, and 5.25" drives secured a 61.6% share. Also in 1992, 3.5" drives rose rapidly to a 34.1% share of overall shipments. However, the movement to smaller disks has moved even faster in 1993, with shrinking shipments of 14" and 8"/9" drives and 5.25" drives falling to 19.2% of the total. In the meantime, 3.5" drives will have jumped to an estimated 79.5% of worldwide shipments, a total of 1.7 million drives.

Total unit shipments for the product group were 1.2 million drives in 1992, up 174.5%, and 1993's total is forecasted at 2.2 million drives, another 76% increase. Sales revenue grew 34.7% in 1992 but is expected to drop 6.8% in 1993 due to falling prices and the changing product mix. The revenue growth in 1992 was built on rapidly growing shipments of 5.25" and 3.5" drives. However, total revenues for 1993 are expected to decline 6.8%, to $3.6 billion, as 5.25" drives start into rapid decline. Not even growth exceeding 300% for 3.5" drives in 1993 will provide enough sales to boost total revenues to a positive figure.

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 fell to $1,516 in 1992. The OEM/Integrator average price per megabyte for 3.5" drives was $1.20 in 1992 and is projected to fall to 74 cents in 1993 -- a very rapid fall, caused by the large increase in shipments during the year, the introduction of 1" high drives using fewer disks and the extreme levels of competition prevailing in the industry during 1993.

Mainframe and supermini applications used to provide the primary market for drives in this group, but these applications were down to a mere 14.5% of the unit shipment total for 1992, with a further decline to only 5% forecasted for 1996. Minicomputers and multiuser micros, including file servers, continued to be the leading application in 1992 with 50% of unit shipments and are forecasted to climb to 57% in 1996. Technical workstations held 21.5% of 1992 shipments and are expected to maintain that share, with 22% of the 1996 total.

Seagate Technology's dominance of the industry's 5.25" drive shipments in this product group again provided the company the leadership in noncaptive worldwide unit shipments with 37.8% of the total, representing a mix of 8", 5.25"

and 3.5" drives, for a total of 332,600 units. Micropolis was second with 14.4% and IBM was third with 13.6%.

Marketing trends

Although revenues will show a weaker pattern of growth due to falling average prices and the continuing movement to smaller disk diameters, unit shipment growth for 1-2 gigabyte drives is projected to provide an average annual increase of 57.3% during the 1994-96 period, with a total of 8.4 million drives forecasted in 1996. While the shipment level of 5.25" drives is being surpassed in 1993 by 1.625" high 3.5" drives, 1" high 3.5" models are destined to rise to the top starting in 1994, due to intrinsic cost advantages created by lower parts count and a package size more convenient for many applications. IBM is expected to start shipments of 2.5" drives with 1 gigabyte capacity in 1994:

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
14"	2.7	.9	--	--	--
	.2%	--	--	--	--
8"/9"	50.0	29.1	11.0	--	--
	4.1%	1.4%	.3%	--	--
5.25"	755.2	414.2	99.0	10.0	--
	61.5%	19.2%	2.7%	.2%	--
3.5" 1.625" high	420.1	1,352.1	1,092.0	368.0	45.0
	34.2%	62.5%	30.3%	6.4%	.5%
3.5" 1" high or less	--	365.5	2,358.0	5,112.0	7,795.0
	--	16.9%	65.3%	89.6%	93.0%
2.5"	--	--	50.0	215.0	540.0
	--	--	1.4%	3.8%	6.5%
	1,228.0	2,161.8	3,610.0	5,705.0	8,380.0

Helping to drive demand for both 5.25" and 3.5" drives will be the emerging market for various types of disk arrays, which are already starting to penetrate the network file server market, engineering workstations, minicomputers and mainframes. Most midrange and high-end arrays introduced initially used 5.25" drives because they were readily available in the desired capacities. But 3.5" drives at the 1 gigabyte level and beyond have already found their way into

arrays from many leading manufacturers. 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 which entered the market in 1993, such as the IBM "Spitfire" drive and the many others which have been announced, 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. For most drive designers the remaining problems involve chips for PRML circuits with adequate data rates, the possibility of motors with higher rotation speeds, uncertainties about magnetoresistive head availability, more sophisticated error detection schemes, and maximizing the number of recording zones. The problems are difficult but they are being solved.

Forecasting assumptions

1. IBM's shipments of Corsair-1 and Corsair-2 full size 3.5" drives will decline through 1995 as the result of a dual migration to higher capacity drives above this product group in capacity and to newer 1" high 3.5" drives with lower parts count. The 1" high 3 platter Spitfire 3.5" drive will be displaced starting in 1994 with the 2 disk 1.1 gigabyte version of the 1" high 3.5" Scorpio expected to go into production in early 1994.
2. The final production of 14" drives will be in 1993, 8" drive shipments will stop in 1994, and the last shipments of 5.25" drives will be in 1995.
3. 3.5" drives will assume shipment leadership of this product group in 1993, with 1" high models becoming dominant starting in 1994.

TABLE 63

FIXED DISK DRIVES, 1 - 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast							
	1993		1994		1995		1996			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	908.0	1,277.0	809.0	1,116.0	717.0	972.5	821.0	1,134.0	986.5	1,447.0
Other U.S. Captive	353.2	736.6	360.4	583.2	174.0	266.5	160.5	253.5	183.6	297.0
TOTAL U.S. CAPTIVE	1,261.2	2,013.6	1,169.4	1,699.2	891.0	1,239.0	981.5	1,387.5	1,170.1	1,744.0
PCM/Reseller	294.5	421.8	272.0	411.3	361.7	540.9	492.7	672.1	514.0	814.5
OEM/Integrator	497.6	678.5	591.9	819.3	795.0	1,069.4	1,122.7	1,553.0	1,470.8	2,107.2
TOTAL U.S. NONCAPTIVE	792.1	1,100.3	863.9	1,230.6	1,156.7	1,610.3	1,615.4	2,225.1	1,984.8	2,921.7
TOTAL U.S. REVENUES	2,053.3	3,113.9	2,033.3	2,929.8	2,047.7	2,849.3	2,596.9	3,612.6	3,154.9	4,665.7
Non-U.S. Manufacturers										
Captive	--	499.4	--	339.0	--	140.0	--	56.0	--	82.5
PCM/Reseller	12.1	13.3	44.0	44.0	16.8	25.5	82.5	126.7	103.7	158.6
OEM/Integrator	135.9	246.6	194.3	296.0	368.9	575.1	371.4	576.2	462.4	709.5
TOTAL NON-U.S. REVENUES	148.0	759.3	238.3	679.0	385.7	740.6	453.9	758.9	566.1	950.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,201.3	3,873.2	2,271.6	3,608.8	2,433.4	3,589.9	3,050.8	4,371.5	3,721.0	5,616.3
OEM Average Price ($000)		1.516		1.011		.759		.613		.530

TABLE 64

FIXED DISK DRIVES, 1 - 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	144.0	195.0	316.0	415.0	433.0	580.0	600.0	830.0	770.0	1,130.0
Other U.S. Captive	62.2	123.4	114.5	195.0	102.0	162.0	125.0	205.0	163.0	270.0
TOTAL U.S. CAPTIVE	206.2	318.4	430.5	610.0	535.0	742.0	725.0	1,035.0	933.0	1,400.0
PCM/Reseller	182.9	261.1	245.0	371.7	435.0	645.0	725.0	980.0	855.0	1,355.0
OEM/Integrator	333.9	440.3	575.0	774.5	1,122.0	1,503.0	1,863.0	2,580.0	2,785.0	3,990.0
TOTAL U.S. NONCAPTIVE	516.8	701.4	820.0	1,146.2	1,557.0	2,148.0	2,588.0	3,560.0	3,640.0	5,345.0
TOTAL U.S. SHIPMENTS	723.0	1,019.8	1,250.5	1,756.2	2,092.0	2,890.0	3,313.0	4,595.0	4,573.0	6,745.0
Non-U.S. Manufacturers										
Captive	--	29.0	--	22.2	--	21.0	--	28.0	--	55.0
PCM/Reseller	9.2	9.3	55.0	55.0	25.0	38.0	125.0	192.0	170.0	260.0
OEM/Integrator	94.4	169.9	218.2	328.4	425.0	661.0	575.0	890.0	860.0	1,320.0
TOTAL NON-U.S. SHIPMENTS	103.6	208.2	273.2	405.6	450.0	720.0	700.0	1,110.0	1,030.0	1,635.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	826.6	1,228.0	1,523.7	2,161.8	2,542.0	3,610.0	4,013.0	5,705.0	5,603.0	8,380.0
Total Capacity (Terabytes)	1,086.0	1,625.8	1,865.3	2,663.4	2,939.5	4,191.0	5,081.7	7,230.1	7,986.5	11,944.0
Cumulative Shipments (Units in millions)										
IBM	.3	.6	.7	1.0	1.1	1.6	1.7	2.4	2.5	3.5
Non-IBM	1.2	2.0	2.4	3.7	4.5	6.7	7.9	11.6	12.7	18.9
WORLDWIDE TOTAL	1.6	2.6	3.1	4.8	5.6	8.4	9.6	14.1	15.3	22.5

TABLE 65

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues				Forecast 1993				1994				1995			1996	
	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	--	--	485.0	792.0	--	--	380.0	736.0	--	70.0	802.5	100.0	--	930.0	204.0	1,125.0	322.0
Other U.S. Captive	--	84.0	594.4	58.2	--	10.0	290.8	282.4	--	59.5	207.0	--	--	202.5	51.0	206.0	91.0
PCM/Reseller	--	7.7	308.5	105.6	--	--	128.6	282.7	--	19.5	521.4	--	--	672.1	--	804.0	10.5
OEM/Integrator	--	38.7	486.8	153.0	--	24.3	234.3	560.7	9.6	50.1	1,009.7	--	11.5	1,499.0	42.5	2,008.2	99.0
TOTAL U.S. REVENUES	--	130.4	1,874.7	1,108.8	--	34.3	1,033.7	1,861.8	9.6	199.1	2,540.6	100.0	11.5	3,303.6	297.5	4,143.2	522.5
NON-U.S. MANUFACTURERS																	
Captive	75.6	363.6	55.7	4.5	26.4	275.2	35.0	2.4	98.0	6.0	36.0	--	--	56.0	--	60.0	22.5
PCM/Reseller	1.0	2.4	--	9.9	--	--	--	44.0	--	--	25.5	--	--	126.7	--	158.6	--
OEM/Integrator	--	36.0	176.5	34.1	--	13.4	65.9	216.7	3.4	24.0	547.7	--	--	563.4	12.8	679.5	30.0
TOTAL NON-U.S. REVENUES	76.6	402.0	232.2	48.5	26.4	288.6	100.9	263.1	101.4	30.0	609.2	--	--	746.1	12.8	898.1	52.5
WORLDWIDE RECAP																	
Captive	75.6	447.6	1,135.1	854.7	26.4	285.2	705.8	1,020.8	98.0	135.5	1,045.5	100.0	--	1,188.5	255.0	1,391.0	435.5
	-85.9%	-60.2%	+222.2%	--	-65.1%	-36.3%	-37.8%	+19.4%	-65.6%	-80.8%	+2.4%	--	--	+13.7%	+155.0%	+17.0%	+70.8%
PCM/Reseller	1.0	10.1	308.5	115.5	--	--	128.6	326.7	--	19.5	546.9	--	--	798.8	--	962.6	10.5
	-64.3%	-36.9%	+229.6%	--	--	--	-58.3%	+182.9%	--	-84.8%	+67.4%	--	--	+46.1%	--	+20.5%	--
OEM/Integrator	--	74.7	663.3	187.1	--	37.7	300.2	777.4	13.0	74.1	1,557.4	--	11.5	2,062.4	55.3	2,687.7	129.0
	--	-50.2%	+75.2%	--	--	-49.5%	-54.7%	+315.5%	-65.5%	-75.3%	+100.3%	--	-84.5%	+32.4%	--	+30.3%	+133.3%
Total Revenues	76.6	532.4	2,106.9	1,157.3	26.4	322.9	1,134.6	2,124.9	111.0	229.1	3,149.8	100.0	11.5	4,049.7	310.3	5,041.3	575.0
	-85.9%	-58.8%	+155.6%	--	-65.5%	-39.4%	-46.1%	+83.6%	-65.6%	-79.8%	+48.2%	--	-95.0%	+28.6%	+210.3%	+24.5%	+85.3%
ANNUAL SHARE, BY DIAMETER	2.0%	13.7%	54.5%	29.8%	.7%	8.9%	31.5%	58.9%	3.1%	6.4%	87.8%	2.7%	.3%	92.7%	7.0%	89.9%	10.1%

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

	1992 Shipments				Forecast											
	1993				1994				1995			1996	
	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	--	--	30.0	165.0	--	--	25.0	390.0	--	5.0	525.0	50.0	--	710.0	120.0	900.0	230.0
Other U.S. Captive	--	7.0	97.1	19.3	--	1.0	74.0	120.0	--	17.0	145.0	--	--	175.0	30.0	205.0	65.0
PCM/Reseller	--	1.8	180.2	79.1	--	--	92.7	279.0	--	15.0	630.0	--	--	980.0	--	1,340.0	15.0
OEM/Integrator	--	10.5	310.6	119.2	--	7.0	166.0	601.5	3.0	40.0	1,460.0	--	10.0	2,520.0	50.0	3,825.0	165.0
TOTAL U.S. SHIPMENTS	--	19.3	617.9	382.6	--	8.0	357.7	1,390.5	3.0	77.0	2,760.0	50.0	10.0	4,385.0	200.0	6,270.0	475.0
NON-U.S. MANUFACTURERS																	
Captive	2.6	20.2	5.3	.9	.9	17.2	3.5	.6	7.0	2.0	12.0	--	--	28.0	--	40.0	15.0
PCM/Reseller	.1	.2	--	9.0	--	--	--	55.0	--	--	38.0	--	--	192.0	--	260.0	--
OEM/Integrator	--	10.3	132.0	27.6	--	3.9	53.0	271.5	1.0	20.0	640.0	--	--	875.0	15.0	1,270.0	50.0
TOTAL NON-U.S. SHIPMENTS	2.7	30.7	137.3	37.5	.9	21.1	56.5	327.1	8.0	22.0	690.0	--	--	1,095.0	15.0	1,570.0	65.0
WORLDWIDE RECAP																	
Captive	2.6	27.2	132.4	185.2	.9	18.2	102.5	510.6	7.0	24.0	682.0	50.0	--	913.0	150.0	1,145.0	310.0
	-91.0%	-55.2%	+251.2%	--	-65.4%	-33.1%	-22.6%	+175.7%	-61.5%	-76.6%	+33.6%	--	--	+33.9%	+200.0%	+25.4%	+106.7%
PCM/Reseller	.1	2.0	180.2	88.1	--	--	92.7	334.0	--	15.0	668.0	--	--	1,172.0	--	1,600.0	15.0
	-50.0%	+25.0%	+237.5%	--	--	--	-48.6%	+279.1%	--	-83.8%	+100.0%	--	--	+75.4%	--	+36.5%	--
OEM/Integrator	--	20.8	442.6	146.8	--	10.9	219.0	873.0	4.0	60.0	2,100.0	--	10.0	3,395.0	65.0	5,095.0	215.0
	--	-39.9%	+94.7%	--	--	-47.6%	-50.5%	+494.7%	-63.3%	-72.6%	+140.5%	--	-83.3%	+61.7%	--	+50.1%	+230.8%
Total Shipments	2.7	50.0	755.2	420.1	.9	29.1	414.2	1,717.6	11.0	99.0	3,450.0	50.0	10.0	5,480.0	215.0	7,840.0	540.0
	-91.0%	-48.4%	+137.2%	--	-66.7%	-41.8%	-45.2%	+308.9%	-62.2%	-76.1%	+100.9%	--	-89.9%	+58.8%	+330.0%	+43.1%	+151.2%
ANNUAL SHARE, BY DIAMETER	.2%	4.1%	61.6%	34.1%	--	1.3%	19.2%	79.5%	.3%	2.7%	95.7%	1.3%	.2%	96.2%	3.6%	93.7%	6.3%
TOTAL CAPACITY (Terabytes)	3.4	86.9	1,090.9	444.6	1.1	52.1	595.2	2,015.0	19.9	142.6	3,978.5	50.0	15.0	7,000.2	215.0	11,404.0	540.0

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	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI				
General purpose	178.1	14.5	419.0	5.0
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	613.8	50.0	4,776.6	57.0
PERSONAL COMPUTERS				
Business and professional, single user	8.6	.7	1,257.0	15.0
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	163.8	13.3	83.8	1.0
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	263.7	21.5	1,843.6	22.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	1,228.0	100.0	8,380.0	100.0

TABLE 68

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1992	1993	1994	1995	1996
Captive					
14"	22.90	24.00	--	--	--
8"	9.36	8.51	7.40	--	--
5.25"	6.64	5.16	4.22	--	--
3.5"	4.39	1.84	1.40	1.14	1.02
2.5"	--	--	2.00	1.70	1.40
Captive Average	6.03	2.81	1.64	1.21	1.09
PCM/Reseller					
14"	10.00	--	--	--	--
8"	3.24	--	--	--	--
5.25"	1.16	.94	.86	--	--
3.5"	1.22	.78	.69	.52	.40
2.5"	--	--	--	--	.70
PCM/Reseller Average	1.19	.82	.70	.52	.40
OEM/Integrator					
14"	--	--	--	--	--
8"	2.07	2.02	1.94	--	--
5.25"	1.01	.93	.84	.76	--
3.5"	1.20	.74	.63	.46	.35
2.5"	--	--	--	.85	.60
OEM/Integrator Average	1.09	.80	.64	.47	.35

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

14 inch totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

TABLE 69

FIXED DISK DRIVES, 1 - 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 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	--	7.9	208.7	20.1	236.7	38.2	--	12.3	296.9	23.4	332.6	37.8
Micropolis	--	--	91.0	7.0	98.0	15.8	--	--	117.0	9.4	126.4	14.4
IBM	--	--	--	95.0	95.0	15.3	--	--	5.0	115.0	120.0	13.6
Fujitsu	.1	6.0	48.9	8.5	63.5	10.2	.1	6.1	84.9	24.5	115.6	13.1
Hitachi	--	.7	29.0	.4	30.1	4.9	--	4.4	46.9	2.1	53.4	6.1
Hewlett-Packard	--	--	32.0	8.7	40.7	6.6	--	--	40.0	10.8	50.8	5.8
Maxtor	--	--	21.5	2.9	24.4	3.9	--	--	31.9	3.7	35.6	4.0
Digital Equipment	--	--	--	17.0	17.0	2.7	--	--	--	27.0	27.0	3.1
Other U.S.	--	--	--	5.0	5.0	.8	--	--	--	9.0	9.0	1.0
Other Non-U.S.	--	--	--	10.0	10.0	1.6	--	--	.2	10.0	10.2	1.1
TOTAL	.1	14.6	431.1	174.6	620.4	100.0	.1	22.8	622.8	234.9	880.6	100.0

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

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

1993 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, 3390-9

9.5" disk diameter

Hitachi	H-6587

9" disk diameter

NEC	N7795

8" disk diameter

Fujitsu	M2671P, F6427K
Seagate Technology	ST83220K, ST82500N/J

6.5" disk diameter

Hitachi	H-6588-314

5.25" disk diameter

Digital Equipment	DSP5350, RF 73
Fujitsu	M2654S/P
Gigastorage Technology	Phoenix 2.5
Hewlett-Packard	C3010
Hitachi	DK517C-37
Micropolis	1924D, 1936D
Seagate Technology	ST42400N, ST43200K

3.5" disk diameter

Conner Peripherals	CFP-2120S/D*
Digital Equipment	R228*, DSP3210*
Hewlett-Packard	C2490A*
IBM	0664-N1H*, 9333-011*
Seagate Technology	ST12400N*, ST-32430N**

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

Until 1991 this product group was an exclusive club, consisting mostly of drives in the 8" to 14" range used with mainframe computers. However, volume

production of 5.25" drives destined for OEM markets started in 1991, opening the capacity range above 2 gigabytes to an entirely new type of activity.

Disk drives with individual spindles containing capacities above 2 gigabytes first appeared in 1985 with IBM's 3380-E, the double capacity model in the 3380 series. It was replaced by the triple capacity 3380-K in 1987, which in turn was obsoleted 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 in 1989. The 3390-3, with 50% more capacity per spindle and further price reductions per megabyte, shipped in September, 1991. In June, 1993, the 3390-9 appeared, with 3 times more capacity, lower costs and lower performance.

The 10.5" and 9.5" drives in this group are intended for mainframe and supermini applications similar to IBM's, and most use standard industry technology, but generally more conservatively, to facilitate reliable production. The 8" and 9" drives 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 included in plug compatible subsystems equivalent to IBM 3380 and 3390 drives, although the newest PCM models will use 5.25" and 6.5" disks.

5.25" drives above 2 gigabytes were shipped for the first time in 1991, and are now available from seven 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. 3.5" drives first became available in late 1992, with introduction of IBM's 1.625" high Allicat series, which is now used in several system applications, but has not yet appeared in the mainframe market. Four additional manufacturers have announced 1.625" high 3.5" drives in this product group in 1993, and the first 1" high shipments are expected in early 1994, from both IBM and Seagate.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1992	1993	1994	1995	1996
U.S. manufacturers	4,764.5	6,086.1	5,805.6	6,087.7	7,317.4
All manufacturers	5,954.6	7,089.6	6,922.1	7,366.7	8,712.4

After a 6.2% decline in 1992, total revenues for disk drives with capacities over 2 gigabytes are increasing by an estimated 19.1% in 1993, to $7.1 billion. The continuing decline in shipments of 8"-10.8" drives is being overshadowed by rapid growth for both 5.25" and 3.5" drives. Total shipments for the product group grew a modest 19.4% in 1992, but are increasing at a robust 230.9% rate in 1993, to an estimated 954,000 drives. It is projected that 5.25" drives will provide 48.3% of 1993's unit shipments and 3.5" drives will grow to 37.9%.

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. The availability of 5.25" and 3.5" drives has helped to increase the share of 1992 shipments used with network servers and minicomputers to 26.4% of the year's total, while mainframe and supermini usage was down to 67.9%. By 1996 the mainframe and supermini share is forecasted to be down to 6%, while network servers and minicomputers will be up to 83%. Significantly, personal computers, currently not a factor in this product group, are projected to use 6% of 1996 unit shipments.

Seagate Technology continued to hold a strong lead in 1992 noncaptive shipments with 36.4% of the worldwide total, including both 8" and 5.25" drives. Fujitsu held second with 20%, reflecting a mix of 10.5", 8" and 5.25" drives. Hitachi's strength in the PCM mainframe market was reflected in its third place position, with 18.5% of the total.

Marketing trends

Although the changing product mix and nonstop price reductions will minimize growth in sales revenue, increases in shipments will remain at a high level through the 1996 forecast horizon of this report. Total unit shipments are expected to reach 4.3 million drives in 1996, an average annual increase for the 1994-96 period of 64.6%. After a slight decline in 1994 caused by lower U.S. captive shipments, worldwide sales revenue is forecasted to increase 6.4% in 1995 and 18.3% in 1996, reaching $8.7 billion.

After three years of outstanding growth in shipments, 5.25" drives are expected to peak in 1994, with a 1994 increase of only 5.4% expected, followed by

two years of rapid shipment declines. The first 9 gigabyte 5.25" drives will be available by early 1994, and it is expected that the 5.25" survivors in 1996 will have a very high average capacity. However, exuberant growth in 3.5" drive shipments will boost total shipments for the product group despite weakness in 5.25" drives. 1.625" high 3.5" drives will double in shipments in 1994, and again in 1995, reaching 2.4 million units in 1996. 1" high 3.5" drives are expected to start volume shipments early in 1994 and are projected to reach 1.7 million drives in 1996. By that year, 8"-10.8" drives are expected to be only memories:

Worldwide total Unit shipments(000)	1992	1993	1994	1995	1996
10.5"-14"	91.9 31.9%	81.2 8.5%	52.0 3.2%	6.0 .2%	-- --
8"-9.5"	67.3 23.3%	51.0 5.4%	38.5 2.3%	10.0 .4%	-- --
5.25"-6.5"	129.1 44.8%	460.2 48.2%	485.0 29.5%	315.0 11.5%	100.0 2.4%
3.5" 1.625" high	-- --	361.6 37.9%	724.0 44.0%	1,635.0 60.0%	2,405.0 56.6%
3.5" 1" high	-- --	-- --	345.0 21.0%	760.0 27.9%	1,740.0 41.0%
	288.3	954.0	1,644.5	2,726.0	4,245.0

It seems clear that the 3390-9, which is apparently receiving a cool reception from the market, is the last mid-life kicker in the 3390 series. It is expected that IBM will utilize existing and new 3.5" drives in a series of mainframe storage subsystems during the next several years, starting in early 1994. It is likely that early arrivals will be a heavily cached subsystem to counterattack the heavy PCM inroads by EMC, fault tolerant arrays to head off the StorageTek Iceberg and other expected offerings, and replacements for the 9345 5.25" and 3390 10.8" subsystems. IBM might stretch the capacity of the Allicat 2 gigabyte drive now in quantity production for some of these applications, but it will also have other attractive alternatives. The 2.2 gigabyte Scorpio, a 1" high 3.5" drive which will succeed the 1 gigabyte Spitfire, is scheduled for large scale production in early 1994, and the 4.4 gigabyte 1.625" high 3.5" Starfire will be available later in 1994.

Technical trends

This product group continues to enjoy much of the disk drive industry's leading edge development efforts to improve areal density and performance. The expected IBM 3.5" drives mentioned above will probably have areal densities in the range of 500 megabits per square inch, up from 1993's leader, the IBM Spitfire, at 354. It seems clear that IBM will achieve its frequently stated objective of producing drives in 1996 with areal densities of at least 1 gigabit per square inch. At that recording density it will require only one 3.5" disk for each gigabyte -- or much higher capacities depending on the encoding method and zoning technique, and whether compression is used.

The barriers to other companies achieving recording densities comparable to those in IBM's new 3.5" drives will gradually fall during the next few years. Independent head manufacturers are expected to achieve quantity production capability for magnetoresistive heads in 1994, and Seagate Technology's Minneapolis head manufacturing facility is already ready to produce. Semiconductor manufacturers are also expected to provide several sources for PRML chips, with adequate data rates, in 1994. Due to Seagate's pioneering 7,200 RPM Barracuda drive family, other firms will probably be able to find the appropriate drive motors and other scarce components needed for similar performance.

Forecasting assumptions

1. IBM will introduce the 1" high Scorpio 2.2 gigabyte drive in late 1993, for production start early in 1994, and will introduce the 4.4 gigabyte 3.5" Starfire by 4th quarter, 1994, preceded by a temporary version early in 1994 utilizing two 2.2 gigabyte 3.5" drives in a single enclosure. 1994 will be the last production year for the 3390-3 and 9345 drives, and production of 3390-9 will stop in 1995.
2. PCM vendors will continue to match IBM's 3390 series with 8"-9.5", and with newly announced 5.25" and 6.5" drives, plus new 9 gigabyte 5.25" models, later adding 3.5" drives to compete with IBM's expected 1994 subsystem introductions.
3. Shipments of 5.25" drives in OEM/Integrator markets will peak in 1994, with 3.5" drives taking a strong lead in total shipments for the product group starting in 1994.

TABLE 70

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	2,784.0	4,128.0	2,988.5	4,406.5	2,435.8	3,640.5	2,275.0	3,322.0	2,627.5	3,595.0
Other U.S. Captive	71.6	171.6	315.0	504.5	260.0	490.4	282.0	506.0	298.0	511.0
TOTAL U.S. CAPTIVE	2,855.6	4,299.6	3,303.5	4,911.0	2,695.8	4,130.9	2,557.0	3,828.0	2,925.5	4,106.0
PCM/Reseller	42.1	61.8	180.1	306.1	283.5	432.5	289.5	441.5	348.0	540.5
OEM/Integrator	192.3	403.1	518.6	869.0	817.9	1,242.2	1,196.2	1,818.2	1,691.9	2,670.9
TOTAL U.S. NONCAPTIVE	234.4	464.9	698.7	1,175.1	1,101.4	1,674.7	1,485.7	2,259.7	2,039.9	3,211.4
TOTAL U.S. REVENUES	3,090.0	4,764.5	4,002.2	6,086.1	3,797.2	5,805.6	4,042.7	6,087.7	4,965.4	7,317.4
Non-U.S. Manufacturers										
Captive	--	270.0	--	303.6	--	308.0	--	225.0	--	220.0
PCM/Reseller	388.4	846.2	291.5	600.1	333.0	644.0	390.7	673.0	246.0	450.0
OEM/Integrator	56.1	73.9	69.8	99.8	113.5	164.5	240.0	381.0	460.0	725.0
TOTAL NON-U.S. REVENUES	444.5	1,190.1	361.3	1,003.5	446.5	1,116.5	630.7	1,279.0	706.0	1,395.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	3,534.5	5,954.6	4,363.5	7,089.6	4,243.7	6,922.1	4,673.4	7,366.7	5,671.4	8,712.4
OEM Average Price ($000)		4.270		2.253		1.649		1.354		1.195

TABLE 71

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	58.0	86.0	161.5	232.0	213.0	309.0	348.0	514.0	445.0	630.0
Other U.S. Captive	7.2	17.2	53.0	90.0	71.0	130.0	96.0	170.0	114.0	195.0
TOTAL U.S. CAPTIVE	65.2	103.2	214.5	322.0	284.0	439.0	444.0	684.0	559.0	825.0
PCM/Reseller	17.3	25.4	96.0	160.3	195.0	295.0	210.0	320.0	280.0	435.0
OEM/Integrator	56.9	81.8	251.2	370.0	514.0	742.0	892.0	1,339.0	1,425.0	2,250.0
TOTAL U.S. NONCAPTIVE	74.2	107.2	347.2	530.3	709.0	1,037.0	1,102.0	1,659.0	1,705.0	2,685.0
TOTAL U.S. SHIPMENTS	139.4	210.4	561.7	852.3	993.0	1,476.0	1,546.0	2,343.0	2,264.0	3,510.0
Non-U.S. Manufacturers										
Captive	--	10.8	--	13.2	--	16.0	--	18.0	--	25.0
PCM/Reseller	17.1	37.2	13.8	28.5	21.3	41.5	46.4	80.0	60.0	120.0
OEM/Integrator	22.2	29.9	42.0	60.0	76.0	111.0	180.0	285.0	375.0	590.0
TOTAL NON-U.S. SHIPMENTS	39.3	77.9	55.8	101.7	97.3	168.5	226.4	383.0	435.0	735.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	178.7	288.3	617.5	954.0	1,090.3	1,644.5	1,772.4	2,726.0	2,699.0	4,245.0
Total Capacity (Terabytes)	652.2	1,061.8	1,723.3	2,700.3	2,952.6	4,534.8	5,044.1	7,783.9	8,711.0	13,677.0
Cumulative Shipments (Units in millions)										
IBM	.3	.5	.5	.8	.7	1.1	1.1	1.6	1.5	2.2
Non-IBM	.2	.4	.7	1.2	1.6	2.5	3.0	4.7	5.3	8.3
WORLDWIDE TOTAL	.6	1.0	1.2	2.0	2.3	3.6	4.1	6.4	6.8	10.6

TABLE 72

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues			Forecast													
	1993				1994				1995				1996				
	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	4,128.0	--	--	3,616.0	--	--	790.5	2,327.5	--	--	1,313.0	232.0	--	--	3,090.0	--	3,595.0
Other U.S. Captive	--	--	171.6	--	--	457.5	47.0	--	--	230.0	260.4	--	--	100.0	406.0	30.0	481.0
PCM/Reseller	--	--	61.8	--	--	185.5	120.6	--	--	153.0	279.5	--	--	88.0	353.5	32.5	508.0
OEM/Integrator	184.5	85.8	132.8	152.0	37.2	512.1	167.7	108.0	19.2	536.5	578.5	70.0	9.2	297.1	1,441.9	65.0	2,605.9
TOTAL U.S. REVENUES	4,312.5	85.8	366.2	3,768.0	37.2	1,155.1	1,125.8	2,435.5	19.2	919.5	2,431.4	302.0	9.2	485.1	5,291.4	127.5	7,189.9
NON-U.S. MANUFACTURERS																	
Captive	--	270.0	--	--	303.6	--	--	--	252.0	56.0	--	--	60.0	120.0	45.0	50.0	170.0
PCM/Reseller	26.6	819.6	--	3.6	596.5	--	--	--	430.0	200.0	14.0	--	95.0	180.0	398.0	--	450.0
OEM/Integrator	--	20.4	53.5	--	7.8	92.0	--	--	3.5	80.0	81.0	--	--	56.0	325.0	14.0	711.0
TOTAL NON-U.S. REVENUES	26.6	1,110.0	53.5	3.6	907.9	92.0	--	--	685.5	336.0	95.0	--	155.0	356.0	768.0	64.0	1,331.0
WORLDWIDE RECAP																	
Captive	4,128.0	270.0	171.6	3,616.0	303.6	457.5	837.5	2,327.5	252.0	286.0	1,573.4	232.0	60.0	220.0	3,541.0	80.0	4,246.0
	-16.8%	+327.9%	--	-12.4%	+12.4%	+166.6%	--	-35.6%	-17.0%	-37.5%	+87.9%	-90.0%	-76.2%	-23.1%	+125.1%	-63.6%	+19.9%
PCM/Reseller	26.6	819.6	61.8	3.6	596.5	185.5	120.6	--	430.0	353.0	293.5	--	95.0	268.0	751.5	32.5	958.0
	-80.6%	+8.6%	+175.9%	-86.5%	-27.2%	+200.2%	--	--	-27.9%	+90.3%	+143.4%	--	-77.9%	-24.1%	+156.0%	-87.9%	+27.5%
OEM/Integrator	184.5	106.2	186.3	152.0	45.0	604.1	167.7	108.0	22.7	616.5	659.5	70.0	9.2	353.1	1,766.9	79.0	3,316.9
	+59.6%	-39.5%	+57.7%	-17.6%	-57.6%	+224.3%	--	-28.9%	-49.6%	+2.1%	+293.3%	-35.2%	-59.5%	-42.7%	+167.9%	-77.6%	+87.7%
Total Revenues	4,339.1	1,195.8	419.7	3,771.6	945.1	1,247.1	1,125.8	2,435.5	704.7	1,255.5	2,526.4	302.0	164.2	841.1	6,059.4	191.5	8,520.9
	-16.8%	+20.4%	+191.3%	-13.1%	-21.0%	+197.1%	--	-35.4%	-25.4%	+.7%	+124.4%	-87.6%	-76.7%	-33.0%	+139.8%	-77.2%	+40.6%
ANNUAL SHARE, BY DIAMETER	73.0%	20.1%	6.9%	53.3%	13.3%	17.6%	15.8%	35.3%	10.2%	18.1%	36.4%	4.1%	2.2%	11.4%	82.3%	2.2%	97.8%

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

	1992 Shipments			1993 Forecast				1994 Forecast				1995 Forecast				1996 Forecast	
	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	86.0	--	--	77.0	--	--	155.0	49.0	--	--	260.0	4.0	--	--	510.0	--	630.0
Other U.S. Captive	--	--	17.2	--	--	75.0	15.0	--	--	46.0	84.0	--	--	25.0	145.0	10.0	185.0
PCM/Reseller	--	--	25.4	--	--	83.7	76.6	--	--	85.0	210.0	--	--	55.0	265.0	25.0	410.0
OEM/Integrator	4.5	15.9	61.4	4.0	7.5	243.5	115.0	3.0	4.0	290.0	445.0	2.0	2.0	180.0	1,155.0	50.0	2,200.0
TOTAL U.S. SHIPMENTS	90.5	15.9	104.0	81.0	7.5	402.2	361.6	52.0	4.0	421.0	999.0	6.0	2.0	260.0	2,075.0	85.0	3,425.0
NON-U.S. MANUFACTURERS																	
Captive	--	10.8	--	--	13.2	--	--	--	12.0	4.0	--	--	3.0	10.0	5.0	5.0	20.0
PCM/Reseller	1.4	35.8	--	.2	28.3	--	--	--	21.5	10.0	10.0	--	5.0	10.0	65.0	--	120.0
OEM/Integrator	--	4.8	25.1	--	2.0	58.0	--	--	1.0	50.0	60.0	--	--	35.0	250.0	10.0	580.0
TOTAL NON-U.S. SHIPMENTS	1.4	51.4	25.1	.2	43.5	58.0	--	--	34.5	64.0	70.0	--	8.0	55.0	320.0	15.0	720.0
WORLDWIDE RECAP																	
Captive	86.0	10.8	17.2	77.0	13.2	75.0	170.0	49.0	12.0	50.0	344.0	4.0	3.0	35.0	660.0	15.0	835.0
	-21.1%	+369.6%	--	-10.5%	+22.2%	+336.0%	--	-36.4%	-9.1%	-33.3%	+102.4%	-91.8%	-75.0%	-30.0%	+91.9%	-57.1%	+26.5%
PCM/Reseller	1.4	35.8	25.4	.2	28.3	83.7	76.6	--	21.5	95.0	220.0	--	5.0	65.0	330.0	25.0	530.0
	-79.1%	+16.2%	+130.9%	-85.7%	-20.9%	+229.5%	--	--	-24.0%	+13.5%	+187.2%	--	-76.7%	-31.6%	+50.0%	-61.5%	+60.6%
OEM/Integrator	4.5	20.7	86.5	4.0	9.5	301.5	115.0	3.0	5.0	340.0	505.0	2.0	2.0	215.0	1,405.0	60.0	2,780.0
	+18.4%	-41.5%	+105.0%	-11.1%	-54.1%	+248.6%	--	-25.0%	-47.4%	+12.8%	+339.1%	-33.3%	-60.0%	-36.8%	+178.2%	-72.1%	+97.9%
Total Shipments	91.9	67.3	129.1	81.2	51.0	460.2	361.6	52.0	38.5	485.0	1,069.0	6.0	10.0	315.0	2,395.0	100.0	4,145.0
	-23.1%	-1.8%	+141.3%	-11.6%	-24.2%	+256.5%	--	-36.0%	-24.5%	+5.4%	+195.6%	-88.5%	-74.0%	-35.1%	+124.0%	-68.3%	+73.1%
ANNUAL SHARE, BY DIAMETER	32.0%	23.3%	44.7%	8.5%	5.3%	48.3%	37.9%	3.2%	2.3%	29.6%	64.9%	.2%	.4%	11.6%	87.8%	2.4%	97.6%
TOTAL CAPACITY (Terabytes)	518.9	250.6	292.3	596.8	215.1	1,152.9	735.5	472.4	166.4	1,554.3	2,341.8	92.1	42.5	1,330.3	6,319.0	550.0	13,127.0

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)									
	1992		FORECAST							
	Shipments		1993		1994		1995		1996	
	US	WW	US	WW	US	WW	US	WW	US	WW
3380J Type (1260 MB)										
PCM	.2	.3	--	--	--	--	--	--	--	--
3380K Type (3780 MB)										
PCM	2.2	4.2	.4	.7	--	--	--	--	--	--
3390-2 type (3784 MB)										
PCM	6.7	16.4	1.4	3.4	.5	1.5	--	--	--	--
3390-3 type (5676 MB)										
IBM	58.0	86.0	43.0	65.0	22.0	34.0	--	--	--	--
PCM	8.2	16.6	12.0	24.4	9.8	20.0	2.4	5.0	--	--
TOTAL	66.2	102.6	55.0	89.4	31.8	54.0	2.4	5.0	--	--
3390-9 type (17028 MB)										
IBM	--	--	8.5	12.0	10.0	15.0	2.4	4.0	--	--
PCM	--	--	--	--	3.0	5.0	1.6	3.0	--	--
TOTAL	--	--	8.5	12.0	13.0	20.0	4.0	7.0	--	--
5.25 Inch drives										
IBM 9345 (1500 MB)	15.0	25.0	13.0	20.0	3.0	5.0	--	--	--	--
PCM (Average 2000 MB)	19.5	30.0	31.0	48.0	16.0	25.0	6.5	10.0	3.0	5.0
PCM (Average 9000 MB)	--	--	--	--	7.0	10.0	8.0	12.0	9.0	15.0
3.5 Inch drives										
IBM (4400 MB)	--	--	--	--	28.0	40.0	105.0	160.0	135.0	210.0
PCM (4400 MB)	--	--	--	--	--	--	16.0	35.0	28.0	60.0
TOTAL 3.5 INCH	--	--	--	--	28.0	40.0	121.0	195.0	163.0	270.0
TOTAL SPINDLES	109.8	178.5	109.3	173.5	99.3	155.5	141.9	229.0	175.0	290.0
TOTAL FORMATTED CAPACITY (Terabytes)		758.2		853.3		976.2		1,133.6		1,333.0
		+24%		+13%		+14%		+16%		+18%

NOTE: When PCM drives are designed to emulate specific IBM drive models, quantities of such drives are counted in units equivalent in capacity to IBM individual spindles, even though different disk diameters and physical file organizations may be used. In some cases, an "equivalent" PCM spindle may be composed of two or more physical spindles in order to equal the capacity of a specific IBM spindle.

TABLE 75

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI				
General purpose	195.8	67.9	254.7	6.0
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	76.3	26.4	3,523.3	83.0
PERSONAL COMPUTERS				
Business and professional, single user	--	--	254.7	6.0
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	1.9	.7	--	--
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	14.3	5.0	212.3	5.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	288.3	100.0	4,245.0	100.0

TABLE 76

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1992	Forecast 1993	1994	1995	1996
Captive					
14"	8.45	6.30	5.19	3.40	--
8"	8.79	8.13	7.36	7.01	--
5.25"	4.99	2.34	1.85	1.91	1.60
3.5"	--	2.45	1.97	1.67	1.34
Captive Average	8.26	4.54	3.09	1.75	1.35
PCM/Reseller					
14"	5.01	4.50	--	--	--
8"	4.91	3.88	3.60	3.34	--
5.25"	1.08	.87	.83	.68	.21
3.5"	--	.76	.62	.91	.58
PCM/Reseller Average	3.96	1.72	1.06	.89	.55
OEM/Integrator					
14"	7.23	6.69	4.50	2.91	--
8"	1.99	1.84	1.73	1.64	--
5.25"	.92	.81	.63	.42	.22
3.5"	--	.70	.61	.52	.39
OEM/Integrator Average	1.70	.94	.67	.52	.39

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

14 inch totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

TABLE 77

FIXED DISK DRIVES, MORE THAN 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 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	--	10.6	32.2	42.8	37.7	--	15.9	47.6	63.5	36.4
Fujitsu	.8	7.2	17.3	25.3	22.3	1.4	9.4	24.0	34.8	20.0
Hitachi	--	13.4	.6	14.0	12.3	--	31.2	1.1	32.3	18.5
Micropolis	--	--	14.5	14.5	12.8	--	--	16.6	16.6	9.5
Digital Equipment	--	--	8.0	8.0	7.0	--	--	14.0	14.0	8.0
Other U.S.	.9	--	8.0	8.9	7.9	4.5	--	8.6	13.1	7.6
Other Non-U.S.	--	--	--	--	--	--	--	--	--	--
TOTAL	1.7	31.2	80.6	113.5	100.0	5.9	56.5	111.9	174.3	100.0

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

1993 DISK/TREND REPORT

RIGID MAGNETIC DISK DRIVE SPECIFICATIONS

Coverage

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

Specifications on drive models sold by computer system manufacturers, but purchased on an OEM basis from others, have been included in some cases, for identification purposes. In the case of IBM's disk drives and those produced by some other system manufacturers, captive drives which are similar to OEM/Integrator models made by the same manufacturer are not listed.

Capacities

Beginning last year, formatted capacity has been used to determine the appropriate DISK/TREND product group for each drive. Prior to last year, 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 only for OEM/Integrator and PCM/Reseller drives without embedded controllers, and formatted capacities are given for captive drives and noncaptive drives with embedded controllers, such as SCSI 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.

1993 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	DR311C90
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 37044
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	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	DR311C91	DR311D90	DR311D91	DR312C90	DR312C91
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	MIG	MIG
Interface	PC AT	SCSI-2	SCSI-2	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 122.8	F: 105.8	F: 122.8	F: 211.5	F: 245.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,160	F: 25,088	F: 28,160	F: 25,088	F: 28,160
Data surfaces per spindle	2	2	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	2180	2108	2180	2108	2180
Track density (TPI)	2540	2419	2540	2419	2540
Maximum linear density (BPI) (FCI)	49393 37044	49393 37044	49393 37044	49393 37044	49393 37044
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3448	3448	3448	3448	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)	13	13	13	13	13
Average rotational delay (msec)	8.7	8.7	8.7	8.7	8.7
Average access time (msec)	21.7	21.7	21.7	21.7	21.7
Data transfer rate (KBytes/sec)	8000	8000 synch. 4000 asynch.	8000 synch. 4000 asynch.	8000	8000
FIRST CUSTOMER SHIPMENT	4/93	4/92	4/93	12/92	4/93
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	DR312D90	DR312D91	DR321C	DR321D	DR322C
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	MIG	MIG	MIG	MIG	MIG
Interface	SCSI-2	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 211.5	F: 245.6	F: 272.6	F: 272.6	F: 545.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	F: 28,160	*	*	*
Data surfaces per spindle	4	4	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	2108	2180	3623	3623	3623
Track density (TPI)	2419	2540	4097	4097	4097
Maximum linear density (BPI) (FCI)	49393 37044	49393 37044	56370 42278	56370 42278	56370 42278
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3448	3448	4510	4510	4510
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	13	12	12	12
Average rotational delay (msec)	8.7	8.7	6.7	6.7	6.7
Average access time (msec)	21.7	21.7	18.7	18.7	18.7
Data transfer rate (KBytes/sec)	8000 synch. 4000 asynch.	8000 synch. 4000 asynch.	8000	10000 synch. 4000 asynch.	8000
FIRST CUSTOMER SHIPMENT	1/92	4/93	9/93	9/93	9/93
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	ALPS ELECTRIC	AMDAHL	AMDAHL	AMDAHL	AMDAHL
DRIVE	DR322D	6380-AJ4 6380-BJ4	6380-AK4 6380-BK4	6390-A/B24 6390-A/B28 6390-A/B2C 6390-A/B2F	6390-A/B34 6390-A/B38 6390-A/B3C 6390-A/B3F
DISK/TREND GROUP	6	7	8	8	9
MARKET	OEM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Sputtered	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI-2	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 545.3	F: 630	F: 1,890	F: 1,892	F: 2,838/3,390
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 47,476	F: 47,476	F: 56,664	F: 56,664
Data surfaces per spindle	4	8	15	15	15
Heads per data surface	1	2	2	1	1
Tracks per surface	3623	1770	2656	2226	3339/3987
Track density (TPI)	4097	1350	1350	2050	
Maximum linear density (BPI) (FCI)	56370 42278	21300 15975	24440 18330	32733 24550	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4510	3620	3620	4348	4348
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	16	10.7	11.5/13
Average rotational delay (msec)	6.7	8.3	8.3	6.9	6.9
Average access time (msec)	18.7	20.3	24.3	17.6	18.4/19.9
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	3000	3000	4500	4500
FIRST CUSTOMER SHIPMENT	9/93	1Q89	1Q89	4Q91	9/92
COMMENTS	25.4 mm high *Varies by zone	PCM 3380J Drive has 4 spindles Manufactured by Fujitsu	PCM 3380K Drive has 4 spindles Manufactured by Fujitsu	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

MANUFACTURER	AMDAHL	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY
DRIVE	6395-A 6395-A9C 6395-A9X	A85	A130	A131	A135
DISK/TREND GROUP	9	3	4	4	4
MARKET	PCM	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	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film*	Thin Film*	Thin Film*	Thin Film*
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,255	F: 86.0	F: 131.48	F: 131.48	F: 131.48
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 31,250	**	**	**
Data surfaces per spindle	20	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	3339	1344	1453	1453	1453
Track density (TPI)		2764	2763	2763	2763
Maximum linear density (BPI) (FCI)		71000 47333	80000 60000	80000 60000	80000 60000
Recording code		2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4340	2981	2981	2981	2981
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)	14.5	15	15	15	15
Average rotational delay (msec)	6.9	10.1	10.1	10.1	10.1
Average access time (msec)	21.4	25.1	25.1	25.1	25.1
Data transfer rate (KBytes/sec)	4500	1875	2000	2000	2000
FIRST CUSTOMER SHIPMENT	3Q94	6/93	6/93	9/93	8/93
COMMENTS	PCM 3390-9 Drive has 4, 8, 12, 16, 20, 24, 28 or 32 spindles. Mfg. by Fujitsu	12.4 mm high *Glass disk	12.4 mm high *Glass disk **Varies by zone	15.0 mm high *Glass disk **Varies by zone	10 mm high *Glass disk **Varies by zone

MANUFACTURER	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AURA ASSOCIATES	AURA ASSOCIATES	AURA ASSOCIATES
DRIVE	A170	A260	AU43	AU63	AU63-III
DISK/TREND GROUP	4	5	2	3	3
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Removable Drive
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	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	PC AT	PC AT	PC AT	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 172.0	F: 262.96	F: 42.6	F: 62.9	--
REMOVABLE	--	--	--	--	F: 62.9
Capacity per track (Bytes)	F: 31,250	**	*	*	*
Data surfaces per spindle	4	4	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1344	1453	1125	1410	1500
Track density (TPI)	2764	2763	2550	3200	3200
Maximum linear density (BPI) (FCI)	71000 47333	80000 60000	49000 37000	59000 44000	57000 43000
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	2981	2981	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	15	15	17	17	16
Average rotational delay (msec)	10.1	10.1	5.5	5.5	5.5
Average access time (msec)	25.1	25.1	22.5	22.5	21.5
Data transfer rate (KBytes/sec)	1875	2000	4500	4500	5000
FIRST CUSTOMER SHIPMENT	7/93	9/93	3Q92	4Q93	4Q93
COMMENTS	15.0 mm high *Glass disk	15.0 mm high *Glass disk **Varies by zone	12.7 mm high *Varies by zone	12.7 mm high *Varies by zone	10.5 mm high *Varies by zone PCMCIA type III

MANUFACTURER	AURA ASSOCIATES	AURA ASSOCIATES	AURA ASSOCIATES	AURA ASSOCIATES	AURA ASSOCIATES
DRIVE	AU85	AU126	AU211A	AU211S	AU245A
DISK/TREND GROUP	3	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 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	PCMCIA-ATA	PC AT, IDE	SCSI-2	PC AT, IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85.3	F: 125.8	F: 211.5	F: 211.5	F: 245
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 25,088	F: 25,088	F: 28,160
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1125	1410	2108	2108	2180
Track density (TPI)	2550	3200	2419	2419	2540
Maximum linear density (BPI) (FCI)	49000 37000	59000 44000	49393 37044	49393 37044	49393 37044
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	3448	3448	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)	17	17	13	13	13
Average rotational delay (msec)	5.5	5.5	8.7	8.7	8.7
Average access time (msec)	22.5	22.5	21.7	21.7	21.7
Data transfer rate (KBytes/sec)	4500	4500	8000	8000 synch. 4000 asynch.	8000
FIRST CUSTOMER SHIPMENT	2Q93	4Q93	2Q93	2Q93	2Q93
COMMENTS	15.0 mm high *Varies by zone	10.5 mm high *Varies by zone	25.4 mm high Mfg. by Alps Electric	25.4 mm high Mfg. by Alps Electric	25.4 mm high Mfg. by Alps Electric

MANUFACTURER	AURA ASSOCIATES	AVATAR SYSTEMS	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	COMPAREX
DRIVE	AU245S	ASR-80 ASR-80M	CT-80	CT-80MC	6480AK 6480BK
DISK/TREND GROUP	5	1	3	3	8
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Generic type	Fixed	2.5" Cartridge	Fixed	Removable Drive	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	9.5"
Recording medium	Thin Film	Thin Film*	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI, PC AT, IDE	IDE	PCMCIA-ATA	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245	--	F: 85.33	--	F: 1,890
REMOVABLE	--	F: 85.98	--	F: 85.33	--
Capacity per track (Bytes)	F: 28,160	**	*	*	F: 47,476
Data surfaces per spindle	4	2	4	4	8
Heads per data surface	1	1	1	1	4
Tracks per surface	2180	1730	1084	1084	2655
Track density (TPI)	2540	3100	2490	2490	*
Maximum linear density (BPI) (FCI)	49393 37044	53800 40350	50411 37808	50411 37808	*
Recording code	1,7 RLL	1, 7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3448	4500	4800	4800	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	13	12	18	18	12.5
Average rotational delay (msec)	8.7	6.7	6.25	6.25	8.3
Average access time (msec)	21.7	18.7	24.25	24.25	20.8
Data transfer rate (KBytes/sec)	8000 synch. 4000 asynch.	2000	4000	4000	3000
FIRST CUSTOMER SHIPMENT	2Q93	2Q93	4/93	4/93	1988
COMMENTS	25.4 mm high Mfg. by Alps Electric	17.5 mm high 80M includes floppy drive *Glass disk **Varies by zone	10.0 mm high *Varies by zone	10.5 mm high *Varies by zone PCMCIA type III	PCM 3380K Drive has 2 or 4 spindles. *Not announced. Manufactured by Hitachi

MANUFACTURER	COMPAREX	COMPAREX	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	6490-A24 6490-A28 6490-B24 6490-B28 6490-B2C	6490-A34 6490-A38 6490-B34 6490-B38 6490-B3C	CP-30080E Jaguar	CP-30084E Jaguar	CFN-170A FilePro Notebook
DISK/TREND GROUP	8	9	3	3	4
MARKET	PCM	PCM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	9.5"	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	Thin Film	Thin Film	MIG	MIG	Thin Film, MIG
Interface	IBM	IBM	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,892	F: 2,838	F: 85.0	F: 85.0	F: 168.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 56,664	F: 23,552	F: 23,552	*
Data surfaces per spindle	15	15	2	2	4
Heads per data surface	2	2	1	1	1
Tracks per surface	2226	3339	1806	1806	1339
Track density (TPI)	*	*	2150	2150	2611
Maximum linear density (BPI) (FCI)	*	*	42173 31630	42173 31630	58230 43684
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	4260	3833	3833	4500
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)	10	12.5	17	17	12
Average rotational delay (msec)	7.1	7.1	7.8	7.8	6.7
Average access time (msec)	17.1	19.6	24.8	24.8	18.7
Data transfer rate (KBytes/sec)	4200	4200	5000 synch. 2000 asynch.	6000 max.	8000
FIRST CUSTOMER SHIPMENT	4Q90	2Q92	3Q91	3Q91	4Q93
COMMENTS	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	25.4 mm high	25.4 mm high	19.5 mm high *Varies by zone

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CFN-170S FilePro Notebook	CP-2124 Pancho	CP-30104H Allegheny	CP-30170 FilePro	CP-30170E Jaguar
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	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	Thin Film	MIG	MIG	MIG
Interface	SCSI-2	PC AT	PC AT, EISA	SCSI-2	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 168.2	F: 121.6	F: 120	F: 172	F: 170.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 27,136	F: 19,968	*	F: 23,552
Data surfaces per spindle	4	4	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1339	1120	1522	2116	1806
Track density (TPI)	2611	2450	1850	2553	2150
Maximum linear density (BPI) (FCI)	58230 43684	59500 44625	33184 24888	56833 42662	42173 31630
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3776		4011	3833
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	17	19	13	17
Average rotational delay (msec)	6.7	7.9	8.8	7.5	7.8
Average access time (msec)	18.7	24.9	27.8	20.5	24.8
Data transfer rate (KBytes/sec)	6000 synch. 3000 asynch.	8000	4000	10000 synch. 5000 asynch.	5000 synch. 2000 asynch.
FIRST CUSTOMER SHIPMENT	4Q93	4Q91	2Q91	3Q93	3Q91
COMMENTS	19.5 mm high *Varies by zone	19 mm high	25.4 mm high	25.4 mm high *Varies by zone	25.4 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-30174 FilePro	CP-30174E Jaguar	CFN-250A FilePro Notebook	CFN-250S FilePro Notebook	CFS-210A FilePro
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	MIG	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	Thin Film, MIG	Thin Film, MIG	Thin Film, MIG
Interface	PC AT	PC AT	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 172	F: 170.0	F: 252.7	F: 252.7	F: 213.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 23,552	*	*	*
Data surfaces per spindle	2	4	6	6	2
Heads per data surface	1	1	1	1	1
Tracks per surface	2116	1806	1339	1339	2388
Track density (TPI)	2553	2150	2611	2611	2774
Maximum linear density (BPI) (FCI)	56833 42662	42173 31630	58230 43684	58230 43684	58566 43924
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4011	3833	4500	4500	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	17	12	12	14
Average rotational delay (msec)	7.5	7.8	6.7	6.7	8.3
Average access time (msec)	20.5	24.8	18.7	18.7	22.3
Data transfer rate (KBytes/sec)	7500	6000 max.	8000	6000 synch. 3000 asynch.	7500
FIRST CUSTOMER SHIPMENT	2Q93	3Q91	4Q93	4Q93	4Q93
COMMENTS	25.4 mm high *Varies by zone	25.4 mm high	19.5 mm high *Varies by zone	19.5 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-2254 Trigger	CP-30200 Cougar	CP-30204 Cougar	CP-30254 Monterey	CP-30254H FilePro
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	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	PC AT	SCSI	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 252.7	F: 212.6	F: 212.6	F: 252	F: 252
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 25,088	F: 25,088	F: 31,744	F: 31,744
Data surfaces per spindle	6	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1339	2124	2124	1985	1985
Track density (TPI)	2611	2496	2496	2450	2450
Maximum linear density (BPI) (FCI)	58230 43684	45610 30407	45610 30407	52270 39202	52270 39202
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4542	4542
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	14	14
Average rotational delay (msec)	6.67	6.7	6.7	6.6	6.6
Average access time (msec)	18.67	18.7	18.7	20.6	20.6
Data transfer rate (KBytes/sec)	8000	5000 synch. 2500 asynch.	2500	6000	6000
FIRST CUSTOMER SHIPMENT	2Q93	3Q91	3Q91	4Q92	2Q93
COMMENTS	19 mm high *Varies by zone	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	CFN-340A FilePro Notebook	CFN-340S FilePro Notebook	CFS-420A FilePro	CP-30340 FilePro	CP-30344 FilePro
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	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	Thin Film, MIG	Thin Film, MIG	MIG	MIG
Interface	PC AT	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 344.5	F: 344.5	F: 426.8	F: 343	F: 343
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	6	6	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1598	1598	2388	2111	2111
Track density (TPI)	3004	3004	2774	2553	2553
Maximum linear density (BPI) (FCI)	65564 49173	65564 49173	58566 43924	56833 42662	56833 42662
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	4000	3600	4011	4011
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	13	14	13	13
Average rotational delay (msec)	6.7	6.7	8.3	7.5	7.5
Average access time (msec)	19.7	19.7	22.3	20.5	20.5
Data transfer rate (KBytes/sec)	8000	6000 synch. 3000 asynch.	7500	10000 synch. 5000 asynch.	7.5
FIRST CUSTOMER SHIPMENT	4Q93	4Q93	4Q93	3Q93	2Q93
COMMENTS	19.5 mm high *Varies by zone	19.5 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	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-3360 Summit	CP-3364 Summit	CFA-540A FilePro Advantage	CFA-540S FilePro Advantage	CP-30540 FilePro
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	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, MIG	Thin Film, MIG	Thin Film
Interface	SCSI-2	PC AT	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 362.8	F: 362.8	F: 541	F: 541	F: 545.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	F: 25,088	*	*	*
Data surfaces per spindle	8	8	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1808	1808	2805	2805	2243
Track density (TPI)	2150	2150	3253	3253	2628
Maximum linear density (BPI) (FCI)	44325 29550	44325 29550	62500 46850	62500 46850	54224 40668
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4500	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	10
Average rotational delay (msec)	6.7	6.7	6.7	6.7	5.56
Average access time (msec)	18.7	18.7	18.7	18.7	15.56
Data transfer rate (KBytes/sec)	5000 synch. 2500 asynch.	2500	10000	10000 synch. 5000 asynch.	10000 synch.
FIRST CUSTOMER SHIPMENT	3Q91	3Q91	4Q93	4Q93	4Q92
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-30544 FilePro	CP-3540 Summit	CP-3544 Summit	CFA-1080A FilePro Advantage	CFA-1080S FilePro Advantage
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	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, MIG	Thin Film, MIG
Interface	PC AT	SCSI-2	PC AT	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 545.9	F: 543.7	F: 543.7	F: 1,080	F: 1,080
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 25,088	F: 25,088	*	*
Data surfaces per spindle	6	12	12	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	2243	1806	1806	2842	2842
Track density (TPI)	2628	2150	2150	3245	3245
Maximum linear density (BPI) (FCI)	54224 40668	44325 29550	44325 29550	65000 48740	65000 48740
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	12	12	10.5	10.5
Average rotational delay (msec)	5.56	6.7	6.7	6.7	6.7
Average access time (msec)	15.56	18.7	18.7	17.2	17.2
Data transfer rate (KBytes/sec)	6000	5000 synch. 2500 asynch.	2500	10000	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	4Q92	3Q91	4Q90	4Q93	4Q93
COMMENTS	25.4 mm high *Varies by zone	41.3 mm high	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	DAEYOUNG
DRIVE	CFP-1060S/D CFP-1060W/E FilePro Performance	CP-31370 FilePro	CP-31374 FilePro	CFP-2120S/D CFP-2120W/E FilePro Performance	DX-3120A
DISK/TREND GROUP	8	8	8	9	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	Thin Film, MIG	Thin Film	Thin Film	Thin Film, MIG	Ferrite
Interface	SCSI-2	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,062.44	U: 1,600 F: 1,371.8	U: 1,600 F: 1,371.8	F: 2,124.88	F: 120
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	8	14	14	16	4
Heads per data surface	1	1	1	1	1
Tracks per surface	2757	2386	2386	2757	940
Track density (TPI)	3147	2694	2694	3147	1167
Maximum linear density (BPI) (FCI)	65131 48848	54478 40961	54478 40961	64980 48848	39900 29925
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 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, Stepping Motor
Servo type	Embedded	Embedded	Embedded	Embedded	
Average positioning time (msec)	9.0 RD/9.5 WR	10	10	9.5 RD/10.5 WR	19
Average rotational delay (msec)	5.6	5.56	5.56	5.6	8.3
Average access time (msec)	14.6 RD/15.1 WR	15.56	15.56	15.1 RD/16.1 WR	27.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	10000 synch.	6000	20000 synch.	2500
FIRST CUSTOMER SHIPMENT	4Q93	1Q93	1Q93	4Q93	4/93
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	25.4 mm high *Varies by zone

MANUFACTURER	DIGIREDE	DIGIREDE	DIGIREDE	DIGIREDE	DIGIREDE
DRIVE	W525/85	W525/140	W525/190	W525R/125	W525R/240
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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.3	U: 140.2	U: 191.2	U: 128	U: 240
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 15,624	U: 15,624
Data surfaces per spindle	9	11	15	8	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1224	1224	1024	1024
Track density (TPI)	1022	1022	1022	1070	1070
Maximum linear density (BPI) (FCI)	11555	11555	11555	14901 9934	14901 9934
Recording code	MFM	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	28	30	30	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	38.3	38.3	36.3	36.3
Data transfer rate (KBytes/sec)	625	625	625	937.5	937.5
FIRST CUSTOMER SHIPMENT	1987	1987	1987	1989	1989
COMMENTS				For use with RLL controller	For use with RLL controller

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	RF31T	RZ25	DSP3053L	DSP3085	RA71
DISK/TREND GROUP	6	6	7	7	7
MARKET	Captive	Captive	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	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	MIG	MIG
Interface	DSSI	SCSI-2	SCSI-2	SCSI-2	DEC, SDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 508 F: 381	F: 426	F: 535	U: 1,119 F: 852	F: 700
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,184	*	*	F: 29,184	F: 26,112
Data surfaces per spindle	14	9	4	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	933	1474	3100	2086	1915
Track density (TPI)	2650	1760	3218	2650	1928
Maximum linear density (BPI) (FCI)	48256 36192	38000 28500	60431 45323	48256 36192	30469 22851
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4412	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)	6.9	14	9.5	9.5	12.5
Average rotational delay (msec)	5.6	6.8	5.6	5.6	8.3
Average access time (msec)	12.5	20.8	15.1	15.1	20.8
Data transfer rate (KBytes/sec)	4000	5000 synch. 2500 asynch.	20000 synch.** 10000 asynch.**	10000 synch. 5000 asynch.	2000
FIRST CUSTOMER SHIPMENT	7/92	9/90	3Q93	11/91	10/91
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone **16 bit	41.3 mm high	

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	RF35	RZ25L	DSP3105	DSP3107L	DSP3133L
DISK/TREND GROUP	7	7	8	8	8
MARKET	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	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	Thin Film	Thin Film
Interface	DEC, DSSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 852	F: 535	U: 1,342 F: 1,050	F: 1,070	F: 1,337.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,184	*	F: 29,184	*	*
Data surfaces per spindle	14	7	14	8	10
Heads per data surface	1	1	1	1	1
Tracks per surface	2086	1072	2570	3100	3100
Track density (TPI)	2650	2150	2756	3218	3218
Maximum linear density (BPI) (FCI)	48256 36192	49000 36750	56000 42000	60431 45323	60431 45323
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	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.5	10.5	9.5	9.5	9.5
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	15.1	16.1	15.1	15.1	15.1
Data transfer rate (KBytes/sec)	4000 synch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	20000 synch.** 10000 asynch.**	20000 synch.** 10000 asynch.**
FIRST CUSTOMER SHIPMENT	2/92	7/93	3/92	3Q93	3Q93
COMMENTS	41.3 mm high	25.4 mm high *Varies by zone	41.3 mm high	25.4 mm high *Varies by zone **16 bit	25.4 mm high *Varies by zone **16 bit

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	DSP3160	RA72	RF36	RF72	RZ26
DISK/TREND GROUP	8	8	8	8	8
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	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	Thin Film	MIG	Thin Film
Interface	SCSI-2	DEC, SDI	DSSI	DEC, DSSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,045 F: 1,600	F: 1,000	F: 1,600	U: 1,370 F: 1,000	U: 1,342 F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 26,112	*	F: 25,600	F: 29,184
Data surfaces per spindle	16	20	16	21	14
Heads per data surface	1	1	1	1	1
Tracks per surface	2599	1915	2651	1861	2570
Track density (TPI)	2756	1928	2756	1875	2756
Maximum linear density (BPI) (FCI)	54000 40500	30469 22851	54100 40575	30064 22548	55530 41647
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	3600	5400	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	12.5	9.5	13.3	9.5
Average rotational delay (msec)	5.6	8.3	5.6	8.9	5.6
Average access time (msec)	15.6	20.8	15.1	22.2	15.1
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	2000	4000	4000 synch.	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	3/93	10/91	5/93	11/90	7/92
COMMENTS	41.3 mm high *Varies by zone		41.3 mm high *Varies by zone	"Hispeed" mode with 10.3 msec. average seek	41.3 mm high

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	DSP3210	DSP5200	DSP5300	DSP5350	DSP5400
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	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,103	U: 2,600 F: 2,000	F: 3,000	U: 4,300 F: 3,500	F: 4,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 36,352	*	*	*
Data surfaces per spindle	16	21	20	25	26
Heads per data surface	1	1	1	1	1
Tracks per surface	3042	2620	3035	3035	3035
Track density (TPI)	3218	2432	2756	2756	2756
Maximum linear density (BPI) (FCI)	60431 45323	43880 32910		44000 33000	50500 37875
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	3600	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	12	11.5	11.5	11.5
Average rotational delay (msec)	5.6	8.3	5.6	5.6	5.6
Average access time (msec)	15.6	20.3	17.1	17.1	17.1
Data transfer rate (KBytes/sec)	20000 synch.** 10000 asynch.**	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.
FIRST CUSTOMER SHIPMENT	2Q93	4Q91	8/93	1Q93	8/93
COMMENTS	41.3 mm high *Varies by zone **16 bit		*Varies by zone	*Varies by zone	

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	RA73	RF73	RF74	RZ28	RZ73
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SDI	DSSI	DSSI	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,600 F: 2,000	U: 2,600 F: 2,000	F: 3,570	F: 2,103	U: 2,600 F: 2,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 35,840	F: 36,352	*	*	F: 36,352
Data surfaces per spindle	21	21	25	16	21
Heads per data surface	1	1	1	1	1
Tracks per surface	2667	2631	3035	3042	2631
Track density (TPI)	2468	2432	2756	3318	2432
Maximum linear density (BPI) (FCI)	45000 33750	43880 32910	43380 32535	60431 45323	43880 32910
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	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	12.5	12	9.5	12.5
Average rotational delay (msec)	8.3	8.3	5.6	5.6	8.3
Average access time (msec)	20.8	20.8	17.6	15.1	20.8
Data transfer rate (KBytes/sec)	2800	4000	4000	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	8/92	11/91	5/93	7/93	9/92
COMMENTS			*Varies by zone	41.3 mm high *Varies by zone	

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DMA TECHNOLOGIES	ELEBRA	EZI	EZI
DRIVE	RZ74	360	W570-ST	4410	4420
DISK/TREND GROUP	9	1	3	6	6
MARKET	Captive	OEM	OEM, PCM	OEM	OEM
MEDIA: Generic type	Fixed	5.25" Cartridge	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	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI-2	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,570	--	U: 77.26*	U: 382.55	F: 334.54
REMOVABLE	--	U: 12.75	--	--	--
Capacity per track (Bytes)	*	U: 10,416	U: 15,624*	U: 31,616	F: 27,648
Data surfaces per spindle	25	2	5	11	11
Heads per data surface	1	1	1	1	1
Tracks per surface	3035	612	989	1100	1100
Track density (TPI)	2756	612	960	1207	1207
Maximum linear density (BPI)	43380	10894	14100	29607	29607
(FCI)	32535		9400	19736	19736
Recording code	1,7 RLL	MFM	2,7 RLL/MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	3473	3600	3558	3558
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	98 (including settling)	28	16.5	16.5
Average rotational delay (msec)	5.6	8.6	8.3	8.43	8.43
Average access time (msec)	17.6	106.6	36.3	24.93	24.93
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	625	937.5*	1875	4000 synch. 2000 asynch.
FIRST CUSTOMER SHIPMENT	5/93	5/84	2Q91	1991	1991
COMMENTS	*Varies by zone	41.3 mm high	41.3 mm high *With RLL controller	Previously manufactured by Siemens	Previously manufactured by Siemens

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK314S-45R	FK316A-45R	FK202A-60R	FK202A-80R	FK202S-80R
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	95 mm OD 25 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	MIG	MIG	MIG	MIG	MIG
Interface	SCSI	PC AT	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 45.12	F: 44.6	F: 63.7	F: 84.9	F: 84.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F:	F:	F:	F:
Data surfaces per spindle	2	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1106	1116	759	1012	1012
Track density (TPI)	1440	1752	1881	1881	1881
Maximum linear density (BPI) (FCI)	33500 25125	31800 23850	40400 30300	48500 36375	48500 36375
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3540	3540	3450	3450	3450
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	25	19	19	19	19
Average rotational delay (msec)	8.47	8.47	8.7	8.7	8.7
Average access time (msec)	33.47	27.47	27.7	27.7	27.7
Data transfer rate (KBytes/sec)					
FIRST CUSTOMER SHIPMENT	1991	1991	1991	1991	1991
COMMENTS	25.4 mm high	25.4 mm high	19.05 mm high	19.05 mm high	19.05 mm high

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK314S-90R	FK205A-105Z	FK316A-105R	FK317S-210R	FK317S-240R
DISK/TREND GROUP	3	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	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	MIG	MIG	MIG
Interface	SCSI	PC AT	PC AT	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 91.0	F: 105	F: 105.0	F: 210.1	F: 249.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,400	*	F:	F:	F:
Data surfaces per spindle	4	4	4	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1113	1073	1315	1319	1510
Track density (TPI)	1440	1881	1752	1880	1880
Maximum linear density (BPI) (FCI)	33500 25125	55000 41250	31800 23850	44400 33300	49500 37125
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3540	3500	3540	4020	4020
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	25	16	19	16	16
Average rotational delay (msec)	8.5	8.57	8.47	7.46	7.46
Average access time (msec)	33.5	24.57	27.47	23.46	23.46
Data transfer rate (KBytes/sec)	1500				
FIRST CUSTOMER SHIPMENT	4Q90	1991	1991	1991	1991
COMMENTS	25.4 mm high	19.05 mm high *Varies by zone	25.4 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2225D2	M2226D2	M2227D2	M2611S/SA/SB	M2611T
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	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.62	U: 38.43	U: 51.24	F: 45.07	F: 45.07
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	F: 17,408	F: 16,896
Data surfaces per spindle	4	6	8	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	1334	1334
Track density (TPI)	834	834	834	1681	1681
Maximum linear density (BPI) (FCI)	14845	14845	14845	29571 22178	29571 22178
Recording code	MFM	MFM	MFM	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3490	3490
PERFORMANCE					
Actuator type	Rotary, Encoder Motor	Rotary, Encoder Motor	Rotary, Encoder Motor	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Open Loop	Embedded	Embedded
Average positioning time (msec)	35	35	35	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.6	8.6
Average access time (msec)	43.3	43.3	43.3	33.6	33.6
Data transfer rate (KBytes/sec)	625	625	625	2500 synch. 1500 asynch.	7400 max.
FIRST CUSTOMER SHIPMENT	2Q87	1Q87	1Q87	4Q88	3Q89
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2631S	M2631T	M2612ES/ESA/ESB M2612S/SA/SB	M2612ET/T	M2633S
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	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	Ferrite	Ferrite	MIG
Interface	SCSI-2	PC AT	SCSI	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 58 F: 45	U: 58 F: 45	F: 90.84	F: 90.15	U: 116 F: 90
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 17,408	F: 16,896	*
Data surfaces per spindle	2	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	916	916	1334	1334	916
Track density (TPI)	2000	2000	1681	1681	2000
Maximum linear density (BPI) (FCI)	42500 31875	42500 31875	29571 22178	29571 22178	42500 31875
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3609	3609	3490	3490	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	18	20/25*	20/25	18
Average rotational delay (msec)	8.3	8.3	8.6	8.6	8.3
Average access time (msec)	26.3	26.3	28.6/33.6*	28.6/33.6	26.3
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.	6300 max.	2500 synch. 1500 asynch.	7400 max.	5000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	2Q92	2Q92	4Q88	3Q89	2Q92
COMMENTS	17 mm high *Varies by zone	17 mm high *Varies by zone	41.3 mm high *ESA/S/SA/SB	41.3 mm high	17 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2633T	M2613ES/ESA/ESB M2613S/SA/SB	M2613ET/T	M2614ES/ESA/ESB M2614S/SA/SB	M2614ET/T
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	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	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 116 F: 90	F: 136.6	F: 135.23	F: 182.36	F: 180.31
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 17,408	F: 16,896	F: 17,408	F: 16,896
Data surfaces per spindle	4	6	6	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	916	1334	1334	1334	1334
Track density (TPI)	2000	1681	1681	1681	1681
Maximum linear density (BPI) (FCI)	42500 31875	29571 22178	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)	3609	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)	18	20/25*	20/25	20/25*	20/25
Average rotational delay (msec)	8.3	8.6	8.6	8.6	8.6
Average access time (msec)	26.3	28.6/33.6*	28.6/33.6	28.6/33.6*	28.6/33.6
Data transfer rate (KBytes/sec)	6300 max.	2500 synch. 1500 asynch.	7400 max.	2500 synch. 1500 asynch.	7400 max.
FIRST CUSTOMER SHIPMENT	2Q92	4Q88	3Q89	4Q88	3Q89
COMMENTS	17 mm high *Varies by zone	41.3 mm high *ESA/S/SA/SB	41.3 mm high	41.3 mm high *ESA/S/SA/SB	41.3 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2616ES/ESA/ESB M2616SA	M2616ET/T	M2617T	M2635S	M2635T
DISK/TREND GROUP	4	4	4	4	4
MARKET	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	Ferrite	Ferrite	MIG	Thin Film	Thin Film
Interface	SCSI	PC AT	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105	F: 105	F: 105	F: 160	F: 160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 16,896	*	*	*
Data surfaces per spindle	4	4	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1542	1542	2010	1574	1574
Track density (TPI)	1681	1681	2267	2600	2600
Maximum linear density (BPI) (FCI)	32069 24052	32069 24052	39297 29457	57000 42750	57000 42750
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	3490	3490	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	20	20	16	14.5	14.5
Average rotational delay (msec)	8.6	8.6	8.6	6.7	6.7
Average access time (msec)	28.6	28.6	24.6	21.2	21.2
Data transfer rate (KBytes/sec)	2500 synch. 1500 asynch.	7400 max.	6300	10000 synch. 5000 asynch.	8000
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	7/92	2Q93	2Q93
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high *Varies by zone	17 mm high *Varies by zone	17 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2636S	M2636T	M2248E	M2248S/SA/SB	M2618T
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	65 mm OD 20 mm ID	65 mm OD 20 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	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	MIG
Interface	SCSI-2	PC AT	ESDI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 200	F: 200	U: 285.3	F: 244.6	F: 210
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	U: 20,864	F: 16,640	*
Data surfaces per spindle	5	5	11	11	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1574	1574	1243	1243	2010
Track density (TPI)	2600	2600	1267	1267	2267
Maximum linear density (BPI) (FCI)	57000 42750	57000 42750	19295 14471	19295 14471	39297 29457
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	3600	3600	3490
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	14.5	14.5	18	18	16
Average rotational delay (msec)	6.7	6.7	8.3	8.3	8.6
Average access time (msec)	21.2	21.2	26.3	26.3	24.6
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	8000	1250	2500 synch. 1500 asynch.	6300
FIRST CUSTOMER SHIPMENT	1Q93	1Q93	3Q87	1Q88	7/92
COMMENTS	17 mm high *Varies by zone	17 mm high *Varies by zone			25.4 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2637S	M2637T	M2249E	M2249S/SA/SB	M2261E
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	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	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	PC AT	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 240	F: 240	U: 389	F: 333.6	U: 415.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	U: 20,864	F: 16,640	U: 31,296
Data surfaces per spindle	6	6	15	15	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1574	1574	1243	1243	1658
Track density (TPI)	2600	2600	1267	1267	1712
Maximum linear density (BPI) (FCI)	57000 42750	57000 42750	19295 14471	19295 14471	28816 21612
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	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)	14.5	14.5	18	18	16
Average rotational delay (msec)	6.7	6.7	8.3	8.3	8.3
Average access time (msec)	21.2	21.2	26.3	26.3	24.3
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	8000	1250	2500 synch. 1500 asynch.	1875
FIRST CUSTOMER SHIPMENT	2Q93	1Q93	3Q87	1Q88	2Q88
COMMENTS	17 mm high *Varies by zone	17 mm high *Varies by zone			

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2261H/HA/HB M2261S/SA/SB	M2262E	M2262H/HA/HB M2262S/SA/SB	M2343K/KS	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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	Ferrite	MIG	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	Modified SMD	Mod. SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 357.1	U: 570.8	F: 492	U: 383.38	U: 555.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	U: 31,296	F: 27,136	U: 40,960	U: 49,728
Data surfaces per spindle	8	11	11	7.5	7.5
Heads per data surface	1	1	1	2/1	2/1
Tracks per surface	1658	1658	1658	1248	1490
Track density (TPI)	1712	1712	1712	846	1193
Maximum linear density (BPI) (FCI)	28816 21612	28816 21612	28816 21612	20767 13844	25211 18908
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	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	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	4000 synch. 1750 asynch.	1875	4000 synch. 1750 asynch.	2458	3000
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	2Q88	4Q87	1Q88
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2622F/FA/FB M2622H/HA/HB	M2622S/SA/SB	M2622T	M2623F/FA/FB M2623H/HA/HB	M2623S/SA/SB
DISK/TREND GROUP	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	MIG
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	14	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)	3074-18444	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	M2690ESA	M2691EH/EHA/EHB M2691ES/ESA/ESB	M2691H/HA/HB M2691S/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: 560	F: 648.4	F: 648.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	11	11	8	9	9
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	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	12	8	10	10
Average rotational delay (msec)	6.8	6.8	5.6	5.6	6.8
Average access time (msec)	18.8	18.8	13.6	15.6	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	1/93	11/92	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	M2692EH/EHA/EHB M2692ES/ESA/ESB	M2692H/HA/HB M2692S/SA/SB	M2693EH/EHA/EHB M2693ES/ESA/ESB	M2693H/HA/HB M2693S/SA/SB	F6425H
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.5" OD 4.0" ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Sputtered
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 793.6	F: 793.6	F: 938.7	F: 938.7	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	F: 47,476
Data surfaces per spindle	11	11	13	13	16
Heads per data surface	1	1	1	1	2
Tracks per surface	1819	1819	1819	1819	2654
Track density (TPI)	2208	2208	2208	2208	1370
Maximum linear density (BPI) (FCI)	48724 36543	48724 36543	48724 36543	48724 36543	24440 18330
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4400	4400	4400	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)	10	10	10	10	16
Average rotational delay (msec)	5.6	6.8	5.6	6.8	8.3
Average access time (msec)	15.6	16.8	15.6	16.8	24.3
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	3000
FIRST CUSTOMER SHIPMENT	11/92	5/92	11/92	5/92	12/88
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	Drive has 4 spindles

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6425M4/N4	F6427H	M2266H/HA/HB M2266S/SA/SB	M2392D	M2392K
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Sputtered	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Fujitsu	Fujitsu	SCSI	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	F: 1,890	F: 1,079.1	U: 1,842	U: 2,027
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 43,520	U: 45,792	U: 50,400
Data surfaces per spindle	12	15	15	21	21
Heads per data surface	2	1	1	1	1
Tracks per surface	2360	2655	1658	1916	1916
Track density (TPI)	1160	2080	1634	1456	1456
Maximum linear density (BPI) (FCI)	24425 16283	33310 24980	46635 34976	22764 17073	25055 18791
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3620	4340	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)	17	12	14.5	12	12
Average rotational delay (msec)	8.3	6.9	8.3	8.3	8.3
Average access time (msec)	25.3	18.9	22.8	20.3	20.3
Data transfer rate (KBytes/sec)	3000	4500	4800 synch. 2000 asynch.	2750	3000
FIRST CUSTOMER SHIPMENT	3Q86	12/90	2Q90	1Q90	1Q90
COMMENTS	Drive has 4 spindles	Drive has maximum 16 spindles			

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2651H/HA/HB M2651S/SA/SB	M2652H/HA/HB M2652HD/HDA/HDB M2652S/SA/SB	M2652P	M2694EH/EHA/EHB M2694ES/ESA/ESB	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	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	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IPI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,313	F: 1,752	U: 2,001	F: 1,083.9	F: 1,083.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 45,056	F: 45,056	U: 52,864	*	*
Data surfaces per spindle	15	20	20	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1944	1944	1893	1819	1818
Track density (TPI)	1840	1840	1780	2208	2208
Maximum linear density (BPI) (FCI)	50257 37692	50257 37692	50257 37692	48724 36543	48724 36543
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	4400	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	11	11	10	10
Average rotational delay (msec)	5.56	5.56	5.56	5.6	6.8
Average access time (msec)	16.56	16.56	16.56	15.6	16.8
Data transfer rate (KBytes/sec)	10000 synch. 3000 asynch.	10000 synch. 3000 asynch.	4758	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	2Q91	2Q91	2Q91	11/92	10/92
COMMENTS				41.3 mm high *Varies by zone	41.3 mm high *Varies by zone

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	GIGASTORAGE TECHNOLOGY	GIGASTORAGE TECHNOLOGY
DRIVE	F6427K	M2654H/HA/HB M2654S/SA/SB	M2671P	PHOENIX 1.2	PHOENIX 2.5
DISK/TREND GROUP	9	9	9	8	9
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	130 mm OD 40 ID	130 mm OD 40 ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	Fujitsu	SCSI-2	IPI-2	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,835	F: 2,055	U: 2,648	F: 1,200.5	F: 2,505.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 45,056	U: 66,096	*	*
Data surfaces per spindle	15	21	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	4007	2179	2671	1927	2993
Track density (TPI)	2820	1953	2080	1700	2400
Maximum linear density (BPI) (FCI)	33310 24982	50871 38153	33310 24983	40622 30466	42666 32000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4340	5400	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)	13	12	12	14	14
Average rotational delay (msec)	6.9	5.56	6.91	8.3	8.3
Average access time (msec)	19.9	17.56	18.91	22.3	22.3
Data transfer rate (KBytes/sec)	4758	10000 synch. 4000 asynch.	4781	4000 synch. 2000 asynch.	10000 synch.
FIRST CUSTOMER SHIPMENT	7/92	7/92	2Q90	5/93	10/93
COMMENTS	Drive has maximum of 16 spindles			*Varies by zone	*Varies by zone

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C3013A KITTYHAWK	C3014A KITTYHAWK II	97548D 97548S	C2244	97560-0pt050
DISK/TREND GROUP	2	2	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	34 mm OD 8 mm ID	34 mm OD 8 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film*	Thin Film*	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	PC AT, PCMCIA	PC AT, PCMCIA	SCSI	SCSI-2	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 35.4 F: 21.4	U: 54.0 F: 42.8	F: 664	F: 566	U: 1,605
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	**	**	F: 28,672	*	U: 43,056
Data surfaces per spindle	3	4	16	7	19
Heads per data surface	1	1	1	1	1
Tracks per surface			1447	1918	1962
Track density (TPI)	2400	2700	1667	2304	1865
Maximum linear density (BPI)	56000	68600	30552	49987	42000
(FCI)	42000	51540	20368	33325	28000
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	4002	5400	4002
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	16.5	10.5	13.5
Average rotational delay (msec)	5.56	5.56	7.5	5.56	7.5
Average access time (msec)	23.56	23.56	24	16.06	21
Data transfer rate (KBytes/sec)	900	1500	4000 synch. 1500 asynch.	20000 synch. 2500-5000 asyn.	2875
FIRST CUSTOMER SHIPMENT	3Q92	1Q93	4Q88	1Q92	5/90
COMMENTS	10.5 mm high *Glass disk **Varies by zone	10.5 mm high *Glass disk **Varies by zone		41.3 mm high *Varies by zone	

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97560-0pt001, 002	C2247	C2482A	C3007	C3009
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	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-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,355	F: 1,052	F: 1,355	U: 1,692 F: 1,370	U: 2,213 F: 1,792
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 36,864	*	F: 36,864	*	*
Data surfaces per spindle	19	13	19	13	17
Heads per data surface	1	1	1	1	1
Tracks per surface	1935	1918	1935	2255	2255
Track density (TPI)	1865	2304	1865	2000	2000
Maximum linear density (BPI) (FCI)	42000 28000	49987 33325	42000 28000	46666 35000	46666 35000
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4002	5400	4002	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	10.5	13.5	9	11.5
Average rotational delay (msec)	7.5	5.56	7.5	5.56	5.56
Average access time (msec)	21	16.06	21	14.56	17.06
Data transfer rate (KBytes/sec)	5000 synch. 1500 asynch.	20000 synch. 5000 asynch.	5000 synch. 1500 asynch.	20000 synch. 5000 asynch.	20000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	5/90	1Q92	7/91	1Q92	1Q92
COMMENTS		41.3 mm high *Varies by zone		*Varies by zone	*Varies by zone

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C3010-Opt100	C3032T	C3036T	C3037U	C3323A
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	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	Thin Film	Thin Film	Thin Film	MIG	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,207 F: 1,052	U: 1,207 F: 1,027	U: 1,207 F: 1,027	F: 1,052	F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 49,152	F: 49,152	F: 49,152	*	*
Data surfaces per spindle	19	19	19	13	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1100	1100	1100	1918	2898
Track density (TPI)	2000	2000	2000	2304	3223
Maximum linear density (BPI) (FCI)	46666 35000	46666 35000	46666 35000	49987 33325	69200 51900
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 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)	11.5	9	9	10.5	9.5 RD/10.5 WR
Average rotational delay (msec)	5.56	5.56	5.56	5.56	5.56
Average access time (msec)	17.06	14.56	14.56	16.06	15.06/16.06
Data transfer rate (KBytes/sec)	20000 synch. 5000 asynch.	20000 synch.	20000 synch.	20000 synch. 5000 asynch.	20000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	1Q92			4Q92	4Q93
COMMENTS		Packaged as 1 drive in tower	Packaged as 7 drives in tower	*Varies by zone Expansion kit for C303xT	25.4 mm high *Varies by zone

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C3601A C3611A	C2490A	C3010	C3021T/R	C3023T/R
DISK/TREND GROUP	8	9	9	9	9
MARKET	PCM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	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: 1,050	F: 2,100	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
Data surfaces per spindle	13	18	19	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	1984	2465	2255	2255	2255
Track density (TPI)	2250	2735	2000	2000	2000
Maximum linear density (BPI) (FCI)	52000 39000	59000 44250	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	6400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10.5	8.9	11.5	11.5	11.5
Average rotational delay (msec)	5.6	4.9	5.56	5.56	5.56
Average access time (msec)	16.1	13.8	17.06	14.56	14.56
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	20000 synch. 5000 asynch.	20000 synch. 5000 asynch.	10000 synch.	10000 synch.
FIRST CUSTOMER SHIPMENT	4Q93	2Q93	1Q92	3Q92	3Q92
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	*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	HEWLETT-PACKARD
DRIVE	C3024T/R	C3028U	C3033T	C3034T	C3038U
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	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: 2,473 F: 2,003	U: 2,473 F: 2,003	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	F: 49,152
Data surfaces per spindle	19	19	19	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	2255	2255	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)	11.5	11.5	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	14.56	14.56	14.56
Data transfer rate (KBytes/sec)	10000 synch.	10000 synch.	20000 synch.	20000 synch.	20000 synch.
FIRST CUSTOMER SHIPMENT	3Q92	3Q92		4Q92	4Q92
COMMENTS	Packaged as 2 drives in either tower or rack mount	Expansion kit for C302xT/R	Packaged as 1 drive in tower	Packaged as 2 drives in tower	Expansion kit for C303xT

MANUFACTURER	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	C3602A C3612A	DK522-10	DK522C-10	DK512-17	DK512C-17
DISK/TREND GROUP	9	3	3	4	4
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,100	U: 103.4	F: 87.5	U: 172.3	F: 146.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	U: 20,944	F: 17,920	U: 20,944	F: 17,920
Data surfaces per spindle	17	6	6	10	10
Heads per data surface	1	1	1	1	1
Tracks per surface	2531	823	819	823	819
Track density (TPI)		960	960	925	925
Maximum linear density (BPI) (FCI)		18500 12333	18500 12333	18500 12333	18500 12333
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	6400	3600	3600	3482	3482
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)	8.9	25	25	23	23
Average rotational delay (msec)	4.69	8.3	8.3	8.6	8.6
Average access time (msec)	13.59	33.3	33.3	31.6	31.6
Data transfer rate (KBytes/sec)	10000 synch. 2500 asynch.	1250	1500 max.	1209	1500 max.
FIRST CUSTOMER SHIPMENT	4Q93	12/86	1/87	3/85	1/87
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high		

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK512S-17	DK524-20	DK524C-20	DK312C-20	DK312C-25
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	MIG	MIG
Interface	SMD	ESDI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 172.3	U: 200.5	F: 168.9	F: 209	F: 251
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,944	U:	F:	F: 19,456	F: 19,456
Data surfaces per spindle	10			10	12
Heads per data surface	1	1	1	1	1
Tracks per surface	823	1105	1105	1076	1076
Track density (TPI)	925	1100	1100	1660	1660
Maximum linear density (BPI) (FCI)	18500 12333	29800 19866	29800 19866	38800 25866	38800 25866
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3482	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	23	25	25	16.8*	16.8*
Average rotational delay (msec)	8.6	8.3	8.3	8.3	8.3
Average access time (msec)	31.6	33.3	33.3	25.1	25.1
Data transfer rate (KBytes/sec)	1215	1814	4000	4000 synch. 1500 asynch.	4000 synch. 1500 asynch.
FIRST CUSTOMER SHIPMENT	3/85	3Q88	4Q88	3Q89	3Q89
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.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK324C-21A	DK314C-41	DK514-38	DK514C-38	DK514S-38
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	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	MIG	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ESDI	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 215.0	F: 418.9	U: 382.3	F: 321.8	U: 382.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,624	F: 25,600	U: 30,240	F: 25,600	U: 30,240
Data surfaces per spindle	6	14	14	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1346	1169	903	898	903
Track density (TPI)	2117	1803	1033	1033	1033
Maximum linear density (BPI) (FCI)	43000 32250	44222 29466	26000 17333	26000 17333	26000 17333
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	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	17	16.8	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	25.3	25.1	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	4000 synch. 1500 asynch.	4000 synch. 1500 asynch.	1815	4000 synch. 1500 asynch.	1815
FIRST CUSTOMER SHIPMENT	8/91	2Q91	3Q87	1Q88	3Q87
COMMENTS	25.4 mm high	41.3 mm high			

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK815-5	DK325C-57	DK515-78	DK515C-78 DK515C-78D	DK515S-78D DK515S-78S
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	224 mm OD 100 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	MIG	MIG	MIG
Interface	Modified SMD	SCSI-2	ESDI	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 525.38	F: 573	U: 780	F: 660.9	U: 780
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	*	U: 40,960	F: 34,816	U: 40,960
Data surfaces per spindle	14	6	14	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1241	2458	1361	1356	1391
Track density (TPI)	860	2800	1296	1296	1296
Maximum linear density (BPI) (FCI)	14585 9723	52200 39150	40210 26806	40210 26806	40210 26806
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	4500	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	12.4	16	16	16
Average rotational delay (msec)	8.3	6.7	8.3	8.3	8.3
Average access time (msec)	26.3	19.1	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1815	5000 synch. 2500 asynch.	2458	4000 synch. 1500 asynch.	2458
FIRST CUSTOMER SHIPMENT	11/84	3Q92	4Q88	4Q88	2Q89
COMMENTS		25.4 mm high *Varies by zone			

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK711S-60D DK711S-60S	DK815-10A	DKU-861-J14 DKU-861-J24 H-6586-J14 H-6586-J24	DKU-871-114 DKU-871-124 H-6587-114 H-6587-124	H-6555
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive, OEM	OEM	Captive,OEM,PCM	Captive,OEM,PCM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	224 mm OD 100 mm ID	9.5"	9.5"	224 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	High Dens Oxide
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	Modified SMD	Modified SMD	IBM, Hitachi	IBM, Hitachi	Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 600	U: 1,067	F: 630	F: 946	F: 500
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 40,960	F: 47,476	F: 56,664	F: 28,884
Data surfaces per spindle	22	15	15	15	14
Heads per data surface	1	1	1	2	1
Tracks per surface	903	1737	885	1113	1237
Track density (TPI)	1033	1220			860
Maximum linear density (BPI) (FCI)	26000 17333	19560 14670			14585 9723
Recording code	2,7 RLL	1,7 RLL		1,7 RLL	2,7 RLL
Rotational speed (RPM)	4876	3600	3600	4260	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	13	11	8.5	18
Average rotational delay (msec)	6.15	8.3	8.3	7.1	8.3
Average access time (msec)	18.15	21.3	19.3	15.6	26.3
Data transfer rate (KBytes/sec)	2458	2460	3000	4200	1815
FIRST CUSTOMER SHIPMENT	4Q87	4Q87	3Q88	9/90	1Q85
COMMENTS	Oversized packaging		Drive has 8 spindles	-114: max. 8 HDAs -124: max. 12 HDAs Also compatible mode to H-6586J	Drive has 1 to 4 spindles

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK315C-10	DK315C-11	DK315C-14	DK516-12	DK516-15
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	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	SCSI-2	SCSI-2	SCSI-2	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,054	F: 1,100	F: 1,400	U: 1,229	U: 1,538
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 30,200	*	U: 45,880	U: 45,880
Data surfaces per spindle	11	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2469	2488	2464	1787	2235
Track density (TPI)	2800	2800	2800	1512	2000
Maximum linear density (BPI) (FCI)	52300 39225	54000 40500	52300 39225	46375 34780	44060 33045
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	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)	11.8	10.4	11.8	14	14
Average rotational delay (msec)	6.7	6.7	6.7	8.3	8.3
Average access time (msec)	18.5	17.1	18.5	22.3	22.3
Data transfer rate (KBytes/sec)	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.	2750	2753
FIRST CUSTOMER SHIPMENT	3Q92	2Q92	3Q92	3Q90	1Q91
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high *Varies by zone		

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK516C-16	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
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	14"	9.5"	9.5"	9.5"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI	IBM, Hitachi	IBM, Hitachi	IBM, Hitachi	IBM, Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,342	F: 1,260	F: 1,260	F: 1,890	F: 1,892
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 41,472	F: 47,476	F: 47,476	F: 47,476	F: 56,664
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	2	1	2	2
Tracks per surface	2172	1770	1770 (Physical)	2655	2226
Track density (TPI)	1954	910			
Maximum linear density (BPI) (FCI)	48525 36393	15200			
Recording code	1,7 RLL				1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	4260
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13.5	17	13	12.5	10.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.1
Average access time (msec)	21.8	25.3	21.3	20.8	17.6
Data transfer rate (KBytes/sec)	5000 synch. 2000 asynch.	3000	3000	3000	4200
FIRST CUSTOMER SHIPMENT	3Q90	12/85	3Q88	3Q88	9/90
COMMENTS		Drive has 4 spindles	Drive has 8 spindles	Drive has 8 spindles	-214: max. 8 HDAs -224: max. 12 HDAs

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	H-6556-1	DK517C-26	DK517C-37	H-6587-314 H-6587-324	H-6588-314
DISK/TREND GROUP	8	9	9	9	9
MARKET	Captive	OEM	OEM	Captive	Captive
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"	6.5"
Recording medium	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Hitachi	SCSI-2	SCSI-2	Hitachi, IBM	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: 2,920
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	1
Tracks per surface	1770 (Physical)	3307	3307	3436	3436
Track density (TPI)		2800	2800	1930	2520
Maximum linear density (BPI) (FCI)		54000 40500	54000 40500	29100 21825	47300 35475
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	13.5
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	20.6
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	6/93
COMMENTS	Drive has 4 spindles			-314: max. 8 HDAs -324: max. 12 HDAs Also compatible mode to H-6586K	Available with 4 to 32 HDAs

MANUFACTURER	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS	IBM
DRIVE	7390-1	7390-2	7390-F	7390-3	H2171 Wakasa
DISK/TREND GROUP	7	8	8	9	4
MARKET	PCM	PCM	PCM	PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	9.5"	9.5"	9.5"	65 mm OD 20 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	IBM	IBM	IBM	IBM	SCSI, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 946	F: 1,892	F: 1,890/1,892	F: 2,838	F: 172
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 56,664	F: 47,476/ 56,664	F: 56,664	*
Data surfaces per spindle	15	15	15	15	2
Heads per data surface	2	2	2	2	1
Tracks per surface	1113	2226	2655/2226	3339	2264
Track density (TPI)	1900	1900	1900	1900	4300
Maximum linear density (BPI) (FCI)	29000 21750	29000 21750	29000 21750	29000 21750	74800 56100
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	4260	4260	4260	3800
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	8.5	10	11/10	12.5	14
Average rotational delay (msec)	7.1	7.1	7.1	7.1	7.9
Average access time (msec)	15.6	17.1	18.1/17.1	19.6	21.9
Data transfer rate (KBytes/sec)	4200	4200	4200	4200	4500 synch. 6000 asynch.
FIRST CUSTOMER SHIPMENT	10/90	10/90	1/91	2/92	3Q93
COMMENTS	PCM 3390-1 Drive has 4, 8, or 12 spindles	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	17 mm high *Varies by zone

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	H3171-A2 Tosa	WDS-3100 Kai	H2258 Wakasa	H3256-A3 Tosa	WDS-3200 Kai
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	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
DRIVE: Heads	MIG	MIG		MIG	MIG
Interface	PC AT	SCSI-2	SCSI, PC AT	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 171	F: 104.9	F: 258	F: 256	F: 209.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	2	3	3	4
Heads per data surface	1	1	1	1	1
Tracks per surface	2420	1990	2264	2420	1990
Track density (TPI)	2800	2300	4300	2800	2300
Maximum linear density (BPI) (FCI)	55000 41250	40000	74800 56100	55000 41250	40000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	4320	3800	3600	4320
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	14	12	14	14	12
Average rotational delay (msec)	8.3	6.94	7.9	8.3	6.94
Average access time (msec)	22.3	18.94	21.9	22.3	18.94
Data transfer rate (KBytes/sec)	8300	5000 synch.	4500 synch. 6000 asynch.	8300	5000 synch.
FIRST CUSTOMER SHIPMENT	2Q93	12/91	3Q93	2Q93	12/91
COMMENTS	25.4 mm high *Varies by zone	19.9 mm high *Varies by zone	17 mm high *Varies by zone	25.4 mm high *Varies by zone	19.9 mm high *Varies by zone

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0661-371 Lightning	0661-467 Turbo	9336-10 Redwing	H2344 Wakasa	H3342-A4 Tosa
DISK/TREND GROUP	6	6	6	6	6
MARKET	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	130 mm OD 40 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	MR Thin Film	MIG
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI, PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 371 F: 320.1	U: 467 F: 400	F: 471	F: 344	F: 342
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 24,576	F: 29,696	*	*
Data surfaces per spindle	14	14	11	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	949	1199	1458	2264	2420
Track density (TPI)	1201.5	1469	1677	4300	2800
Maximum linear density (BPI) (FCI)	37341 28006	38427 28820	30320 26951	74800 56100	55000 41250
Recording code	1,7 RLL	1,7 RLL	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4317.8	4316	4986	3800	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	12.5	11.5	11.2	14	14
Average rotational delay (msec)	6.95	6.95	6.02	7.9	8.3
Average access time (msec)	19.45	18.45	17.22	21.9	22.3
Data transfer rate (KBytes/sec)	4000 max.	5000 max.	4000	4500 synch. 6000 asynch.	8300
FIRST CUSTOMER SHIPMENT	8/89	8/90	9/90	3Q93	2Q93
COMMENTS	41.3 mm high	41.3 mm high	AS/400 9406 Disk unit, contains 2-4 disk drives	17 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0662-508 Spitfire	9333-010 9333-500 9333-3100 Redwing	9336-20 Redwing	9337-010 9337-110 9337-210 Corsair	9337-015 9337-115 9337-215 Spitfire
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	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MIG	MIG	MR Thin Film	MR Thin Film
Interface	SCSI-2	IBM Serial	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 625	F: 857	F: 857	F: 542	F: 542
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 29,696	F: 29,696	F: 41,705	*
Data surfaces per spindle	3	20	20	13	5
Heads per data surface	1	1	1	1	1
Tracks per surface	4116	1458	1458	1410	2234
Track density (TPI)	4077	1677	1677	2685	4077
Maximum linear density (BPI) (FCI)	86900 77245	30320 26951	30320 26951	58879 52332	78202
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5400	4986	4986	4316	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8.5 RD/10.0 WR	11.2	11.2	7.4	6.5
Average rotational delay (msec)	5.6	6.02	6.02	6.95	5.6
Average access time (msec)	14.1/15.6	17.22	17.22	14.35	12.1
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	4000	4000	5000 synch. 3000 asynch.	20000 synch. 6000 asynch.
FIRST CUSTOMER SHIPMENT	3Q93	9/92	9/90	3Q92	9/93
COMMENTS	25.4 mm high *Varies by zone	RS/6000 Up to 4 HDAs	AS/400 Disk unit, contains 2-4 disk drives	41.3 mm high	25.4 mm high *Varies by zone

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0615	0662-S12 0662-S1D Spitfire	0662-SW1 0662-SWD Spitfire	0663-E12 Corsair-1	0663-E15 Corsair-2
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	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	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IPI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,639	F: 1,052	F: 1,052	F: 1,044	F: 1,206
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 50,668	*	*	F: 41,705	F: 41,705
Data surfaces per spindle	15	5	5	13	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2157	4116	4116	2469	2469
Track density (TPI)	2403	4077	4077	2685	2685
Maximum linear density (BPI) (FCI)	44663 33497	86900 77245	86900 77245	58874 52332	58874 52332
Recording code	1,7 RLL	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5380	5400	5400	4317	4317
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)	12	8.6 RD/10.1 WR	8.6 RD/10.1 WR	9.4 RD/11.4 WR	9.4 RD/11.4 WR
Average rotational delay (msec)	5.58	5.6	5.6	6.95	6.95
Average access time (msec)	17.58	14.2 RD/15.7 WR	14.2 RD/15.7 WR	16.35/18.35	16.35/18.35
Data transfer rate (KBytes/sec)	4550	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	10000	10000
FIRST CUSTOMER SHIPMENT	5/91	2Q93	2Q93	3Q92	3Q92
COMMENTS	2 HDAs per drawer	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	41.3 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0663-W2H Corsair-2	0664-P1S Allicat P10	3390-A14 3390-A18 3390-B14 3390-B18 3390-B1C	9333-3110 Redwing	9334-011 9334-501 Corsair-1
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.8"	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	MIG	MR Thin Film
Interface	SCSI-2	IPI-2	IBM	IBM Serial-Link	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,206	U: 2,005 F: 1,741	F: 1,892	F: 1,007	F: 1,044
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 41,705	U: 58,024	F: 56,664	F: 29,696	F: 41,705
Data surfaces per spindle	15	15	15	20	13
Heads per data surface	1	1	2	1	1
Tracks per surface	2469	2304	2226	1695	2469
Track density (TPI)	2685	3168	2242	2098	2685
Maximum linear density (BPI) (FCI)	58874 52332	68700	27940 20955	30320 26951	58874 52332
Recording code	PRML	PRML	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4317	5400	4260	4986	4317
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Dual, 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)	9.8	9.4 RD/11 WR	9.5	11.2	9.4 RD/11.4 WR
Average rotational delay (msec)	6.95	5.6	7.1	6.02	6.95
Average access time (msec)	16.75	15 RD/16.6 WR	16.6	17.22	16.35/18.35
Data transfer rate (KBytes/sec)	10000	5220	4200	4000	10000
FIRST CUSTOMER SHIPMENT	4Q92	12/92	12/89	5/92	3Q93
COMMENTS	41.3 mm high 2 1.2 GB drives in 5.25" form factor	41.3 mm high	A14=2 HDAs A18=4 HDAs B14=2 HDAs B18=4 HDAs B1C=6 HDAs	RS/6000 available on 9333-010 or 9333-500 subsystem	RS/6000 Up to 4 HDAs

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9334-2590 Corsair-2	9345-B12	9345-B22	0664-CSH 0664-DSH Allicat S20	0664-ESH 0664-FSH Allicat S20
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	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	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	IBM	IBM	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,200	F: 1,001	F: 1,502	F: 4,027	F: 4,027
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 41,705	F: 46,456	F: 46,456	F: 48,128	F: 48,128
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2469	1438	2156	2870	2870
Track density (TPI)	2685	2403	2403	3168	3168
Maximum linear density (BPI) (FCI)	58874 52332	44663 33497	44663 33497	81913	81913
Recording code	PRML	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4317	5380	5380	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9.4 RD/11.4 WR	10	12	9.3 RD/11 WR	9.3 RD/11 WR
Average rotational delay (msec)	6.95	5.58	5.58	5.6	5.6
Average access time (msec)	16.35/18.35	15.58	17.58	14.9 RD/16.6 WR	14.9 RD/16.6 WR
Data transfer rate (KBytes/sec)	10000 synch.	4400	4400	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.
FIRST CUSTOMER SHIPMENT	10/92	1Q92	1Q92	2Q93	2Q93
COMMENTS	41.3 mm high SCSI expansion unit for RS/6000	2 HDAs per drawer	2 HDAs per drawer	Two 3.5" drives in HH 5.25" package, addressed as single drive	Two 3.5" drives in HH 5.25" package, addressed as single drive

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0664-M1H Allicat S10	0664-N1H Allicat S10	3390-A24 3390-A28 3390-B24 3390-B28 3390-B2C	3390-A34 3390-A38 3390-B34 3390-B38 3390-B3C	3390-A94 3390-A98 3390-B94 3390-B98 3390-B9C
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.8"	10.8"	10.8"
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,490 F: 2,013.7	U: 2,490 F: 2,013.7	F: 3,784	F: 5,676	F: 17,028
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 48,128	F: 48,128	F: 56,664	F: 56,664	F: 169,992
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	2	2	2
Tracks per surface	2870	2870	4452	6678	6678
Track density (TPI)	3168	3168	2242	2984	2984
Maximum linear density (BPI) (FCI)	81913	81913	27940 20955	30008 22506	
Recording code	PRML	PRML	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	5400	5400	4260	4260	1320
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9.2 RD/10.7 WR	9.2 RD/10.7 WR	12.5	15	22.5
Average rotational delay (msec)	5.6	5.6	7.1	7.1	22.8
Average access time (msec)	14.8 RD/16.3 WR	14.8 RD/16.3 WR	19.6	22.18	45.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	4200	4200	3900
FIRST CUSTOMER SHIPMENT	11/92	11/92	12/89	9/91	6/93
COMMENTS	41.3 mm high	41.3 mm high	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 B3C= 6 HDAs	A94= 2 HDAs A98= 4 HDAs B94= 2 HDAs B98= 4 HDAs B9C= 6 HDAs

MANUFACTURER	IBM	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	9333-011 9333-501 Allicat	1841PA Ranger	1842 Stingray	PocketFile 42	1882PA
DISK/TREND GROUP	9	2	2	2	3
MARKET	Captive	OEM	OEM	OEM, PCM	OEM
MEDIA: Generic type	Fixed	Removable Drive	Fixed	Removable Drive	Removable Drive
Nominal disk diameter	95 mm OD 25 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MIG	MIG	MIG	MIG
Interface	IBM Serial-Link	PCMCIA-ATA	IDE	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,013.7	--	F: 42.5	--	--
REMOVABLE	--	F: 42.5	--	F: 42.5	F: 85
Capacity per track (Bytes)	F: 48,128	*	*		*
Data surfaces per spindle	15	2	3	2	3
Heads per data surface	1	1	1	1	1
Tracks per surface	2870	1015	868	1015	1203
Track density (TPI)	3168	2409	2065	2409	2750
Maximum linear density (BPI) (FCI)	81913	58500 43875	48100 36075	58500 43875	71100 53325
Recording code	PRML	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	3571	3571	3571	3571
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.2 RD/10.7 WR	18	18	18	18
Average rotational delay (msec)	5.6	8.4	8.4	8.4	8.4
Average access time (msec)	14.8/16.3	26.4	26.4	26.4	26.4
Data transfer rate (KBytes/sec)	8000	5000	4000	5000	5000
FIRST CUSTOMER SHIPMENT	8/93	4Q92	1Q92	5/93	3Q92
COMMENTS	RS/6000 Up to 4 HDAs	10.5 mm high *Varies by zone Ramp loaded heads PCMCIA Type III	15 mm high *Varies by zone Ramp loaded heads	10.5 mm high *Varies by zone Ramp loaded heads PCMCIA Type III	12.5 mm high *Varies by zone Ramp loaded heads

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	1885 McKinley	PocketFile 85	8105PA Viper	8170PA Viper	PocketFile 105
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	PCM	OEM	OEM	PCM
MEDIA: Generic type	Fixed	Removable Drive	Removable Drive	Removable Drive	Removable Drive
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	48 mm OD 12 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	MIG
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85	--	--	--	--
REMOVABLE	--	F: 85	F: 105.1	F: 170	F: 105.1
Capacity per track (Bytes)	*		*	*	*
Data surfaces per spindle	3	3	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1203	1203	1107		1107
Track density (TPI)	2750	2750	2750	3375	2750
Maximum linear density (BPI) (FCI)	71100 53325	71100 53325	67400 50550	92700 69525	70600 53000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3571	3571	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	18	18	15	15	15
Average rotational delay (msec)	8.4	8.4	6.7	6.7	6.7
Average access time (msec)	26.4	26.4	21.7	21.7	21.7
Data transfer rate (KBytes/sec)	5000	5000	6000	6000	6000
FIRST CUSTOMER SHIPMENT	3Q92	5/93	11/93	2Q94	1/94
COMMENTS	15 mm high *Varies by zone Ramp loaded heads	12.5 mm high *Varies by zone Ramp loaded heads	10.5 mm high *Varies by zone Ramp loaded heads. PCMCIA Type III	10.5 mm high *Varies by zone Ramp loaded heads. PCMCIA Type III	10.5 mm high *Varies by zone Ramp loaded heads

MANUFACTURER	KALOK	KALOK	KALOK	MAXTOR	MAXTOR
DRIVE	P3250	P3360	P3500	25128A	7131A
DISK/TREND GROUP	5	6	7	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Generic type	Removable Drive	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	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	Thin Film
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	F: 128.2	F: 131.1
REMOVABLE	F: 251.9	F: 362.8	F: 505.4	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	4	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1922	3164	3332	1092	2096
Track density (TPI)	2048	3155	3350	2550	2500
Maximum linear density (BPI) (FCI)	43100 32325	41822 31366	51137 38352	46000 34500	42600 31950
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	4201.7	3551	3551
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16.5	16.5	11/16**	14.2	14
Average rotational delay (msec)	8.3	8.3	7.14	8.45	8.45
Average access time (msec)	24.8	24.8	18.14/23.14**	22.65	22.45
Data transfer rate (KBytes/sec)	10000	10000	10000	8000	9000
FIRST CUSTOMER SHIPMENT	1Q93	3Q93	4Q93	6/92	2Q93
COMMENTS	12.7 mm high *Varies by zone	12.7 mm high *Varies by zone	12.7 mm high *Varies by zone **Varies with power supply	17.5 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	MXL-105-III	25252A	25252S	7213A	7213S
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Removable Drive	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	48 mm OD 12 mm ID	65 mm OD 20 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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PCMCIA/ATA	PC AT	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 251.7	F: 251.7	F: 212.78	F: 211.57
REMOVABLE	F: 105	--	--	--	--
Capacity per track (Bytes)	**	**	**	*	*
Data surfaces per spindle	4	6	6	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1249	1418	1418	1698	1698
Track density (TPI)	2700	2560	2560	1973	1973
Maximum linear density (BPI) (FCI)	58000 43500	55000 41250	55000 41250	42700 32000	42700 32000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4464	4247	4247	3551	3551
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 RD/19 WR	12	12	15	15
Average rotational delay (msec)	6.72	7.1	7.1	8.45	8.45
Average access time (msec)	24.72/25.72	19.1	19.1	23.45	23.45
Data transfer rate (KBytes/sec)	4000	9000	7500 synch. 3000 asynch.	9000	10000 synch.
FIRST CUSTOMER SHIPMENT	2Q93	1Q93	1Q93	4/92	4/92
COMMENTS	10.5 mm high *Glass disk **Varies by zone PCMCIA Type III	17 mm high *Glass disk **Varies by zone	17 mm high *Glass disk **Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7245A	7245S	7345A	7345S	MXT-540AL
DISK/TREND GROUP	5	5	6	6	7
MARKET	OEM, PCM	OEM, PCM	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	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	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245.6	F: 245.6	F: 345.1	F: 345.1	F: 540
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	4	4	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1952	1952	2233	2233	2616
Track density (TPI)	2340	2340	2762	2762	2364
Maximum linear density (BPI) (FCI)	42600 31950	42600 31950	50600 37950	50600 37950	44000 33000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3551	3551	3551	3551	6300
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)	15	15	14	14	8.5 RD/9.5 WR
Average rotational delay (msec)	8.45	8.45	8.45	8.45	4.76
Average access time (msec)	23.45	23.45	22.45	22.45	13.26/14.26
Data transfer rate (KBytes/sec)	9000	10000 synch.	9000	10000 synch.	8000
FIRST CUSTOMER SHIPMENT	1/93	1/93	4/93	4/93	3Q92
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	25.4 mm high *Varies by zone

MANUFACTURER	MAXTOR	MAXTOR	MEMOREX TELEX	MEMOREX TELEX	MFM TECHNOLOGY
DRIVE	MXT-540SL	MXT-1240S	3890-00K6 3890-02K6	3892-00K7 3892-02K7	11/11 Micro-Magnum
DISK/TREND GROUP	7	8	8	8	1
MARKET	OEM	OEM	PCM	PCM	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	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Thin Film	Ferrite
Interface	SCSI-2	SCSI-2	IBM	IBM	ST506
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 540	F: 1,240	F: 1,890	F: 1,890	U: 13.6
REMOVABLE	--	--	--	--	U: 13.6
Capacity per track (Bytes)	*	*	F: 47,476	F: 58,664	U: 10,640
Data surfaces per spindle	7	15	21	15	4
Heads per data surface	1	1	1	1	1
Tracks per surface	2616	2512	1916	2226	640
Track density (TPI)	2364	2472	1456	2080	908
Maximum linear density (BPI) (FCI)	44000 33000	44000 33000	25055 18791	30706 23029	10890
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	6300	6300	3600	4200	3254
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.	Embedded
Average positioning time (msec)	8.5 RD/9.5 WR	8.5 RD/9.5 WR	12	12	40
Average rotational delay (msec)	4.76	4.76	8.3	7.1	9.2
Average access time (msec)	13.26/14.26	13.26/14.26	20.3	19.1	49.2
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	3000	4260	625
FIRST CUSTOMER SHIPMENT	3Q92	2Q92	1Q91	4Q91	1986
COMMENTS	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone	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/R Micro-Magnum	20/20 Micro-Magnum	20/R Micro-Magnum	5/5 Micro-Magnum	5/R 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: 24.25	--	U: 6.4	--
REMOVABLE	U: 13.6	U: 24.25	U: 24.25	U: 6.4	U: 6.75
Capacity per track (Bytes)	U: 10,640	U: 10,640	U: 10,640	U: 10,032	F: 10,890
Data surfaces per spindle	2	4	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	640	1120	1120	320	311
Track density (TPI)	908	1250	1250	454	454
Maximum linear density (BPI) (FCI)	10890	11080	11080	8725	8617
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	3254	3248	3248	3443	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	8.7	8.7
Average access time (msec)	49.2	49.2	49.2	48.7	48.7
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	1986	1990	1987	1986	1986
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	2105A	2105S	2108S	2205A	2205S
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	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: 560	F: 557	F: 698	F: 542	F: 585
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	8	8	10	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1760	1760	1760	2372	2372
Track density (TPI)	1980	1980	1980	2764	2764
Maximum linear density (BPI) (FCI)	48750 36563	48750 36563	48750 36563	63331 47498	63331 47498
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	10	10
Average rotational delay (msec)	5.6	5.6	5.6	5.56	5.56
Average access time (msec)	15.6	15.6	15.6	15.56	15.56
Data transfer rate (KBytes/sec)	5000	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	5000 max.	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	2Q92	3Q92	3Q92	3Q93	2Q93
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	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	2210A	4105D 4105S	2112A	2112D 2112S	2112DPD 2112DPS
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	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	PC AT, IDE	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 976	F: 580	F: 1,050	F: 1,050	F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	9	3	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2372	2415	1760	1760	1760
Track density (TPI)	2764	2750	1980	1980	1980
Maximum linear density (BPI) (FCI)	63331 47498	60000 45000	48750 36563	48750 36563	48750 36563
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	8.5	10	10	10
Average rotational delay (msec)	5.56	5.56	5.6	5.6	5.56
Average access time (msec)	15.56	14.06	15.6	15.6	15.56
Data transfer rate (KBytes/sec)	5000 max.	10000 synch. 5000 asynch.	5000	10000 synch. 5000 asynch.	10000 synch.** 5000 asynch.**
FIRST CUSTOMER SHIPMENT	3Q93	3Q93	3Q91	3Q91	4Q92
COMMENTS	41.3 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	41.3 mm high *Varies by zone **Each data port Dual port

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	2210AV	2210D, OPT. 2210S	2217A	2217AV	2217D, OPT. 2217S
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,056	F: 1,056	F: 1,626	F: 1,765	F: 1,765
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	9	9	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2360	2372	2372	2360	2372
Track density (TPI)	2764	2764	2764	2764	2764
Maximum linear density (BPI) (FCI)	63331 47498	63331 47498	63331 47498	63331 47498	63331 47498
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	10	10
Average rotational delay (msec)	5.6	5.6	5.56	5.56	5.6
Average access time (msec)	15.6	15.6	15.56	15.56	15.6
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	5000 max.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	10/93	2Q93	3Q93	10/93	2Q93
COMMENTS	41.3 mm high *Varies by zone Optimized for video applications	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone Optimized for video applications	41.3 mm high *Varies by zone

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	4110A	4110D 4110S	4110WD 4110WS	1924D, OPT. 1924S	1926S
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	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,052	F: 1,052	F: 1,052	F: 2,100	F: 2,158
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	5	5	5	21	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2415	2415	2415	2246	2772
Track density (TPI)	2750	2750	2750	2000	2280
Maximum linear density (BPI) (FCI)	60000 45000	60000 45000	60000 45000	42130 31600	53860 40400
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)	8.5	8.5	8.5	11.5	13
Average rotational delay (msec)	5.56	5.56	5.56	5.6	5.6
Average access time (msec)	14.06	14.06	14.06	17.1	18.6
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	4Q93	2Q93	4Q93	2Q91	3Q93
COMMENTS	25.4 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	MICROPOLIS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS
DRIVE	1936D, OPT. 1936S	MiniPORT 32	MiniPORT 32P	MiniPORT 42A	MiniPORT 42P
DISK/TREND GROUP	9	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Removable Drive	Fixed	Removable Drive
Nominal disk diameter	130 mm OD 40 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 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-2	PC AT	PCMCIA	PC AT	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,022	F: 32	--	F: 42	--
REMOVABLE	--	--	F: 32	--	F: 42
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	21	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	2772	958	958	1062	1062
Track density (TPI)	2280	2400	2400	2587	2587
Maximum linear density (BPI) (FCI)	53860 40400	50000 37500	50000 37500	55300 41500	55300 41500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	16	16	16	16
Average rotational delay (msec)	5.6	6.67	6.67	6.67	6.67
Average access time (msec)	18.6	22.67	22.67	22.67	22.67
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.				
FIRST CUSTOMER SHIPMENT	3Q92	4Q92	4Q92	2Q93	2Q93
COMMENTS	*Varies by zone	9.8 mm high *Varies by zone	10.5 mm high *Varies by zone	9.8 mm high *Varies by zone	10.3 mm high *Varies by zone PCMCIA Type III

MANUFACTURER	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS
DRIVE	MiniPORT 64A	MiniPORT 64P	MiniPORT 85A	MiniPORT 85P	MiniPORT 128P
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Removable Drive	Fixed	Removable Drive	Removable Drive
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	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	PC AT	PCMCIA	PC AT	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 64	--	F: 85	--	--
REMOVABLE	--	F: 64	--	F: 85	F: 128
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	958	958	1062	1062	1304
Track density (TPI)	2400	2400	2587	2587	3300
Maximum linear density (BPI) (FCI)	50000 37500	50000 37500	55300 41500	55300 41500	75000 50000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	6.67	6.67	6.67	6.67	6.67
Average access time (msec)	22.67	22.67	22.67	22.67	22.67
Data transfer rate (KBytes/sec)					
FIRST CUSTOMER SHIPMENT	3Q92	4Q92	1Q93	1Q93	3Q93
COMMENTS	12.5 mm high *Varies by zone	13.5 mm high *Varies by zone	12.5 mm high *Varies by zone	13.5 mm high *Varies by zone	13.5 mm high *Varies by zone

MANUFACTURER	MINISTOR PERIPHERALS	MYRICA	MYRICA	NEC	NEC
DRIVE	MiniPORT 128A	3259AP	3259TS	D1711	D3142
DISK/TREND GROUP	4	5	5	2	2
MARKET	OEM	OEM	OEM	OEM	Captive, 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	48 mm OD 12 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Thin Film	Ferrite
Interface	PC AT	PC AT	SCSI, SCSI-2	PC AT	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 128	F: 213.0	F: 210.02	F: 42.6	U: 53.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	F:	U: 10,416
Data surfaces per spindle	4	9	9	2	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1304	1235	1216	1125	642
Track density (TPI)	3300	1700	1700	2564	850
Maximum linear density (BPI) (FCI)	75000 50000	25804 17202	25826 17217	49320 36990	14000
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	4500	3600	3600	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Torque Motor
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	16	16	16	19	28
Average rotational delay (msec)	6.67	8.3	8.3	5.5	8.3
Average access time (msec)	22.67	24.3	24.3	24.5	36.3
Data transfer rate (KBytes/sec)			5000 synch. 3000 asynch.	4500	625
FIRST CUSTOMER SHIPMENT	3Q93	1Q92	1Q92	7/92	1Q88
COMMENTS	12.5 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	12.7 mm high	41.3 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3735	D3741	D3835	D3841	D1721
DISK/TREND GROUP	2	2	2	2	3
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	48 mm OD 12 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	MIG	Ferrite	MIG	Ferrite	Thin Film
Interface	PC AT	PC AT	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 45	F: 45.09	F: 45	F: 45.05	F: 62.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,992	F: 12,800	F: 20,992	F: 12,800	*
Data surfaces per spindle	2	8	2	8	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1074	440	1075	440	1411
Track density (TPI)	1800	850	1800	850	3200
Maximum linear density (BPI) (FCI)	30000 22500	17000 11333	30000 22500	17000 11333	59140 44355
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3456	3600	3456	3600	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	25	23	25	28	17
Average rotational delay (msec)	8.7	8.3	8.7	8.3	5.56
Average access time (msec)	33.7	31.3	33.7	36.3	22.56
Data transfer rate (KBytes/sec)	1500	937.5	1500 asynch.	937.5	4500
FIRST CUSTOMER SHIPMENT	6/90	7/89	2/90	12/87	3Q93
COMMENTS	25.4 mm high	41.3 mm high	25.4 mm high	41.3 mm high	12.7 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D1731	D1741	D3661	D3746	D3755 D3756
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	Captive, OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 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	Thin Film	MIG
Interface	PC AT	PC AT	ESDI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85.3	F: 125.9	U: 134.5	F: 128	F: 105
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	*	U: 20,992	*	F: 20,992
Data surfaces per spindle	4	4	7	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1125	1411	915	1673	1251
Track density (TPI)	2564	3200	1311	2200	1800
Maximum linear density (BPI) (FCI)	49320 36990	59140 44355	25484 16989	51000 38250	32000 24000
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4500	3573	4500	3456
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	19	17	20	14	19
Average rotational delay (msec)	5.5	5.56	8.4	6.67	8.7
Average access time (msec)	24.5	22.56	28.4	20.67	27.7
Data transfer rate (KBytes/sec)	4500	4500	1250	5000	1500
FIRST CUSTOMER SHIPMENT		3Q93	11/88	3Q93	6/90
COMMENTS	12.7 mm high	12.7 mm high *Varies by zone	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3761	D3765	D3855 D3856	D3861	D3865
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	Thin Film	MIG	Ferrite	Thin Film
Interface	PC AT	PC AT	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 114.78	F: 176.5	F: 105	F: 114.78	F: 176.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 29,690	F: 20,992	F: 17,920	F: 29,690
Data surfaces per spindle	7	4	4	7	4
Heads per data surface	1	1	1	1	1
Tracks per surface	915	1486	1251	915	1486
Track density (TPI)	1311	2036	1800	1311	2036
Maximum linear density (BPI) (FCI)	25484 16989	49403 37052	32000 24000	25484 16989	49403 37052
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3573	3600	3456	3573	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	Dedicated Surf.	Embedded
Average positioning time (msec)	20	16.5	25	20	16.5
Average rotational delay (msec)	8.4	8.3	8.7	8.4	8.3
Average access time (msec)	28.4	24.8	33.7	28.4	24.8
Data transfer rate (KBytes/sec)	1250	2365	1500 asynch.	1250	2365
FIRST CUSTOMER SHIPMENT	9/89	2Q91	12/89	3/89	2Q91
COMMENTS	41.3 mm high	25.4 mm high	25.4 mm high D3856 has 19 msec. average positioning time	41.3 mm high	25.4 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5652	D5655	D5852	D3766	D3772
DISK/TREND GROUP	4	4	4	5	6
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ESDI	ESDI	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 172.76	U: 179.86	F: 147.48	F: 245	F: 331.46
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,992	U: 20,992	F: 17,920	*	F: 32,200
Data surfaces per spindle	10	7	10	4	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	1224	823	1673	1468
Track density (TPI)	926	1240	925	2200	2000
Maximum linear density (BPI) (FCI)	18758 12505	19610 13073	18759 12506	51000 38250	49000 36750
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3573	3573	3573	4500	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	Dedicated Surf.
Average positioning time (msec)	23	18	23	14	14
Average rotational delay (msec)	8.4	8.4	8.4	6.67	8.3
Average access time (msec)	31.4	26.4	31.4	20.67	22.3
Data transfer rate (KBytes/sec)	1250	1250	1250	5000	5000 synch. 2365 asynch.
FIRST CUSTOMER SHIPMENT	2/86	12/87	5/87	3Q93	2Q91
COMMENTS		41.3 mm high		25.4 mm high *Varies by zone	41.3 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3781	D3872	D3881	D5662	D5862
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive, OEM	Captive, 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	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	PC AT	SCSI-2	SCSI-2	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 426.16	F: 331.46	F: 426.16	U: 385.41	F: 328.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,200	F: 32,200	F: 32,200	U: 20,992	F: 17,920
Data surfaces per spindle	9	7	9	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1468	1468	1468	1224	1221
Track density (TPI)	2000	2000	2000	1240	1240
Maximum linear density (BPI) (FCI)	49000 36750	49000 36750	49000 36750	19660 13106	19660 13106
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3573	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	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.4	8.4
Average access time (msec)	22.3	22.3	22.3	26.4	26.4
Data transfer rate (KBytes/sec)	5000 synch. 2365 asynch.	5000 synch. 2365 asynch.	5000 synch. 2365 asynch.	1250	1250
FIRST CUSTOMER SHIPMENT	2Q91	2Q91	2Q91	11/87	11/87
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high		

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	N7756	D5682	D5882	N7757	N7759
DISK/TREND GROUP	6	7	7	7	7
MARKET	Captive	Captive, OEM	Captive, OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 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	NEC	ESDI	SCSI	NEC	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 486.2	U: 765.42	F: 675.99	F: 750.5	F: 972
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 34,036	U: 31,248	F: 27,648	F: 38,708	F: 38,708
Data surfaces per spindle	9.5	15	15	11.5	11.5
Heads per data surface	2/1	1	1	2	2/1
Tracks per surface	1506	1633	1630	1686	1686
Track density (TPI)	1000	1480	1480	1070	1070
Maximum linear density (BPI) (FCI)	18600 12400	30760 23070	30760 23070	21400 14266	21400 14266
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3070	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	16	16	15	13
Average rotational delay (msec)	9.8	8.3	8.3	8.3	8.3
Average access time (msec)	24.8	24.3	24.3	23.3	21.3
Data transfer rate (KBytes/sec)	1860	1875	4800 synch. 1875 asynch.	2460	2460
FIRST CUSTOMER SHIPMENT	3Q84	4/89	6/89	9/87	9/88
COMMENTS	Drive has 2 spindles			Drive has 2 spindles	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	N7767	D3392	D3892	N7760	N7766
DISK/TREND GROUP	7	8	8	8	8
MARKET	Captive	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 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	Ferrite	Thin Film	Thin Film	Thin Film	Ferrite
Interface	NEC	IPI-2	SCSI-2	NEC	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 635.3	F: 1,434	F: 1,434	F: 1,281	F: 1,301.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,768	F: 30,208	F: 30,208	F: 46,740	F: 47,476
Data surfaces per spindle	11.5	19	19	19	13.5
Heads per data surface	2	1	1	1	2/1
Tracks per surface	1686	2495	2495	1443	2030
Track density (TPI)	1070	2840	2840	1603	1290
Maximum linear density (BPI) (FCI)	21400 14266	55900 41925	55900 41925	45850 34388	26800 20100
Recording code	2,7 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	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	11.8	11.8	12.5	15
Average rotational delay (msec)	8.3	5.56	5.56	5.55	8.3
Average access time (msec)	23.3	17.36	17.36	18.05	23.3
Data transfer rate (KBytes/sec)	19600	5000 synch. 2500 asynch.	5000 synch. 2500 asynch.	4500	3000
FIRST CUSTOMER SHIPMENT	1988	2Q93	2Q93	1Q93	9/90
COMMENTS	N7767 uses 8 spindles in parallel array with 5 GB total capacity	41.3 mm high	41.3 mm high	Drive has maximum 8 spindles	Drive has 4 spindles

MANUFACTURER	NEC	NEC	NEC	QUALITRON	QUALITRON
DRIVE	N7768	N7797	N7795	QW-540	QW-560
DISK/TREND GROUP	8	8	9	2	3
MARKET	Captive	Captive	Captive	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	230 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Ferrite	Ferrite
Interface	NEC	NEC	NEC	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,301.1	F: 1,536	F: 2,855	U: 51.3	U: 76.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,552	F: 69,416	U: 10,416	U: 15,624
Data surfaces per spindle	13.5	15	15	4	4
Heads per data surface	2/1	1	2/1	1	1
Tracks per surface	2030	2154	2742	820	820
Track density (TPI)	1290	2400	1670	777	777
Maximum linear density (BPI) (FCI)	26800 20100	44660 33495	37800 28350	9935	14903 9935
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	MFM	2,7 RLL
Rotational speed (RPM)	3600	5400	3700	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Open Loop	Open Loop
Average positioning time (msec)	15	12	12	40 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	5.6	8.1	8.3	8.3
Average access time (msec)	23.3	17.6	20.1	48.3	48.3
Data transfer rate (KBytes/sec)	3000	4500	4500	625	937.5
FIRST CUSTOMER SHIPMENT	9/89	4/92	6/91	1988	1988
COMMENTS	Drive has 8 spindles	Maximum 32 HDAs per drive		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	EZ242 Hardcard
DISK/TREND GROUP	2	2	2	2	2
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	PC AT	SCSI, SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43	F: 43	F: 42	F: 42	F: 42
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	2	1	1	1
Heads per data surface	1	1	1	1	1
Tracks per surface	870	870	1536	1536	1536
Track density (TPI)	1700	1700	1800	1800	1800
Maximum linear density (BPI) (FCI)	48371 36278	48371 36278	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)	19	19	19	19	19
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	27.2
Data transfer rate (KBytes/sec)	4000 max.	4000 synch. 2000 asynch.	4000	3000 asynch.	4000
FIRST CUSTOMER SHIPMENT	6/91	6/91	8/92	8/92	10/92
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	27.8 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	XL42 Passport	XL50 Passport	60AT Go.Drive	80AT Go.Drive	80AT GRS Go.Drive
DISK/TREND GROUP	2	2	3	3	3
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Generic type	Removable Drive	Removable Drive	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	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	Thin Film
Interface	IBM, Mac	IBM PC, Mac	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 64.7	F: 86	F: 84
REMOVABLE	F: 42	F: 52.2	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	1	2	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1536	1219	1097	870	1376
Track density (TPI)	1800	1330	2000	1700	2500
Maximum linear density (BPI) (FCI)	38624 28968	29307 19538	56688 42516	48371 36278	58878 44159
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3663	3662	3600	3600	3600
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)	19	18	17	19	17
Average rotational delay (msec)	8.2	8.2	8.3	8.3	8.3
Average access time (msec)	27.2	26.2	24.3	27.3	25.3
Data transfer rate (KBytes/sec)	3000 asynch.	4000	4000	4000 max.	4000
FIRST CUSTOMER SHIPMENT	10/92	1/92	1/92	8/91	3Q92
COMMENTS	Drive with adapter mounts in 5.25" slot *Varies by zone	Drive with adapter mounts in half high 5.25" slot *Varies by zone	19 mm high *Varies by zone	19 mm high *Varies by zone	15.6 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	80AT ProDrive	80S Go.Drive	80S GRS Go.Drive	85AT ELS ProDrive	85AT 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	95 mm OD 25 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	Ferrite	Thin Film	Thin Film	MIG	Thin Film
Interface	PC AT	SCSI	SCSI-2	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 84	F: 86	F: 84	F: 85	F: 85
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	6	4	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	834	870	1376	1536	1395
Track density (TPI)	1000	1700	2500	1800	2529
Maximum linear density (BPI) (FCI)	22050 14700	48371 36278	58878 44159	38624 28968	57812 43359
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	3600	3600	3663	3600
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)	19	19	17	17	17
Average rotational delay (msec)	8.2	8.3	8.3	8.2	8.3
Average access time (msec)	27.2	27.3	25.3	25.2	25.3
Data transfer rate (KBytes/sec)	4000 max.	4000 synch. 2000 asynch.	4000 synch. 2500 asynch.	4000	4000
FIRST CUSTOMER SHIPMENT	5/88	8/91	3Q92	8/92	6/93
COMMENTS	41.3 mm high *Varies by zone	19 mm high *Varies by zone	15.6 mm high *Varies by zone	25.4 mm high *Varies by zone	12.5 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	85S ELS ProDrive	85S Go.Drive	EZ85 Hardcard	XL85 Passport	105AT LPS ProDrive
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Drive On Card	Removable Drive	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, SCSI-2	SCSI-2	PC AT, IBM PC	IBM, Mac	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85	F: 85	F: 85	--	F: 105
REMOVABLE	--	--	--	F: 85	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	2	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1536	1395	1536	1536	1219
Track density (TPI)	1800	2529	1800	1800	1330
Maximum linear density (BPI) (FCI)	38624 28968	57812 43359	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)	3663	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)	17	17	17	17	17
Average rotational delay (msec)	8.2	8.3	8.2	8.2	8.2
Average access time (msec)	25.2	25.3	27.2	25.2	25.2
Data transfer rate (KBytes/sec)	3000 asynch.	4000 synch. 3000 asynch.	4000	3000 asynch.	4000 max.
FIRST CUSTOMER SHIPMENT	8/92	6/93	10/92	10/92	--
COMMENTS	25.4 mm high *Varies by zone	12.5 mm high *Varies by zone	27.8 mm high *Varies by zone	Drive with adapter mounts in 5.25" slot *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	105S LPS ProDrive	120AT Go.Drive	120AT LPS ProDrive	120S Go.Drive	120S LPS 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	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	Thin Film	MIG	Thin Film
Interface	SCSI	PC AT	PC AT	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105	F: 130	F: 122	F: 130	F: 122
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1219	1097	1818	1097	1818
Track density (TPI)	1330	2000	1930	2000	1930
Maximum linear density (BPI) (FCI)	29307 19538	56688 42516	38600 29000	56688 42516	38600 29000
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	3600	4306	3600	4306
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	Optical Encoder
Average positioning time (msec)	17	17	16	17	16
Average rotational delay (msec)	8.2	8.3	7	8.3	7
Average access time (msec)	25.2	24.3	23	24.3	23
Data transfer rate (KBytes/sec)	4000 synch. 2000 asynch.	4000	5000	4000 synch. 2500 asynch.	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	2/90	1/92	10/91	1/92	10/91
COMMENTS	25.4 mm high *Varies by zone	19 mm high *Varies by zone	25.4 mm high *Varies by zone	19 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	127AT ELS ProDrive	127AT Go.Drive	127AT LPS	127S ELS ProDrive	127S Go.Drive
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	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	MIG	Thin Film
Interface	PC AT	PC AT	PC AT	SCSI, SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 127	F: 127	F: 127	F: 127	F: 127
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	3	3	2	3	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1536	1395	1745	1536	1395
Track density (TPI)	1800	2529	2670	1800	2529
Maximum linear density (BPI) (FCI)	38624 28968	57812 43359	48865 36648	38624 28968	57812 43359
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3663	3600	3600	3663	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	17	14	17	17
Average rotational delay (msec)	8.2	8.3	8.3	8.2	8.3
Average access time (msec)	25.2	25.3	22.3	25.2	25.3
Data transfer rate (KBytes/sec)	4000	4000	6000	3000 asynch.	4000 synch. 3000 asynch.
FIRST CUSTOMER SHIPMENT	8/92	6/93	4Q93	8/92	6/93
COMMENTS	25.4 mm high *Varies by zone	17 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	17 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	127S LPS ProDrive	160AT GRS Go.Drive	160S GRS Go.Drive	170AT ELS ProDrive	170AT Go.Drive
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	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	MIG	Thin Film
Interface	SCSI-2	PC AT	SCSI-2	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 127	F: 169	F: 169	F: 170	F: 170
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1745	1376	1376	1536	1395
Track density (TPI)	2670	2500	2500	1800	2529
Maximum linear density (BPI) (FCI)	48865 36648	58878 44159	58878 44159	38624 28968	57812 43359
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3663	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)	14	17	17	17	17
Average rotational delay (msec)	8.3	8.3	8.3	8.2	8.3
Average access time (msec)	22.3	25.3	25.3	25.2	25.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	4000	4000 synch. 2500 asynch.	4000	4000
FIRST CUSTOMER SHIPMENT	4Q93	3Q92	3Q92	8/92	6/93
COMMENTS	25.4 mm high *Varies by zone	19 mm high *Varies by zone	19 mm high *Varies by zone	25.4 mm high *Varies by zone	17 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	170AT LPS	170S ELS ProDrive	170S Go.Drive	170S LPS	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	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	Thin Film	MIG	Thin Film	Thin Film	MIG
Interface	PC AT	SCSI, SCSI-2	SCSI-2	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 170	F: 170	F: 170	F: 170	F: 127
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	4	4	2	3
Heads per data surface	1	1	1	1	1
Tracks per surface	2337	1536	1395	2337	1536
Track density (TPI)	2670	1800	2529	2670	1800
Maximum linear density (BPI) (FCI)	48865 36648	38624 28968	57812 43359	48865 36648	38624 28968
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3663	3600	3600	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)	14	17	17	14	17
Average rotational delay (msec)	8.3	8.2	8.3	8.3	8.2
Average access time (msec)	22.3	25.2	25.3	22.3	27.2
Data transfer rate (KBytes/sec)	6000	3000 asynch.	4000 synch. 3000 asynch.	10000 synch. 5000 asynch.	4000
FIRST CUSTOMER SHIPMENT	4Q93	8/92	6/93	4Q93	10/92
COMMENTS	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	17 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 Passport	XL120 Passport	XL127 Passport	XL170 Passport	240AT LPS ProDrive
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Generic type	Removable Drive	Removable Drive	Removable Drive	Removable Drive	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	MIG	MIG	Thin Film
Interface	IBM, Mac	IBM, Mac	SCSI-2	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	F: 245
REMOVABLE	F: 105	F: 120	F: 127	F: 170	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	2	3	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1219	1800	1536	1536	1818
Track density (TPI)	1330	1930	1800	1800	1930
Maximum linear density (BPI) (FCI)	29307 19538	38600 29000	38624 28968	38624 28968	38600 29000
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	4306	3663	3663	4306
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	Optical Encoder
Average positioning time (msec)	18	17	17	17	16
Average rotational delay (msec)	8.2	7.0	8.2	8.2	7
Average access time (msec)	26.2	24.0	25.2	25.2	23
Data transfer rate (KBytes/sec)	4000	10000	3000 asynch.	3000 asynch.	5000
FIRST CUSTOMER SHIPMENT	1/92	3/92	10/92	10/92	10/91
COMMENTS	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	Drive with adapter mounts in 5.25" slot *Varies by zone	Drive with adapter mounts in 5.25" slot *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	240S LPS ProDrive	256AT Go.Drive	256S Go.Drive	270AT LPS	270S LPS
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	65 mm OD 20 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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	PC AT	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245	F: 256	F: 256	F: 270.6	F: 270.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	6	6	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1818	1395	1395	2740	2740
Track density (TPI)	1930	2529	2529	2875	2875
Maximum linear density (BPI) (FCI)	38600 29000	57812 43359	57812 43359	62600 45900	62600 45900
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4306	3600	3600	4500	4500
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)	16	17	17	12	12
Average rotational delay (msec)	7	8.3	8.3	6.7	6.7
Average access time (msec)	23	25.3	25.3	18.7	18.7
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	4000	4000 synch. 3000 asynch.	6000	10000 synch. 6000 asynch.
FIRST CUSTOMER SHIPMENT	10/91	6/93	6/93	4Q93	4Q93
COMMENTS	25.4 mm high *Varies by zone	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

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	EZ240 Hardcard	XL240 Passport	340AT LPS	340S LPS	425iAT ProDrive
DISK/TREND GROUP	5	5	6	6	6
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	PC AT	IBM, Mac	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245	--	F: 342.6	F: 342.6	F: 426
REMOVABLE	--	F: 240	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	4	4	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1800	1800	2493	2493	1520
Track density (TPI)	1930	1930	2670	2670	1695
Maximum linear density (BPI) (FCI)	38600 29000	38600 29000	49273 36954	49273 36954	37146 27860
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4306	4306	3600	3600	3606
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	Dedicated Surf.
Average positioning time (msec)	16	17	12	12	13 RD/14 WR
Average rotational delay (msec)	7.0	7.0	8.3	8.3	8.3
Average access time (msec)	23.0	24.0	20.3	20.3	21.3 RD/22.3 WR
Data transfer rate (KBytes/sec)	5000	10000	6000	10000 synch. 6000 asynch.	4000 max.
FIRST CUSTOMER SHIPMENT	8/92	3/92	4Q93	4Q93	5/91
COMMENTS	27.8 mm high *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	41.3 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	425iS ProDrive	525AT LPS ProDrive	525S LPS ProDrive	540AT LPS	540S Empire
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	SCSI-2	PC AT	SCSI-2	PC AT	SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 426	F: 525	F: 525	F: 541.3	U: 616 F: 540
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	9	6	6	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1520	2448	2448	2740	2874
Track density (TPI)	1695	2670	2670	2875	3014
Maximum linear density (BPI) (FCI)	37146 27860	50500 37900	50500 37900	62600 45900	61300 46000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3606	4500	4500	4500	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13 RD/14 WR	10 RD/11 WR	10 RD/11 WR	12	9.5 RD/11 WR
Average rotational delay (msec)	8.3	6.7	6.7	6.7	5.6
Average access time (msec)	21.3 RD/22.3 WR	16.7/17.7	16.7/17.7	18.7	15.1 RD/16.6 WR
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	5000	10000 synch. 5000 asynch.	6000	20000 synch. 10000 asynch.
FIRST CUSTOMER SHIPMENT	1/91	9/92	9/92	4Q93	4Q93
COMMENTS	41.3 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	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	540S LPS	700S ProDrive	XL525 Passport	1050S ProDrive	1080S Empire
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM	OEM	OEM, PCM	OEM	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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IBM, Mac	SCSI-2	SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 541.3	F: 700	--	F: 1,050	U: 1,232 F: 1,080
REMOVABLE	--	--	F: 525	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	8	6	12	8
Heads per data surface	1	1	1	1	1
Tracks per surface	2740	2448	2448	2448	2874
Track density (TPI)	2875	2670	2670	2670	3014
Maximum linear density (BPI) (FCI)	62600 45900	50500 37900	50500 37900	50500 37900	61300 46000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4500	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	10 RD/12 WR	10	10 RD/12 WR	9.5 RD/11 WR
Average rotational delay (msec)	6.7	6.7	6.7	6.7	5.6
Average access time (msec)	18.7	16.7/18.7	16.7	16.7/18.7	15.1 RD/16.6 WR
Data transfer rate (KBytes/sec)	10000 synch. 6000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.
FIRST CUSTOMER SHIPMENT	4Q93	9/92	1/93	9/92	4Q93
COMMENTS	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone	Drive with adapter mounts in 5.25" slot *Varies by zone	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	RICOH	SAGEM	SAMSUNG ELECTRONICS
DRIVE	1225S ProDrive	1800S ProDrive	RH5500	MSA 252-200	SHD-3062A
DISK/TREND GROUP	8	8	1	5	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	5.25" Cartridge	Removable HDA	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	Ferrite	
Interface	SCSI-2	SCSI-2	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,225	U: 2,133 F: 1,800	--	--	F: 120
REMOVABLE	--	--	F: 50.0	F: 200	--
Capacity per track (Bytes)	*	*	F: 19,455	F: 23,040	F: 20,480
Data surfaces per spindle	14	14	2	16	4
Heads per data surface	1	1	1	1	1
Tracks per surface	2959	2959	1285	720	1478
Track density (TPI)	3260	3260	1200	950	1752
Maximum linear density (BPI) (FCI)	50500 37900	63691 47768	25750 17166	19680 14760	36139 27172
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	3183	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)	10 RD/12 WR	10 RD/12 WR	25	17	16
Average rotational delay (msec)	6.7	6.7	9.4	8.3	8.3
Average access time (msec)	16.7/18.7	16.7 RD/18.7 WR	34.4	25.3	24.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	2000	1500	1250
FIRST CUSTOMER SHIPMENT	9/92	8/93	2Q89	10/90	1992
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high	Militarized Subsystem Removable Head/Disk Module	25.4 mm high

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	SHD-3121A	SHD-3122A	SHD-3252S	ST351A/X	ST7050P
DISK/TREND GROUP	4	5	7	2	2
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	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	48 mm OD 12 mm ID
Recording medium		Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG			Ferrite	Thin Film
Interface	PC AT	PC AT	SCSI-2	PC AT/XT	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 125	F: 251.9	F: 513	F: 42.8	--
REMOVABLE	--	--	--	--	F: 42.6
Capacity per track (Bytes)	F: 30,231	F: 32,239	*	*	*
Data surfaces per spindle	2	4	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1902	1902	2719	820	1074
Track density (TPI)	2251	2251	2850	1290	2748
Maximum linear density (BPI) (FCI)	45269 33952	45269 33952	62400 46800	28922 19281	53200 39900
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	1, 7 RLL
Rotational speed (RPM)	3600	3600	4500	3048	3545
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	11	28	16
Average rotational delay (msec)	8.3	8.3	6.67	9.8	8.46
Average access time (msec)	24.3	24.3	17.67	37.8	24.46
Data transfer rate (KBytes/sec)	8000	8000	10000 synch. 5000 asynch.	1250-1750	4000
FIRST CUSTOMER SHIPMENT	2Q93			4Q90	1993
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	10.5 mm high *Varies by zone PCMCIA Type III

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3096A	ST9080A	ST9100A	ST3120A	ST3144A
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 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	Thin Film	Thin Film	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: 89.2	F: 64.0	F: 85.3	F: 106.9	F: 130
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	3	2	2	3	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1024			1024	1001
Track density (TPI)	1760	2650	2650	1760	1760
Maximum linear density (BPI) (FCI)	34600 23000	45600 30400	58200 43760	34600 23000	34600 23000
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3528	3450	3545	3528	3528
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	8.5	8.7	8.5	8.5	8.5
Average access time (msec)	24.5	24.7	24.5	24.5	24.5
Data transfer rate (KBytes/sec)	4000 max.	4000	4000	4000	4000
FIRST CUSTOMER SHIPMENT	1Q90	3Q92	1Q93	1/91	3Q91
COMMENTS	25.4 mm high *Varies by zone	12.5 mm high *Varies by zone	12.5 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	ST3145A	ST9140AG	ST9144A	ST9145AG	ST9190AG
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	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	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 130.7	F: 127	F: 127.9	F: 127	F: 170
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	4	6	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface			1065		
Track density (TPI)	2400	2760	2165	2650	2760
Maximum linear density (BPI) (FCI)	42700 32025	57120 42840	40500 27000	45600 30400	57120 42840
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3811	3546	3450	3449	3546
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	7.87	8.46	8.7	8.7	8.46
Average access time (msec)	23.87	24.46	24.7	24.7	24.46
Data transfer rate (KBytes/sec)	5000	8000	4000	4000	8000
FIRST CUSTOMER SHIPMENT	3Q93	3Q93	4Q91		3Q93
COMMENTS	25.4 mm high *Varies by zone	12.5 mm high *Varies by zone	19.05 mm high *Varies by zone	19.05 mm high *Varies by zone	12.5 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3243A	ST3283A	ST3283N	ST3290A	ST9235AG
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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	PC AT	SCSI-2	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 214	F: 245.38	F: 248.62	F: 262	F: 209.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	5	5	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1996	1672	1672		
Track density (TPI)	2178	1960	1960	2400	2750
Maximum linear density (BPI) (FCI)	42700 32000	35000 26250	35000 26250	42700 32025	45500 30300
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3811	4500	4500	3811	3450
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	12	12	16	16
Average rotational delay (msec)	7.87	6.7	6.7	7.87	8.69
Average access time (msec)	23.87	18.7	18.7	23.87	24.69
Data transfer rate (KBytes/sec)	4000	3000	10000 synch. 3000 asynch.	5000	4000
FIRST CUSTOMER SHIPMENT	2Q92	1Q92	1Q92	2Q93	3Q92
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	19.05 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST9235N	ST3390A	ST3390N	ST3550A	ST3550N
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	PC AT	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 209	F: 341.3	F: 341.3	F: 452.4	F: 456.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	6	3	3	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface		2676	2676	2126	2126
Track density (TPI)	2750	3000	3000	2400	2400
Maximum linear density (BPI) (FCI)	45500 30300	42700 32000	42700 32000	52602 39451	52602 39451
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3450	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	12	12	12	12
Average rotational delay (msec)	8.69	6.7	6.7	6.7	6.7
Average access time (msec)	24.69	18.7	18.7	18.7	18.7
Data transfer rate (KBytes/sec)	5000 synch.	5500	10000 synch. 5000 asynch.	5500	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	3Q92	3/93	3/93	4Q92	4Q92
COMMENTS	19.05 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	25.4 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST9385AG	ST1980N ST1980ND	ST3600A	ST3600N ST3600ND	ST3610N ST3610NC ST3610ND
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	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI-2	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 341	U: 980 F: 860	U: 600 F: 525	U: 600 F: 525	U: 635 F: 535
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	6	13	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface		1730	1877	1877	1872
Track density (TPI)	3282		2150	2150	2150
Maximum linear density (BPI) (FCI)	59124 44343		47000 35250	47000 35250	42000 31500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3980	5400	4500	4500	5411
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	9.9 RD/11.4 WR	10.5 RD/12 WR	10.5 RD/12 WR	10.5 RD/12 WR
Average rotational delay (msec)	7.54	5.56	6.7	6.7	5.5
Average access time (msec)	23.54	15.46/16.96	17.2/18.7	17.2/18.7	16/17.5
Data transfer rate (KBytes/sec)	10000	10000 synch. 4000 asynch.	4000	10000 synch. 4000 asynch.	10000 synch. 5000 asynch.
FIRST CUSTOMER SHIPMENT	4Q93	1Q92	1Q92	1Q92	12/92
COMMENTS	19 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	25.4 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3620N ST3620NC ST3620ND	ST3620W ST3620WC ST3620WD	ST3655A	ST3655N	ST11200N ST11200NC ST11200ND
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 650 F: 560	U: 650 F: 560	F: 528.5	F: 545.3	U: 1,200 F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	5	5	5	5	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2700	2700			1877
Track density (TPI)	3000	3000	3000	3000	2150
Maximum linear density (BPI) (FCI)	49000 36750	49000 36750	53192 39894	53192 39894	42000 31500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	4500	4500	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 RD/10.5 WR	9 RD/10.5 WR	12	12	10.5 RD/12 WR
Average rotational delay (msec)	5.56	5.56	6.7	6.7	5.56
Average access time (msec)	14.56/16.06	14.56/16.06	18.7	18.7	16.06/17.56
Data transfer rate (KBytes/sec)	10000 synch.	20000 synch.	5500	10000 synch. 5000 asynch.	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	3Q93	3Q93	2Q93	3Q93	2Q92
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 *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST11900N ST11900ND	ST11901N ST11901ND	ST11950N ST11950ND Barracuda 1	ST11950W ST11950WD Barracuda 1	ST31200N ST31200NC ST31200ND
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,003 F: 1,700	U: 2,003 F: 1,700	U: 2,031 F: 1,689	U: 2,031 F: 1,689	U: 1,260 F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	13	13	15	15	9
Heads per data surface	1	1	1	1	1
Tracks per surface	2626	2626	2706	2706	2626
Track density (TPI)	3000	3000	3047	3047	3000
Maximum linear density (BPI) (FCI)	50000 37500	50000 37500	52187 39140	52187 39140	55000 41250
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	7200	7200	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9 RD/10.5 WR	9 RD/10.5 WR	8 RD/9 WR	8 RD/9 WR	9 RD/10.5 WR
Average rotational delay (msec)	5.6	5.6	4.17	4.17	5.56
Average access time (msec)	14.6/15.6	14.6/15.6	12.17/13.17	12.17/13.17	14.56/16.06
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	10000 synch. 4000 asynch.
FIRST CUSTOMER SHIPMENT	2Q93	2Q93	4/93	9/93	2Q93
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	25.4 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST31230N ST31930NC ST31930ND	ST31230W ST31930WC ST31930WD	ST31930N ST31930NC ST31930ND	ST31930W ST31930WC ST31930WD	ST41201J ST41201K Elite 1
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	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	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	Mod. SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,200 F: 1,050	U: 1,200 F: 1,050	U: 2,003 F: 1,700	U: 2,003 F: 1,700	U: 1,200
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	U: 33,600
Data surfaces per spindle	5	5	7	7	17
Heads per data surface	1	1	1	1	1
Tracks per surface	3898	3898	3898	3898	2101
Track density (TPI)	4200	4200	4200	4200	1801
Maximum linear density (BPI) (FCI)	78000 58500	78000 58500	78000 58500	78000 58500	33344 22229
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 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)	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	11.5
Average rotational delay (msec)	5.56	5.56	5.56	5.56	5.56
Average access time (msec)	13.56/14.56	13.56/14.56	13.56/14.56	13.56/14.56	17.06
Data transfer rate (KBytes/sec)	10000 synch.	20000 synch.	10000 synch.	20000 synch.	3000
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q94	2Q94	1Q90
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	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST41520N ST41520ND Elite 1	ST41600N ST41600ND ST41601N ST41601ND Elite 1	ST41650N ST41650ND Wren 8	ST41651N ST41651ND Wren 8	ST41800K Elite 2
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	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,600 F: 1,370	U: 1,600 F: 1,370	U: 1,650 F: 1,420	U: 1,650 F: 1,420	U: 1,986
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	U: 84,000
Data surfaces per spindle	17	17	15	15	18
Heads per data surface	1	1	1	1	1
Tracks per surface	2101	2101	2110	2107	2627
Track density (TPI)	1801	1801	1760	1760	
Maximum linear density (BPI) (FCI)			40000 30000	40000 30000	
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	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)	11.5	11.5	15	15	11
Average rotational delay (msec)	5.56	5.56	8.3	8.3	5.56
Average access time (msec)	17.06	17.06	23.3	23.3	16.56
Data transfer rate (KBytes/sec)	5000 synch.	5000 synch.	5000 synch.	10000 synch.	7500
FIRST CUSTOMER SHIPMENT	12/90	12/90	12/90	9/91	3Q91
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	ST42000N ST42000ND Elite 2	ST42100N Wren 9	ST12400N ST12400NC ST12400ND	ST12401N ST12401ND	ST12550N ST12550ND Barracuda 2
DISK/TREND GROUP	8	8	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,000 F: 1,790	U: 2,200 F: 1,900	U: 2,500 F: 2,100	U: 2,500 F: 2,100	U: 2,572 F: 2,139
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	19	15	19	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	2627	2574	2626	2626	2707
Track density (TPI)		2150	3000	3000	
Maximum linear density (BPI) (FCI)		46000 34500	50000 37500	50000 37500	
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	3600	5400	5400	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	12.9	9 RD/10.5 WR	9 RD/10.5 WR	8 RD/9 WR
Average rotational delay (msec)	5.56	8.3	5.6	5.6	4.17
Average access time (msec)	16.56	21.2	14.6/15.6	14.6/15.6	12.17/13.7
Data transfer rate (KBytes/sec)	10000 synch.	10000 synch.	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	10000 synch.
FIRST CUSTOMER SHIPMENT	3Q92	3Q91	2Q93	2Q93	2/93
COMMENTS	*Varies by zone	*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	ST12550W ST12550WD Barracuda 2	ST32430N ST32430NC ST32430ND	ST32430W ST32430WC ST32430WD	ST42400N ST42400ND Elite 2	ST43200K Elite 3, 2HP
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	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	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,572 F: 2,139	U: 2,600 F: 2,147	U: 2,600 F: 2,147	U: 2,500 F: 2,129	U: 3,338
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	19	9	9	19	20
Heads per data surface	1	1	1	1	1
Tracks per surface	2707	3898	3898	2627	2627
Track density (TPI)		4200	4200		
Maximum linear density (BPI) (FCI)		78000 58500	78000 58500		
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	11	11
Average rotational delay (msec)	4.17	5.56	5.56	5.56	5.56
Average access time (msec)	12.17/13.17	13.56/14.56	13.56/14.56	16.56	16.56
Data transfer rate (KBytes/sec)	20000 synch.	10000 synch.	20000 synch.	5000 synch.	25000
FIRST CUSTOMER SHIPMENT	7/93	1Q94	1Q94	3Q91	3/92
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 2 head parallel version of Elite 3

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST43400N ST43400ND Elite 3	ST43401N ST43401ND ST43402ND Elite 3	ST82368K Sabre PTD	ST82500J ST82500K Sabre 6	ST82500N 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	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IPI-2	SMD, IPI-2	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 3,557 F: 2,904	U: 3,557 F: 2,904	U: 2,368	U: 2,500	U: 2,500 F: 2,140
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	U: 50,400	U: 50,400	F: 43,142
Data surfaces per spindle	21	21	18	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	2627	2627	2611	2611	2611
Track density (TPI)			1880	1880	1880
Maximum linear density (BPI) (FCI)			24200 16133	25409 16939	25409 16939
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	11	12	12	12
Average rotational delay (msec)	5.56	5.56	8.3	8.3	8.3
Average access time (msec)	16.56	16.56	20.3	20.3	20.3
Data transfer rate (KBytes/sec)	10000 synch. 6000 asynch.	20000 synch.	27000	3000	3000
FIRST CUSTOMER SHIPMENT	2/92	4/92	3Q90	1Q90	2Q90
COMMENTS	*Varies by zone	*Varies by zone Dual port optional	9 head parallel version of Sabre 6		

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEQUEL	SEQUEL	SEQUEL
DRIVE	ST83050K Sabre 7 2HP	ST83220K Sabre 7	XT-1085	806	XT-1120R
DISK/TREND GROUP	9	9	3	4	4
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	130 mm OD 40 mm ID	200 mm OD 63.5 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	Ferrite	Ferrite	Ferrite
Interface	IPI-2	IPI-2	ST412	Priam,SMD,SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 3,050	U: 3,220	U: 85.32	U: 227	U: 127.99*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 127,680	U: 63,840	U: 10,416	U: 20,160	U: 15,624*
Data surfaces per spindle	18	19	8	11	8
Heads per data surface	1	1	1	1	1
Tracks per surface	2655	2655	1024	1023	1024
Track density (TPI)	1912	1912	1070	1040	1070
Maximum linear density (BPI) (FCI)	32202 24151	32202 24151	9934	9167	14901 9934
Recording code	1,7 RLL	1,7 RLL	MFM	MFM	2,7 RLL*
Rotational speed (RPM)	4365	4365	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	27	20	27
Average rotational delay (msec)	6.87	6.87	8.3	8.3	8.3
Average access time (msec)	18.87	18.87	35.3	28.3	35.3
Data transfer rate (KBytes/sec)	9340	4670	625	1210	937.5*
FIRST CUSTOMER SHIPMENT	3/91	1/91	2Q83	5/84	2Q87
COMMENTS	2 head parallel version of Sabre 7				*With RLL controller

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-1140	XT-1240R	XT-2190	XT-4170E	XT-4170S
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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ST412	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 143.42	U: 239.98*	U: 191.23	U: 179.45	F: 157.93
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624*	U: 10,416	U: 20,940	F: 18,432
Data surfaces per spindle	15	15	15	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	918	1024	1224	1224	1224
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI) (FCI)	9280	14901 9934	11155	21064 14043	21064 14043
Recording code	MFM	2,7 RLL*	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	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)	25.8	27	28.9	14	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	34.1	35.3	37.2	22.3	22.3
Data transfer rate (KBytes/sec)	625	937.5*	625	1250	4800 synch.
FIRST CUSTOMER SHIPMENT	2Q83	2Q87	3Q84	2Q87	2/86
COMMENTS		*With RLL controller			

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-4230E	807	XT-4380E	XT-4380S	XT-8380EH
DISK/TREND GROUP	4	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	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	Thin Film	Ferrite	Thin Film	Thin Film	Ferrite
Interface	ESDI	Priam,SMD,SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 230.6	U: 344	U: 384.53	F: 338.41	U: 410.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,940	U: 20,160	U: 20,940	F: 18,432	U: 31,410
Data surfaces per spindle	9	11	15	15	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1552	1224	1224	1632
Track density (TPI)	1070	1040	1070	1070	1376
Maximum linear density (BPI) (FCI)	21064 14042	12096	21064 14043	21064 14043	31596 21064
Recording code	2,7 RLL	MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	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)	16	25	16	16	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	33.3	24.3	24.3	22.8
Data transfer rate (KBytes/sec)	1250	1210	1250	4800 synch.	1875
FIRST CUSTOMER SHIPMENT	3Q90	6/84	2Q87	4Q87	1Q87
COMMENTS					

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	XT-8380SH	XT-8760EH	XT-8760SH	SQ555	SQ5110
DISK/TREND GROUP	6	7	7	1	1
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	SQ400	SQ800
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 360.31	U: 768.9	F: 675.58	--	--
REMOVABLE	--	--	--	F: 44.39	F: 88.8
Capacity per track (Bytes)	F: 27,648	U: 31,410	F: 27,648	F: 17,408	*
Data surfaces per spindle	8	15	15	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	1632	1632	1275	1774
Track density (TPI)	1376	1376	1376	1086	1470
Maximum linear density (BPI) (FCI)	31596 21064	31596 21064	31596 21064	23642 15761	28546 19031
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3220	3220
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)	14.5	16.5	16.5	20	20
Average rotational delay (msec)	8.3	8.3	8.3	9.32	9.32
Average access time (msec)	22.8	24.8	24.8	29.32	29.32
Data transfer rate (KBytes/sec)	4800 synch.	1875	4800 synch.	1250	4000 synch. 1250 asynch.
FIRST CUSTOMER SHIPMENT	1Q88	1Q87	1Q88	1Q88	2/91
COMMENTS				41.3 mm high Removable data cartridge	41.3 mm high Removable data cartridge *Varies by zone

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	SQ1080	SQ3105A	SQ3105S	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	Removable Drive	SQ310	SQ310	SQ400	SQ800
Nominal disk diameter	48 mm OD 12 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	MIG	MIG	Ferrite	Ferrite
Interface	PCMCIA	PC AT	SCSI-2	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 80	F: 110	F: 110	F: 44.39	F: 88.8
Capacity per track (Bytes)	F: 36,864	*	*	F: 17,408	*
Data surfaces per spindle	2	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1463	2043	2043	1275	1774
Track density (TPI)	3200	2100	2100	1086	1475
Maximum linear density (BPI) (FCI)	74200 55700	40000 30000	40000 30000	23642 15761	28546 19031
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	3600	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)	15	14.5	14.5	20	20
Average rotational delay (msec)	5.5	8.3	8.3	9.32	9.32
Average access time (msec)	20.5	22.8	22.8	29.32	29.32
Data transfer rate (KBytes/sec)	10000	4000	4000 synch.	4000 synch. 1250 asynch.	4000 synch. 1250 asynch.
FIRST CUSTOMER SHIPMENT	4Q93	3Q92	3/93	7/91	7/91
COMMENTS	10.5 mm high PCMCIA Type III Removable media cartridge	25.4 mm high 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	SYQUEST TECHNOLOGY	TEAC	TEAC	TOSHIBA	TOSHIBA
DRIVE	SyDOS 105e SyDOS 105i	SD-3250N	SD-3360N	MK-1032FB	MK-1122FC
DISK/TREND GROUP	1	5	5	2	2
MARKET	PCM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	SQ310	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		
Interface	SCSI, IDE	PC AT	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 251.9	F: 362.8	F: 53	F: 43
REMOVABLE	F: 110	--	--	--	--
Capacity per track (Bytes)	*	*	*	F: 19,968	F: 22,016
Data surfaces per spindle	2	4	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	243	1922	3164	1339	977
Track density (TPI)	2100	2048	3155	1850	2000
Maximum linear density (BPI) (FCI)	40000 30000	43100 32325	41822 31366	36080 27060	51891 38918
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3402	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)	14.5	17	17	16	23
Average rotational delay (msec)	8.3	8.3	8.3	8.8	9.4
Average access time (msec)	22.8	25.3	25.3	24.8	32.4
Data transfer rate (KBytes/sec)	4000 synch. 1250 asynch.	10000 synch.	10000 synch.	5000 synch. 1500 asynch.	5000
FIRST CUSTOMER SHIPMENT	7/93	1993	1993	4/91	4/91
COMMENTS	25.4 mm high Removable data cartridge *Varies by zone	12.7 mm high *Varies by zone	12.7 mm high *Varies by zone	25.4 mm high	17 mm high

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-134FA	MK-1422FCV	MK-1522FCV	MK-2124FC	MK-1624FCV
DISK/TREND GROUP	2	3	4	4	5
MARKET	Captive, OEM	OEM	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	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film		Thin Film
Interface	ST412	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 53.4	F: 86	F: 126	F: 130.1	F: 213
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 28,672	*	F: 28,160	F: 28,672
Data surfaces per spindle	7	2	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	733	1501	1840	1155	1857
Track density (TPI)	1000	2910	3528	2360	
Maximum linear density (BPI) (FCI)	13600	69204 52003	66100 49575	65524 49620	
Recording code	MFM	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3200	4000
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)	25	15	15	17	13
Average rotational delay (msec)	8.3	8.3	8.3	9.4	7.5
Average access time (msec)	33.3	23.3	23.3	26.4	20.5
Data transfer rate (KBytes/sec)	625	6500	4000	6500	6500
FIRST CUSTOMER SHIPMENT	3Q87	10/92	7/93	1Q92	12/93
COMMENTS	41.3 mm high	12.7 mm high	12.7 mm high *Varies by zone	19 mm high	12.7 mm high

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-2224FB	MK-2224FC	MK-2326FB	MK-2326FC	MK-2428FB
DISK/TREND GROUP	5	5	6	6	7
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	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	SCSI-2	PC AT	SCSI-2	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 213	F: 213	F: 340	F: 340	F: 520
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	4	6	6	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1560	1560	1830	1830	1920
Track density (TPI)	2840	2840	3528	3528	
Maximum linear density (BPI) (FCI)	70500 52900	70500 52900	62200 46650	62200 46650	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	4000	4200	4200	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	12
Average rotational delay (msec)	7.5	7.5	7.1	7.1	7.5
Average access time (msec)	19.5	19.5	19.1	19.1	19.5
Data transfer rate (KBytes/sec)	10000 synch. 6000 asynch.	4000	10000 synch. 6000 asynch.	4000	10000 synch. 6000 asynch.
FIRST CUSTOMER SHIPMENT	10/92	10/92	3Q93	2Q93	12/93
COMMENTS	19 mm high *Varies by zone	19 mm high *Varies by zone	19 mm high *Varies by zone	19 mm high *Varies by zone	19 mm high *Varies by zone

MANUFACTURER	TOSHIBA	TOSHIBA	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	MK-2428FC	MK-538FB	CU140 Caviar Ultralite	AL2170 Caviar Lite	WDAC1170 Caviar
DISK/TREND GROUP	7	8	2	4	4
MARKET	OEM	Captive, OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Drive on Card	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	48 mm OD 12 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	Thin Film		Thin Film	Thin Film/MIG
Interface	PC AT	SCSI-2	PCMCIA/ATA	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 520	F: 1,200	--	F: 170.6	F: 170.6
REMOVABLE	--	--	F: 42	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	8	15	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1920	1979	1050	1781	2233
Track density (TPI)		2044	3004	2950	2481
Maximum linear density (BPI) (FCI)		48000 36000	54000 40500	53170 39900	55200 41400
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	3600	4503	3600	3322
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)	12	12	19	16	13
Average rotational delay (msec)	7.5	8.3	6.7	8.3	9
Average access time (msec)	19.5	20.3	25.7	24.3	22
Data transfer rate (KBytes/sec)	6000	10000 synch. 5000 asynch.	4500	5000	5750
FIRST CUSTOMER SHIPMENT	12/93	10/92	1Q93	1Q93	4Q92
COMMENTS	19 mm high *Varies by zone	41.3 mm high *Varies by zone	10.5 mm high *Varies by zone PCMCIA Type III	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	WDAC1210 Caviar	WDAC2250 Caviar	WDAC2340 Caviar	WDAC2420 Caviar	WDAC2540 Caviar
DISK/TREND GROUP	5	5	6	6	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film/MIG	Thin Film/MIG	Thin Film/MIG	Thin Film/MIG	Thin Film/MIG
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 212.6	F: 255.9	F: 341.3	F: 425.3	F: 540.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	2	3	4	4	4
Heads per data surface	1	1	1	1	2
Tracks per surface	2720	2233	2233	2720	3132
Track density (TPI)	2985	2481	2481	2985	3300
Maximum linear density (BPI) (FCI)	56500 42400	55200 41400	55200 41400	56500 42400	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3314	3322	3322	3314	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	13	13	13	13
Average rotational delay (msec)	9	9	9	9	6.67
Average access time (msec)	22	22	22	22	19.67
Data transfer rate (KBytes/sec)	5750	5750	5750	5750	5750
FIRST CUSTOMER SHIPMENT	2Q93	4Q92	3Q92	1Q93	9/93
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	25.4 mm high *Varies by zone

MANUFACTURER	WINTEC TECNOLOGIA S.A.	XEBEC	XEBEC	XEBEC	XEBEC
DRIVE	WD-40/A	XE-3080	XE-3100	XE-3120	XE-3245A
DISK/TREND GROUP	2	3	4	4	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	PC AT, IDE	PC AT, IDE	PC AT, IDE	PC AT, IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43.24	F: 80	F: 105.2	F: 120.6	F: 245.06
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	*	*	*	F: 31,744
Data surfaces per spindle	4	4	6	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	782	820	820	820	1930
Track density (TPI)	1021				2400
Maximum linear density (BPI) (FCI)	22175 14783	33455 22303	29093 19395	33455 22303	54777 41083
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3329	3662	3662	3662	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Open Loop	Open Loop	Embedded
Average positioning time (msec)	28	19 (including settling)	19 (including settling)	19 (including settling)	13
Average rotational delay (msec)	9	8.2	8.1	8.2	8.3
Average access time (msec)	37	27.2	27.1	27.2	21.3
Data transfer rate (KBytes/sec)	640	4500	1800	4500	4000
FIRST CUSTOMER SHIPMENT	1990	9/92	2Q91	4Q91	3Q93
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	25.4 mm high

MANUFACTURER	XEBEC	ZENTEK	ZENTEK	ZENTEK	
DRIVE	XE-3245S	ZM 3140	ZQ 2140	ZM 3260 ZM 3260A	
DISK/TREND GROUP	5	4	4	5	
MARKET	OEM, PCM	OEM	OEM	OEM	
MEDIA: Generic type	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	
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	
Interface	SCSI	PC AT	PC AT	PC AT	
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245.06	F: 120	F: 124	F: 242.2	
REMOVABLE	--	--	--	--	
Capacity per track (Bytes)	F: 31,744	F: 20,680	F: 17,408	F: 31,000	
Data surfaces per spindle	4	4	4	4	
Heads per data surface	1	1	1	1	
Tracks per surface	1930	1560	935	2000	
Track density (TPI)	2400	1850	1300	2500	
Maximum linear density (BPI) (FCI)	54777 41083	36000 24000	27500 18333	46666 32000	
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	
Rotational speed (RPM)	3600	3393	3600	3600	
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	
Servo type	Embedded	Embedded	Embedded	Embedded	
Average positioning time (msec)	13	14	18	12	
Average rotational delay (msec)	8.3	8.8	8.3	8.3	
Average access time (msec)	21.3	22.8	26.3	20.3	
Data transfer rate (KBytes/sec)	1500 asynch.	1200	4500	1200	
FIRST CUSTOMER SHIPMENT	3Q93	1Q93	2Q93	2Q93	
COMMENTS	25.4 mm high	25.4 mm high	19 mm high	25.4 mm high ZM 3260A is cost reduced version	

MANUFACTURER PROFILES

1993 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 "1992 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. "1992 total net sales" covers the fiscal year ending December 31, 1992, 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 1992 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	6781.0
France	Franc	5.29
Germany	Deutschmark	1.56
Italy	Lira	1232.0
Japan	Yen	127.0
South Korea	Won	785.0
Taiwan	Dollar	25.2
United Kingdom	Pound	0.568

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

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

Areal Technology was founded in February, 1988 by Jack Swartz, an industry veteran and cofounder of Maxtor. The initial target was development of a 3.5" single disk 105 megabyte drive for production start in 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, with the current product line of 2.5" drives covering the range from 85 to 260 megabytes.

AURA ASSOCIATES
2605 South Winchester Boulevard
Campbell, CA 95008

Aura Associates, founded by industry veterans in mid-1986, initially planned to develop a 2.5" drive using multiple actuators and offering very fast access time and transfer rate. An early model of the drive was demonstrated at the 1988 Fall Comdex, but was never produced. More recently, Aura designed 1.8" drives which are now in production by NEC, but for which Aura also retains manufacturing and sales rights. The company has also 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.

AVATAR SYSTEMS CORPORATION
1455 McCarthy Boulevard
Milpitas, CA 95035

Avatar was founded in 1991 by John Bizjak, a veteran of several pioneering disk drive programs, to develop high capacity disk cartridge drives. The company started production of an 85 megabyte 2.5" disk cartridge drive in mid-1993, using glass disks, and intended for portable and desktop applications. Drive development will be centered in Milpitas, with manufacturing in Asia.

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, but was unable to compete effectively at modest production levels and stopped production in 1992.

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

1992 disk sales: $2,234,200,000
1992 total net sales: $2,238,423,000 Net income: $121,072,000

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. 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.

In December, 1992, Conner acquired Archive Corporation, a leading tape drive manufacturer, and undertook a difficult integration of the two organizations. Archive's products have all been renamed with the Conner logo, and include, in addition to tape drives, the software products group, offering storage management software, the storage systems group, offering a variety of tape and disk aftermarket products, and the distribution products group, selling storage products through large scale retailers and a network of commercial and industrial distributors.

While Conner Peripherals has indicated its desire to concentrate upon drive assembly rather than become vertically integrated, the firm has made acquisitions of what it believes are key technologies, including the sputtered disk production facilities of bankrupt Domain Technology, now being expanded with two new sputtering lines, and the 1991 purchase of VISqUS Corporation, a development firm working on a method of near-contact recording using a continuous lubrication technique. Conner has sold off its head stack assembly operation.

Because of the firm's early entrance into the 2.5" market, combined with the ability to deliver large quantities of drives, Conner secured a major share of the market for hard disk drives in the notebook computer market in 1991, but later slowed its development efforts for 2.5" drives and relinquished market leadership. Conner subsequently purchased many of the patents developed by Prairietek for its 2.5" drives. After a period of delayed product development for its core product lines, coupled with an intense industry price war, Conner suffered reduced revenue and significant losses in the first half of 1993. The firm has announced plans for dropping older products and an active product introduction program for the second half of 1993.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1992 disk sales: $886,900,000
1993 total net sales: $14,371,269,000 (FY ending 7/03/93) Net income: ($251,330,000)

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 also out of production. In recent years Digital has also been a major customer for OEM 5.25" and 3.5" SCSI drives for use with its engineering workstations and personal computers.

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 high-end 5.25" drives have been produced at Digital's manufacturing facility in Kaufbeuren, Germany, which the company announced in 1993 will be closed, in favor of a new manufacturing capability to be established in Asia. The high-end 3.5" 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" and 3.5", with reorganized management and manufacturing organizations, and utilizing vertical integration in production of critical components. While there was initially skepticism concerning Digital's viability as an OEM supplier, Digital has established a position as a major OEM supplier of 1 and 2 gigabyte 3.5" drives, plus 5.25" drives up to 4 gigabytes.

DMA TECHNOLOGIES
95 South La Patera
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.

GIGASTORAGE TECHNOLOGY, INC.
12930 Saratoga Avenue
Saratoga, CA 95070

Gigastorage is the latest reincarnation of high-end 5.25" drive designs originally undertaken at Priam, later purchased from the bankruptcy court by Orca, then subsequently purchased from the Orca bankruptcy by a combination of disk drive industry veterans and German investors. The disk drives are being assembled in Germany and as of late 1993 consist of 1.2 and 2.5 gigabyte models.

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

1992 disk sales: $519,400,000
1992 total net sales: $16,410,000,000 (FY ending 10/31/92) Net income: $549,000,000

Hewlett-Packard has an extensive manufacturing operation for disk drives at Boise, Idaho, established in 1977, supplemented in mid-1983 with a facility in Bristol, England. H-P has made disk cartridge, disk pack, and fixed Winchester disk drives at Boise. In 1987, the company launched an OEM sales program for rigid disk drives, spearheaded by new 5.25" models. In 1989, H-P startled the industry by announcing 150,000 hour MTBF and a five year warranty for its 5.25" drives, an action which substantially improved H-P's visibility in the OEM market. The MTBF specification on the newest high end drives has been extended to 300,000 hours. The OEM disk drive program has proved to be successful for H-P, and the product line has been expanded to include both 5.25" and 3.5" drives with capacities over 2 gigabytes. H-P's credentials as an OEM disk drive producer were significantly enhanced with its announcement of the pioneering 1.3" drive in 1992. The original 21 megabyte "Kittyhawk" drive has been supplemented with a 42 megabyte model, and a contract manufacturing arrangement has been established with Citizen Watch. The Kittyhawk's market has been slow to take off, and may depend upon the potential future sales of personal digital assistants, personal communicators, pen based computers and other mobile computing developments.

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 85 megabyte models in production since mid-1992. The existing 1.8" drives use ramp loaded MIG heads, and are designed to high operating shock and vibration specifications, with low power requirements, in anticipation of wide usage in subnotebook computers and other portable computer applications. Integral began its high volume manufacturing in Singapore in mid-1992. A 105 megabyte PCMCIA Type III drive has been announced for late 1993 availability, and a 170 megabyte version has been promised for mid-1994.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1992 disk sales: $9,373,700,000
1992 total net sales: $64,523,000,000 Net income: ($4,965,000,000)

IBM shipped the world's first moving head disk drive in 1956, and the company has provided a large share of the industry's advanced technology during the following 37 years. Until the end of the 1970's, most of IBM's product designs were routinely copied by the rest of the industry. However, the advent of personal computers and engineering workstations intensified the development race and inspired the appearance of dozens of new disk drive manufacturers intent upon producing smaller drives, using new interfaces and exploring new marketing approaches.

After a flurry of activity during the first half of the 1980's resulted in various 14", 8", 5.25" and 3.5" drives without much distinction, IBM since 1989 has introduced several drives which place it in the first tier of mid-range and low-end disk drive manufacturers. These include the Lightning/Turbo/Corsair/Allicat series of full size 3.5" drives with capacities up to 2 gigabytes and the Spitfire 1" high 3.5" drives with capacities up to 1 gigabyte. Several generations of drives developed at the Fujisawa plant have now matched the industry's current standards for personal computers, with 1" high 3.5" offering up to 340 megabytes on 2 platters and 2.5" drives using 2 disks with MR heads to provide 340 megabytes. After taking 5.25" drives up to 1.5 gigabytes in capacity, IBM has stopped 5.25" development, in favor of smaller disk diameter drives.

The 1993 introduction of the 3390-9, offering 17 gigabytes per spindle with comparatively low prices for mainframe disk drives, but at the expense of slow performance, is probably a short-lived product. It will be impacted by the advent of new generations of disk subsystems and arrays, probably in the first quarter of 1994, using new families of small diameter disk drives. IBM plans significant improvements for 1994, using both 3.5" and 2.5" disk formats. The Scorpio, a 1" high 3.5" drive family with 1, 2 and 3 disk versions offering up to 2.2 gigabytes capacity, is due for high volume production starting in early 1994. Later in 1994 IBM will also start production of the Starfire, with 4.4 gigabytes in a full size 3.5" drive. The Skyhawk 2.5" 1 gigabyte drive is also scheduled for production in 1994.

IBM manufactures 10.8", 5.25", 3.5" and 2.5" fixed disk drives at several factories in the United States, Europe and Japan, but major changes are under way. The original San Jose facility is converting manufacturing space to make 3.5" and smaller drives in addition to the 10.8" 3390 series. Fujisawa (Japan) is reducing staffing levels and transferring a significant portion of its manufacturing activities to a contract manufacturing organization in Thailand. Mainz (Germany), traditionally the internal IBM second source for mainframe drives, is reorganizing to make smaller drives. The Havant (U.K.) plant is scrambling to maintain its disk

drive manufacturing role and has announced a contract manufacturing deal to make the Western Digital disk drive product line.

IBM's first significant OEM sales of disk drives were made in 1984, when the firm began selling the 3380 to both Siemens and Honeywell. Some low-end 3.5" drives with Microchannel interfaces were also sold to European system manufacturers who chose to offer personal computer models with the Microchannel bus. For disk drives broadly sold on an OEM basis, it was more difficult for IBM to establish significant sales, due to tough competition. Despite the difficulties, IBM has had 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 is selling the 1 gigabyte Corsair and Spitfire drives, plus the 2 gigabyte Allicat, to numerous subsystem and system manufacturers on an OEM basis.

IBM has been confused as to how to label all of this activity. After changing from more than 20 years of "General Products Division" to "Storage Systems Products Division" (which also included the separate "Low End Disk Operations') in 1990, the name became "AdStaR" in early 1992 -- with the general plan to establish the entity as a separate, wholly owned IBM subsidiary. However, with new corporate management and a new spirit of corporate togetherness, the AdStaR name and the separate subsidiary status are being quietly abandoned, in favor of the still tentative title of "Storage Systems Division".

KALOK CORPORATION
1287 Anvilwood Avenue
Sunnyvale, CA 94089

Kalok was founded in 1987 by Wayne Lockhart and Steve Kaczeus, a well-known designer of low-end disk drives, 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" high 250 megabyte 3.5" drive. After a series of management changes, a Chapter 11 filing, and negotiation of contract manufacturing arrangements with Teac in Japan and DZU in Bulgaria, Kalok is now actively selling a removable version of the .5" high drive.

MAXTOR CORPORATION
150 River Oaks Parkway
San Jose, CA 95134

1992 disk sales: $1,299,900,000
1993 total net sales: $1,442,546,000 Net income: $46,112,000
(FY ending 3/27/93)

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

Maxtor maintained its place in the spotlight by announcing a 760 megabyte 5.25" drive, with first shipments in 1987. A 3.5" drive with 200 megabyte capacity was announced in 1988, along with a magneto-optical 5.25" drive produced by a joint venture with Kubota, maintaining the Maxtor role as a leading edge supplier of OEM disk drives. In 1990, Maxtor acquired the Miniscribe product line and manufacturing facilities, providing the firm with a 1" high 3.5" drive product line and a 2.5" 85 megabyte drive that was ready to be announced.

Starting with the departure of several key employees in 1987, a succession of management changes, combined with the numerous internal changes which followed, disrupted Maxtor's ability to continue the pioneering product development activities upon which most of the company's growth was based. Most of the 5.25" drives are in an end of life phase and have been sold to Sequel. The high-end 3.5" drive program arrived late in the market and is poor competition for the new 1" high 3.5" drives from several manufacturers. Most of Maxtor's revenues are now derived from 3.5" drives sold for personal computer applications. Maxtor is the first major disk drive manufacturer to launch a major effort to develop products for the 1.8" drive market and is hoping for significant market growth in 1994.

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 responsibili-

ty for the entire company in the Memorex organization. In late 1986, however, Burroughs sold the plug compatible 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. In 1993, the company is phasing out of new disk drive installations in the mainframe market. 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 "prepackaged 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

1992 disk sales: $382,100,000
1992 total net sales: $396,579,000 Net income: $19,557,000

Known as the originator of what were then considered high capacity 5.25" flexible disk drives, Micropolis started production of 8" Winchester disk drives in 1979 and became a factor in the marketplace, after the usual Winchester early production problems. Micropolis was the 5.25" industry leader at 85 megabytes and 170 megabytes, and a close contender for leadership at 380 megabytes, 760 megabytes, and the 1-2 gigabyte range. 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 array market in late 1991, creating a separate division to market a modular array in the subsystem market.

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 started production of 32 and 64 megabyte 1.8" drives in late 1992. Despite management changes and a skeptical venture capital market, the firm has managed to acquire the necessary resources to continue its program, establish manufacturing in Singapore, and now offers 1.8" drives up to 128 megabytes. In September, 1993, MiniStor and Hitachi announced agreements under which MiniStor will license Hitachi to utilize the firm's 1.8" drive technology and the two companies will jointly develop a new family of high capacity 2.5" disk drives.

QUANTUM CORPORATION
500 McCarthy Boulevard
Milpitas, CA 95035

1992 disk sales: $1,529,100,000
1993 total net sales: $1,697,240,000 (FY ending 3/31/93) Net income: $93,811,000

Quantum's original product strategy was to manufacture an upgrade to the Shugart Associates 8" Winchester drives. The Quantum plan worked well, and 5.25" drives with capacities up to 40 megabytes were added in 1983, becoming the company's major product. As the Quantum full-size 40 megabyte 5.25" drives peaked, the firm announced half high OEM 5.25" drives with up to 80 megabytes 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 facility in California. MKE has established a factory in Dundalk, Ireland, to manufacture Quantum drives for the European market, with production since October, 1992. The Quantum-MKE relationship is successful and has contributed to gross margins typically higher than the industry averages until the price wars of 1993.

In August, 1993, Quantum formed separate operating groups for high capacity storage, to manage the development, production and marketing of the high-end 3.5" drives manufactured at Milpitas, and desktop and portable storage, to manage the development and marketing of drives manufactured by MKE. After a period of evolving organizational changes, the previously separate Plus Development program and various industrial distribution activities have now been folded into the new operating groups. With product announcements in the Autumn of 1993, the Quantum product line has been updated with 2 platter 3.5" drives for the desktop PC market with 342 and 541 megabyte capacities, plus 1 gigabyte 1" high and 1.8 gigabyte full size 3.5" drives.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1992 disk sales: $2,916,600,000
1993 total net sales: $3,043,604,000 (FY ending 7/2/93) Net income: $195,434,000

In 1981, Seagate shipped two thirds of the 5.25" drives produced worldwide, with 35,000 units -- and another de facto standard was created. Seagate took the lead in moving production for its high volume drives offshore to secure lower manufacturing costs. But the world changed for Seagate in mid-1984, with a sharp reduction in sales to its largest customer, IBM -- and an up-and-down

buying pattern which continued in 1985. Through tough management, Seagate stayed profitable, rebuilt its revenues, and starting in 1986 became the worldwide leader in OEM disk drive revenues.

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

In October, 1989, Seagate completed an agreement with Control Data to acquire Imprimis Technology in a deal valued at $450 million. There was little overlap between the product lines of Seagate and Imprimis, or between Seagate's predominantly aftermarket distribution and Imprimis' predominantly OEM sales. In late 1991, the company made key changes in executive management in an attempt to reassert product leadership and has been successful in establishing an aggressive product development program. The new Seagate has maintained an aggressive pace of product development and market leadership with the high end 5.25" and 3.5" drives developed at the Oklahoma and Minneapolis operations. But because its lower capacity 5.25" drives were fading fast, and in order to improve penetration of the OEM market for its small diameter products, Seagate undertook a "time to market strategy" to catch up with the industry leaders in the 2.5" and low end 3.5" markets. High-end full size 3.5" drives in both 5,400 and 7,200 RPM models offer capacities up to 2.1 gigabytes. 1" high 3.5" drives at the 1 gigabyte level went into production in the first half of 1993. The Elite 5.25" drive series is being extended in late 1993 to 9 gigabytes, with an extremely competitive price per megabyte.

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 most of Maxtor's older 5.25" drives.

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

1992 total net sales: $1,056,965,000 Net income: $15,494,000

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 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 were strong, and were 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 currently incorporates array hardware and software from Array Technology, which is resold by a Storage Technology subsidiary. The high-end "Iceberg" array project, using purchased 5.25" drives, was to be available in the first half of 1992, but suffered several slips and the company now plans to install "beta" test sites in late 1993. In the meantime, STC has announced the acquisition of Amperif, including yet another disk drive array program intended for 1994 introduction in the IBM mainframe market.

SYQUEST TECHNOLOGY
47071 Bayside Parkway
Fremont, CA 94538

1992 disk sales: $75,100,000
1992 total net sales: $174,852,000 Net income: $13,583,000

SyQuest was started in early 1982 to make disk drives using 3.9" (100 mm) plated disks, in both fixed and removable disk configurations. After initial early emphasis on the personal computer aftermarket, SyQuest established significant OEM sales, with major shipments to the segment of the PC market controlled by governmental security requirements. The firm 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, and with

its 5.25" disk cartridges eventually becoming the dominant "prepress" interchange standard for graphics and desktop publishing. In early 1991, SyQuest began shipping an 88 megabyte 5.25" removable drive, which is now the firm's major product. A 3.5" disk cartridge drive program resulted in first shipments of a 105 megabyte drive in 1993, and a unique 1.8" drive is being introduced in late 1993, utilizing a disk cartridge which is removable from a PCMCIA Type III disk drive. In 1989, Syquest began operations in Singapore. SyQuest also manufactures the disk cartridges for the drives, and cartridges accounted for a majority of the firm's revenue.

WESTERN DIGITAL CORPORATION
8105 Irvine Center Drive
Irvine, CA 92718

1992 disk sales: $941,300,000
1993 total net sales: $1,225,231,000 (FY ending 6/30/93) Net income: ($25,108,000)

Western Digital, a major supplier of controllers and specialized semiconductor components, entered the rigid disk drive market by purchasing the rigid disk drive operations of Tandon at the end of 1987. Western Digital plans to be a broad-line disk drive producer, and maintains a disk drive development facility in San Jose. The company has aggressively moved from heavy dependence on aftermarket distribution with the original product line purchased from Tandon to a primary emphasis on OEM sales. WD's early development and shipment of a two platter 340 megabyte 3.5" drive in the first half of 1992 boosted the firm's share of the personal computer disk drive market, and impacted the product development plans of most competitors. Western Digital's 3.5" product line has since been enhanced with 425 and 540 megabyte versions of the same 2 disk design, plus a single disk model, all shipped long before competitive products.

The company has passed through a difficult period of several losing quarters and has undergone significant structural and management changes, and although WD returned to profitability in mid-1992, the impact of the 1993 disk drive price wars resulted in further losses.

Asian Manufacturers

(All fiscal years end in March, 1992, unless otherwise noted. All companies are in Japan unless otherwise noted.)

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

1992 disk sales: $145,800,000
1992 total net sales: $3,632,433,000 Net income: $57,535,000

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 19% 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 now includes a 2 disk 545 megabyte drive, plus a 272 megabyte single platter model.

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 is out of business. 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 Co., Ltd. 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, but Orca's bankruptcy seriously hampered this effort, and production of all disk drives ceased in 1992.

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 has management with extensive Korean disk drive industry experience and in 1993 transitioned to a 1" high 120 megabyte 3.5" drive.

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

1992 total net sales: $7,160,299,000 Net income: $132,047,000

Fuji Electric was established in 1923 and is the firm from which Fujitsu was born in 1935. Fuji Electric still owns 13.4% of Fujitsu (which owns 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. Fuji Electric's disk drive products currently include 2.5" drives with up to 105 megabytes capacity and 1" high 3.5" drives with up to 250 megabytes. In 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

1992 disk sales: $1,588,700,000
1992 total net sales: $27,101,945,000 Net income: $96,142,000

Fujitsu derives about 73% 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 participant in the IBM plug compatible disk drive market through Amdahl, with sales first of 10.5" drives, now with 8" models, and in the future with new 5.25" drives. Particularly effective in the OEM market was the series of high performance 8" 48/84/168/337/690/824/1000/2000/2600 megabyte drives. Fujitsu's 5.25" product line now extends to 2 gigabytes, and an extensive 3.5" line ranges from 25 megabytes to 1 gigabyte. A 240 megabyte 2.5" drive was added in 1993. 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 up to 105 megabytes were announced, but production never ramped up and the firm subsequently shut down operations.

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

1992 disk sales: $1,247,800,000
1992 total net sales: $61,146,024,000 Net income: $1,004,811,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. 47% of the company's sales are in equipment for information systems. The firm currently makes a wide range of Winchester technology fixed disk drives for both captive and noncaptive markets.

In addition to significant OEM sales of smaller capacity fixed disk drives, Hitachi also sells IBM compatible 3380/3390 equivalent drives through Hitachi Data Systems (formerly National Advanced Systems, before acquisition by Hitachi), and in 1983 started selling PCM drives for distribution in the European PCM market through BASF, and currently through Comparex. Hitachi was the first independent disk drive supplier to ship a double capacity drive equivalent to the IBM 3380E, and was an early supplier of 3380K equivalent drives. 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, plus new 6.5" drives announced in 1993. In the spring of 1987, Hitachi began shipping rigid disk drives from a manufacturing facility in Norman, Oklahoma, which makes high-end rigid disk drives and 5.25" optical disk drives. In September, 1993, MiniStor and Hitachi announced agreements under which MiniStor will license Hitachi to utilize the firm's 1.8" drive technology and the two companies will jointly develop a new family of high capacity 2.5" disk drives.

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

1992 total net sales: $6,603,393,000 Net income $15,669,000

JVC's revenues are generated mostly by consumer electronics products. About 14% of 1992 revenues came from computers and related products. The firm, of which Matsushita Electric has a 52.4% share, has been the beneficiary of sharp growth in the home video recorder market, and consumer electronics now account for 88% of total revenues. Starting in 1984, JVC expanded into software and computer peripherals, initially with 5.25" floppy disk drives, a program since dropped due to small market share and unfavorable exchange rates. 3.5" rigid disk drives were first shipped in 1985, later supplemented with an extensive line of 2.5" drives. In 1993, JVC phased out rigid disk drive production, but continues to manufacture optical disk drives.

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

1992 total net sales: $2,432,228,000 Net income: $67,535,000

During the 1980's Matsushita-Kotobuki Electronics concentrated on production of VCRs on an OEM basis for a number of U.S. consumer electronics manufacturers and distributors, as well as for sale under the Matsushita "Panasonic" brand name. 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 product companies. MKE produces rigid disk drives in Japan and established a subsidiary in Ireland to manufacture Quantum products for the European market.

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

1992 total net sales: $26,324,969,000 Net income: $284,047,000

In addition to being one of Japan's largest electronic and electrical product 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, rigid 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 were produced until a year ago.

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

1992 total net sales: $1,406,669,000 (FY ending 1/31/92) Net income: $22,929,000

Mitsumi is primarily a component manufacturer, but also manufactures CD-ROMs and floppy disk drives (about 21% of 1992 sales) and has had a low-key program to develop 3.5" rigid disk drives. However, the rigid disk drive industry's

product life cycles have been so brief in recent years, the company had difficulty in having appropriate products ready in time for each wave of market demand, and the program has been phased out.

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 of Rodime's R&D facilities in Scotland. The firm is planning to produce some of Rodime's 3.5" disk drive designs and is currently in production of models in the 200 megabyte range.

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

1992 disk sales: $614,800,000
1992 total net sales: $29,715,354,000 Net income: $120,283,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 52% 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 9", 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 3.5" drives have been very strong as a result of NEC's leadership position in the Japanese personal computer market. 3.5" drives have now reached 1.4 gigabytes and 5.25" drives are up to 1.5 gigabytes. 9" drives have now been deemphasized in the OEM market, but are still used with NEC captive disk subsystems. 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.

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

1992 total net sales: $8,011,157,000 Net income: $16,071,000

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 26% 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

1992 total net sales: $7,778,395,000 Net income: $92,327,000

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. startup, and manufactured Comport's 3.5" line of disk drives until Comport went out of business. Samsung's production of disk drives is entirely in 1" high 3.5" models ranging from 120 to 513 megabytes. Samsung maintains an R&D center for disk drive design in San Jose.

TEAC CORPORATION
3-7-3, Naka-cho
Musashino, Tokyo 180

1992 total net sales: $965,331,000 Net income: $16,441,000

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 78% of sales, mostly in floppy disk drives, with TEAC now the worldwide leader in total shipments of 5.25" and 3.5" floppy drives. Shinano Tokki, a subsidiary producing motors for disk drives, was sold in 1989. In 1982, TEAC acquired a manufacturing license from Seagate Technology for its 5.25" 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 in 1989, and later licensed the Kalok .5" high 250 megabyte 3.5" drive design. Teac currently makes the drive on a contract manufacturing basis for Kalok, as well as offering it under its own name.

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

1992 disk sales: $371,900,000
1992 total net sales: $37,184,118,000 Net income: $310,921,000

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 at Toshiba has a history of more than two decades including 14", 8", 5.25", 3.5" and 2.5" disk diameters. Toshiba's presence in the U.S. OEM rigid disk drive market was strongly enhanced when it acquired the OEM disk drive operations of Memorex from Burroughs, and Toshiba has continued to expand its U.S. operations, establishing a design center in Southern California. 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.

In 1992 the company established a San Jose factory to manufacture high-end 3.5" drives originally developed at its design center in Southern California, but after it became clear that the firm's product designs would be eclipsed by the industry leaders, it was announced that the 3.5" San Jose program will be phased out. Despite the company's problems with the high-end 3.5" program, Toshiba has established a very successful 2.5" drive program at its Ome plant near Tokyo, as a result of an aggressive development program which has provided much of the industry's product leadership in 2.5" drives in the last two years. In 1993, the company was the first to produce a single platter 126 megabyte 2.5" drive, plus the first to offer a 340 megabyte 2.5" model, which has since been increased in capacity to 520 megabytes.

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. Xebec still produces the stepping motor products but also has announced a 245 megabyte, 3.5" voice coil disk drive.

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, and has extended the product line to 240 megabytes in a 1" high form factor.

European Manufacturers

CALLUNA TECHNOLOGY LIMITED
Blackwood Road, Eastfield
Glenrothes, Fife KY7 4NP
Scotland

Calluna Technology is a disk drive manufacturing startup founded 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 started production of 85 megabyte drives in the PCMCIA Type III format in mid-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 operated factories with perhaps the highest level of vertical integration to be found anywhere in the disk drive industry, began production of 14", 8" and 5.25" Winchester drives in late 1985. The disintegration of the Eastern Bloc and the movement of all of its old Comecon trading partners to hard currencies as a basis for international trade 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 announced contract manufacturing programs to manufacture head/disk assemblies for 1.8" drives for Aura Associates and to make 3.5" drives for Kalok.

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 with 200 megabytes capacity.

South American Manufacturers

DIGIREDE INFORMATICA LTDA.
Av. Angelica, 2582
01228 Sao Paulo SP
Brazil

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, with key components purchased from Hewlett-Packard, which also supplied much of the manufacturing equipment used by Edisa. As a result of the opening of the Brazilian computer market, Edisa decided to terminate production in 1992.

ELEBRA INFORMATICA
Rua Geraldo Flausino Gomes, 78
04575 Sao Paulo SP
Brazil

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.

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. Other products were licensed from Seagate including 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, and although eventually able to resume disk drive manufacturing at a low level, ceased manufacturing in 1992 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.

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. More recent production includes 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.

DISK/TREND ON DISK

1993 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 1993 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1993 DISK/TREND Report volume.

YOU MAY:

1. Install and use the information on a single computer system, provided that you or the organization by which you are employed has purchased at least one copy of the DISK/TREND report volume associated with the information.
2. Make backup copies of the information for your own use. Such backup copies may be used only on the computer on which the information is installed. You must reproduce the copyright notice on any copies.
3. Reproduce the information, but not the associated programs or documentation, contained in the Product for use within internal documents distributed within the organization by which you are employed.

YOU MAY NOT:

1. Install, or allow the use of, the information on more than a single computer system.
2. Transfer the information through or within a computer network.
3. Distribute the information or any portion thereof in any form outside the organization by which you are employed or modify the information for purposes of distribution.
4. Transfer this license to another party.

AUTOIMPORT

Use of AutoImport is subject to the terms and conditions provided by White Crane Systems, Inc.

Trademarks

Getting started

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

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

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

DISK/TREND ON DISK for the Rigid Disk Drive Report is normally shipped on 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)
   A (Disk drive array 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
   File AT3.WK1 is Disk Drive Array Report Table 3

   The file selected will be loaded as a worksheet. If this is the first time the file has been loaded, you may want to create your own formulas linking the cells of the spreadsheet. See your spreadsheet reference manual for details on numerical manipulations and graphics.

If you don't use AutoImport

If you don't use AutoImport but still want to translate ASCII files to your spreadsheet format, you will have to use spreadsheet tools such as the Lotus 1-2-3 Data Parse commands. They allow the user to convert a table which has been imported in the form of a block of text to a form in which the individual numbers and labels can be manipulated as spreadsheet elements or used to prepare graphics. Let's take Lotus 1-2-3 as an example. Before proceeding, it would be useful to read the Lotus reference manual on this subject if you are not a regular user of the Data Parse commands.

The trickiest and most time-consuming part of using the Data Parse commands is setting up the format line. Several utility files have been provided on the tables disk to make this process easier. These are used with various table formats encountered in the DISK/TREND Reports and correspond with the precomputed masks provided for use with AutoImport:

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	Array Report
MASKA	<-------- Table 1--------->		Tables 1,2	Table 1
	<-------------- Product Group Revenue ------------------>			
	<-------------- Product Group Shipment ------------------>			
MASKB	<-------- Table 2 -------->		Tables 3,4	Table 2
MASKC	Tables 3,4,6,9, 10,11	Tables 3,4	Tables 5 to 12	Tables 3 to 7
MASKD	<-- All Product Group Application Tables ---->			N/A
MASKE	N/A	Drive Height, Track Density, Drive Capacity	Write-Once/ Erasable Analysis	N/A
MASKF	N/A	Applications Summary	N/A	N/A
MASKG	*	Product Group Market Share	*	*
MASKH	Tables 7,8	N/A	N/A	N/A
MASKI	Product Group Price/Megabyte	N/A	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	1993 Rigid Report	1992 Flexible Report	1993 Optical Report	1993 Array Report
1	MASKA	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA	MASKB
3	MASKC	MASKC	MASKB	MASKC
4	MASKC	MASKC	MASKB	MASKC
5	MASKC	--	MASKC	MASKC
6	MASKC	--	MASKC	MASKC
7	MASKH	MASKF	MASKC	MASKC
8	MASKH	MASKA	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKE	MASKC	MASKA
11	MASKC	MASKD	MASKC	MASKA
12	--	MASKG	MASKC	--
13	--	MASKA	--	--
14	MASKA	MASKA	--	--
15	MASKA	MASKE	--	MASKA
16	--	MASKE	--	MASKA
17	--	MASKD	MASKA	--
18	MASKD	MASKG	MASKA	--
19	MASKI	MASKA	--	--
20	--	MASKA	--	MASKA
21	MASKA	--	MASKD	MASKA
22	MASKA	--	--	--
23	--	MASKE	MASKA	--
24	--	MASKE	MASKA	--
25	MASKD	MASKD	--	MASKA
26	MASKI	MASKG	--	MASKA
27	--	MASKA	--	--
28	MASKA	MASKA	--	--
29	MASKA	--	MASKE	--
30	--	--	MASKD	
31	--	MASKD	--	
32	MASKD	MASKG	MASKA	
33	MASKI		MASKA	
34	--		--	
35	MASKA		--	
36	MASKA		MASKD	
37	--		MASKA	
38	--		MASKA	
39	MASKD		MASKA	
40	MASKI		MASKA	
41	--		--	
42	MASKA		--	
43	MASKA		MASKE	
44	--		MASKA	
45	--		MASKA	
46	MASKD		--	
47	MASKI		--	

Cross reference (continued)

Table Number	1993 Rigid Report	1992 Flexible Report	1993 Optical Report	1993 Array Report
48	--		MASKE	
49	MASKA		MASKA	
50	MASKA		MASKA	
51	--		--	
52	--		--	
53	MASKD		MASKE	
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 AT20

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: RT4.93R FT12.93F OT14.93O AT19.93A

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, O or A), nn is the table number and yy is the report year.

   Example: RT50.93R

   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)
A (Disk drive array 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: RS193 Rigid disk specification table, Groups 1 to 5
RS293 Rigid disk specification table, Groups 6 to 9
RS393 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 data base is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

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

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

- o There are other 'pop-up' programs resident in the memory of your computer. These should be removed.

- o You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.

- o If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You may have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have 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 RS193 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 RS293 from the specification diskette (or specification diskette 2) using the Lotus command /FCC.

3. Edit the worksheet to remove the header and criteria range areas that were loaded with the second worksheet.

4. Using the data query (/DQ) command, select the new input range so that it covers the entire worksheet area in which there is data. Remember, the column header row must be included in the input range. Quit the DQ menu.

5. Copy the column header row using the /C command to a row 5 to 10 lines below the input range. Using the /DQ command, select the output range. It should include the header row you just established plus as many rows as you would like, and should extend to the last column of data.

6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it to a new file name first so that you can easily reload if you make an unrecoverable alteration.

Saving time

The specification data base is large and takes significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

Another way to save time is to use the SORT capabilities of your spreadsheet to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, and so on.

Make sure that when you save a worksheet using the FILE SAVE command that you save it in a new file name. If you save it in the file name from which it was loaded, the original copy will be overwritten. If a file is overwritten unintentionally, it can take a long time to recreate.

If you are interested in a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and use the second file for analysis. The smaller file will take less time to process.

Special data: The specification data base contains one category of information not present in the hard copy report. This is the country code field, representing the continental region in which the headquarters of the drive producer is located. A key is located at the top of the adjacent column to the right.

All specification files have been prepared as Lotus 1-2-3 spreadsheets set up for data extraction. Criterion, input, and output ranges are predefined.

File RS193.WK1 contains DISK/TREND Product Groups 1 through 5. File RS293.WK1 contains Product Groups 6 through 9. File RS393.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 RS393.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.