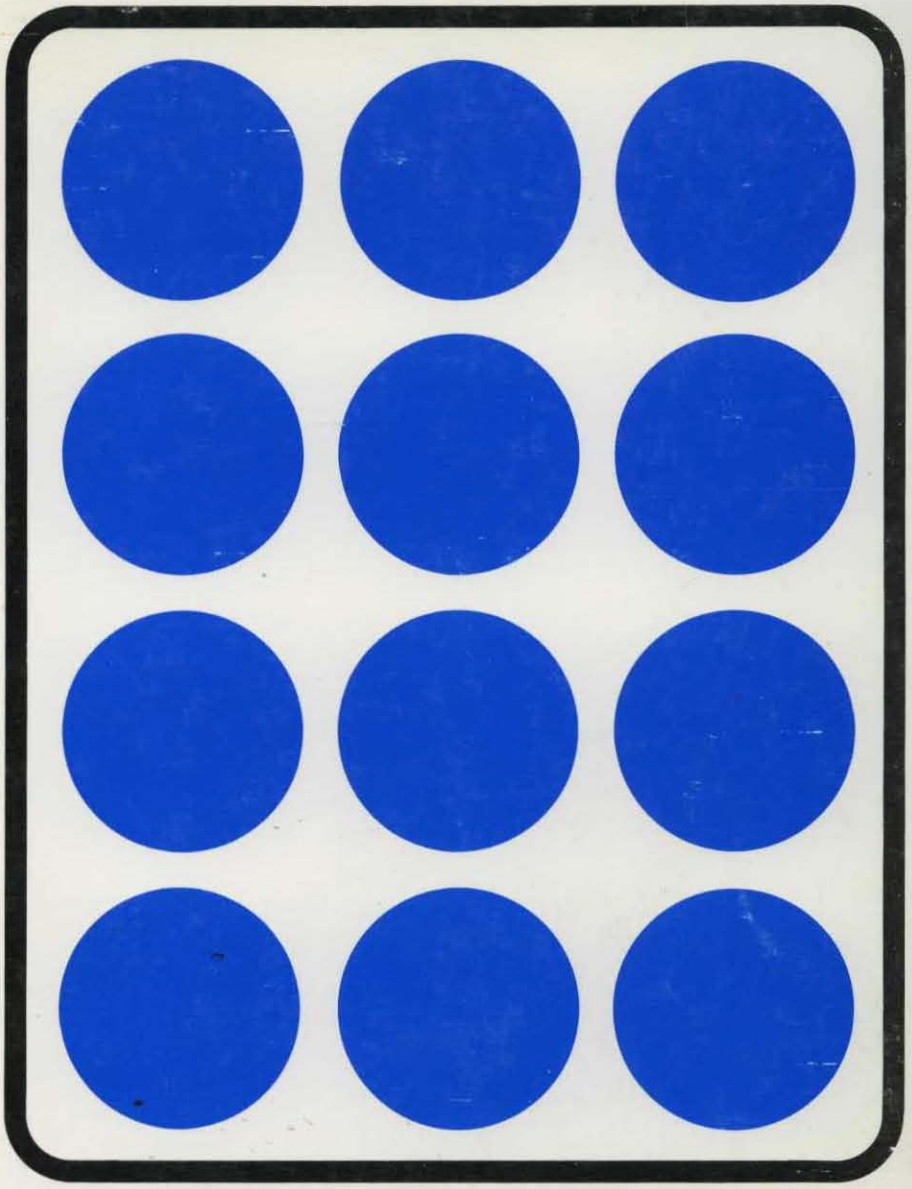
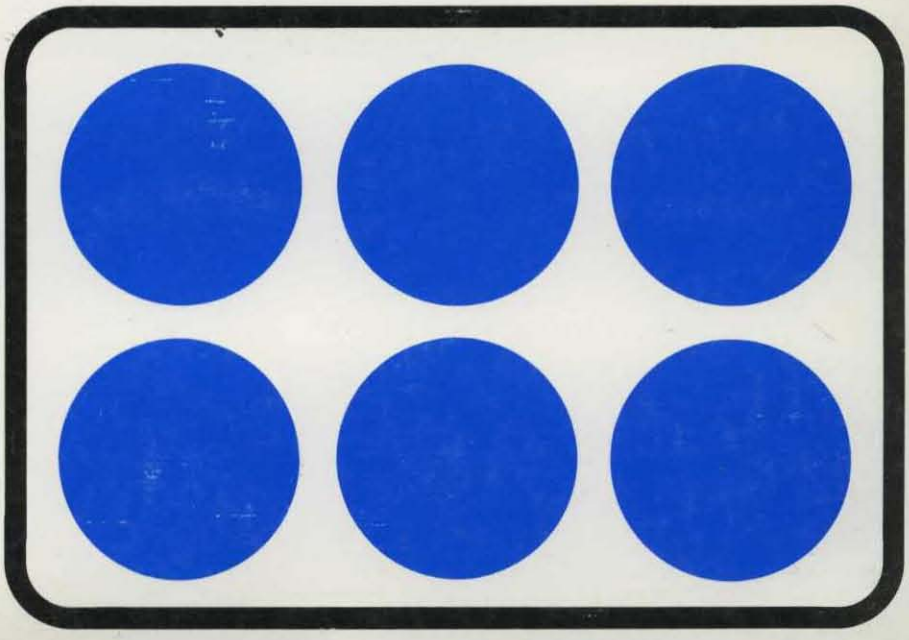


1987 DISK/TREND® REPORT



RIGID DISK DRIVES

1987 DISK/TREND® REPORT

RIGID DISK DRIVES

October, 1987

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

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

FOREWORD

At the peak in 1984, there were 75 participating companies in the rigid disk drive industry. The number is now down to 60 firms, ten less than shown in last year's DISK/TREND Report.

As the industry structure is realigned in the classic patterns which accompany the maturing process, the companies with small market shares, chronic product problems and stale product lines tend to disappear. Contrary to the expectations of many, most U.S. drive manufacturers have been among the survivors. In fact, there are five newly listed U.S. firms in this year's report, while six Japanese companies which are no longer making rigid disk drives have been dropped.

The DISK/TREND Report is now eleven years old, and since last year has been published in three volumes. The report on optical disk drives was published in July, and this report on rigid disk drives will be followed, as usual, with a separate report of flexible disk drives to be released in November.

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

James N. Porter

Robert H. Katzive

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

FIGURES

INTRODUCTION

The DISK/TREND product groups have been changed this year

We do not revise the main groups into which data for this report is organized very frequently, recognizing that many DISK/TREND users employ the same groups in their internal plans, but we have done so this year in recognition of basic changes in the magnitude of some groups.

The removable disk drive groups have been consolidated into only two product groups, due to lower shipment levels. Fixed disk drives over 500 megabytes have been split into two groups, because the revenue generated by high-end drives has become so large. Drives with more than 1 gigabyte capacity have been split into a new product group. Here is the current list of DISK/TREND product groups for rigid disk drives:

1. Disk cartridge drives
2. Disk pack drives
3. Fixed disk drives, less than 30 megabytes
4. Fixed disk drives, 30-100 megabytes
5. Fixed disk drives, 100-300 megabytes
6. Fixed disk drives, 300-500 megabytes
7. Fixed disk drives, 500 megabytes - 1 gigabyte
8. Fixed disk drives, more than 1 gigabyte

This information will help you use the report

* All unit totals are given in spindles. A disk drive containing two spindles is counted in DISK/TREND statistics as two spindles.

* Prices for most OEM drives sold in the United States are shown, usually at the 100 unit level. When prices for higher quantities have been used, the applicable quantity is shown in parentheses. Please remember that prices may be changed without notice by the manufacturers.

SUMMARY: RIGID MAGNETIC DISK DRIVES

Industry size

Although the label of "mature industry" is hardly fitting for any human activity as volatile as the disk drive industry, the outlook for growth in total revenues has settled down to a steadier pattern than in the past decade, but at a lower level. 1987 worldwide revenues are expected to increase 23.2%, to $18.1 billion, reflecting a recovery from two years of very modest increases -- but the next three years are expected to average only 13.7% in revenue increase.

After a 12% growth year in 1986 (reflecting a revision in DISK/TREND estimates of previous IBM sales), IBM's disk drive revenues are expected be up over 20% in 1987, reaching $7.7 billion. But product mix changes are expected to hold growth in IBM's 1988 revenues to 4.3%, before moving up again to the 15% to 18% range. Other captive producers will also have an up and down growth pattern due to product changes, but worldwide revenues will range only from $3.8 billion in 1986 to $6.7 billion in 1990.

Revenues for plug compatible drives are also following a seesaw pattern, as PCM vendors struggle with the classic problem of reacting quickly to IBM's product changes. 1990's PCM revenue forecast is almost $1 billion, but with completely different products from those of 1986.

Current growth in worldwide revenues for OEM drives is strong -- up 26.4% in 1986, plus an estimated 39.2% for 1987. Total OEM revenues were $3.8 billion in 1986, going to $8 billion in 1990, reflecting the product line diversity and development leadership demonstrated by the large number of OEM disk drive manufacturers active in today's industry.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

ALL EXISTING MOVING HEAD DISK DRIVE GROUPS

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986		Forecast							
	Revenues		1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	3,810.3	6,412.0	4,791.9	7,707.0	4,987.9	8,039.2	5,865.2	9,313.3	6,815.3	10,943.7
Other U.S. Captive	1,123.8	1,902.8	1,355.0	2,059.3	1,808.9	2,649.3	2,212.9	3,300.8	2,436.1	3,646.0
TOTAL U.S. CAPTIVE	4,934.1	8,314.8	6,146.9	9,766.3	6,796.8	10,688.5	8,078.1	12,614.1	9,251.4	14,589.7
PCM	118.2	161.9	212.5	289.1	227.9	301.9	316.8	422.4	365.2	486.1
OEM	1,958.7	2,490.3	2,879.1	3,611.2	3,718.1	4,614.8	4,076.4	5,131.1	4,056.1	5,232.5
TOTAL U.S. NON-CAPTIVE	2,076.9	2,652.2	3,091.6	3,900.3	3,946.0	4,916.7	4,393.2	5,553.5	4,421.3	5,718.6
TOTAL U.S. REVENUES	7,011.0	10,967.0	9,238.5	13,666.6	10,742.8	15,605.2	12,471.3	18,167.6	13,672.7	20,308.3
Non-U.S. Manufacturers										
Captive	133.5	1,953.4	207.4	2,274.6	244.4	2,651.7	303.7	2,827.5	321.9	3,099.4
PCM	203.9	465.7	222.2	481.7	205.2	427.7	271.0	492.8	288.2	490.6
OEM	563.4	1,371.3	723.3	1,762.9	1,023.2	2,200.3	1,209.6	2,653.2	1,259.0	2,830.8
TOTAL NON-U.S. REVENUES	900.8	3,790.4	1,152.9	4,519.2	1,472.8	5,279.7	1,784.3	5,973.5	1,869.1	6,420.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	7,911.8	14,757.4	10,391.4	18,185.8	12,215.6	20,884.9	14,255.6	24,141.1	15,541.8	26,729.1

Marketing channels

Shrinkage in the list of rigid disk drive manufacturers is now very noticable, with ten fewer companies listed in this year's edition of the DISK/TREND Report. The worldwide total is now 60 firms in production or with announced products. The group of 34 U.S. companies is still the largest, but it contains numerous changes, representing acquisitions, departures from the industry and company closings -- plus five newly listed drive manufacturers.

The list of 18 Asian manufacturers has also seen many changes since last year. Five Japanese companies have stopped making rigid disk drives because of small market shares and exchange rate pressures, and a joint venture firm has been dissolved -- while only two manufacturers have been added. Two European manufacturers have also stopped producing rigid disk drives.

An understanding of the relative price levels of captive, PCM and OEM drives is important in interpreting DISK/TREND revenue statistics, to avoid an exaggerated impression of the share of the industry's total unit shipments held by captive drives. An approximation of the OEM value of typical captive drives can be obtained by dividing captive revenues for most types of drives by a factor of 4 to 5.

Users of the DISK/TREND Report should note that revenues are reported at the level of each drive's first public sale. The price used for each drive is the estimated value at the first time it is sold to a non-affiliated buyer, at captive end user, PCM or OEM levels. Prices are based on disk drives alone, without controllers or other accessories, and leased drives are valued at the price they would command if actually sold.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES

MARKET CLASS REVIEW
REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1986 Revenues $M	1986 Revenues %	Forecast 1987 $M	1987 %	1988 $M	1988 %	1989 $M	1989 %	1990 $M	1990 %
U.S. Manufacturers										
IBM Captive	6,412.0 +12.6%	43.4%	7,707.0 +20.2%	42.3%	8,039.2 +4.3%	38.4%	9,313.3 +15.8%	38.5%	10,943.7 +17.5%	40.9%
Other U.S. Captive	1,902.8 -1.8%	12.8%	2,059.3 +8.2%	11.3%	2,649.3 +28.7%	12.6%	3,300.8 +24.6%	13.6%	3,646.0 +10.5%	13.6%
PCM	161.9 -14.9%	1.0%	289.1 +78.6%	1.5%	301.9 +4.4%	1.4%	422.4 +39.9%	1.7%	486.1 +15.1%	1.8%
OEM	2,490.3 +30.5%	16.8%	3,611.2 +45.0%	19.8%	4,614.8 +27.8%	22.0%	5,131.1 +11.2%	21.2%	5,232.5 +2.0%	19.5%
Total U.S. Manufacturers	10,967.0 +12.7%	74.0%	13,666.6 +24.6%	74.9%	15,605.2 +14.2%	74.4%	18,167.6 +16.4%	75.0%	20,308.3 +11.8%	75.8%
Non-U.S. Manufacturers										
Captive	1,953.4 +16.1%	13.2%	2,274.6 +16.4%	12.5%	2,651.7 +16.6%	12.6%	2,827.5 +6.6%	11.7%	3,099.4 +9.6%	11.5%
PCM	465.7 -6.7%	3.1%	481.7 +3.4%	2.6%	427.7 -11.2%	2.0%	492.8 +15.2%	2.0%	490.6 -.4%	1.8%
OEM	1,371.3 +19.6%	9.7%	1,762.9 +28.6%	10.0%	2,200.3 +24.8%	11.0%	2,653.2 +20.6%	11.3%	2,830.8 +6.7%	10.9%
Total Non-U.S. Manufacturers	3,790.4 +13.9%	26.0%	4,519.2 +19.2%	25.1%	5,279.7 +16.8%	25.6%	5,973.5 +13.1%	25.0%	6,420.8 +7.5%	24.2%
Worldwide Recap										
Captive	10,268.2 +10.2%	69.6%	12,040.9 +17.3%	66.2%	13,340.2 +10.8%	63.9%	15,441.6 +15.8%	64.0%	17,689.1 +14.6%	66.2%
PCM	627.6 -9.0%	4.3%	770.8 +22.8%	4.2%	729.6 -5.3%	3.5%	915.2 +25.4%	3.8%	976.7 +6.7%	3.7%
OEM	3,861.6 +26.4%	26.1%	5,374.1 +39.2%	29.6%	6,815.1 +26.8%	32.6%	7,784.3 +14.2%	32.2%	8,063.3 +3.6%	30.1%
Total All Manufacturers	14,757.4 +13.0%	100.0%	18,185.8 +23.2%	100.0%	20,884.9 +14.8%	100.0%	24,141.1 +15.6%	100.0%	26,729.1 +10.7%	100.0%

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

Product mix

Fixed disk drives less than 30 megabytes have been the industry's leading product group in unit shipments during most of this decade, hitting a peak of 77% of worldwide shipments in 1984 by riding the wave of the PC boom and by displacing older removable disk drive models.

More recently, the share held by this group has been declining, although actual quantities have been rising, going over 5 million drives in 1986, representing 64% of all drives shipped. The forecasted 1990 shipments of 11.5 million drives will be only 45% of the worldwide total.

30-100 megabyte drives have been the fastest growing product group in recent years, with 1986 unit shipments over 2 million drives and extraordinary growth underway in 1987. Increasing data storage demand for high-end personal computers, technical workstations and minicomputers will boost 1987 shipments to an estimated 5 million drives, 38% of the worldwide total for all drives.

Although the unit shipments for fixed disk drives over 100 megabytes are much smaller, their value to the industry is greater, due to much higher average prices. By 1990, 100-300 megabyte drives are forecasted to top the 2 million drives per year level, and 300-500 megabyte drives should exceed the 1 million mark. Both groups will benefit from the booming technical workstation market, plus increased requirements for high-end personal computers and file servers.

Unit shipments of drives over 1 gigabyte are expected to quadruple by 1990, approaching one half million per year. Most of the increase will come from growing OEM and captive shipments of drives smaller than 14" diameter, including multiple spindle arrays of 5.25" drives.

Figure 1

CHANGING PRODUCT MIX
CONSOLIDATED WORLDWIDE RIGID DISK DRIVE REVENUES

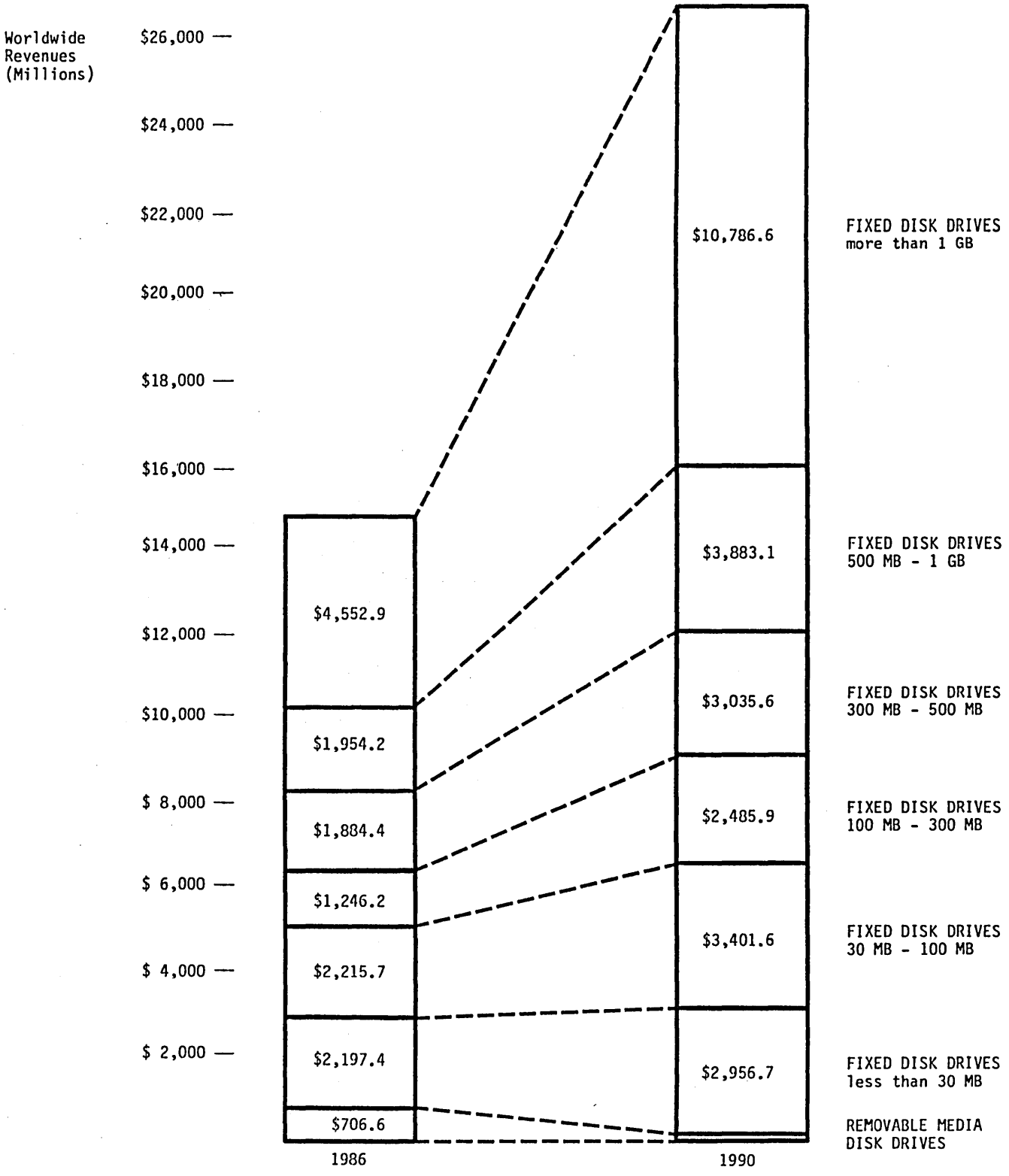


TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1986 Revenues $M	1986 Revenues %	1987 Forecast $M	1987 Forecast %	1988 Forecast $M	1988 Forecast %	1989 Forecast $M	1989 Forecast %	1990 Forecast $M	1990 Forecast %
DISK CARTRIDGE DRIVES	197.9 -26.5%	1.3%	133.2 -32.7%	.7%	115.1 -13.6%	.6%	106.7 -7.3%	.4%	97.3 -8.8%	.4%
DISK PACK DRIVES	508.7 -24.0%	3.4%	340.6 -33.0%	1.9%	227.4 -33.2%	1.1%	142.8 -37.2%	.6%	82.3 -42.4%	.3%
FIXED DISK DRIVES less than 30 Megabytes	2,197.4 +18.0%	14.9%	2,466.8 +12.3%	13.6%	2,864.1 +16.1%	13.7%	3,062.9 +6.9%	12.7%	2,956.7 -3.5%	11.1%
FIXED DISK DRIVES 30 - 100 Megabytes	2,215.7 +73.3%	15.0%	3,322.6 +50.0%	18.3%	3,362.2 +1.2%	16.1%	3,481.3 +3.5%	14.4%	3,401.6 -2.3%	12.7%
FIXED DISK DRIVES 100 - 300 Megabytes	1,246.2 +12.7%	8.4%	1,449.2 +16.3%	8.0%	1,725.9 +19.1%	8.3%	2,056.1 +19.1%	8.5%	2,485.9 +20.9%	9.3%
FIXED DISK DRIVES 300 - 500 Megabytes	1,884.4 +41.5%	12.8%	2,125.6 +12.8%	11.7%	2,683.4 +26.2%	12.8%	3,088.6 +15.1%	12.8%	3,035.6 -1.7%	11.4%
FIXED DISK DRIVES 500 Megabytes to 1 GB	1,954.2 +11.3%	13.2%	2,756.2 +41.0%	15.2%	3,552.8 +28.9%	17.0%	3,608.5 +1.6%	14.9%	3,883.1 +7.6%	14.5%
FIXED DISK DRIVES more than 1 Gigabyte	4,552.9 -4.9%	30.9%	5,591.6 +22.8%	30.6%	6,354.0 +13.6%	30.4%	8,594.2 +35.3%	35.6%	10,786.6 +25.5%	40.3%
Total Worldwide Revenue	14,757.4 +13.0%	100.0%	18,185.8 +23.2%	100.0%	20,884.9 +14.8%	100.0%	24,141.1 +15.6%	100.0%	26,729.1 +10.7%	100.0%
% U.S. Mfg.	74.3%		75.1%		74.7%		75.2%		75.9%	

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

TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1986 Shipments Units	1986 Shipments %	1987 Forecast Units	1987 Forecast %	1988 Forecast Units	1988 Forecast %	1989 Forecast Units	1989 Forecast %	1990 Forecast Units	1990 Forecast %
DISK CARTRIDGE DRIVES	104.0 -19.4%	1.3%	105.2 +1.2%	.8%	116.9 +11.1%	.7%	124.2 +6.2%	.6%	133.5 +7.5%	.5%
DISK PACK DRIVES	58.5 -18.5%	.7%	41.3 -29.4%	.3%	30.0 -27.4%	.2%	20.2 -32.7%	.1%	12.8 -36.6%	--
FIXED DISK DRIVES less than 30 Megabytes	5,086.3 +54.8%	64.0%	6,627.6 +30.3%	51.2%	8,383.0 +26.5%	48.7%	10,144.0 +21.0%	46.8%	11,565.0 +14.0%	45.0%
FIXED DISK DRIVES 30 - 100 Megabytes	2,028.5 +146.4%	25.5%	5,038.5 +148.4%	38.9%	6,643.8 +31.9%	38.6%	8,372.0 +26.0%	38.7%	9,880.0 +18.0%	38.4%
FIXED DISK DRIVES 100 - 300 Megabytes	253.3 +31.4%	3.2%	523.0 +106.5%	4.0%	983.0 +88.0%	5.7%	1,499.0 +52.5%	6.9%	2,147.0 +43.2%	8.3%
FIXED DISK DRIVES 300 - 500 Megabytes	179.1 +48.8%	2.3%	264.8 +47.9%	2.0%	566.0 +113.7%	3.3%	829.0 +46.5%	3.8%	1,017.0 +22.7%	4.0%
FIXED DISK DRIVES 500 Megabytes to 1 GB	107.2 +47.3%	1.3%	190.1 +77.3%	1.5%	292.3 +53.8%	1.7%	373.0 +27.6%	1.7%	467.0 +25.2%	1.8%
FIXED DISK DRIVES more than 1 Gigabyte	125.0 -11.3%	1.6%	160.5 +28.4%	1.2%	183.9 +14.6%	1.1%	295.7 +60.8%	1.4%	499.1 +68.8%	1.9%
Total Worldwide Shipments	7,941.9 +64.2%	100.0%	12,951.0 +63.1%	100.0%	17,198.9 +32.8%	100.0%	21,657.1 +25.9%	100.0%	25,721.4 +18.8%	100.0%
% U.S. Mfg.	71.5%		79.4%		78.3%		77.0%		77.6%	

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

OEM market

The loss of OEM market share for United States disk drive manufacturers which was underway in the 1984-86 period has been reversed. The reasons are probably found in the vigorous rate of new product introductions by U.S. manufacturers, primarily in small diameter disk drives, and in the dramatic movement in the dollar/yen exchange rate.

After holding over 80% of worldwide OEM disk drive shipments for many years, U.S. manufacturers dropped to 66.7% in 1985, but gained in 1986 and are forecasted to reach 80% again in 1987. The revenue share for U.S. firms is a lower percentage, in the mid-60% range, because U.S. companies lead in low-end drives selling at lower average prices.

For the first time in the eleven years that the DISK/TREND Report has been tracking the industry's history, the leadership position in worldwide OEM disk drive revenues changed in 1986. Although new management at Control Data's Data Storage Products Group has brought renewed growth to the long-term leader in OEM disk drives, which held 55.1% of 1980 worldwide OEM revenues, the firm's 15.3% share for 1986 qualifies only for second place. The new leader with 18.3% of 1986's revenues is Seagate Technology, a company which was just shipping its first products when Control Data was at its peak.

OEM drive manufacturers led the way in pioneering smaller diameter disk drives, and that thrust is continuing. Starting with the first shipment of the Seagate 5.25" 6 megabyte drive in 1980, OEM drive manufacturers have been pushing 5.25" drives into higher and higher capacity ranges, now capped by Maxtor's 760 megabyte drive promised for shipment this year.

The full size 5.25" form factor, in turn, is losing ground to half

high 5.25" drives. 97% of 5.25" fixed drives less than 30 megabytes are now half high models, as are almost half of the 30-100 megabyte drives.

The basic 5.25" form factor itself is also being displaced by 3.5" drives in the group of fixed drives less than 30 megabytes. 3.5" drives already comprise over half of the 1987 shipments in this group, and by 1990 are expected to provide 98% of worldwide shipments -- with some help from IBM, which is now producing almost one million 3.5" drives per year at its factory at Fujisawa, Japan. The OEM drive pioneers are now moving up to the next capacity range, with almost 600,000 3.5" drives expected in the 30-100 megabyte group this year and over 8 million predicted for 1990.

While intense product and market development activities for OEM drives have been underway in the capacity ranges below 100 megabytes, drive manufacturers also have been achieving excellent growth for higher capacity models. Only about 40% of current worldwide OEM revenues are generated by drives over 100 megabytes, but 1990's OEM revenue level for this capacity range is expected to approach half of the worldwide total.

As in the lower capacity ranges, 5.25" drives are leading shipment growth for OEM 100-300 megabyte drives. 5.25" drives are expected to comprise over 80% of 1987 unit shipments for the group, up from 50% the previous year, and OEM shipments dominate these totals. However, the volume shipments of 3.5" drives starting in 1987 are expected to surge to two thirds of the 1990 total for all drives in the product group.

5.25" drives will continue to work their way into increasingly high capacity ranges. By 1990, 5.25" drives are forecasted to assume unit shipment leadership in the 300-500 megabyte and 500 megabyte - 1 gigabyte ranges, and in that year will be starting to rival 14" drive shipments in the product group for drives with over 1 gigabyte capacity.

TABLE 5

OEM WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1986 Revenues $M	1986 Revenues %	1987 $M	1987 %	1988 $M	1988 %	1989 $M	1989 %	1990 $M	1990 %
DISK CARTRIDGE DRIVES	84.0 -36.3%	2.2%	85.3 +1.5%	1.6%	89.1 +4.5%	1.3%	85.2 -4.4%	1.1%	78.3 -8.1%	1.0%
DISK PACK DRIVES	232.3 -20.7%	6.0%	162.5 -30.0%	3.0%	129.2 -20.5%	1.9%	88.0 -31.9%	1.1%	59.0 -33.0%	.7%
FIXED DISK DRIVES less than 30 Megabytes	1,219.6 +24.0%	31.7%	1,235.2 +1.3%	23.1%	1,326.3 +7.4%	19.6%	1,440.4 +8.6%	18.6%	1,517.3 +5.3%	18.9%
FIXED DISK DRIVES 30 - 100 Megabytes	1,112.7 +53.1%	28.8%	1,939.7 +74.3%	36.1%	2,408.1 +24.1%	35.3%	2,635.5 +9.4%	33.9%	2,466.4 -6.4%	30.6%
FIXED DISK DRIVES 100 - 300 Megabytes	352.6 -.8%	9.1%	567.8 +61.0%	10.6%	706.3 +24.4%	10.4%	814.1 +15.3%	10.4%	894.6 +9.9%	11.1%
FIXED DISK DRIVES 300 - 500 Megabytes	392.0 +32.7%	10.2%	535.6 +36.6%	9.9%	892.4 +66.6%	13.1%	1,021.1 +14.4%	13.2%	1,002.5 -1.8%	12.4%
FIXED DISK DRIVES 500 Megabytes to 1 GB	269.4 +98.7%	6.9%	506.6 +88.0%	9.4%	798.6 +57.6%	11.7%	982.7 +23.1%	12.6%	1,019.8 +3.8%	12.7%
FIXED DISK DRIVES more than 1 Gigabyte	199.0 +48.6%	5.1%	341.4 +71.6%	6.3%	465.1 +36.2%	6.7%	717.3 +54.2%	9.1%	1,025.4 +43.0%	12.6%
Total Worldwide Revenues	3,861.6 +26.4%	100.0%	5,374.1 +39.2%	100.0%	6,815.1 +26.8%	100.0%	7,784.3 +14.2%	100.0%	8,063.3 +3.6%	100.0%
% U.S. Mfg.	64.4%		67.1%		67.7%		65.9%		64.8%	

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

TABLE 6

OEM WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1986 Shipments Units	1986 Shipments %	1987 Units	1987 %	1988 Units	1988 %	1989 Units	1989 %	1990 Units	1990 %
DISK CARTRIDGE DRIVES	87.1	1.4%	96.9	.9%	111.0	.8%	118.0	.7%	127.0	.6%
	-19.4%		+11.3%		+14.6%		+6.3%		+7.6%	
DISK PACK DRIVES	41.2	.6%	29.7	.3%	23.0	.2%	16.0	.1%	11.0	.1%
	-10.0%		-27.9%		-22.6%		-30.4%		-31.2%	
FIXED DISK DRIVES less than 30 Megabytes	4,251.2	67.3%	5,137.2	50.5%	6,288.0	45.7%	7,695.0	44.2%	9,206.0	44.4%
	+55.7%		+20.8%		+22.4%		+22.4%		+19.6%	
FIXED DISK DRIVES 30 - 100 Megabytes	1,635.5	25.9%	4,255.3	41.7%	6,011.8	43.6%	7,649.0	43.9%	8,900.0	42.9%
	+126.0%		+160.2%		+41.3%		+27.2%		+16.4%	
FIXED DISK DRIVES 100 - 300 Megabytes	181.6	2.9%	414.2	4.1%	755.5	5.4%	1,064.0	6.1%	1,384.0	6.6%
	+33.2%		+128.1%		+82.4%		+40.8%		+30.1%	
FIXED DISK DRIVES 300 - 500 Megabytes	83.3	1.3%	162.4	1.6%	412.5	3.0%	597.0	3.4%	723.0	3.5%
	+58.1%		+95.0%		+154.0%		+44.7%		+21.1%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	39.1	.6%	83.7	.8%	150.3	1.1%	226.5	1.3%	287.0	1.4%
	+135.5%		+114.1%		+79.6%		+50.7%		+26.7%	
FIXED DISK DRIVES more than 1 Gigabyte	7.2	--	21.2	.1%	37.7	.2%	68.1	.3%	122.3	.5%
	+38.5%		+194.4%		+77.8%		+80.6%		+79.6%	
Total Worldwide Shipments	6,326.2	100.0%	10,200.6	100.0%	13,789.8	100.0%	17,433.6	100.0%	20,760.3	100.0%
	+65.6%		+61.2%		+35.2%		+26.4%		+19.1%	
% U.S. Mfg.	72.3%		80.1%		79.6%		77.7%		78.1%	

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

TABLE 7

1986 ESTIMATED MARKET SHARES
WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1986 rates)

	CAPTIVE		PCM		OEM		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Century Data	--	--	--	--	20.4	.5	20.4	.1
Control Data	603.4	5.9	--	--	589.4	15.3	1,192.8	8.1
Data General	120.0	1.2	--	--	--	--	120.0	.8
Digital Equipment	629.9	6.1	--	--	--	--	629.9	4.3
Hewlett-Packard	246.5	2.4	--	--	4.9	.1	251.4	1.7
Ibis	--	--	--	--	40.0	1.0	40.0	.3
IBM	6,412.0	62.4	--	--	107.4	2.8	6,519.4	44.2
LaPine	--	--	--	--	24.9	.6	24.9	.2
Maxtor	--	--	--	--	148.3	3.8	148.3	1.0
Micropolis	--	--	--	--	210.8	5.5	210.8	1.4
Microscience International	--	--	--	--	63.6	1.6	63.6	.4
Miniscribe	--	--	--	--	175.4	4.5	175.4	1.2
Priam	--	--	--	--	120.4	3.1	120.4	.8
Quantum	--	--	--	--	115.0	3.0	115.0	.7
Seagate Technology	--	--	--	--	708.3	18.3	708.3	4.8
Storage Technology	--	--	129.5	20.6	--	--	129.5	.9
SyQuest	--	--	--	--	28.6	.7	28.6	.2
Tandon	101.2	1.0	--	--	75.1	1.9	176.3	1.2
Unisys	201.1	2.0	32.4	5.2	--	--	233.5	1.6
Other U.S.	.7	.0	--	--	57.8	1.5	58.5	.4
U.S. Total	8,314.8	81.0	161.9	25.8	2,490.3	64.5	10,967.0	74.3
NON-U.S. MANUFACTURERS								
Bull	36.7	.4	--	--	8.2	.2	44.9	.3
Fuji Electric	--	--	--	--	21.3	.6	21.3	.1
Fujitsu	464.2	4.5	182.1	29.0	457.8	11.9	1,104.1	7.5
Hitachi	227.4	2.2	283.6	45.2	131.3	3.4	642.3	4.4
ISOT	35.2	.3	--	--	113.6	2.9	148.8	1.0
JVC (Victor Company)	--	--	--	--	24.0	.6	24.0	.2
Mitsubishi Electric	49.9	.5	--	--	4.2	.1	54.1	.4
NEC	789.6	7.7	--	--	258.1	6.7	1,047.7	7.1
Nippon Peripherals	--	--	--	--	38.7	1.0	38.7	.3
Olivetti	172.6	1.7	--	--	12.5	.3	185.1	1.3
Rodime	--	--	--	--	87.4	2.3	87.4	.6
Seiko Epson	78.0	.8	--	--	8.5	.2	86.5	.6
Tokico	--	--	--	--	32.5	.8	32.5	.2
Toshiba	81.5	.8	--	--	50.5	1.3	132.0	.9
Other Non-U.S.	18.3	.2	--	--	122.7	3.2	141.0	1.0
Non-U.S. Total	1,953.4	19.0	465.7	74.2	1,371.3	35.5	3,790.4	25.7
WORLDWIDE TOTAL	10,268.2	100.0	627.6	100.0	3,861.6	100.0	14,757.4	100.0

NOTE: Drives sold in the PCM market by other than the original manufacturer are valued at PCM price levels above, to avoid distortion of total market values.

Codes: 3 = 3"-3.9" C = Captive
5 = 5.25" P = PCM
8 = 8"-9" O = OEM
10 = 10.5"
14 = 14"

TABLE 8

CURRENT PRODUCT LINES
MANUFACTURERS OF MOVING HEAD MAGNETIC DISK DRIVES

DISK/TREND PRODUCT GROUP:		1	2	3	4	5	6	7	8
U.S. Manufacturers	Type	Disk Cartridge Drives	Disk Pack Drives	Fixed Disk Drives <30 MB	Fixed Disk Drives 30-100 MB	Fixed Disk Drives 100-300 MB	Fixed Disk Drives 300-500 MB	Fixed Disk Drives 500 MB-1 GB	Fixed Disk Drives >1 GB
Alpha Data	O							14	
Brand Technologies	O				5	5			
Cardiff Peripherals	O				3	3			
Century Data	O	8	14		5	5	14	8,14	
Conner Peripherals	O				3	3			
Control Data	O,C		8,14		5	5,8	5,8	8,14	8,14
Data General	C		14				14	14	
Data-Tech Memories	O				5				
Digital Equipment	C	8,14	14			5,14	14	14	
DMA Technologies	O	5							
Hewlett-Packard	C,O		14	3		5	5,8	8	
Ibis	O								14
IBM	C,O			3,8	5,8	5,8,14	5,8,14	14	14
Josephine County Technology	O			5					
Maxtor	O				5	3,5	5	5	
MFM Technology	O	5							
Micropolis	O				5	5	5		
Microscience International	O			3,5	3,5	5			
Miltope	O			5	3,5	5			
Miniscribe	O			3,5	3,5	5	5		
Northern Telecom	O				8	8	8	8	
Peripheral Technology	O			3	3				
Pertec	O					8	8	8	
Plus Development	P,O			3	3				
Priam	O				5,8	5,8,14	5,8		
Quantum	O			5,8	5,8				
Seagate Technology	O			3,5	3,5	5			
Storage Technology	P,O								14
SyQuest Technology	O	3,5							
Tandon	O			3	3,5	5			
Tulin	O			5	5				
Unisys	C,P		14					14	14
Vermont Research	O							8	
Xebec	O			5	5				
Asian Manufacturers									
Alps Electric	O			3					
Cogito	O			5					
Fuji Electric	O			3	3				
Fujitsu	C,O,P	14		3,5	3,5,8	5,8,14	5,8,10,14	8,10,14	10
Hitachi	C,O,P			3,5,8	3,5,8	5,8	5,8	8,14	8,14
JVC (Victor Company)	O			3					
Matsushita Com. Ind.	O			3,5	3				
Mitsubishi Electric	C,O			3,5	5	5,8	8		
NEC	C,O		14	3,5	5	5,8	8	8,14	8,14
Ricoh	C,O	5							
Seiko Epson	C,O			3	3				
Shinwa Digital	O			3,5					
Sony	C,O			5	5				
Teac	O				5				
Tokico	O			5	5				
Toshiba	C,O			3	3,5,8	5,8	5,8	8	
Toyo Soda	O					5			
YE Data	O				3				
European Manufacturers									
ISOT	C,O	14	14	5,8			14		
Kovo	C,O	14	14						
Lexikon	C,O			3,5	3,5	5			
Newbury Data	O				3,5	5	5		
Nixdorf	C				5	8			
Rodime	O			3	3,5	5		8	
Sagem	O			5	5	5			
Siemens	C,O					5	5		

TECHNICAL REVIEW

Competing technologies

The large size and the high growth rate of the market for rigid magnetic disk drives continue to inspire attempts to apply other storage technologies in an effort to capture a significant share of market. Of these competitive technologies, only a few are likely contenders.

One perennial candidate for serious consideration as a data storage technology still has long-term promise: Magnetic bubbles are now used in many harsh environment applications and are being designed into selected data processing systems. Optical disks, a second candidate, have now achieved the status of actual commercial products, with over 25 manufacturers currently making shipments. Both technologies are discussed in more detail later in this section. A separate DISK/TREND report, published earlier this year, covers the market for optical disk drives.

Sponsors of other would-be alternates to magnetic rigid disk recording, such as semiconductor memory, continue to find the competition tougher than expected. Magnetic disk technology is rightly described as a "moving target", and as this target moves, it becomes increasingly more cost effective.

The history of magnetic disk recording is one of continually improving recording densities; this advancement translates directly into lower cost for data storage. Higher density means fewer heads and disks for a given capacity, thus reduced physical size, smaller motors, less heat, lower power, etc. And as densities have been improved, development in head positioning techniques has provided faster data access.

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

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

* Non-reversible optical disks: The first optical disk recording systems to enter the market are "non-reversible" or "write-once" systems. After many years of costly development programs undertaken by several European and Japanese manufacturers, such devices are being shipped by major suppliers, including IBM.

  Because they use track densities approaching 16,000 tracks per inch, write-once drives are capable of higher areal densities than magnetic disk drives now in use. The write-once systems now available or entering the market use comparable, but differing technologies, with capacities per side per disk in the range of one hundred megabytes to three gigabytes. Some systems, such as Eastman Kodak's 14 inch drive, provide several gigabytes on a single removable disk.

  Although not yet demonstrated, advocates of the various types of optical disk media technologies believe that their disks will provide archival lives which equal or exceed those of magnetic media, with 10 years being a commonly encountered specification for archival life of the media. Lifetime is limited by the gradual appearance of defects on the recording layer due to the corrosive effects of water and oxygen on the metal films used in the recording layers of the media. The termination point of media lifetime occurs when the error correction capability of

the drive is no longer capable of coping with the gradually increasing media defect density. More recently introduced media using organic dyes as the recording material have no metallic films and may offer improved stability.

In broad terms, two kinds of systems will be offered: Image storage and data storage systems. Systems intended to store images of documents were early entries to the market in Japan, offered by Toshiba, Matsushita Electric, and others. The early emphasis on optical document storage systems in the Japanese market is explained by the extremely complicated character of the written Japanese language. Since most business communication and records are in handwritten characters, the Japanese emphasis first on copying machines, then facsimile transmission, and now optical document storage systems is understandable. At this time, it does not appear that optical document storage systems will be able to compete on a price per image basis with microfilm for bulk storage of images. However, the fast and convenient access to stored images provided by optical disk systems will probably create a major place for them in the emerging office automation market for large-scale specialized applications, and firms such as Eastman Kodak and Bell and Howell are beginning to approach that market.

Data storage systems have been later to develop, partly because of more stringent demands upon the media and the difficulty of developing a drive with performance suitable for data processing applications, but also because of complex system development necessary to provide library devices and system support for them. Optical data storage systems and disk drives from a variety of firms, including Optical Storage International, Optotech, Optimem, ISI, Art Tech Gigadisc, Hitachi, Toshiba, NEC and Sony are being shipped in increasing numbers, but most of them are being used in image storage applications. These firms have identified a number of target applications involving image or text databases which are infrequently or never updated, and for which a write-once system would not be at a disadvantage -- such as stock market history, legal files, seismic data, banking transaction logs and law enforcement records. Replacement of magnetic tape based mass storage systems is also high on the target list.

Obviously, the market for this generation of optical disk systems will be limited to the niches which can tolerate nonreversibility. These niches do exist and the low cost per byte of optical storage will start to open selected markets to optical disk systems. In some applications, the ability of write-once storage systems to maintain an audit trail or indicate whether or not stored data has been modified is a significant benefit.

Large automated libraries that provide random access to tens or hundreds of disks make the use of large scale optical storage potentially very attractive for banks, insurance companies and

other organizations with massive records that must be easily accessed. Library systems are needed in order to make optical storage practical in a larger system environment. But the markets will be specialized, with system manufacturers slow to act. Little displacement of magnetic disk drives by non-reversible optical storage will result in the foreseeable future. Some displacement of tape in archival applications is probable, but the growth of write-once technology will be limited by the imminent availability of erasable optical drives.

* Erasable optical disks: The possibility for real inroads into the market for magnetic disk drives exists with reversible optical disk systems, when cost effective drives with improved performance are available. Magneto-optical recording has seen development activity for more than twenty years, and "phase change" optical recording has attracted considerable attention during the past few years.

  Low-end erasable optical drives offer the promise of capacities and access times equivalent to those offered by many of today's small magnetic rigid drives. Such drives should be more reliable than magnetic disk drives due to the increased head/disk separation characteristic of optical disk drives. High end erasable drives await the availability of larger diameter erasable media, which is difficult to fabricate within the current state of the art.

  Especially impacted will be magnetic tape. By using an optical disk for backup with the same controller used for other system disks, the system OEM can reduce system complexity and cost while simultaneously improving performance. Erasable drives, used with automated library devices, are expected to impact larger magnetic tape and tape cartridge systems after 1990.

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

  Phase change optical recording involves a different type of amorphous coating, in which individual spots on the disk are changed by polarized light from a crystalline state, during

which light is reflected, to a noncrystalline state, during which light is absorbed. Fujitsu has revealed a comparable process in which different crystalline states are used to vary reflectivity.

A third possibility, potentially the least expensive to manufacture, is erasable dye-based technology. As of yet, only limited success has been obtained with this technique because developers have not been able to demonstrate an adequately large number of write/erase cycles. Individual firms are also working on other proposed reversible optical recording technologies, but none of them have overcome all of the problems, which have included: Slow completion of the reversal cycle, limitations on the number of reversals before degradation, poor shelf life, and low recording density.

Magneto-optical storage is close to being in a manufacturable status. Most of the technical problems have been overcome by some of the U.S., Japanese or European companies working in the area, and a few of these firms have committed to the heavy investment required to establish volume production capability. Technology announcements of products in 3.5" and 5.25" formats have been made by Verbatim, 3M, Sony and Sharp, and several firms are preparing to manufacture magneto-optical drives and media in volume in 1988. Phase change media production could follow in a few years if acceptable stability and producibility are feasible.

* Read-only optical disks: The read-only optical disk category is dominated by the CD-ROM. High storage capacities of 550 to 600 megabytes, but long access times, are typical of CD-ROM technology, which borrows heavily from the designs of the 4.72" CD audio players now in volume production. This technological loan will keep CD-ROM costs low. Further, CD-ROM acceptance benefits from industry agreement on the CD standards developed jointly by Sony and Philips. In addition to the 4.72" CD-ROM, which is limited in capability, high performance 12" read-only drives are being shipped by Reference Technology.

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

Most read-only optical drives will be used with small systems to provide personal access to large amounts of information. The success of read-only optical disks depends upon the existence and timely development of a data base publishing industry willing to make use of the CD-ROM format. As of mid-1987, there were still relatively few titles available on CD-ROM, and of these, few seem likely to generate high volume sales.

Another significant factor is the need to have a common standard for recording format that allows disks to be interchanged between systems. An ad hoc group of companies proposed such a standard and submitted it to the appropriate standards committees. As it has been agreed upon by most of the companies involved, the newer CD-ROM releases should be usable on almost any system, enhancing their appeal.

* Magnetic bubbles: If regarded as a specialized data storage product, magnetic bubbles still look like a product with a future, despite a serious loss of credibility after the 1981 departure of National Semiconductor, Texas Instruments and Rockwell International from the field. The rate at which the market for magnetic bubbles developed was clearly not acceptable for the drop-outs, who wanted more immediate returns on their investments.

  Bubbles' markets were obviously not the mainstream data storage applications dominated by magnetic disk and tape drives. As expected by disk and tape manufacturers, but not by many bubble manufacturers, the older products were well established, mostly multiple sourced, and getting better all the time. But there are many practical limitations for disk and tape, and applications where they are unsuitable or marginal because of environmental limitations or minimum practical size thresholds.

  Bubbles started to find suitable applications, once they were actually in production and support chips became available. The highest manufacturing levels are still maintained by Hitachi, with most production used by Nippon Telephone and Telegraph for a variety of telecommunication applications. AT&T, with manufacturing by Western Electric, is believed to be much further behind in developing internal bubble applications, despite the fact that the basic technology was invented at Bell Labs.

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

  The non-volatility of magnetic bubbles and their suitability for capacities too small to be cost effective for magnetic disk drives has proven to be attractive to system manufacturers for applications such as industrial control systems, robots, point of sale terminals, portable computers, medical instrumentation, avionic systems and militarized systems.

The future market available to magnetic bubbles will be directly proportional to their price level as compared to magnetic disk for equivalent capacities. During the rest of the 1980's it still seems probable that bubbles' prices will not approach disks' prices -- and bubbles' main markets will be smaller and more specialized.

In the 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. R&D efforts at Carnegie-Mellon University and in Japan have shown promise, but much remains to be done to make VBL a practical technology.

* High capacity flexible disk drives: It is within the capabilities of today's technology to fabricate a floppy disk drive offering over 30 megabytes of storage capacity by using media capable of 40,000 FCI recording density and 2,7 RLL coding. Although such a product is not expected soon, when available, it could compete in the very low end of potential magnetic and optical disk drive markets. 3.5" drives with capacity in the 15-20 megabyte range are expected to be announced in late 1987.

The 12 megabyte 5.25" floppy disk drive announced by Eastman Kodak and DTC, and the 10 megabyte drive offered by Konica, are aimed at applications with specialized systems needs and the personal computer add-on market. Both types of drives are still in the market introduction phase and the extent of market response is uncertain. Future products may double capacities to 24 megabytes, or shift to a 3.5" format. Iomega has already announced a 5.25", 20 megabyte Bernoulli disk drive. But capacities in this range are only the beginning of the potential expansion of floppy drive capabilities. Two other significant rival technologies are waiting in the wings to boost floppy capacity.

Perpendicular recording for flexible disks has received considerable attention in recent years, and has the potential to increase capacity for a 5.25" drive to 5-10 megabytes without significant increases in track density. Toshiba has designed a 4 megabyte, 3.5" drive based on barium ferrite as the recording material and is offering manufacturing licenses. By using a sputtered thin film on a Mylar substrate, perpendicular recording disks could achieve linear densities of at least 50,000 BPI. Increased track densities using embedded servo techniques or optical tracking methods could increase capacities by a factor of four or more.

It is likely that the largest limitation to the development of markets for floppy drives using sputtered media will be media availability. Success would require that media be produced by the millions of units, which would be difficult with today's

batch sputtering processes, and durability remains a problem for thin film media used with head in-contact floppy disk drives. In addition to Toshiba, Sony and Matsushita Electric have revealed programs to develop 3.5" drives and media using perpendicular recording.

Another technology with yet unrealized promise for improving floppy capacities involves use of very small magnetic particles, not much longer than they are wide. Use of such particles in coatings with conventional binder systems could result in "isotropic" magnetic recording, in which many more flux changes per inch could be obtained than with conventional recording. The big advantage for this technique may be producibility of the media, with little to change in existing floppies but the magnetic particles. Presumably, existing coating lines operated by the several major floppy media suppliers could be used. The principal difficulty with isotropic media to date has been oversensitivity to thermal change, with the potential under some circumstances to lose recorded data. As a result, activity in the area of isotropic media is low at present.

* Stretched surface recording: SSR, as this technique is commonly known, was devised by the 3M Corporation over the last several years. It employs a disk composed of a plastic film with a magnetic coating stretched across concentric cylindrical rings. The chief characteristic of this technology is that it allows a head to fly on an air cushion backed by a deformable surface under the head. This provides close head-media separation needed for high capacity but also makes the product head crash proof. Disk drives using this design technique could be produced in either fixed or removable format and could offer the same capacity as a small Winchester drive. The media, however, will have a cost only 1/3 to 1/4 that of the rigid disk media in current or projected use. 3M appears to have lost interest in developing products using SSR, but if adequately supported and promoted by 3M, SSR still has the potential to be a major commercial technology.

Disk drive enhancements

Most of the major technology innovations now in use in the disk drive industry have come from IBM. IBM developed all the basic disk recording technology, and independent firms merely adapted heads, disks and other components to the specific drive configurations desired. However, due to IBM's lack of activity in development of small disk drives for several years, many variations in the technology have been introduced by others.

* Recording heads: Ferrite Winchester heads patterned after IBM's 3340/3350 designs still dominate in fixed media disk drives, except for PCM drives using heads designed to compete against IBM's 3370, 3375, 3380, and other new drives with ferrite heads having sliders with 3370 contours. The conventional ferrite heads are available from multiple sources, are routinely produced with good manufacturing yields, and are competitively priced. They will continue to be used for the majority of other captive and OEM drives until thin film heads are widely available and are price competitive with Winchester heads. 1984 saw the beginning of thin film head shipments for small diameter OEM disk drives, and production is expected to gradually increase as more vendors start to master the process and gain control of process yields, which remains a demanding task for some.

  The U.S. manufacturers of PCM 3380 equivalent drives and some smaller drives are using thin film heads, however, despite limited current availability. A few drive manufacturers have established internal development and manufacturing programs for thin film heads, and are continuing to maintain close liaison with outside head manufacturers until availability becomes more routine.

  Heads capable of reading or writing multiple tracks simultaneously are not in use yet, but are likely to be employed when small diameter drives used in multi-spindle arrays enter the market place. Because the smaller diameter drives may have difficulty providing mainframe transfer rates from individual tracks, simultaneous track addressing may be needed if linear densities and rotation rates cannot be adequately increased. Multi-track heads will also be used to improve performance by increasing the amount of data available as a result of a single head movement because the cylinder size has been effectively increased by simultaneous access to multiple tracks.

* Recording disks: As IBM progressed through succeeding generations of disk drives, the disk media employed underwent only a refinement of the basic process of applying an oxide coating, to

achieve a continually thinner application of a uniform coating, plus improvements in surface lubricants. The disks used in a majority of Winchester drives today are derived from IBM's process improvements.

For several years, there has been a stampede by numerous established and new firms to install production capability for thin film disks. Most have aimed at the market for 5.25" and smaller disk drives, and the managements involved recognize the need to establish credibility by offering facilities capable of producing large quantities of disks, with adequate process controls, at prices competitive with oxide disks of comparable quality. Most of this activity has been generated because of the higher density potential of thin film disks (few 5.25" drives with less than 100 megabyte capacity need higher density than oxide disks offer).

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

A second wave of companies using sputtering methods to deposit thin magnetic films is shipping disks in significant quantities. These firms claim that the sputtering process is easier to control than the plating process, usually resulting in substantially higher yields. Sputtering is also less subject to water contamination. Sputtering lines are less flexible than a plating line, however, which is a factor in the difficulty that producers of 8" disk drives have in obtaining assured sources of sputtered 8" media. Sputtered disk producers are concentrating on 5.25" or 3.5" media because the bulk of the near term demand is in those sizes.

Many firms use both plating and sputtering technologies in multiple layer disks, sputtering the magnetic recording layer on top of a layer of plated nickel that isolates the substrate from the magnetic layer. Like the plated disk, disks with sputtered magnetic layers usually have carbon overcoats for protection.

Despite the increasing acceptance of thin film media, oxide media retains a dominant position in the low end of the rigid disk drive market due to improved performance and considerably reduced prices.

* Head positioning methods: The industry is not moving forward rapidly with TPI improvements. Several of the highest performance small drives operate at over 1000 TPI, but such precision is too costly for most drives. The industry still has plenty of room for innovation in this area. IBM introduced a triple density version of the 3380 in the last half of 1987 that uses an estimated 2,100 TPI. It will be influential in moving the rest of the industry to higher track densities.

* Perpendicular recording: Today's disk drives all use longitudinal recording, making use of long, thin magnetic particles oriented parallel to the surface of the recording medium. As many as 100,000 BPI could theoretically be resolved by recording heads if magnetization were oriented in a plane perpendicular to the recording surface, and TPI could also be sharply increased.

  A very large amount of development activity in perpendicular recording has been underway in Japan, with application objectives in video and audio recording, as well as for data storage. In the United States, IBM and other manufacturers have development programs, but it appears that the earliest products may come from small firms. Lanx supplied sputtered small diameter disks to manufacturers of existing high performance small drives, with the objective of making significant increases in capacity possible for existing drive mechanisms at modest cost increases, but the firm ran out of money before the drive manufacturers adopted the technology. Censtor has announced production availability for a matched set of disks and heads, and hopes to entice manufacturers of high-end drives to improve the capacity of existing drive models.

  Until now, the resources required to provide appropriate system channels and drive controllers are more than most firms have chosen to expend. The high bit densities implicit in previous perpendicular recording programs resulted in very high data transfer rates that available controllers for small disk drives couldn't handle. However, drives for which high performance controllers already exist or may be adapted may appear with perpendicular recording technology in the not too distant future, and near term attempts to introduce perpendicular recording will probably concentrate on improved track density.

* 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 similar to that of the larger drive. Such arrays can offer substantially higher performance than a single large drive limited by a single actuator. Depending upon the way the array is configured and upon the degree of sophistication of associated subsystems, it can also offer redundancy, very high data transfer rates, and volumetric efficiencies, compared to single

large drives. Options such as caching and multiple data pathing can also be added. It is highly likely that drive arrays competing with larger mainframe oriented drives such as the IBM 3380 will be available in the market place from multiple sources in 1988. Amperif is already offering a multi-spindle subsystem using 8" drives for use with Unisys mainframes. Both 8" and 5.25" drives will probably be used to construct such arrays for mainframes, and it is likely that 3.5" drives will be used to fabricate multi-spindle arrays for minicomputer and large microcomputer storage.

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 and OEM disk drive marketing activities.

Captive: Disk drives manufactured internally or by a subsidiary of a computer manufacturer or system OEM, 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 or OEM 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 DEC, Hewlett-Packard or Unisys to computer system end users are considered captive, if internally manufactured.

* In the case of a joint venture disk drive manufacturer, such as Magnetic Peripherals, Inc, a joint venture of Control Data, Bull, and Honeywell, drive sales are considered captive, or OEM depending upon the method of sale by each joint venture partner. All MPI shipments are credited to Control Data, the managing partner.

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

Examples:

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

* Shipments by Tandon are non-captive if not used in Tandon manufactured systems.

OEM: Disk drives sold through any non-captive distribution channel except PCM. Drives are normally sold to OEMs to be included in complete systems or subsystems; such drives are included in OEM totals whether or not the OEM actually manufactures the remainder of the system or subsystem, or merely assembles components and adds software. Sales by a disk drive manufacturer to a second drive manufacturer for resale are

included only in shipment totals for the originating drive manufacturer, except when drives are produced on a contract manufacturing basis with a design supplied by the disk drive manufacturer which finally sells the drive to a third party. Distributors and dealers are arbitrarily defined as included in OEM totals.

PCM: Disk drives sold or leased by "plug compatible manufacturers" directly to end users; shipments of internally manufactured drives by computer manufacturers or system OEMs are not included unless supplied in plug compatible configurations for installation with systems supplied by other manufacturers. This category is not limited to plug compatible drives installed on IBM systems. It includes any drives which are suitably equipped to be connected without additional hardware to systems of all types, including minicomputers and small business systems.

Examples:

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

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

UNITS OF MEASUREMENT

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

Revenue: Based on sales of disk drives alone, as normally sold by individual manufacturers. Controllers sold as separate units are not included, nor are spare parts or service. When individual disk drive models include integral control functions, such as may be required for the first drive on a string of drives, the actual value of the complete unit is used. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM or OEM levels. Prices used for leased drives are on an "if sold" basis, at captive or PCM levels, as appropriate. All prices are in 1987 constant dollars, unless otherwise noted.

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

Examples:

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

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

GEOGRAPHIC CLASSIFICATION

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

U.S. vs. Worldwide SHIPMENTS: Shipments are classified U.S. or worldwide depending on the shipment destination of a drive's first public sale.

Examples:

* An OEM shipment by a U.S. drive manufacturer to a European system manufacturer is included in worldwide totals.

* An OEM shipment by a Japanese drive manufacturer to a U.S. system manufacturer is included in U.S. totals.

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

Examples:

* Maxtor and Priam are considered U.S. manufacturers, even though each firm manufactures some of its disk drives in non-U.S. locations.

* Cogito and Northern Telecom are considered non-U.S. manufacturers, since they are owned by non-U.S. organizations.

APPLICATION CLASSIFICATION

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

Mainframe/superminicomputer: Disk drives attached to the processor or connected terminal of a mainframe or superminicomputer.

Minicomputers/multiple user microcomputers: Drives attached to smaller general-purpose processors, including network file servers, that serve multiple users. Examples: IBM System/36, DEC PDP-11/44.

Microcomputers: Business and professional computers normally used by a single user. Examples: IBM PS/2 model 60, Apple Macintosh.

Office systems/workstations: Specialized equipment for dedicated use in specific office applications such as word processing or document storage. Examples: Wang OIS series, typesetters.

Non-office systems/workstations: Specialized equipment for dedicated non-office applications such as engineering, order processing/shipping, industrial control, military, medical, law enforcement applications.

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

Other applications: Any application not included above.

DISK CARTRIDGE DRIVES

1987 DISK/TREND REPORT

DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Digital Equipment	RL02
ISOT	CM 5400, CM 5410
Kovo (Zbrojovka Brno)	KDP 724

8" disk diameter

Century Data	Amcodyne 7110, 7130
Digital Equipment	RC25

5.25" disk diameter

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

3.9" disk diameter

SyQuest Technology	SQ306RD, SQ312RD

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

The number of disk cartridge drives in production continues to shrink, as older models are discontinued. None of the companies which led in shipments of 14" OEM disk cartridge drives during the heyday of this group -- Control Data, Diablo or Western Dynex -- are currently represented with products. Consistent with the rest of the industry, the trend in this

group has been to smaller diameter drives, and the remaining 14" drives are expected to be phased out soon, except for Eastern Bloc production.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1986	1987	1988	1989	1990
U.S. manufacturers	129.6	59.8	43.6	37.4	36.8
All manufacturers	197.9	133.2	115.1	106.7	97.3

The historical sawtooth sales curve for disk cartridge drives continued in its normal pattern in 1986, with worldwide unit shipments dropping 19.6%, to 104,000 drives. Worldwide revenues for the product group were $197,900,000, down 26.7%, with a further drop to $133,200,000 expected in 1987.

Sales for the disk cartridge product group has failed to meet DISK/TREND forecasts for several years, due primarily to the inability of drive manufacturers to adhere to their planned new product introduction schedules. The main shortfalls have been in OEM production of 5.25" drives and in 8" drives from both captive and OEM producers.

Until the last few years, the leading product in the group was the 14" Control Data 9448 "Phoenix", which peaked in 1982 with 28,500 drives in that year. The competition from smaller, lower cost fixed disk drives has been effective, however, and shipments of 14" disk cartridge drives from manufacturers in Western countries are no longer significant.

Unfortunately, the growth expectations of several years ago for 8" and 5.25" drives have been largely unfulfilled to date. Disk cartridge drives are more difficult to design and manufacture than fixed disk drives of the same capacity and disk diameter, due to increased mechanical com-

plexity and greater risk of contamination. The extent of these problems was not clearly recognized by most would-be producers of 8" and 5.25" drives, resulting in long delays for availability of announced products, shipment of many unreliable disk drives, and several failed programs.

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

In 1986, the growth products in this group continued to be the SyQuest 3.9" drive and, to a lesser degree, 5.25" OEM drives from several producers. Although these small diameter disk cartridge drives continue to find use with general purpose personal computers and minicomputers, almost half of all drives in the group shipped in 1986 were used in dedicated application non-office systems and workstations, primarily those with security requirements. SyQuest shipped 54,000 drives in 1986, all 3.9", for 62% of the worldwide OEM market, followed by Ricoh with 9,000 drives, all 5.25", for 10.3%

Marketing trends

It has been necessary to reduce DISK/TREND forecasts for disk cartridge drives again this year. Substantial growth is now expected only for 5.25" drives, especially those with higher capacities. Most of the lower capacity drives included in the disk cartridge drive group below 12 megabytes in previous editions of the DISK/TREND Report will be out of production before 1990.

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

Despite the negative influences, disk cartridge drives provide removability, which is highly desirable for some applications. The most important of these consists of a variety of requirements frequently called the "security" market -- the various government offices and defense contractors which are required to remove all data from computer systems when not in use, so that it may be kept under lock and key. Other current markets for disk cartridge drives consist of specialized systems employing exchangable data bases and some personal computer users with specialized requirements.

Shipments of 3.9" drives, flat in 1987, are expected to drop sharply starting in 1988, with 5.25" drives forecasted to assume strong growth leadership for the product group in 1988. The markets still available to high end disk cartridge drives want the larger capacities that 5.25" drives will be able to provide and will generally find the 5.25" form factor to be satisfactory. 93% of 1990 worldwide shipments are expected to be 5.25" drives.

The 8" form factor for disk cartridge drives has had few advocates and several unsuccessful programs. The end of Digital Equipment's 8" shipments are expected next year, closing the last captive production. The Eastern Bloc shipments of 14" disk cartridge drives are stable, due to the slow rate of change in centrally planned economies. Declines are expected, but production will continue through 1990.

Technical trends

The basic recording technologies now in use for products in this group will continue to predominate for years. Most of the 14" drives still in production use variations to the older 2314 technology.

The 8" and smaller drives introduced to date incorporate elements of the older technologies, but utilize head designs similar to Winchester heads, sometimes with "mini" sliders. All of the existing 8" drives use oxide coated disks, while the various 5.25" and 3.9" models use oxide or thin film disks. All use embedded servo techniques in order to maximize the disk surface area available for recording.

The major difference in high density recording between disk cartridge drives and fixed disk drives is higher probability of particulate contamination in removable disk drives. At existing linear recording densities, removability appears to be completely practical. But at densities well above 10,000 BPI, already in use with high capacity fixed disk drives, heads must fly at lower altitudes, increasing the need for lower contamination levels. It is possible to increase density in removable disk drives, but the degree of engineering difficulty is high. Changes in heads, filtration systems and seals may be necessary, and thin film disks are likely to be used because of improved surface durability.

Forecasting assumptions

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

2. Production for 5.25" disk cartridge drives, including models with higher capacities, will be available in large production quantities from multiple sources starting in 1987, with good acceptance.

TABLE 9

DISK CARTRIDGE DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986 Revenues		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	31.2	90.7	11.2	26.9	2.4	4.0	--	--	--	--
TOTAL U.S. CAPTIVE	31.2	90.7	11.2	26.9	2.4	4.0	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	33.7	38.9	30.7	32.9	37.3	39.6	35.7	37.4	35.0	36.8
TOTAL U.S. NON-CAPTIVE	33.7	38.9	30.7	32.9	37.3	39.6	35.7	37.4	35.0	36.8
TOTAL U.S. REVENUES	64.9	129.6	41.9	59.8	39.7	43.6	35.7	37.4	35.0	36.8
Non-U.S. Manufacturers										
Captive	--	23.2	--	21.0	--	22.0	--	21.5	--	19.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	4.6	45.1	7.8	52.4	9.6	49.5	11.8	47.8	12.5	41.5
TOTAL NON-U.S. REVENUES	4.6	68.3	7.8	73.4	9.6	71.5	11.8	69.3	12.5	60.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	69.5	197.9	49.7	133.2	49.3	115.1	47.5	106.7	47.5	97.3
OEM Average Price ($000)	.5	.9	.5	.8	.5	.8	.5	.7	.4	.6

TABLE 10

DISK CARTRIDGE DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986 Shipments		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	4.8	12.6	2.0	4.3	.3	.5	--	--	--	--
TOTAL U.S. CAPTIVE	4.8	12.6	2.0	4.3	.3	.5	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	57.6	62.4	58.3	62.9	67.0	72.0	69.2	73.0	76.0	80.0
TOTAL U.S. NON-CAPTIVE	57.6	62.4	58.3	62.9	67.0	72.0	69.2	73.0	76.0	80.0
TOTAL U.S. SHIPMENTS	62.4	75.0	60.3	67.2	67.3	72.5	69.2	73.0	76.0	80.0
Non-U.S. Manufacturers										
Captive	--	4.3	--	4.0	--	5.4	--	6.2	--	6.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	7.0	24.7	12.0	34.0	16.5	39.0	21.8	45.0	25.0	47.0
TOTAL NON-U.S. SHIPMENTS	7.0	29.0	12.0	38.0	16.5	44.4	21.8	51.2	25.0	53.5
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	69.4	104.0	72.3	105.2	83.8	116.9	91.0	124.2	101.0	133.5
Cumulative Shipments										
IBM	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0
Non-IBM	924.1	1,631.1	996.4	1,736.3	1,080.2	1,853.2	1,171.2	1,977.4	1,272.2	2,110.9
WORLDWIDE TOTAL	977.4	1,710.1	1,049.7	1,815.3	1,133.5	1,932.2	1,224.5	2,056.4	1,325.5	2,189.9

TABLE 11

DISK CARTRIDGE DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues				Forecast													
					1987				1988				1989				1990	
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	5.25"
U.S. MANUFACTURERS																		
Captive	31.6	59.1	--	--	8.0	18.9	--	--	--	4.0	--	--	--	--	--	--	--	--
OEM	4.6	8.6	2.6	23.1	--	6.4	4.5	22.0	--	7.0	22.6	10.0	--	3.5	30.7	3.2	--	36.8
TOTAL U.S. REVENUES	36.2	67.7	2.6	23.1	8.0	25.3	4.5	22.0	--	11.0	22.6	10.0	--	3.5	30.7	3.2	--	36.8
NON-U.S. MANUFACTURERS																		
Captive	11.2	7.2	3.0	1.8	12.8	2.2	6.0	--	11.2	--	10.8	--	8.0	--	13.5	--	4.0	15.0
OEM	34.9	2.1	8.1	--	38.5	1.8	12.1	--	35.0	--	14.5	--	30.0	--	17.8	--	22.5	19.0
TOTAL NON-U.S. REVENUES	46.1	9.3	11.1	1.8	51.3	4.0	18.1	--	46.2	--	25.3	--	38.0	--	31.3	--	26.5	34.0
WORLDWIDE RECAP																		
Captive	42.8	66.3	3.0	1.8	20.8	21.1	6.0	--	11.2	4.0	10.8	--	8.0	--	13.5	--	4.0	15.0
	-23.6%	-16.9%	--	+20.0%	-51.4%	-68.2%	+100.0%	--	-46.2%	-81.0%	+80.0%	--	-28.6%	--	+25.0%	--	-50.0%	+11.1%
OEM	39.5	10.7	10.7	23.1	38.5	8.2	16.6	22.0	35.0	7.0	37.1	10.0	30.0	3.5	48.5	3.2	22.5	55.8
	-43.1%	-49.3%	+25.9%	-29.8%	-2.5%	-23.4%	+55.1%	-4.8%	-9.1%	-14.6%	+123.5%	-54.5%	-14.3%	-50.0%	+30.7%	-68.0%	-25.0%	+15.1%
Total Revenues	82.3	77.0	13.7	24.9	59.3	29.3	22.6	22.0	46.2	11.0	47.9	10.0	38.0	3.5	62.0	3.2	26.5	70.8
	-34.4%	-23.7%	+61.2%	-27.6%	-27.9%	-61.9%	+65.0%	-11.6%	-22.1%	-62.5%	+111.9%	-54.5%	-17.7%	-68.2%	+29.4%	-68.0%	-30.3%	+14.2%
ANNUAL SHARE, BY DIAMETER	41.7%	38.9%	6.9%	12.5%	44.6%	22.0%	17.0%	16.4%	40.2%	9.6%	41.6%	8.6%	35.7%	3.3%	58.1%	2.9%	27.3%	72.7%

Note: 8 inch totals include 10.5 inch drives.

TABLE 12

DISK CARTRIDGE DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments				Forecast													
					1987				1988				1989				1990	
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	5.25"
U.S. MANUFACTURERS																		
Captive	5.5	7.1	--	--	2.0	2.3	--	--	--	.5	--	--	--	--	--	--	--	--
OEM	1.0	2.7	4.7	54.0	--	1.9	7.0	54.0	--	2.0	45.0	25.0	--	1.0	64.0	8.0	--	80.0
TOTAL U.S. SHIPMENTS	6.5	9.8	4.7	54.0	2.0	4.2	7.0	54.0	--	2.5	45.0	25.0	--	1.0	64.0	8.0	--	80.0
NON-U.S. MANUFACTURERS																		
Captive	1.4	1.3	1.0	.6	1.6	.4	2.0	--	1.4	--	4.0	--	1.0	--	5.2	--	.5	6.0
OEM	13.8	.5	10.4	--	15.4	.4	18.2	--	14.0	--	25.0	--	12.0	--	33.0	--	9.0	38.0
TOTAL NON-U.S. SHIPMENTS	15.2	1.8	11.4	.6	17.0	.8	20.2	--	15.4	--	29.0	--	13.0	--	38.2	--	9.5	44.0
WORLDWIDE RECAP																		
Captive	6.9 -31.7%	8.4 -18.4%	1.0 --	.6 +20.0%	3.6 -47.8%	2.7 -67.9%	2.0 +100.0%	-- --	1.4 -61.1%	.5 -81.5%	4.0 +100.0%	-- --	1.0 -28.6%	-- --	5.2 +30.0%	-- --	.5 -50.0%	6.0 +15.4%
OEM	14.8 -36.5%	3.2 -61.9%	15.1 +60.6%	54.0 -19.4%	15.4 +4.1%	2.3 -28.1%	25.2 +66.9%	54.0 --	14.0 -9.1%	2.0 -13.0%	70.0 +177.8%	25.0 -53.7%	12.0 -14.3%	1.0 -50.0%	97.0 +38.6%	8.0 -68.0%	9.0 -25.0%	118.0 +21.6%
Total Shipments	21.7 -35.0%	11.6 -38.0%	16.1 +71.3%	54.6 -19.1%	19.0 -12.4%	5.0 -56.9%	27.2 +68.9%	54.0 -1.1%	15.4 -18.9%	2.5 -50.0%	74.0 +172.1%	25.0 -53.7%	13.0 -15.6%	1.0 -60.0%	102.2 +38.1%	8.0 -68.0%	9.5 -26.9%	124.0 +21.3%
ANNUAL SHARE, BY DIAMETER	20.9%	11.2%	15.5%	52.4%	18.1%	4.8%	26.0%	51.1%	13.2%	2.1%	63.4%	21.3%	10.5%	.8%	82.4%	6.3%	7.1%	92.9%

Note: 8 inch totals include 10.5 inch drives.

TABLE 13

DISK CARTRIDGE DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	26.5	25.5	18.7	14.0
MICROCOMPUTERS Business and professional, single user	24.9	24.0	18.7	14.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	3.4	3.3	2.7	2.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	49.2	47.2	93.4	70.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	104.0	100.0	133.5	100.0

TABLE 14

DISK CARTRIDGE DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	14"	8"	5.25"	<5.25"	Total		14"	8"	5.25"	<5.25"	Total	
SYQUEST	--	--	--	50.0	50.0	77.4	--	--	--	54.0	54.0	62.0
RICOH	--	--	7.0	--	7.0	10.8	--	--	9.0	--	9.0	10.3
Other U.S.	.3	2.6	4.7	--	7.6	11.8	1.0	2.7	4.7	--	8.4	9.6
Other Non-U.S.	--	--	--	--	--	--	13.8	.5	1.4	--	15.7	18.1
TOTAL	.3	2.6	11.7	50.0	64.6	100.0	14.8	3.2	15.1	54.0	87.1	100.0

NOTE: 8 inch totals include 10.5 inch drives.

DISK PACK DRIVES

1987 DISK/TREND REPORT

DISK PACK DRIVES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Century Data	T306, T472
Control Data	9762, 9766
Data General	6060, 6122
Digital Equipment	RA60
Hewlett-Packard	7935H
ISOT	CM 5412, ES 5066, ES 5067
Kovo (Aritma)	4080, 5080
NEC	N7745
Unisys	9484-13

9" disk diameter

Control Data	9710

IBM's 1971 introduction of the 3330, with 19 data surfaces, set the physical model for larger disk pack drives. The Control Data 300 megabyte SMD is the major large disk pack drive still in production. Large disk pack files introduced in more recent years include the Digital Equipment RA60 (14" 205 MB using 6 data surfaces) and the Hewlett-Packard 7935H (14" 404 MB using 13 data surfaces).

The Control Data 9760 series, the original "storage module drives" introduced in 1974, exerted broad influence in the industry. "SMD" became the generally used term for drives using 3330 technology in packs with five data surfaces, as well as for the larger 19 surface drives. The SMD interface also became widely used for high performance OEM disk drives.

Control Data's 9" "RSD", or 9710, is functionally similar to the 80 megabyte SMD except for smaller size and lower price. Its size is matched to the Control Data "FSD" 9" family of fixed disk drives. The

continuing Eastern Bloc production of drives equivalent to the older IBM 2314 is also included in this product group.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1986	1987	1988	1989	1990
U.S. manufacturers	407.4	250.1	144.0	71.6	22.5
All manufacturers	508.7	340.6	227.4	142.8	82.3

Large disk pack drives have remained in volume production longer than anyone expected, mostly in the United States, but a substantial reduction in shipments is underway in 1987. Worldwide shipments of all 14" disk pack drives are expected to be down 33% in 1987, to 30,300 units. Shipments of 9" drives are forecasted at 11,000 units, down 16%.

Control Data remained the dominant producer of disk pack drives in 1986. The firm's 27,500 combined unit shipments of both 14" and 9" drives provided 66.7% of the worldwide non-captive unit total. Bulgarian production by ISOT of disk pack drives using 2314 and SMD technology accounted for most of the remainder.

Marketing trends

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

The trend is also moving against 9" disk pack drives, once expected to find continued growth due to the security requirements of the U.S. government -- which requires that many types of applications connected

with national defense utilize disk media which is removable, to facilitate secure storage of confidential data. 1990 worldwide OEM shipments of 9" drives are now forecasted to drop to 2,300 units.

This group has suffered from intense competition from fixed disk drives, first 14", then 8" and now 5.25" models -- offering lower price, improved reliability, and usually smaller size. Control Data's 9" RSD provides a smaller form factor for those system manufacturers which still want disk pack drives in this capacity range, but the limited size of the potential market is not likely to attract further competition.

Nothing on the horizon is likely to reverse the basic trend. Fixed disk drives are obviously being designed into most new systems requiring capacities in this range.

Technical trends

It remains unclear whether any significant new disk pack drives will be introduced. Higher effective areal densities have been achieved by DEC's RA60 and H-P's 7935H, partially through use of run length limited encoding. However, there are no known plans by any drive manufacturer to develop a new drive in this group using today's technology -- with the possible exception of Control Data, which has previously indicated to customers that the firm might produce a 160 megabyte version of its RSD 9" disk pack drive.

Forecasting assumptions

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

TABLE 15

DISK PACK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986 Revenues		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	93.5	245.7	61.7	158.1	34.1	79.8	19.5	42.0	8.1	15.3
TOTAL U.S. CAPTIVE	93.5	245.7	61.7	158.1	34.1	79.8	19.5	42.0	8.1	15.3
PCM	--	--	--	--	--	--	--	--	--	--
OEM	99.8	161.7	60.5	92.0	43.3	64.2	20.0	29.6	5.0	7.2
TOTAL U.S. NON-CAPTIVE	99.8	161.7	60.5	92.0	43.3	64.2	20.0	29.6	5.0	7.2
TOTAL U.S. REVENUES	193.3	407.4	122.2	250.1	77.4	144.0	39.5	71.6	13.1	22.5
Non-U.S. Manufacturers										
Captive	--	30.7	--	20.0	--	18.4	--	12.8	--	8.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	70.6	--	70.5	--	65.0	--	58.4	--	51.8
TOTAL NON-U.S. REVENUES	--	101.3	--	90.5	--	83.4	--	71.2	--	59.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	193.3	508.7	122.2	340.6	77.4	227.4	39.5	142.8	13.1	82.3
OEM Average Price ($000)	5.7	5.6	5.1	5.4	5.2	5.6	4.8	5.5	3.5	5.3

TABLE 16

DISK PACK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986 Shipments		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	6.6	15.7	4.7	10.5	2.6	6.0	1.6	3.4	.7	1.3
TOTAL U.S. CAPTIVE	6.6	15.7	4.7	10.5	2.6	6.0	1.6	3.4	.7	1.3
PCM	--	--	--	--	--	--	--	--	--	--
OEM	17.5	28.1	11.7	17.6	8.2	12.0	4.1	6.0	1.4	2.0
TOTAL U.S. NON-CAPTIVE	17.5	28.1	11.7	17.6	8.2	12.0	4.1	6.0	1.4	2.0
TOTAL U.S. SHIPMENTS	24.1	43.8	16.4	28.1	10.8	18.0	5.7	9.4	2.1	3.3
Non-U.S. Manufacturers										
Captive	--	1.6	--	1.1	--	1.0	--	.8	--	.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	13.1	--	12.1	--	11.0	--	10.0	--	9.0
TOTAL NON-U.S. SHIPMENTS	--	14.7	--	13.2	--	12.0	--	10.8	--	9.5
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	24.1	58.5	16.4	41.3	10.8	30.0	5.7	20.2	2.1	12.8
Cumulative Shipments										
IBM	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6
Non-IBM	504.1	902.0	520.5	943.3	531.3	973.3	537.0	993.5	539.1	1,006.3
WORLDWIDE TOTAL	545.4	974.6	561.8	1,015.9	572.6	1,045.9	578.3	1,066.1	580.4	1,078.9

TABLE 17

DISK PACK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues		Forecast							
			1987		1988		1989		1990	
	14"	9"	14"	9"	14"	9"	14"	9"	14"	9"
U.S. MANUFACTURERS										
Captive	243.3	2.4	155.7	2.4	74.0	5.8	37.5	4.5	12.0	3.3
OEM	115.3	46.4	53.1	38.9	39.0	25.2	15.2	14.4	--	7.2
TOTAL U.S. REVENUES	358.6	48.8	208.8	41.3	113.0	31.0	52.7	18.9	12.0	10.5
NON-U.S. MANUFACTURERS										
Captive	30.7	--	20.0	--	18.4	--	12.8	--	8.0	--
OEM	70.6	--	70.5	--	65.0	--	58.4	--	51.8	--
TOTAL NON-U.S. REVENUES	101.3	--	90.5	--	83.4	--	71.2	--	59.8	--
WORLDWIDE RECAP										
Captive	274.0	2.4	175.7	2.4	92.4	5.8	50.3	4.5	20.0	3.3
	-26.5%	--	-35.9%	--	-47.4%	+141.7%	-45.6%	-22.4%	-60.2%	-26.7%
OEM	185.9	46.4	123.6	38.9	104.0	25.2	73.6	14.4	51.8	7.2
	-30.2%	+73.8%	-33.5%	-16.2%	-15.9%	-35.2%	-29.2%	-42.9%	-29.6%	-50.0%
Total Revenues	459.9	48.8	299.3	41.3	196.4	31.0	123.9	18.9	71.8	10.5
	-28.1%	+67.7%	-34.9%	-15.4%	-34.4%	-24.9%	-36.9%	-39.0%	-42.1%	-44.4%
ANNUAL SHARE, BY DIAMETER	90.5%	9.5%	88.0%	12.0%	86.5%	13.5%	86.9%	13.1%	87.3%	12.7%

TABLE 18

DISK PACK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments		Forecast							
	1987		1988		1989		1990			
	14"	9"	14"	9"	14"	9"	14"	9"	14"	9"
U.S. MANUFACTURERS										
Captive	15.5	.2	10.3	.2	5.5	.5	3.0	.4	1.0	.3
OEM	15.2	12.9	6.8	10.8	5.0	7.0	2.0	4.0	--	2.0
TOTAL U.S. SHIPMENTS	30.7	13.1	17.1	11.0	10.5	7.5	5.0	4.4	1.0	2.3
NON-U.S. MANUFACTURERS										
Captive	1.6	--	1.1	--	1.0	--	.8	--	.5	--
OEM	13.1	--	12.1	--	11.0	--	10.0	--	9.0	--
TOTAL NON-U.S. SHIPMENTS	14.7	--	13.2	--	12.0	--	10.8	--	9.5	--
WORLDWIDE RECAP										
Captive	17.1	.2	11.4	.2	6.5	.5	3.8	.4	1.5	.3
	-33.5%	--	-33.3%	--	-43.0%	+150.0%	-41.5%	-20.0%	-60.5%	-25.0%
OEM	28.3	12.9	18.9	10.8	16.0	7.0	12.0	4.0	9.0	2.0
	-26.7%	+79.2%	-33.2%	-16.3%	-15.3%	-35.2%	-25.0%	-42.9%	-25.0%	-50.0%
Total Shipments	45.4	13.1	30.3	11.0	22.5	7.5	15.8	4.4	10.5	2.3
	-29.5%	+77.0%	-33.3%	-16.0%	-25.7%	-31.8%	-29.8%	-41.3%	-33.5%	-47.7%
ANNUAL SHARE, BY DIAMETER	77.7%	22.3%	73.5%	26.5%	75.1%	24.9%	78.3%	21.7%	82.1%	17.9%

TABLE 19

DISK PACK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	8.0	13.8	1.2	9.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	30.4	51.9	8.0	63.0
MICROCOMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	18.8	32.0	.5	4.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	1.3	2.3	3.1	24.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	58.5	100.0	12.8	100.0

TABLE 20

DISK PACK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	14"	9"	Total		14"	9"	Total	
CONTROL DATA	8.1	9.0	17.1	97.7	14.6	12.9	27.5	66.7
Other U.S.	.4	--	.4	2.3	.6	--	.6	1.5
Other Non-U.S.	--	--	--	--	13.1	--	13.1	31.8
TOTAL	8.5	9.0	17.5	100.0	28.3	12.9	41.2	100.0

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

Coverage

Examples of disk drives in this group include:

8 disk diameter

Hitachi	DK811-2
IBM	5525-021/031
Quantum	Q2010, Q2020

5.25" disk diameter

Cogito Systems	CG912*, PT925*
Fujitsu	M2225D*, M2235AS
Hitachi	DK502-1/2/3, DK503-2*
Josephine County Technology	JCT-100, JCT-110
Lexikon	HD 670*
Matsushita Communication Ind.	JU-614, JU-616, JU-664*
Microscience International	HH-725*, HH-825*
Miniscribe	3425 Plus*
Mitsubishi	MR521*, MR522*
NEC	D5126H*
Quantum	Q520
Seagate Technology	ST225*, ST225N*, ST4026
Shinwa Digital	D110*, D220*
Sony	SRD1020C*
Tokico	DK502-3, DK505-2*
Tulin	TL226*, TL326*
Xebec	Owl II*

3.5" disk diameter

Alps Electric	DRM020A*, DRP020A*
Fuji Electric	FK305-26*
Fujitsu	M2223AD*, M2225D
Hewlett-Packard	97501B
Hitachi	DK301-1*, DK301-2*
IBM	WD-325*
JVC (Victor)	JD-3824R*
Lexikon	362*, 372*
Matsushita Com. Ind.	JU-114*, JU-116*
Microscience International	HH-325*
Miniscribe	8425*, 8425S*, 8425F*
Mitsubishi Electric	MR321*, MR322*
NEC	D3126*
Peripheral Technology	PT-225*
Plus Development	Hardcard*, Hardcard 20*
Rodime	R0652A*

3.5" disk diameter (continued)

Seagate Technology	ST125*
Seiko Epson	HMD-720*, HMD-726*
Shinwa Digital	D3510*, D3520*
Tandon	TM362*, Businesscard 21*
Toshiba	MK-132FA*

*Indicates drives with maximum 41 mm height, or less.

All drives in this group use variations of the technology loosely described as "Winchester". Many use 3340/3350 type ferrite heads, but most of the newer drives use "mini-slider" heads which employ ferrite cores in 3370/3380-type sliders. The majority of 5.25" and larger drives in the group use conventional oxide disks, but most of the 3.5" drives, with the exception of IBM's, use plated or sputtered disks.

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

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1986	1987	1988	1989	1990
U.S. manufacturers	1,355.4	1,714.0	1,981.3	2,127.1	2,056.7
All manufacturers	2,197.4	2,466.8	2,864.1	3,062.9	2,956.7

The 1986 growth rate in unit shipments for fixed disk drives less than 30 megabytes rose to 54.7%, reflecting a strong recovery from 1985's lower growth rate in the personal computer industry, during which drives in this group grew only 30% in shipments. Worldwide shipments in

1986 were 5,086,300 drives, producing revenues of $2,197,400,000. However, the 1987 estimates indicate that shipment growth for this group will again level off to 30%, as many users transition to higher capacity drives.

The previously forecasted shift in product mix to 3.5" drives is now occurring. The forecasted worldwide unit shipment total of 3.5" drives for 1987 is 3,587,300 drives, up 168.5% over the previous year. 3.5" drives accounted for 1.4% of 1984's worldwide shipments of all drives in this group, 10.7% of 1985's shipments, 26.2% of 1986's shipments -- and are expected to produce slightly over half of 1987's shipments.

Total shipments of 5.25" drives in this group peaked in 1986 and are now declining. The 1987 worldwide shipment total is forecasted at 3,036,800 drives, down 18.8% from 1986. The original "full size" 5.25" drives (3.25" high) continue to fade, with only 79,300 units shipped in 1987, compared to 2,957,500 half high drives.

Although there is a broad customer base for OEM 5.25" and 3.5" drives, consisting of hundreds of manufacturers of personal computers and other small systems, in this segment of the industry IBM has assumed a dominant role which cannot be overlooked.

IBM's actions, both as a customer and as a captive producer, thoroughly shook the stability of the leading manufacturers of 5.25" drives in this group during the 1984-85 period. With the introduction of the PC XT, IBM became the largest OEM customer for 10 megabyte 5.25" drives from Seagate, Miniscribe and International Memories. And with the advent of the PC AT in 1984, IBM's purchases of 20 megabyte drives overwhelmed Computer Memories, becoming over 80% of the firm's sales. Eventually, IBM abruptly terminated each of these procurements.

IBM's erratic buying patterns had created chaos among vendors of low-end 5.25" drives starting in early 1984, but the more severe stroke was establishment of major internal production programs by IBM for stepping motor 5.25" drives at Fujisawa and voice coil 5.25" drives at Rochester, Minnesota, and Havant, in England.

For over a year IBM appears to have relied completely on internal production of 5.25" stepping motor drives for the PC XT product family, finally adding a 20 megabyte model for the XT in 1986. In the autumn of 1986 IBM again started buying 5.25" stepping motor drives from Seagate, with a contract for 20 megabyte drives -- apparently a move to cover its internal production shortfall while the Fujisawa plant was being converted to manufacture 3.5" drives. Since 1985, IBM has also been buying Seagate voice coil 5.25" drives, initially for PC AT systems, later for mid-level PS/2 models.

With the April, 1987, introduction of the PS/2 family of personal computers, IBM's requirements for low end 3.5" drives has grown immensely. DISK/TREND estimates of captive IBM shipments of 3.5" drives indicate a sharp increase from 60,000 units in 1986 to 925,000 in 1987. It now appears certain that IBM will produce all of these drives internally at Fujisawa, obviating the contract with Miniscribe, which was apparently intended only as an insurance policy against potential IBM startup problems or forecasting errors.

Despite IBM's boost in captive production and increases in shipments by other captive producers, OEM drives continue to hold two thirds of 3.5" shipments and over 90% of 5.25" shipments in 1987. OEM shipments of 3.5" drives are expected to exceed 2.3 million units in 1987, with U.S. manufacturers increasing their share to 71% of the worldwide total.

In 1986, Seagate continued to dominate non-captive unit shipments, with 1,855,000 drives, all 5.25", and a market share which rose to 43.6%. NEC held 11.6%, mostly with 5.25" drives. Miniscribe, Tandon and Rodime trailed with 9.9%, 5.6% and 4.9%.

The primary 1986 application for drives in this group continued to be single user microcomputers, mostly personal computers, with 84.5% of unit shipments. Modest decreases in share are anticipated in applications such as minicomputers, multiple user micros and dedicated application office systems, due to the movement to higher capacity drives.

Marketing trends

The huge growth experienced by this product group has been fueled by the continuing increase in the size of the personal computer market and the growing complexity of software, both operating systems and application programs. The basic trends are expected to continue, but will force additional changes in the data storage product mix.

The movement to 3.5" drives has been stimulated by system configurations with smaller footprints, first from Hewlett-Packard, then Apple, and finally IBM, with the usage of 3.5" floppy drives preceding 3.5" fixed disk drives.

Popularity of more sophisticated software, combined with the growth of typical user files, has also produced a change: Small diameter drives started at 5 megabytes (formatted), then quickly upgraded to 10 megabytes, and during the last two years fixed disk drives shipped in this group have become mostly 20 megabyte models. It is clear that the typical office personal computer will eventually use disk drives with capacities above this product range.

In view of the changes expected above, the overall growth rate for fixed drives with less than 30 megabytes capacity is forecasted to level off in 1990, and the impact could be sharper if IBM should de-emphasize the usage of 20 megabyte drives sooner than anticipated. Although OEM shipments of 3.5" drives are still expected to be in a growth mode in 1990, IBM's captive shipments of 3.5" drives are expected to decline that year, with the result that total worldwide shipments are projected to increase only 14% in 1990, with revenues declining slightly.

The dominance of 3.5" drives will continue to accelerate. As other personal computer manufacturers match IBM's PS/2 product line during the next few years, 5.25" drives below 30 megabytes will continue to decline:

Worldwide captive & OEM Unit shipments (000)	1986	1987	1988	1989	1990
5.25" full size	561.9	79.3	39.0	54.0	77.0
	11.1%	1.2%	.5%	.5%	.7%
5.25" half high	3,178.3	2,957.5	2,266.0	586.0	120.0
	62.6%	44.6%	27.1%	5.8%	1.0%
3.5"	1,336.3	3,587.3	6,072.0	9,496.0	11,359.0
	26.3%	54.2%	72.4%	93.7%	98.3%

Full size 5.25" drives have become an insignificant factor in the OEM market. Without Eastern Bloc shipments of full size drives, which will probably continue indefinitely, production of drives in this form factor would stop completely by 1988.

The share of the OEM market for low end drives held by U.S. manufacturers has continued to strengthen, due to the changes in the dollar/yen exchange rate during the last two years. In 1986, U.S. producers shipped 71% of the drives in this group, but their share is projected to increase to 80% in 1990.

Technical trends

As the shift to 3.5" drives continues, the challenges of large production volume and low cost requirements are the key engineering targets for disk drives in this group. The problem is to achieve the high production volumes despite use of continually higher recording densities.

Although several initially available 3.5" drives used disks with 40 mm inner diameters, 25 mm has been more widely used, to increase the recording area per disk. The result is linear densities in the 13,000 to 15,000 bits per inch range. Plated, sputtered and high density oxide disks suitable at this density range are all in use.

Two interrelated future developments may be expected to increase the cost effectiveness of 3.5" drives in this group. It will be cheaper to package the controller function within the disk drive, and SCSI drives, plus those with embedded controllers for IBM personal computers, are expected to gain a high percentage of OEM drive shipments in a few years.

Embedded controllers will also make it possible to take the next step in recording density, since the physical characteristics of drives will be masked from systems. Most 3.5" floppy drives are already produced in one inch high configurations, and as adequate heads and disks become available, production of one inch high 3.5" rigid disk drives using only one disk will further lower drive costs.

Forecasting assumptions

1. IBM will continue to rely on 3.5" drives in this group for major models in the PS/2 series through 1989, but with a reduction in shipments starting in 1990, in favor of higher capacity drives.
2. The dollar/yen exchange rate will stay in the current range, resulting in increased U.S. OEM market share.

TABLE 21

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986		Forecast							
	Revenues		1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	262.1	438.4	453.6	647.5	574.6	845.0	613.8	930.0	477.4	770.0
Other U.S. Captive	67.3	96.0	90.1	128.6	95.6	136.6	98.7	141.0	98.7	141.0
TOTAL U.S. CAPTIVE	329.4	534.4	543.7	776.1	670.2	981.6	712.5	1,071.0	576.1	911.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	666.8	821.0	737.6	937.9	765.9	999.7	778.3	1,056.1	837.6	1,145.7
TOTAL U.S. NON-CAPTIVE	666.8	821.0	737.6	937.9	765.9	999.7	778.3	1,056.1	837.6	1,145.7
TOTAL U.S. REVENUES	996.2	1,355.4	1,281.3	1,714.0	1,436.1	1,981.3	1,490.8	2,127.1	1,413.7	2,056.7
Non-U.S. Manufacturers										
Captive	63.8	443.4	79.4	455.5	83.7	556.2	106.9	551.5	118.6	528.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	119.7	398.6	84.6	297.3	86.9	326.6	94.7	384.3	77.6	371.6
TOTAL NON-U.S. REVENUES	183.5	842.0	164.0	752.8	170.6	882.8	201.6	935.8	196.2	900.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,179.7	2,197.4	1,445.3	2,466.8	1,606.7	2,864.1	1,692.4	3,062.9	1,609.9	2,956.7
OEM Average Price ($000)	.275	.287	.231	.240	.202	.211	.178	.187	.157	.165

TABLE 22

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986		Forecast							
	---Shipments---		------1987-----		------1988-----		------1989-----		------1990-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	234.0	394.0	648.0	925.0	884.0	1,300.0	1,023.0	1,550.0	868.0	1,400.0
Other U.S. Captive	78.1	110.4	114.1	162.5	136.5	195.0	151.9	217.0	164.5	235.0
TOTAL U.S. CAPTIVE	312.1	504.4	762.1	1,087.5	1,020.5	1,495.0	1,174.9	1,767.0	1,032.5	1,635.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	2,448.4	3,020.2	3,235.6	4,120.7	3,845.1	5,008.0	4,431.0	6,015.0	5,398.0	7,385.0
TOTAL U.S. NON-CAPTIVE	2,448.4	3,020.2	3,235.6	4,120.7	3,845.1	5,008.0	4,431.0	6,015.0	5,398.0	7,385.0
TOTAL U.S. SHIPMENTS	2,760.5	3,524.6	3,997.7	5,208.2	4,865.6	6,503.0	5,605.9	7,782.0	6,430.5	9,020.0
Non-U.S. Manufacturers										
Captive	44.0	330.7	61.6	402.9	85.2	600.0	139.0	682.0	176.0	724.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	407.6	1,231.0	321.6	1,016.5	381.0	1,280.0	460.0	1,680.0	431.0	1,821.0
TOTAL NON-U.S. SHIPMENTS	451.6	1,561.7	383.2	1,419.4	466.2	1,880.0	599.0	2,362.0	607.0	2,545.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,212.1	5,086.3	4,380.9	6,627.6	5,331.8	8,383.0	6,204.9	10,144.0	7,037.5	11,565.0
Cumulative Shipments										
IBM	648.4	944.9	1,296.4	1,869.9	2,180.4	3,169.9	3,203.4	4,719.9	4,071.4	6,119.9
Non-IBM	7,983.2	12,001.0	11,716.1	17,703.6	16,163.9	24,786.6	21,345.8	33,380.6	27,515.3	43,545.6
WORLDWIDE TOTAL	8,631.6	12,945.9	13,012.5	19,573.5	18,344.3	27,956.5	24,549.2	38,100.5	31,586.7	49,665.5

TABLE 23

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues				1987 Forecast				1988 Forecast			1989 Forecast			1990 Forecast		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	--	28.4	344.0	66.0	--	--	--	647.5	--	--	845.0	--	--	930.0	--	--	770.0
Other U.S. Captive	1.0	2.0	20.0	73.0	.9	.5	18.4	108.8	--	7.0	129.6	--	--	141.0	--	--	141.0
OEM	--	4.3	626.9	189.8	--	1.0	513.2	423.7	--	357.9	641.8	--	61.7	994.4	--	7.2	1,138.5
TOTAL U.S. REVENUES	1.0	34.7	990.9	328.8	.9	1.5	531.6	1,180.0	--	364.9	1,616.4	--	61.7	2,065.4	--	7.2	2,049.5
NON-U.S. MANUFACTURERS																	
Captive	--	--	339.4	104.0	--	--	286.1	169.4	--	247.2	309.0	--	175.6	375.9	--	102.6	425.8
OEM	--	2.9	258.5	137.2	--	5.6	118.1	173.6	15.0	76.7	234.9	20.0	54.7	309.6	22.5	38.8	310.3
TOTAL NON-U.S. REVENUES	--	2.9	597.9	241.2	--	5.6	404.2	343.0	15.0	323.9	543.9	20.0	230.3	685.5	22.5	141.4	736.1
WORLDWIDE RECAP																	
Captive	1.0	30.4	703.4	243.0	.9	.5	304.5	925.7	--	254.2	1,283.6	--	175.6	1,446.9	--	102.6	1,336.8
	-91.5%	-59.8%	-8.1%	+872.0%	-10.0%	-98.4%	-56.7%	+280.9%	--	-16.5%	+38.7%	--	-30.9%	+12.7%	--	-41.6%	-7.6%
OEM	--	7.2	885.4	327.0	--	6.6	631.3	597.3	15.0	434.6	876.7	20.0	116.4	1,304.0	22.5	46.0	1,448.8
	--	-65.0%	+4.3%	+187.3%	--	-8.3%	-28.7%	+82.7%	+127.3%	-31.2%	+46.8%	+33.3%	-73.2%	+48.7%	+12.5%	-60.5%	+11.1%
Total Revenues	1.0	37.6	1,588.8	570.0	.9	7.1	935.8	1,523.0	15.0	688.8	2,160.3	20.0	292.0	2,750.9	22.5	148.6	2,785.6
	-91.6%	-60.9%	-1.6%	+310.7%	-10.0%	-81.1%	-41.1%	+167.2%	+111.3%	-26.4%	+41.8%	+33.3%	-57.6%	+27.3%	+12.5%	-49.1%	+1.3%
ANNUAL SHARE, BY DIAMETER	--	1.7%	72.4%	25.9%	--	.3%	38.0%	61.7%	.5%	24.0%	75.5%	.7%	9.5%	89.8%	.8%	5.0%	94.2%

Note: 3.5 inch totals include 3.9 inch drives.

TABLE 24

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments				Forecast											
					1987				1988			1989			1990		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	--	4.0	330.0	60.0	--	--	--	925.0	--	--	1,300.0	--	--	1,550.0	--	--	1,400.0
Other U.S. Captive	.1	.4	23.8	86.1	.1	.1	25.8	136.5	--	10.0	185.0	--	--	217.0	--	--	235.0
OEM	--	4.0	2,407.3	608.9	--	1.0	2,463.5	1,656.2	--	1,877.0	3,131.0	--	333.0	5,682.0	--	40.0	7,345.0
TOTAL U.S. SHIPMENTS	.1	8.4	2,761.1	755.0	.1	1.1	2,489.3	2,717.7	--	1,887.0	4,616.0	--	333.0	7,449.0	--	40.0	8,980.0
NON-U.S. MANUFACTURERS																	
Captive	--	--	226.7	104.0	--	--	200.5	202.4	--	188.0	412.0	--	145.0	537.0	--	69.0	655.0
OEM	--	1.3	752.4	477.3	--	2.3	347.0	667.2	6.0	230.0	1,044.0	8.0	162.0	1,510.0	9.0	88.0	1,724.0
TOTAL NON-U.S. SHIPMENTS	--	1.3	979.1	581.3	--	2.3	547.5	869.6	6.0	418.0	1,456.0	8.0	307.0	2,047.0	9.0	157.0	2,379.0
WORLDWIDE RECAP																	
Captive	.1	4.4	580.5	250.1	.1	.1	226.3	1,263.9	--	198.0	1,897.0	--	145.0	2,304.0	--	69.0	2,290.0
	-94.4%	-63.0%	+12.2%	--	--	-97.7%	-61.0%	+405.4%	--	-12.5%	+50.1%	--	-26.8%	+21.5%	--	-52.4%	-.6%
OEM	--	5.3	3,159.7	1,086.2	--	3.3	2,810.5	2,323.4	6.0	2,107.0	4,175.0	8.0	495.0	7,192.0	9.0	128.0	9,069.0
	--	-64.4%	+32.6%	+225.6%	--	-37.7%	-11.1%	+113.9%	+81.8%	-25.0%	+79.7%	+33.3%	-76.5%	+72.3%	+12.5%	-74.1%	+26.1%
Total Shipments	.1	9.7	3,740.2	1,336.3	.1	3.4	3,036.8	3,587.3	6.0	2,305.0	6,072.0	8.0	640.0	9,496.0	9.0	197.0	11,359.0
	-94.7%	-63.8%	+29.0%	+275.3%	--	-64.9%	-18.8%	+168.5%	+76.5%	-24.1%	+69.3%	+33.3%	-72.2%	+56.4%	+12.5%	-69.2%	+19.6%
ANNUAL SHARE, BY DIAMETER	--	.2%	73.6%	26.2%	--	.1%	45.9%	54.0%	.1%	27.6%	72.3%	.1%	6.3%	93.6%	.1%	1.7%	98.2%

Note: 3.5 inch totals include 3.9 inch drives.

TABLE 25

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	6.1	.1	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	303.7	6.0	312.3	2.7
MICROCOMPUTERS Business and professional, single user	4,295.8	84.5	10,281.2	88.9
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	251.3	4.9	266.0	2.3
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	133.3	2.6	370.1	3.2
CONSUMER AND HOBBY COMPUTERS	77.3	1.5	300.7	2.6
OTHER APPLICATIONS	18.8	.4	34.7	.3
Total	5,086.3	100.0	11,565.0	100.0

TABLE 26

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 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	--	1616.0	--	1616.0	56.6	--	1855.0	--	1855.0	43.6
NEC	--	110.0	23.0	133.0	4.7	--	401.0	92.0	493.0	11.6
MINISCRIBE	--	182.2	165.3	347.5	12.2	--	234.5	186.8	421.3	9.9
TANDON	--	47.1	75.4	122.5	4.3	--	81.6	157.8	239.4	5.6
RODIME	--	2.0	160.0	162.0	5.7	--	10.0	200.0	210.0	4.9
MICROSCIENCE	--	95.7	12.0	107.7	3.8	--	165.0	16.0	181.0	4.3
LAPINE	--	--	79.7	79.7	2.8	--	--	106.3	106.3	2.5
PLUS DEVELOPMENT	--	--	84.0	84.0	2.9	--	--	105.0	105.0	2.5
Other U.S.	3.0	61.0	27.0	91.0	3.2	4.0	71.2	37.0	112.2	2.6
Other Non-U.S.	--	23.1	89.5	112.6	3.8	1.3	341.4	185.3	528.0	12.5
TOTAL	3.0	2137.1	715.9	2856.0	100.0	5.3	3159.7	1086.2	4251.2	100.0

NOTE: 3.5 inch totals include 3.9 inch drives.

FIXED DISK DRIVES, 30-100 MEGABYTES

1987 DISK/TREND REPORT

FIXED DISK DRIVES, 30-100 MEGABYTES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Fujitsu	M2312K, M2321K
Hitachi	DK 811-4, DK812S-8
IBM	4963-64A, 8101
Northern Telecom	8204X
Priam	7050, 803
Quantum	Q2030, Q2040
Toshiba	MK-182FB

5.25" disk diameter

Brand Technologies	BT8085
Control Data	94155, 94205*
Data-Tech Memories	DTM 853, DTM 885
Fujitsu	M2241, M2242, M2243
Hitachi	DK511-5, DK512-8
IBM	5364, 667-85
Lexikon	HD 674*
Micropolis	1353, 1373
Microscience International	HH-1050*, HH-830*
Miltope	RDS-5000
Miniscribe	3650*, 6053, 6085
Mitsubishi Electric	MR533*, MR535*
NEC	D5146*, D5452
Newbury Data	NDR 1065, NDR 1065
Priam	V150, V185
Quantum	Q540, Q250*, Q280*
Rodime	R05090*
Seagate	ST4038, ST277N*, ST4096
Sony	SRD1040C*
Tandon	TM 2085, TM 3085
Teac	SD-540*
Tokico	DK5046*
Toshiba	MK-56FB, MK-134FA*
Tulin	TL 340*
Xebec	Owl 40X*

3.5" disk diameter

Cardiff Peripherals	F3053*, F3080*
Conner Peripherals	CP340*
Fuji Electric	FK303-52*, FK308S-58R*
Fujitsu	M2226AD*, M2227D*

3.5" disk diameter (continued)

Matsushita Com. Ind.	JU-127*, JU-128*
Microscience International	HH-330*
Miltope	RDS-3400
Miniscribe	8438*, 8438F*
Newbury Data	NDR 340*
Peripheral Technology	PT-338*, PT-357R*
Plus Development	Hardcard 40*
Rodime	R03055*, R03085*
Seagate Technology	ST138*, ST157*
Seiko Epson	HMD-946*, HMD-976*
Tandon	TM364*, Data Pac
Toshiba	MK-133FA*, MK-134FA*
YE Data	3540*, 3541*

*Indicates drives with maximum 41 mm height, or less

These are all nominally "Winchester" drives, but many variations to that technology are used, including thin film disks and ferrite heads with 3370 type sliders. Most use rotary or linear voice coil head positioning systems, but a few use other techniques, such as stepping or torque motors.

3.5" drives are now being introduced in this product group at a rapid clip. Starting in 1988, intense competition is expected at the 40 megabyte (formatted) level, which will lead to a variety of attempts to reduce product costs, affecting product design.

Conner Peripheral's drive, currently the 3.5" shipment leader, uses only two disks to achieve 40 megabytes, compared to the three or four disks used by competitive drives. The Seagate drive expected to ship by year-end 1987 will use an advanced stepping motor head positioning system instead of the voice coil actuators used in most of the other drives in the group.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1985	1986	1987	1988	1989
U.S. manufacturers	1,707.0	2,654.9	2,591.0	2,660.4	2,631.9
All manufacturers	2,215.7	3,322.6	3,362.2	3,481.3	3,401.6

5.25" drives in this product group continue to grow at an exceptional rate. 1986's worldwide total shipments of 1,911,800 5.25" drives represented an increase of 175% over the previous year, and current DISK/TREND forecasts predict that shipments for 1987 will be more than double the 1986 record.

Half high 5.25" drives have become an important part of these shipments -- half high models are estimated at 2,082,400 drives out of a 1987 total of 4,393,300 units. Heavy shipments of OEM drives with formatted capacities of 30-44 megabytes to the personal computer aftermarket and to clone manufacturers account for a major portion of the jump in half high drive shipments, as well as a significant part of the shipments of full size drives.

1987 also marks the beginning of major shipment growth for 3.5" drives, boosted by the aggressive manufacturing start by Conner Peripherals, plus significant consumption in the Japanese domestic market. While 1986 worldwide shipments of 3.5" drives totaled only 21,700 units, 1987 shipments are estimated at 597,300 drives.

1987 will be the last year for 14" drive shipments in this product group, and 8" drives are fading rapidly. After peaking in 1984, 8" drives were rapidly eclipsed by 5.25" drives, and the 1987 shipment total, over 70% captive, is expected to be down another 48.8%, dropping to only 47,600 drives.

Shipments of captive 5.25" drives are also expected to more than double in 1987, driven by IBM's combined production of "Pixie" and "Grant" drives, estimated at 590,000 units. Captive production by other system manufacturers continues to remain modest, with Tandon, NEC and Lexikon (Olivetti) accounting for most of the remainder.

The major application for drives in this group has moved from minicomputers to microcomputers, mostly high end personal computers. Single user microcomputers generated 58.9% of 1986's worldwide shipments, and are expected to produce 68.8% of 1990's shipments, with the percentage going to minicomputer applications forecasted to decline further.

In 1986, Seagate jumped to the lead in non-captive shipments, as the market expanded for drives in the lower end of this product group's capacity range. Seagate shipped 528,000 drives, for 32.3% of the worldwide shipment total. Micropolis held 13.7%, based on strong shipments of 85 megabyte drives, followed by Control Data, with 12.9%.

Marketing trends

Although worldwide shipments for drives in this group are forecasted to reach 9,880,000 units in 1990, almost five times the 1986 total, revenue growth in 1988-90 is expected to be flat, with a decline by the end of the period. The impact on total revenue will be caused by changes in product mix, as smaller drives become predominant, by stronger growth for OEM drives sold at lower prices than captive drives, and by lower average prices for all drives. Underlying all of these changes is the continually growing demand for more disk storage with high end personal computers.

IBM has become a major producer of 5.25" drives in this capacity range, starting with first production in 1985. However, it is expected

that this production will now decline, in favor of an internal 3.5" drive program, plus the strong possibility of increased outside purchases. Production start-up is not expected until the second half of 1988 for IBM's own 3.5" voice coil drives, so there remains the possibility of using outside disk drive suppliers already in quantity production, to solve a weakness in the PS/2 product line.

Despite the spurt in 5.25" drive shipments during 1987, the shipment peak for total 5.25" drive shipments is expected in 1988, with the peak for full size models actually occuring this year. As 5.25" drives go into a sharp decline, 3.5" drives are expected to enjoy a sharper increase:

Worldwide captive & OEM Unit shipments (000)	1986	1987	1988	1989	1990
5.25" full size	1,535.5	2,310.9	1,759.0	1,015.0	392.0
	79.4%	46.3%	26.5%	12.1%	3.9%
5.25" half high	376.3	2,082.4	2,692.0	2,287.0	1,242.0
	19.5%	41.7%	40.6%	27.3%	12.6%
3.5"	21.8	597.3	2,180.0	5,070.0	8,246.0
	1.1%	12.0%	32.9%	60.6%	83.5%

A classic rivalry is now underway between 5.25" half high drives and 3.5" drives. 5.25" half high drives were available in the marketplace in production quantities well before 3.5" drives, and some models offer better performance than any 3.5" drive. But the movement toward smaller footprint personal computers favors future growth for the 3.5" drives in this capacity range, and they are expected to exceed 80% of the group's 1990 worldwide shipments.

Shipments of 8" drives are falling rapidly and will be out of production by 1989, with the possible exception of Eastern Bloc countries. The first Eastern Bloc production of 8" fixed disk drives started in 1985, and

shipments in the capacity range represented by this product group may be an important factor in upgrading the many applications now served by older disk pack drives, but will not be included in our estimates until plans become firm.

Technical trends

Although not settled, the political battles over interface standards are calming down. The majority of drives in this group are still being shipped with 5 megabit transfer rates, using Seagate type interfaces. But a growing number of system manufacturers are using SCSI interfaces, with drives such as the Conner 3.5" and the Quantum half high 5.25", and it is expected that the next several years will see many drives being offered with embedded SCSI or other intelligent interfaces. It is quite possible that the 3.5" drives expected from IBM next year will use an IBM unique embedded controller.

As disk and head sourcing problems ease, 10 megabit per second drives are expected to grow in importance, many of which will use either ESDI as a drive level interface or intelligent interfaces.

It has been difficult to combine high recording densities and small box sizes with the high production volume and low cost required for the drives in this group. There have been severe sourcing problems with media, as manufacturers transitioned to plated, sputtered and high density oxide disks. The many new disk manufacturers have had trouble maintaining consistent quality and several have shut down operations from time to time to solve problems with production processes. Although media quality has improved greatly, drive manufacturers must still devote excessive resources to media test and inspection.

Although the technology used in recording heads is also changing, both thin film and advanced ferrite heads are usable with the densities now required, and both are in production. Drive manufacturers have favored "mini-sliders", heads using ferrite cores mounted in sliders with contours similar to IBM's 3370/3380 thin film heads. Limited quantities of thin film heads are also being used in production disk drives, with more expected as price competition forces areal densities to increase further.

Forecasting assumptions

1. IBM's production of 5.25" drives will decrease starting in 1988, when a transition to 3.5" drives will start rapid growth. IBM will rely on internal manufacturing for drives in this group, but will supplement internal shortfalls with outside purchases.
2. Growth for OEM 5.25" drives will end in 1988, limited by IBM's competitive inroads at the system level, by movement to higher capacities, and by a movement to 3.5" drives.
3. Availability of 3.5" drives will be adequate in 1988 to satisfy growing demand.

TABLE 27

FIXED DISK DRIVES, 30 - 100 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986 Revenues		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	527.9	778.0	665.9	989.0	335.5	501.6	283.2	421.0	379.8	576.0
Other U.S. Captive	54.7	70.0	62.8	82.1	82.4	113.0	82.5	115.4	67.6	96.8
TOTAL U.S. CAPTIVE	582.6	848.0	728.7	1,071.1	417.9	614.6	365.7	536.4	447.4	672.8
PCM	--	--	--	--	--	--	--	--	--	--
OEM	703.4	859.0	1,295.4	1,583.8	1,635.6	1,976.4	1,754.9	2,124.0	1,594.3	1,959.1
TOTAL U.S. NON-CAPTIVE	703.4	859.0	1,295.4	1,583.8	1,635.6	1,976.4	1,754.9	2,124.0	1,594.3	1,959.1
TOTAL U.S. REVENUES	1,286.0	1,707.0	2,024.1	2,654.9	2,053.5	2,591.0	2,120.6	2,660.4	2,041.7	2,631.9
Non-U.S. Manufacturers										
Captive	63.0	255.0	92.2	311.8	95.0	339.5	99.2	309.4	75.8	262.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	89.1	253.7	110.1	355.9	138.1	431.7	162.4	511.5	151.5	507.3
TOTAL NON-U.S. REVENUES	152.1	508.7	202.3	667.7	233.1	771.2	261.6	820.9	227.3	769.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,438.1	2,215.7	2,226.4	3,322.6	2,286.6	3,362.2	2,382.2	3,481.3	2,269.0	3,401.6
OEM Average Price ($000)	.661	.680	.443	.456	.398	.401	.346	.345	.279	.277

TABLE 28

FIXED DISK DRIVES, 30 - 100 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986 Shipments		Forecast							
			1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	204.3	295.0	420.7	620.0	247.5	368.0	266.0	395.0	422.0	640.0
Other U.S. Captive	16.6	21.6	34.0	46.0	65.9	91.0	81.0	114.0	81.0	116.0
TOTAL U.S. CAPTIVE	220.9	316.6	454.7	666.0	313.4	459.0	347.0	509.0	503.0	756.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	1,083.9	1,299.4	2,961.6	3,554.9	4,113.1	4,948.8	5,039.0	6,067.0	5,664.0	6,942.0
TOTAL U.S. NON-CAPTIVE	1,083.9	1,299.4	2,961.6	3,554.9	4,113.1	4,948.8	5,039.0	6,067.0	5,664.0	6,942.0
TOTAL U.S. SHIPMENTS	1,304.8	1,616.0	3,416.3	4,220.9	4,426.5	5,407.8	5,386.0	6,576.0	6,167.0	7,698.0
Non-U.S. Manufacturers										
Captive	24.2	76.4	40.1	117.2	46.0	173.0	56.0	214.0	54.0	224.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	114.9	336.1	211.0	700.4	347.0	1,063.0	508.0	1,582.0	586.0	1,958.0
TOTAL NON-U.S. SHIPMENTS	139.1	412.5	251.1	817.6	393.0	1,236.0	564.0	1,796.0	640.0	2,182.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,443.9	2,028.5	3,667.4	5,038.5	4,819.5	6,643.8	5,950.0	8,372.0	6,807.0	9,880.0
Cumulative Shipments										
IBM	462.2	684.0	882.9	1,304.0	1,130.4	1,672.0	1,396.4	2,067.0	1,818.4	2,707.0
Non-IBM	2,307.2	3,308.8	5,553.9	7,727.3	10,125.9	14,003.1	15,809.9	21,980.1	22,194.9	31,220.1
WORLDWIDE TOTAL	2,769.4	3,992.8	6,436.8	9,031.3	11,256.3	15,675.1	17,206.3	24,047.1	24,013.3	33,927.1

TABLE 29

FIXED DISK DRIVES, 30 - 100 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues				Forecast										
	1987				1988			1989		1990	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS															
IBM Captive	--	418.0	360.0	--	--	222.0	767.0	--	57.6	400.0	44.0	156.0	265.0	--	576.0
Other U.S. Captive	14.2	--	55.8	--	3.0	--	71.1	8.0	--	66.0	47.0	41.6	73.8	12.0	84.8
OEM	1.7	40.1	814.2	3.0	--	20.4	1,395.4	168.0	4.8	1,488.2	483.4	1,160.3	963.7	608.2	1,350.9
TOTAL U.S. REVENUES	15.9	458.1	1,230.0	3.0	3.0	242.4	2,233.5	176.0	62.4	1,954.2	574.4	1,357.9	1,302.5	620.2	2,011.7
NON-U.S. MANUFACTURERS															
Captive	--	40.2	214.6	.2	--	24.1	274.2	13.5	12.4	246.5	80.6	201.4	108.0	129.2	133.2
OEM	--	18.3	229.7	5.7	--	4.3	263.3	88.3	--	204.2	227.5	136.9	374.6	57.0	450.3
TOTAL NON-U.S. REVENUES	--	58.5	444.3	5.9	--	28.4	537.5	101.8	12.4	450.7	308.1	338.3	482.6	186.2	583.5
WORLDWIDE RECAP															
Captive	14.2	458.2	630.4	.2	3.0	246.1	1,112.3	21.5	70.0	712.5	171.6	399.0	446.8	141.2	794.0
	-54.8%	+13.1%	+466.4%	-33.3%	-78.9%	-46.3%	+76.4%	--	-71.6%	-35.9%	+698.1%	-44.0%	+160.4%	-64.6%	+77.7%
OEM	1.7	58.4	1,043.9	8.7	--	24.7	1,658.7	256.3	4.8	1,692.4	710.9	1,297.2	1,338.3	665.2	1,801.2
	-75.4%	-53.0%	+75.8%	+357.9%	--	-57.7%	+58.9%	--	-80.6%	+2.0%	+177.4%	-23.4%	+88.3%	-48.7%	+34.6%
Total Revenues	15.9	516.6	1,674.3	8.9	3.0	270.8	2,771.0	277.8	74.8	2,404.9	882.5	1,696.2	1,785.1	806.4	2,595.2
	-58.5%	-2.4%	+136.2%	+304.5%	-81.1%	-47.6%	+65.5%	--	-72.4%	-13.2%	+217.7%	-29.5%	+102.3%	-52.5%	+45.4%
ANNUAL SHARE, BY DIAMETER	.7%	23.3%	75.7%	.3%	.1%	8.2%	83.5%	8.2%	2.2%	71.6%	26.2%	48.8%	51.2%	23.7%	76.3%

Note: 3.5 inch totals include 3.9 inch drives
8 inch totals include 10.5 inch drives

TABLE 30

FIXED DISK DRIVES, 30 - 100 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments				Forecast										
					1987				1988			1989		1990	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS															
IBM Captive	--	55.0	240.0	--	--	30.0	590.0	--	8.0	320.0	40.0	130.0	265.0	--	640.0
Other U.S. Captive	1.3	--	20.3	--	.3	--	37.7	8.0	--	44.0	47.0	32.0	82.0	10.0	106.0
OEM	.7	23.9	1,268.8	6.0	--	11.8	3,190.6	352.5	2.8	3,565.0	1,381.0	2,744.0	3,323.0	1,428.0	5,514.0
TOTAL U.S. SHIPMENTS	2.0	78.9	1,529.1	6.0	.3	41.8	3,818.3	360.5	10.8	3,929.0	1,468.0	2,906.0	3,670.0	1,438.0	6,260.0
NON-U.S. MANUFACTURERS															
Captive	--	5.4	70.9	.1	--	3.7	104.5	9.0	2.0	109.0	62.0	106.0	108.0	76.0	148.0
OEM	--	8.6	311.8	15.7	--	2.1	470.5	227.8	--	413.0	650.0	290.0	1,292.0	120.0	1,838.0
TOTAL NON-U.S. SHIPMENTS	--	14.0	382.7	15.8	--	5.8	575.0	236.8	2.0	522.0	712.0	396.0	1,400.0	196.0	1,986.0
WORLDWIDE RECAP															
Captive	1.3	60.4	331.2	.1	.3	33.7	732.2	17.0	10.0	473.0	149.0	268.0	455.0	86.0	894.0
	-53.6%	+11.4%	+734.3%	--	-76.9%	-44.2%	+121.1%	--	-70.3%	-35.4%	+776.5%	-43.3%	+205.4%	-67.9%	+96.5%
OEM	.7	32.5	1,580.6	21.7	--	13.9	3,661.1	580.3	2.8	3,978.0	2,031.0	3,034.0	4,615.0	1,548.0	7,352.0
	-77.4%	-49.8%	+142.9%	+334.0%	--	-57.2%	+131.6%	--	-79.9%	+8.7%	+250.0%	-23.7%	+127.2%	-49.0%	+59.3%
Total Shipments	2.0	92.9	1,911.8	21.8	.3	47.6	4,393.3	597.3	12.8	4,451.0	2,180.0	3,302.0	5,070.0	1,634.0	8,246.0
	-66.1%	-21.9%	+175.7%	+327.5%	-85.0%	-48.8%	+129.8%	--	-73.1%	+1.3%	+265.0%	-25.8%	+132.6%	-50.5%	+62.6%
ANNUAL SHARE, BY DIAMETER	.1%	4.6%	94.3%	1.0%	--	.9%	87.3%	11.8%	.2%	67.1%	32.7%	39.5%	60.5%	16.5%	83.5%

Note: 3.5 inch totals include 3.9 inch drives
8 inch totals include 10.5 inch drives

TABLE 31

FIXED DISK DRIVES, 30 - 100 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	40.4	2.0	49.4	.5
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	443.8	21.9	1,225.1	12.4
MICROCOMPUTERS Business and professional, single user	1,194.9	58.9	6,797.4	68.8
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	132.5	6.5	612.6	6.2
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	203.1	10.0	1,037.4	10.5
CONSUMER AND HOBBY COMPUTERS	12.6	.6	148.2	1.5
OTHER APPLICATIONS	1.2	.1	9.9	.1
Total	2,028.5	100.0	9,880.0	100.0

TABLE 32

FIXED DISK DRIVES, 30 - 100 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 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	--	--	460.0	--	460.0	38.4	--	--	528.0	--	528.0	32.3
MICROPOLIS	--	2.7	175.9	--	178.6	14.9	--	3.4	219.9	--	223.3	13.7
CONTROL DATA	--	--	174.3	--	174.3	14.5	--	--	211.4	--	211.4	12.9
MINISCRIBE	--	--	85.6	.5	86.1	7.2	--	--	92.9	.5	93.4	5.7
NEC	--	1.0	15.0	--	16.0	1.3	--	1.0	85.0	--	86.0	5.3
PRIAM	.4	5.0	55.0	--	60.4	5.0	.6	7.4	61.0	--	69.0	4.2
HITACHI	--	--	46.7	--	46.7	3.9	--	2.2	65.2	--	67.4	4.1
FUJITSU	--	1.8	25.1	--	26.9	2.2	--	5.4	59.4	2.2	67.0	4.1
QUANTUM	--	10.0	36.0	--	46.0	3.8	--	13.0	53.0	--	66.0	4.0
Other U.S.	--	.1	72.9	5.5	78.5	6.6	.1	.1	102.6	5.5	108.3	6.6
Other Non-U.S.	--	--	14.4	10.9	25.3	2.2	--	--	102.2	13.5	115.7	7.1
TOTAL	.4	20.6	1160.9	16.9	1198.8	100.0	.7	32.5	1580.6	21.7	1635.5	100.0

NOTE: 3.5 inch totals include 3.9 inch drives.
8 inch totals include 10.5 inch drives.

FIXED DISK DRIVES, 100-300 MEGABYTES

FIXED DISK DRIVES, 100-300 MEGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Digital Equipment	RA80, RM80
Fujitsu	M2284
IBM	4967-2CX, 5360-BXX
Priam	15450

9" disk diameter

Control Data	9715-160

8" disk diameter

Fujitsu	M2322, M2331
Hitachi	DK812S-12, DK814S-17
IBM	9332-A11, 678-200
Mitsubishi Electric	M4870F
NEC	D2257
Northern Telecom	8208X, 8210X
Pertec	DX199, DX265
Priam	806
Toshiba	MK184FB, MK284FC

5.25" disk diameter

Brand Technologies	BT8128, BT8170E/S
Century Data	CAST 10304*, 14406*
Control Data	94166-182, Wren III HH*
Digital Equipment	RA70
Fujitsu	M2245E, M2243R*
Hewlett-Packard	97532S, 97533E
Hitachi	DK512-17, DK522C-10
IBM	8580-111, 669
Lexikon	LX580
Maxtor	XT-1140, EXT-4280S
Microscience International	HH-1120*, HH-3120*
Micropolis	1554, 1375
Miltope	RDS-1720
Miniscribe	6128
Mitsubishi Electric	MR5310
NEC	D5652, D5852
Newbury Data	NDR 1105, NDR 2190
Priam	514, 519, 728
Rodime	R05180S*

5.25" disk diameter (continued)

Sagem	MSA 250-100
Seagate Technology	ST4144R, ST4192N
Siemens	1100, 2300
Tandon	TM2128, TM2170
Toshiba	MK-154FA, MK-156FB
Toyo Soda	Dart 130, Dart 170

3.5" disk diameter

Cardiff Peripherals	F-3127*
Conner Peripherals	CP3100*
Maxtor	LXT-170

*Indicates drives with maximum 41 mm height, or less.

Previously the exclusive domain of 14" drives, the 1980's have seen numerous introductions of drives using smaller diameter disks in this group. A parade of 8" drives was launched at the beginning of the decade, followed by numerous 5.25" drives in the last two years.

These, as well as the older 14" drives, all use variations of Winchester technology. Disks used with the 14" and 8" drives are oxide coated, but disks used on the 5.25" and 3.5" drives are mostly plated or sputtered. Heads are usually ferrite types, and several are "mini" types patterned after the 3370 slider. There is limited usage of thin film heads, so far mostly on 5.25" drives.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1986	1987	1988	1989	1990
U.S. manufacturers	766.0	922.0	1,200.9	1,501.5	1,891.6
All manufacturers	1,246.2	1,449.2	1,725.9	2,056.1	2,485.9

As expected, 5.25" drives assumed the lead in unit shipments for this

product group during 1986, but older configurations still held the lead in worldwide revenues, sustained by buoyant IBM captive sales of 14" drives and OEM sales of 8" drives. However, 5.25" drives are expected to assume unquestioned leadership in 1987, with estimated shipments of 429,800 units, which will represent 82% of worldwide unit shipments and 52% of total revenues.

Sales for minicomputer, technical workstation and LAN applications have driven the rapid growth in 5.25" drive shipments, as 170 megabyte models supplement the 85 megabyte drives designed into systems during the last few years.

The early lead in high performance 8" drives established by Japanese disk drive manufacturers continues to hold up. Non-U.S. firms shipped 83% of the 8"/9" worldwide drive shipments for 1986, led by OEM drives from Fujitsu and several other leading Japanese disk drive manufacturers.

The story is very different with 5.25" drives. U.S. manufacturers held 72% of 1986 worldwide unit shipments, spurred by vigorous product development programs and advantageous dollar exchange rates. Maxtor dominated 1986 OEM shipments of 5.25" drives with 140 and 190 megabyte models using ST412 interfaces, but 1987 is seeing growing shipments of ESDI drives from other major U.S. producers of high end 5.25" drives such as Micropolis and Control Data. The U.S. firms are also jumping off to an early lead with 3.5" drives in this product group, with first shipments this year.

Maxtor assumed the 1986 leadership in non-captive shipments for this group, with 67,100 5.25" drives for 35.9% of the worldwide total for all unit shipments. Fujitsu held 20.2% and Control Data 8.0%, both shipping a mixture of 14", 8" and 5.25" drives.

Marketing trends

Continually expanding shipments and revenues are predicted for this product group, with the growth surge by 5.25" drives expected to top out in 1989, overtaken by 3.5" drives. While 8" drives fade from the picture, minicomputer, LAN, technical workstation and high end personal computer applications will all have a major role in the extensive changes expected in the product mix for full size 5.25", half high 5.25" and 3.5" drives:

Worldwide captive & OEM Unit shipments (000)	1986	1987	1988	1989	1990
5.25" full size	127.7	394.9	430.0	379.0	266.0
	100.0%	90.1%	46.2%	25.6%	12.4%
5.25" half high	--	34.9	217.0	365.0	443.0
	--	8.0%	23.3%	24.7%	20.7%
3.5"	--	8.4	284.0	734.0	1,434.0
	--	1.9%	30.5%	49.7%	66.9%

The future growth of full size 5.25" drives in this group now looks limited, as the technical workstation market is clearly poised to move many of its requirements to the higher capacity 380 megabyte drives now starting into production from many manufacturers.

Half high 5.25" drives, now just entering the volume production stage, will be preferred for many workstation applications, but 3.5" drives are expected to prevail by 1990, due to growth in sophisticated personal computers, preference for small footprint systems, and competitive prices. 3.5" drive introductions in this capacity range are expected for 1988 from numerous companies, including IBM and Control Data.

Technical trends

This product group continues to make severe demands on the key components used in achieving the high recording densities necessary to pro-

duce 5.25" and 3.5" drives in the 100-300 megabyte range. Most of the 5.25" drives and all of the 3.5" drives with capacities over 100 megabytes now offered use thin film disks, to make possible high areal densities.

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

Most drive manufacturers are offering ESDI interfaces with new 5.25" drives operating at 10 megabit/second transfer rates, and on-board SCSI interfaces are also available from a growing list of manufacturers. Marketability of drives with higher transfer rates will be directly affected by whether the industry reaches an early consensus on interface standards suitable for higher transfer rates, paving the way for availability of appropriate controllers. It is not yet clear which interfaces will prevail with 3.5" drives in this range -- there are design advantages in masking a file organization optimized for high density behind an intelligent interface, so SCSI may be the eventual leader.

Forecasting assumptions

1. Growth in IBM's shipments in this group will be dominated by 3.5" drives starting in 1989.

2. Most major producers of voice coil 5.25" OEM drives will be in production of both 5.25" and 3.5" drives in this group in 1988, but U.S. manufacturers will continue to dominate OEM shipments due to their early market lead and favorable dollar/yen exchange rate.

3. Non-U.S. manufacturers will continue to dominate OEM shipments of 8" drives.

TABLE 33

FIXED DISK DRIVES, 100 - 300 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986		Forecast							
	Revenues		1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	319.7	479.0	331.3	484.6	362.7	515.4	440.9	619.9	583.1	842.5
Other U.S. Captive	39.9	83.3	26.1	51.8	98.5	155.2	175.7	254.4	233.6	338.2
TOTAL U.S. CAPTIVE	359.6	562.3	357.4	536.4	461.2	670.6	616.6	874.3	816.7	1,180.7
PCM	--	--	--	--	--	--	--	--	--	--
OEM	168.2	203.7	306.1	385.6	420.7	530.3	490.8	627.2	538.8	710.9
TOTAL U.S. NON-CAPTIVE	168.2	203.7	306.1	385.6	420.7	530.3	490.8	627.2	538.8	710.9
TOTAL U.S. REVENUES	527.8	766.0	663.5	922.0	881.9	1,200.9	1,107.4	1,501.5	1,355.5	1,891.6
Non-U.S. Manufacturers										
Captive	3.3	331.3	10.3	345.0	9.0	349.0	22.6	367.7	30.5	410.6
PCM	--	--	--	--	--	--	--	--	--	--
OEM	72.8	148.9	77.1	182.2	73.5	176.0	67.1	186.9	57.0	183.7
TOTAL NON-U.S. REVENUES	76.1	480.2	87.4	527.2	82.5	525.0	89.7	554.6	87.5	594.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	603.9	1,246.2	750.9	1,449.2	964.4	1,725.9	1,197.1	2,056.1	1,443.0	2,485.9
OEM Average Price ($000)	1.8	1.9	1.3	1.3	.9	.9	.7	.7	.6	.6

TABLE 34

FIXED DISK DRIVES, 100 - 300 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986		Forecast							
	Shipments		1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	19.6	29.0	42.2	57.0	94.3	126.5	194.4	267.0	367.6	529.0
Other U.S. Captive	3.4	7.0	4.5	8.6	26.7	41.5	60.6	86.0	89.0	126.0
TOTAL U.S. CAPTIVE	23.0	36.0	46.7	65.6	121.0	168.0	255.0	353.0	456.6	655.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	92.5	108.8	240.3	301.4	484.4	605.5	672.0	856.0	861.0	1,131.0
TOTAL U.S. NON-CAPTIVE	92.5	108.8	240.3	301.4	484.4	605.5	672.0	856.0	861.0	1,131.0
TOTAL U.S. SHIPMENTS	115.5	144.8	287.0	367.0	605.4	773.5	927.0	1,209.0	1,317.6	1,786.0
Non-U.S. Manufacturers										
Captive	.3	35.7	1.3	43.2	1.3	59.5	6.2	82.0	10.0	108.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	36.0	72.8	49.2	112.8	61.5	150.0	74.5	208.0	78.0	253.0
TOTAL NON-U.S. SHIPMENTS	36.3	108.5	50.5	156.0	62.8	209.5	80.7	290.0	88.0	361.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	151.8	253.3	337.5	523.0	668.2	983.0	1,007.7	1,499.0	1,405.6	2,147.0
Cumulative Shipments										
IBM	54.1	80.3	96.3	137.3	190.6	263.8	385.0	530.8	752.6	1,059.8
Non-IBM	374.7	634.9	670.0	1,100.9	1,243.9	1,957.4	2,057.2	3,189.4	3,095.2	4,807.4
WORLDWIDE TOTAL	428.8	715.2	766.3	1,238.2	1,434.5	2,221.2	2,442.2	3,720.2	3,847.8	5,867.2

TABLE 35

FIXED DISK DRIVES, 100 - 300 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues			1987				Forecast 1988				1989				1990		
	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																		
IBM Captive	432.0	47.0	--	350.0	62.6	72.0	--	204.0	77.4	184.0	50.0	85.0	53.9	209.0	272.0	28.0	94.5	720.0
Other U.S. Captive	72.2	9.1	2.0	19.0	2.6	30.2	--	5.8	--	149.4	--	--	--	198.4	56.0	--	257.2	81.0
OEM	26.9	26.5	150.3	18.8	17.0	340.6	9.2	6.6	9.1	326.6	188.0	--	--	306.6	320.6	--	257.3	453.6
TOTAL U.S. REVENUES	531.1	82.6	152.3	387.8	82.2	442.8	9.2	216.4	86.5	660.0	238.0	85.0	53.9	714.0	648.6	28.0	609.0	1,254.6
NON-U.S. MANUFACTURERS																		
Captive	--	253.3	78.0	--	153.7	191.3	--	--	85.0	264.0	--	--	30.0	307.7	30.0	--	364.6	46.0
OEM	.6	107.5	40.8	--	62.3	119.9	--	--	32.0	122.4	21.6	--	11.4	114.7	60.8	--	90.6	93.1
TOTAL NON-U.S. REVENUES	.6	360.8	118.8	--	216.0	311.2	--	--	117.0	386.4	21.6	--	41.4	422.4	90.8	--	455.2	139.1
WORLDWIDE RECAP																		
Captive	504.2	309.4	80.0	369.0	218.9	293.5	--	209.8	162.4	597.4	50.0	85.0	83.9	715.1	358.0	28.0	716.3	847.0
	+5.1%	+15.9%	--	-26.8%	-29.3%	+266.9%	--	-43.1%	-25.8%	+103.5%	--	-59.5%	-48.3%	+19.7%	+616.0%	-66.6%	+.2%	+136.6%
OEM	27.5	134.0	191.1	18.8	79.3	460.5	9.2	6.6	41.1	449.0	209.6	--	11.4	421.3	381.4	--	347.9	546.7
	-53.9%	-40.2%	+166.9%	-31.6%	-40.8%	+141.0%	--	-64.9%	-48.2%	-2.5%	--	--	-72.3%	-6.2%	+82.0%	--	-17.4%	+43.3%
Total Revenues	531.7	443.4	271.1	387.8	298.2	754.0	9.2	216.4	203.5	1,046.4	259.6	85.0	95.3	1,136.4	739.4	28.0	1,064.2	1,393.7
	-2.1%	-9.7%	+278.6%	-27.1%	-32.7%	+178.1%	--	-44.2%	-31.8%	+38.8%	--	-60.7%	-53.2%	+8.6%	+184.8%	-70.6%	-6.4%	+88.5%
ANNUAL SHARE, BY DIAMETER	42.8%	35.6%	21.6%	26.9%	20.6%	52.0%	.5%	12.5%	11.8%	60.7%	15.0%	4.1%	4.6%	55.4%	35.9%	1.1%	42.9%	56.0%

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

TABLE 36

FIXED DISK DRIVES, 100 - 300 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments			1987				Forecast 1988				1989				1990		
	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																		
IBM Captive	24.0	5.0	--	20.0	7.0	30.0	--	12.0	9.5	80.0	25.0	5.0	7.0	95.0	160.0	4.0	45.0	480.0
Other U.S. Captive	5.9	.7	.4	1.6	.2	6.8	--	.5	--	41.0	--	--	--	58.0	28.0	--	81.0	45.0
OEM	8.1	9.3	91.4	5.6	6.4	281.0	8.4	2.0	3.5	365.0	235.0	--	--	398.0	458.0	--	375.0	756.0
TOTAL U.S. SHIPMENTS	38.0	15.0	91.8	27.2	13.6	317.8	8.4	14.5	13.0	486.0	260.0	5.0	7.0	551.0	646.0	4.0	501.0	1,281.0
NON-U.S. MANUFACTURERS																		
Captive	--	25.3	10.4	--	15.2	28.0	--	--	8.5	51.0	--	--	3.0	67.0	12.0	--	88.0	20.0
OEM	.1	47.2	25.5	--	28.8	84.0	--	--	16.0	110.0	24.0	--	6.0	126.0	76.0	--	120.0	133.0
TOTAL NON-U.S. SHIPMENTS	.1	72.5	35.9	--	44.0	112.0	--	--	24.5	161.0	24.0	--	9.0	193.0	88.0	--	208.0	153.0
WORLDWIDE RECAP																		
Captive	29.9	31.0	10.8	21.6	22.4	64.8	--	12.5	18.0	172.0	25.0	5.0	10.0	220.0	200.0	4.0	214.0	545.0
	+1.0%	+16.5%	--	-27.8%	-27.7%	+500.0%	--	-42.1%	-19.6%	+165.4%	--	-60.0%	-44.4%	+27.9%	+700.0%	-60.0%	-2.7%	+172.5%
OEM	8.2	56.5	116.9	5.6	35.2	365.0	8.4	2.0	19.5	475.0	259.0	--	6.0	524.0	534.0	--	495.0	889.0
	-53.1%	-34.7%	+261.9%	-31.7%	-37.7%	+212.2%	--	-64.3%	-44.6%	+30.1%	--	--	-69.2%	+10.3%	+106.2%	--	-5.5%	+66.5%
Total Shipments	38.1	87.5	127.7	27.2	57.6	429.8	8.4	14.5	37.5	647.0	284.0	5.0	16.0	744.0	734.0	4.0	709.0	1,434.0
	-19.6%	-22.6%	+295.4%	-28.6%	-34.2%	+236.6%	--	-46.7%	-34.9%	+50.5%	--	-65.5%	-57.3%	+15.0%	+158.5%	-75.0%	-4.7%	+95.4%
ANNUAL SHARE, BY DIAMETER	15.0%	34.6%	50.4%	5.2%	11.0%	82.3%	1.5%	1.5%	3.8%	65.9%	28.8%	.3%	1.1%	49.7%	48.9%	.2%	33.1%	66.7%

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

TABLE 37

FIXED DISK DRIVES, 100 - 300 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	13.8	5.5	47.2	2.2
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	162.8	64.3	1,271.1	59.2
MICROCOMPUTERS Business and professional, single user	10.0	3.9	365.0	17.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	10.9	4.3	36.5	1.7
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	55.8	22.0	418.7	19.5
CONSUMER AND HOBBY COMPUTERS	--	--	2.1	.1
OTHER APPLICATIONS	--	--	6.4	.3
Total	253.3	100.0	2,147.0	100.0

TABLE 38

FIXED DISK DRIVES, 100 - 300 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
MAXTOR	--	--	61.7	61.7	48.0	--	--	67.1	67.1	36.9
FUJITSU	--	11.5	2.0	13.5	10.5	.1	27.9	8.6	36.6	20.2
CONTROL DATA	1.3	1.9	7.6	10.8	8.4	2.9	3.0	8.7	14.6	8.0
MICROPOLIS	--	--	11.5	11.5	8.9	--	--	14.4	14.4	7.9
HITACHI	--	3.6	5.3	8.9	6.9	--	4.9	8.4	13.3	7.3
PRIAM	4.2	3.3	1.0	8.5	6.6	5.2	6.3	1.2	12.7	7.0
Other U.S.	--	--	--	--	--	--	--	--	--	--
Other Non-U.S.	--	11.3	2.3	13.6	10.7	--	14.4	8.5	22.9	12.7
TOTAL	5.5	31.6	91.4	128.5	100.0	8.2	56.5	116.9	181.6	100.0

NOTE: 8 inch totals include 9 and 10.5 inch drives.

FIXED DISK DRIVES, 300-500 MEGABYTES

1987 DISK/TREND REPORT

FIXED DISK DRIVES, 300-500 MEGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Century Data	AMS 315, Tecstor 3020
Data General	6236, 6237
Digital Equipment	RA81
Fujitsu	M2294
IBM	5360-BXA, 4967-3CA

10.5" disk diameter

Fujitsu	M2350A, F6421

9" disk diameter

Control Data	9715-300, 9715-340
NEC	D2332

8" disk diameter

Century Data	C2400, C2476
Control Data	Sabre 368
Fujitsu	M2333K
Hewlett-Packard	7936H
Hitachi	DKU-80, DK-814S
IBM	9332-A12, 678-400
Mitsubishi Electric	MR4875
NEC	D2268, D2268H
Northern Telecom	8308, 8212X
Pertec	DX332, DX368
Priam	807
Toshiba	MK-286FC, MK-287FC

5.25" disk diameter

Control Data	94171
Fujitsu	M2249E
Hewlett-Packard	97536E/S
Hitachi	DK514-38
IBM	8580-311, 671-387
Maxtor	XT-4380E/S, XT-8380E
Micropolis	1556, 1558
Newbury Data	NDR 4380
Priam	638, 738
Siemens	1300
Toshiba	MK-256FA

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

The later 14" drives were rack-mounted 14" drives introduced for both captive (IBM, DEC, Data General) and OEM (Century, Fujitsu) markets -- and many are still in production. Led by the successful Fujitsu 10.5" Eagle, other small drives have included the several 9" models by Control Data, NEC and Hitachi. The latest wave is a group of 5.25" drives, mostly in the 380 megabyte range, following the lead of Maxtor, which made first production shipments of a drive in this capacity range last year. Eleven companies so far have announced drives in this capacity range, and more are expected.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1986	1987	1988	1989	1990
U.S. manufacturers	1,344.5	1,461.8	1,817.8	2,111.5	1,994.6
All manufacturers	1,884.4	2,125.6	2,683.4	3,088.6	3,035.6

Although 14" drives still led in unit shipments for this product group in 1986, the trend is down. 14" drives reached their production peak in 1985, and 1987 will see a 26.5% drop in shipments, putting this year's unit shipments below those for both the 8"/9" and 5.25" groups.

The 1987 growth rate for worldwide shipments of 8" and 9" drives is expected to exceed 50%, with 124,800 units for the year. This expansion is being created by booming OEM drive shipments from both U.S. and non-U.S. manufacturers, plus rapidly growing IBM captive shipments for 9332 drives. 5.25" drive shipments are also going into high gear in 1987, as

numerous manufacturers strive to overcome start-up problems and shortages of critical components. Almost all of the 5.25" drive shipments during 1987 will be OEM drives, with U.S. manufacturers shipping about two thirds of the worldwide total.

1986 saw the close of the once-thriving business in making 317 megabyte drives for IBM and compatible mainframes. The last participant was the plug compatible version of Fujitsu's 10.5" Eagle I, sold in North America and Europe by Amdahl. For PCM markets this drive was formatted to 317 megabytes, to compete with IBM's original 3350 in capacity, performance and price. Total shipments of PCM 317 megabyte drives peaked in 1985, at 15,800 spindles worldwide. PCM shipments in this group ended in 1986, with Amdahl upgrading its plug compatible program to emphasize the 630 megabyte Eagle II.

Captive revenues continue to dominate this product group, providing about 75% of the worldwide total during 1986 and 1987. Captive U.S. producers ship the majority of 14" drives, led by Digital Equipment's RA81, but also including drives from IBM, Hewlett-Packard and Data General. However, captive 14" drive shipments in this group peaked in 1986, as system manufacturers migrated in two directions: To larger capacity 14" drives and to 8" or 9" drives for requirements in the 300-500 megabyte range.

An interesting application area to watch will be the use of multiple spindle subsystems with mainframe computers. Unisys is now offering to the Sperry system customer base a subsystem using 8" drives, assembled as a subsystem by Amperif. Compared to usage of high capacity 14" drives, this approach potentially offers improvements in cost, floor space utilization, and performance -- and may be the pathfinder for similar subsystems

using 8" or smaller drives to be offered by other system manufacturers or plug compatible drive suppliers. In 1986, 55.1% of worldwide unit shipments were used with minicomputer and multiple user microcomputer systems, but this application is expected to rise to 72% of 1990's total.

Fujitsu continued to hold worldwide leadership in non-captive unit shipments with 50.8% of the total, representing 45,700 units, including 14", 10.5" and 8" drives. Control Data increased its share to 22.6%, with both 9" and 8" models.

Marketing trends

It is clear that 5.25" drives are destined to prevail in this product group, driven by system manufacturers' enthusiastic response to the low cost per megabyte, small size and excellent performance of the many new drives now becoming available. Technical workstations, file servers and general purpose mini/microcomputer systems will provide the major growth applications.

The movement to 5.25" drives will include substantial shipments by IBM and other producers of captive drives, but shipments of OEM drives are expected to enjoy outstanding growth in 1988, and are forecasted to provide more than 75% of the 1990 total shipments for 5.25" models. 31% growth in 8" and 9" drives is projected for 1988, but they are expected to peak in 1989, victim of the 5.25" configuration's success.

The role of U.S. OEM drive manufacturers in this capacity range is expected to remain strong. Control Data has emerged as a significant participant in the 8" market, and U.S. firms, taking advantage of early market position and the dollar/yen exchange rate, will hold their strong lead in 5.25" drives.

Technical trends

Development activities in this product group will strive to squeeze more capacity into smaller boxes and to improve performance during the next few years. However, little engineering effort is being devoted to the 8" and 9" drives in this capacity range, which still lead 1987's shipments -- and intense activity is underway on 5.25" drives.

Maxtor was the lonely pioneer in 5.25" drives in the 300-500 megabyte range. The firm's successful production of such drives has inspired a dozen competitors to take on the twin challenges of fitting enough disks into the standard 5.25" form factor and finding ways to improve head positioning time below the sub-20 millisecond average now required to be competitive.

The demand for more capacity in small spaces will continue. Expect to see extensive use of thin film heads and disks, run length limited encoding methods, intelligent interfaces, extensive use of VLSI in drive electronics, and maybe even perpendicular recording. In 1987, limited availability of thin film heads for 5.25" drives in this group has caused severe problems for several companies, but the outlook is for greatly improved availability of required components in 1988.

Forecasting assumptions

1. 14" drive shipments will continue to decline, and 8"/9" drives will peak in 1989.
2. Sustained growth for technical workstations, LANs, general purpose mini/micros and specialized systems will create significant growth for both captive and OEM 5.25" drives.

TABLE 39

FIXED DISK DRIVES, 300 - 500 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986		Forecast							
	Revenues		1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	302.3	412.9	411.4	598.6	522.8	766.9	681.6	982.5	646.4	955.0
Other U.S. Captive	506.3	791.0	404.7	611.8	365.3	514.5	338.2	497.0	271.7	419.1
TOTAL U.S. CAPTIVE	808.6	1,203.9	816.1	1,210.4	888.1	1,281.4	1,019.8	1,479.5	918.1	1,374.1
PCM	--	--	--	--	--	--	--	--	--	--
OEM	115.6	140.6	216.9	251.4	442.8	536.4	502.6	632.0	464.2	620.5
TOTAL U.S. NON-CAPTIVE	115.6	140.6	216.9	251.4	442.8	536.4	502.6	632.0	464.2	620.5
TOTAL U.S. REVENUES	924.2	1,344.5	1,033.0	1,461.8	1,330.9	1,817.8	1,522.4	2,111.5	1,382.3	1,994.6
Non-U.S. Manufacturers										
Captive	3.4	245.6	25.5	379.6	56.7	509.6	75.0	588.0	87.0	659.0
PCM	3.9	42.9	--	--	--	--	--	--	--	--
OEM	171.8	251.4	193.0	284.2	212.3	356.0	210.2	389.1	169.0	382.0
TOTAL NON-U.S. REVENUES	179.1	539.9	218.5	663.8	269.0	865.6	285.2	977.1	256.0	1,041.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,103.3	1,884.4	1,251.5	2,125.6	1,599.9	2,683.4	1,807.6	3,088.6	1,638.3	3,035.6
OEM Average Price ($000)	4.6	4.7	3.2	3.2	2.0	2.1	1.6	1.7	1.3	1.3

TABLE 40

FIXED DISK DRIVES, 300 - 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986 Shipments		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	18.6	25.0	26.9	39.0	50.1	71.0	89.0	124.0	114.0	165.0
Other U.S. Captive	34.0	52.2	28.5	43.1	34.5	48.5	40.4	59.0	40.9	63.0
TOTAL U.S. CAPTIVE	52.6	77.2	55.4	82.1	84.6	119.5	129.4	183.0	154.9	228.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	26.3	32.6	72.5	84.7	224.4	271.5	322.0	404.0	370.5	494.0
TOTAL U.S. NON-CAPTIVE	26.3	32.6	72.5	84.7	224.4	271.5	322.0	404.0	370.5	494.0
TOTAL U.S. SHIPMENTS	78.9	109.8	127.9	166.8	309.0	391.0	451.4	587.0	525.4	722.0
Non-U.S. Manufacturers										
Captive	.2	12.0	1.5	20.3	5.3	34.0	9.0	49.0	13.0	66.0
PCM	.6	6.6	--	--	--	--	--	--	--	--
OEM	35.5	50.7	54.9	77.7	88.1	141.0	110.0	193.0	112.0	229.0
TOTAL NON-U.S. SHIPMENTS	36.3	69.3	56.4	98.0	93.4	175.0	119.0	242.0	125.0	295.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	115.2	179.1	184.3	264.8	402.4	566.0	570.4	829.0	650.4	1,017.0
Cumulative Shipments										
IBM	137.0	226.3	163.9	265.3	214.0	336.3	303.0	460.3	417.0	625.3
Non-IBM	301.5	527.6	458.9	753.4	811.2	1,248.4	1,292.6	1,953.4	1,829.0	2,805.4
WORLDWIDE TOTAL	438.5	753.9	622.8	1,018.7	1,025.2	1,584.7	1,595.6	2,413.7	2,246.0	3,430.7

TABLE 41

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues			Forecast											
				1987			1988			1989			1990		
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS															
IBM Captive	240.0	172.9	--	266.0	332.6	--	126.0	541.8	99.1	51.0	637.5	294.0	--	480.0	475.0
Other U.S. Captive	728.6	62.4	--	529.7	77.6	4.5	319.5	115.0	80.0	165.6	198.0	133.4	13.5	237.6	168.0
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	18.9	112.6	9.1	12.5	145.2	93.7	12.0	159.6	364.8	10.0	118.8	503.2	--	42.1	578.4
TOTAL U.S. REVENUES	987.5	347.9	9.1	808.2	555.4	98.2	457.5	816.4	543.9	226.6	954.3	930.6	13.5	759.7	1,221.4
NON-U.S. MANUFACTURERS															
Captive	103.0	142.6	--	84.8	294.8	--	75.0	396.1	38.5	78.0	420.0	90.0	81.0	434.0	144.0
PCM	42.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	124.5	110.9	16.0	85.3	129.0	69.9	59.6	138.0	158.4	54.0	117.6	217.5	57.0	70.2	254.8
TOTAL NON-U.S. REVENUES	270.4	253.5	16.0	170.1	423.8	69.9	134.6	534.1	196.9	132.0	537.6	307.5	138.0	504.2	398.8
WORLDWIDE RECAP															
Captive	1,071.6	377.9	--	880.5	705.0	4.5	520.5	1,052.9	217.6	294.6	1,255.5	517.4	94.5	1,151.6	787.0
	+17.0%	--	--	-17.8%	+86.6%	--	-40.9%	+49.3%	--	-43.4%	+19.2%	+137.8%	-67.9%	-8.3%	+52.1%
PCM	42.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	-61.2%	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	143.4	223.5	25.1	97.8	274.2	163.6	71.6	297.6	523.2	64.0	236.4	720.7	57.0	112.3	833.2
	-16.7%	+82.6%	--	-31.8%	+22.7%	+551.8%	-26.8%	+8.5%	+219.8%	-10.6%	-20.6%	+37.7%	-10.9%	-52.5%	+15.6%
Total Revenues	1,257.9	601.4	25.1	978.3	979.2	168.1	592.1	1,350.5	740.8	358.6	1,491.9	1,238.1	151.5	1,263.9	1,620.2
	+5.0%	+352.5%	--	-22.2%	+62.8%	+569.7%	-39.5%	+37.9%	+340.7%	-39.4%	+10.5%	+67.1%	-57.8%	-15.3%	+30.9%
ANNUAL SHARE, BY DIAMETER	66.9%	31.9%	1.2%	46.1%	46.1%	7.8%	22.1%	50.4%	27.5%	11.6%	48.4%	40.0%	5.0%	41.7%	53.3%

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

TABLE 42

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments			1987			Forecast 1988			1989			1990		
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS															
IBM Captive	12.0	13.0	--	14.0	25.0	--	7.0	42.0	22.0	3.0	51.0	70.0	--	40.0	125.0
Other U.S. Captive	47.0	5.2	--	35.6	6.6	.9	22.5	10.0	16.0	12.0	18.0	29.0	1.0	22.0	40.0
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	2.3	26.7	3.6	1.8	36.0	46.9	1.5	42.0	228.0	1.0	33.0	370.0	--	12.0	482.0
TOTAL U.S. SHIPMENTS	61.3	44.9	3.6	51.4	67.6	47.8	31.0	94.0	266.0	16.0	102.0	469.0	1.0	74.0	647.0
NON-U.S. MANUFACTURERS															
Captive	4.1	7.9	--	3.5	16.8	--	3.0	24.0	7.0	3.0	28.0	18.0	3.0	31.0	32.0
PCM	6.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	16.9	28.8	5.0	10.4	40.4	26.9	7.0	46.0	88.0	6.0	42.0	145.0	6.0	27.0	196.0
TOTAL NON-U.S. SHIPMENTS	27.6	36.7	5.0	13.9	57.2	26.9	10.0	70.0	95.0	9.0	70.0	163.0	9.0	58.0	228.0
WORLDWIDE RECAP															
Captive	63.1 +23.0%	26.1 --	-- --	53.1 -15.8%	48.4 +85.4%	.9 --	32.5 -38.8%	76.0 +57.0%	45.0 --	18.0 -44.6%	97.0 +27.6%	117.0 +160.0%	4.0 -77.8%	93.0 -4.1%	197.0 +68.4%
PCM	6.6 -58.2%	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
OEM	19.2 -28.9%	55.5 +117.6%	8.6 --	12.2 -36.5%	76.4 +37.7%	73.8 +758.1%	8.5 -30.3%	88.0 +15.2%	316.0 +328.2%	7.0 -17.6%	75.0 -14.8%	515.0 +63.0%	6.0 -14.3%	39.0 -48.0%	678.0 +31.7%
Total Shipments	88.9 -5.5%	81.6 +212.6%	8.6 --	65.3 -26.5%	124.8 +52.9%	74.7 +768.6%	41.0 -37.2%	164.0 +31.4%	361.0 +383.3%	25.0 -39.0%	172.0 +4.9%	632.0 +75.1%	10.0 -60.0%	132.0 -23.3%	875.0 +38.4%
ANNUAL SHARE, BY DIAMETER	49.7%	45.6%	4.7%	24.7%	47.2%	28.1%	7.2%	29.1%	63.7%	3.0%	20.7%	76.3%	1.0%	13.0%	86.0%

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

TABLE 43

FIXED DISK DRIVES, 300 - 500 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	54.1	30.2	111.9	11.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	98.7	55.1	732.2	72.0
MICROCOMPUTERS Business and professional, single user	2.8	1.6	25.4	2.5
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	2.3	1.3	11.2	1.1
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	21.2	11.8	136.3	13.4
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	179.1	100.0	1,017.0	100.0

TABLE 44

FIXED DISK DRIVES, 300 - 500 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
FUJITSU	11.0	17.0	--	28.0	44.9	22.6	23.1	--	45.7	50.8
CONTROL DATA	--	17.1	--	17.1	27.4	--	20.3	--	20.3	22.6
Other U.S.	1.6	4.5	3.1	9.2	14.7	2.3	6.4	3.6	12.3	13.7
Other Non-U.S.	--	4.1	4.0	8.1	13.0	.9	5.7	5.0	11.6	12.9
TOTAL	12.6	42.7	7.1	62.4	100.0	25.8	55.5	8.6	89.9	100.0

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

FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

14" disk diameter

Alpha Data	Atlas 520
Century Data	AMS 513, AMS 571
Control Data	9771, 9772, 9775
Data General	6239, 6290
Digital Equipment	SA482, RA82
Fujitsu	M2298
Hitachi	DKU-97S, DKU-85I-D14
IBM	3370, 3375, 9335
NEC	N7761, N7765

10.5" disk diameter

Fujitsu	F6425, M2361A

9" disk diameter

Control Data	9715-500
Hitachi	DK815-5
NEC	D2352, D2462

8" disk diameter

Century Data	C2600, C2800
Control Data	Sabre 736, Sabre 850
Fujitsu	M2344K/KS
Hewlett-Packard	7937H/S
Northern Telecom	8312, 8412
Pertec	DX548, DX731
Rodime	R08067
Toshiba	MK-288FC, 388FA
Vermont Research	7030

5.25" disk diameter

Maxtor	XT-8760E

Until recently, disk drives in this group consisted mostly of PCM, IBM and other captive floor-standing drives intended for use with mainframe systems. The list of OEM drives was expanded during the last

few years, however, with the addition of several rack-mounted models intended for sale in the growing superminicomputer market.

Control Data's 9" FSD was the pioneer product among drives with disk diameters less than 10.5", but in the past two years several 8" drives with capacities more than 500 megabytes have been announced, and Maxtor's introduction of a 768 megabyte 5.25" drive is expected to stimulate several competitive announcements within the next year.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1986	1987	1988	1989	1990
U.S. manufacturers	1,365.4	2,004.6	2,668.4	2,748.5	3,004.7
All manufacturers	1,954.2	2,756.2	3,552.8	3,608.5	3,883.1

Drive shipments in this product group are now growing rapidly, assisted by heavy captive 14" shipments of IBM's 9335 and DEC's SA482, plus substantial OEM 8"/9" shipments by Fujitsu, NEC and Control Data. 1986's 107,200 worldwide unit shipments will increase to an estimated 190,200 drives in 1987, with captive drives representing about 60% of the unit shipment total for both years. Because of the high proportion of captive drives in the current shipments, captive revenues will be over 80% of the 1987 worldwide revenue total of $2.7 billion.

64.4% of 1986 worldwide unit shipments were 14" drives in 1986, and 14" drive shipments are still growing in 1987, but 8"/9" drives are experiencing a surge in OEM shipments during 1987 and are expected to be slightly more than half of the worldwide total. Shifting application patterns, plus the growing availability during the last few years of lower cost 8"/9" OEM drives in this capacity range, are changing the product

mix. Expanding usage of minicomputers and multiple-user micros in distributed processing applications and in technical workstation markets has stimulated demand for 8"/9" drive models.

Control Data held leadership in non-captive shipments for 1986 with 17,400 drives, 44.5% of the worldwide total. Fujitsu shipped 25.3% of the worldwide total, with Hitachi accounting for 23.0%.

Marketing trends

Although DISK/TREND forecasts predict that 5.25" drives will enjoy a solid start-up of volume production in 1988, with 31,500 drives to be shipped worldwide, 8"/9" drives will still enjoy shipment leadership through 1989. Shipments for drives in this size are estimated at 146,000 for 1988, 104,000 of which will be OEM drives, with Japanese manufacturers enjoying a strong lead as the result of their early dominance in lower capacity high performance 8" drives.

Shipments of 8"/9" drives are not expected to start declining until 1990, when aggressive competition from 5.25" drives will capture the lead in worldwide shipments. Building on the surging growth of 380 megabyte 5.25" models, 760 megabyte 5.25" drive worldwide shipments are expected to reach 111,000 units in 1989 and 225,000 in 1990. Markets such as high-end graphic workstations and LAN file servers will respond to the smaller 5.25" form factor, of course, but substantially lower prices will be the main factor powering strong growth for the smaller drives.

Captive models will continue to dominate shipments of 14" drives. The current forecasts assume continued shipment growth for IBM's 14" 9335 through 1990, and with the last shipments of 3370 models expected in 1988, the 9335 will be IBM's only remaining drive in this product group. Other

captive 14" drive shipments are expected to peak in 1988 with heavy shipments of DEC's SA482/RA82, combined with smaller quantities from Unisys, Control Data, Data General, Fujitsu and NEC.

Although there is considerable speculation regarding the possibility of providing serious competition to IBM in the plug compatible market for mainframe drives through use of multiple spindle arrays of 8" drives, the actual intentions of IBM's competitors in the PCM market toward this approach are not yet clear, and no provision for such programs are included in this year's DISK/TREND Report. If these programs materialize, the potential effect would be the diversion of shipments to this product group from the product group for drives over 1 gigabyte, in the form of enhanced shipments of 8" drives.

The intense competition between U.S. and non-U.S. manufacturers for the OEM market is expected to follow patterns already established. Japanese drive manufacturers are selling 70% of the 8"/9" drives in 1987, and it is expected that they will be selling a slightly higher share of the 1990 market.

However, U.S. drive manufacturers have claimed leadership in shipments of lower capacity high performance 5.25" drives, and that trend is expected to continue as 5.25" drives assume the shipment lead in this group. Critical to this leadership is early development of new products, combined with the pricing leadership which has now been captured by the U.S. producers.

Technical trends

It is believed that the technical developments in this product group through 1990 will consist primarily of refinements to the basic products

already introduced. 8"/9" drives have established high standards for performance and reliability, and the challenge will be for 5.25" drives to equal these standards.

It is expected that the 16 millisecond average positioning time now common in the 8"/9" group will be equalled by many of the new 5.25" drives expected next year, and performance will improve beyond this level in the following years. The 30,000 POH MTBF specification now offered by several vendors will also be matched and bettered by the newcomers.

The principal short-term problem for 5.25" contenders will be to secure reliable sources for the critical components needed for production start-up, a current problem for 760 megabyte drives as well as 380 megabyte models. The well-publicized problems in this area are expected to be solved in time for substantial 1988 production.

Forecasting assumptions

1. IBM will continue to rely on the 9335 to serve its requirements in this capacity range through 1990.
2. Production of 8" and 9" drives will peak in 1989.
3. Significant production quantities of 5.25" drives will be available starting in 1988 from several vendors, and lower prices for these drives will win shipment leadership for 5.25" drives in this capacity range by 1990.

TABLE 45

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986 Revenues		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	341.3	771.2	468.3	928.4	575.3	1,142.4	528.0	1,056.0	542.4	1,128.4
Other U.S. Captive	301.6	477.3	653.5	927.1	852.7	1,253.3	883.2	1,290.8	982.6	1,426.9
TOTAL U.S. CAPTIVE	642.9	1,248.5	1,121.8	1,855.5	1,428.0	2,395.7	1,411.2	2,346.8	1,525.0	2,555.3
PCM	--	--	--	--	--	--	--	--	--	--
OEM	96.4	116.9	129.2	149.1	235.7	272.7	332.3	401.7	354.2	449.4
TOTAL U.S. NON-CAPTIVE	96.4	116.9	129.2	149.1	235.7	272.7	332.3	401.7	354.2	449.4
TOTAL U.S. REVENUES	739.3	1,365.4	1,251.0	2,004.6	1,663.7	2,668.4	1,743.5	2,748.5	1,879.2	3,004.7
Non-U.S. Manufacturers										
Captive	--	436.3	--	394.1	--	358.5	--	279.0	10.0	308.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	105.4	152.5	202.7	357.5	367.3	525.9	377.9	581.0	341.9	570.4
TOTAL NON-U.S. REVENUES	105.4	588.8	202.7	751.6	367.3	884.4	377.9	860.0	351.9	878.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	844.7	1,954.2	1,453.7	2,756.2	2,031.0	3,552.8	2,121.4	3,608.5	2,231.1	3,883.1
OEM Average Price ($000)	6.5	6.8	5.8	6.0	5.1	5.3	4.2	4.3	3.4	3.5

TABLE 46

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986 Shipments		Forecast 1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	13.2	29.0	21.6	42.0	28.2	56.0	27.5	55.0	29.8	62.0
Other U.S. Captive	12.2	19.0	31.3	45.9	46.6	68.5	52.7	76.5	65.6	95.0
TOTAL U.S. CAPTIVE	25.4	48.0	52.9	87.9	74.8	124.5	80.2	131.5	95.4	157.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	14.9	17.5	22.8	26.3	51.8	59.5	92.6	111.0	118.0	149.0
TOTAL U.S. NON-CAPTIVE	14.9	17.5	22.8	26.3	51.8	59.5	92.6	111.0	118.0	149.0
TOTAL U.S. SHIPMENTS	40.3	65.5	75.7	114.2	126.6	184.0	172.8	242.5	213.4	306.0
Non-U.S. Manufacturers										
Captive	--	20.1	--	18.5	--	17.5	--	15.0	1.0	23.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	16.1	21.6	33.5	57.4	65.3	90.8	75.5	115.5	81.0	138.0
TOTAL NON-U.S. SHIPMENTS	16.1	41.7	33.5	75.9	65.3	108.3	75.5	130.5	82.0	161.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	56.4	107.2	109.2	190.1	191.9	292.3	248.3	373.0	295.4	467.0
Cumulative Shipments										
IBM	76.4	174.2	98.0	216.2	126.2	272.2	153.7	327.2	183.5	389.2
Non-IBM	147.2	297.4	234.8	445.5	398.5	681.8	619.3	999.8	884.9	1,404.8
WORLDWIDE TOTAL	223.6	471.6	332.8	661.7	524.7	954.0	773.0	1,327.0	1,068.4	1,794.0

TABLE 47

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues		Forecast											
			1987			1988			1989			1990		
	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS														
IBM Captive	771.2	--	928.4	--	--	1,142.4	--	--	1,056.0	--	--	1,128.4	--	--
Other U.S. Captive	356.3	121.0	531.5	395.6	--	692.3	561.0	--	447.8	759.0	84.0	236.5	960.0	230.4
OEM	48.8	68.1	42.8	100.3	6.0	31.9	134.4	106.4	18.0	151.8	231.9	--	105.6	343.8
TOTAL U.S. REVENUES	1,176.3	189.1	1,502.7	495.9	6.0	1,866.6	695.4	106.4	1,521.8	910.8	315.9	1,364.9	1,065.6	574.2
NON-U.S. MANUFACTURERS														
Captive	273.5	162.8	230.0	164.1	--	178.5	180.0	--	105.0	152.0	22.0	42.0	126.0	140.0
OEM	85.0	67.5	109.3	248.2	--	124.3	387.6	14.0	93.5	410.0	77.5	44.0	352.8	173.6
TOTAL NON-U.S. REVENUES	358.5	230.3	339.3	412.3	--	302.8	567.6	14.0	198.5	562.0	99.5	86.0	478.8	313.6
WORLDWIDE RECAP														
Captive	1,401.0 -4.9%	283.8 +174.5%	1,689.9 +20.6%	559.7 +97.2%	-- --	2,013.2 +19.1%	741.0 +32.4%	-- --	1,608.8 -20.1%	911.0 +22.9%	106.0 --	1,406.9 -12.5%	1,086.0 +19.2%	370.4 +249.4%
OEM	133.8 +39.1%	135.6 +244.2%	152.1 +13.7%	348.5 +157.0%	6.0 --	156.2 +2.7%	522.0 +49.8%	120.4 --	111.5 -28.6%	561.8 +7.6%	309.4 +157.0%	44.0 -60.5%	458.4 -18.4%	517.4 +67.2%
Total Revenues	1,534.8 -4.8%	419.4 +193.7%	1,842.0 +20.0%	908.2 +116.5%	6.0 --	2,169.4 +17.8%	1,263.0 +39.1%	120.4 --	1,720.3 -20.7%	1,472.8 +16.6%	415.4 +245.0%	1,450.9 -15.7%	1,544.4 +4.9%	887.8 +113.7%
ANNUAL SHARE, BY DIAMETER	78.6%	21.4%	66.9%	33.0%	.1%	61.2%	35.5%	3.3%	47.8%	40.8%	11.4%	37.5%	39.8%	22.7%

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

TABLE 48

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments		Forecast											
			1987			1988			1989			1990		
	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS														
IBM Captive	29.0	--	42.0	--	--	56.0	--	--	55.0	--	--	62.0	--	--
Other U.S. Captive	13.5	5.5	23.7	22.2	--	35.5	33.0	--	22.5	46.0	8.0	11.0	60.0	24.0
OEM	4.9	12.6	4.6	20.2	1.5	3.5	28.0	28.0	2.0	33.0	76.0	--	24.0	125.0
TOTAL U.S. SHIPMENTS	47.4	18.1	70.3	42.4	1.5	95.0	61.0	28.0	79.5	79.0	84.0	73.0	84.0	149.0
NON-U.S. MANUFACTURERS														
Captive	12.7	7.4	10.8	7.7	--	8.5	9.0	--	5.0	8.0	2.0	2.0	7.0	14.0
OEM	8.8	12.8	9.8	47.6	--	11.3	76.0	3.5	8.5	82.0	25.0	4.0	72.0	62.0
TOTAL NON-U.S. SHIPMENTS	21.5	20.2	20.6	55.3	--	19.8	85.0	3.5	13.5	90.0	27.0	6.0	79.0	76.0
WORLDWIDE RECAP														
Captive	55.2 +11.1%	12.9 +174.5%	76.5 +38.6%	29.9 +131.8%	-- --	100.0 +30.7%	42.0 +40.5%	-- --	82.5 -17.5%	54.0 +28.6%	10.0 --	75.0 -9.1%	67.0 +24.1%	38.0 +280.0%
OEM	13.7 +42.7%	25.4 +262.9%	14.4 +5.1%	67.8 +166.9%	1.5 --	14.8 +2.8%	104.0 +53.4%	31.5 --	10.5 -29.1%	115.0 +10.6%	101.0 +220.6%	4.0 -61.9%	96.0 -16.5%	187.0 +85.1%
Total Shipments	68.9 +12.8%	38.3 +227.4%	90.9 +31.9%	97.7 +155.1%	1.5 --	114.8 +26.3%	146.0 +49.4%	31.5 --	93.0 -19.0%	169.0 +15.8%	111.0 +252.4%	79.0 -15.1%	163.0 -3.6%	225.0 +102.7%
ANNUAL SHARE, BY DIAMETER	64.4%	35.6%	47.9%	51.4%	.7%	39.4%	49.9%	10.7%	24.9%	45.4%	29.7%	16.9%	35.0%	48.1%

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

TABLE 49

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	82.1	76.5	308.3	66.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	17.1	16.0	134.5	28.8
MICROCOMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	3.2	3.0	2.3	.5
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	4.8	4.5	21.9	4.7
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	107.2	100.0	467.0	100.0

TABLE 50

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	14"	8"	Total		14"	8"	Total	
CONTROL DATA	3.4	11.4	14.8	47.7	4.8	12.6	17.4	44.5
FUJITSU	4.9	1.0	5.9	19.0	8.6	1.3	9.9	25.3
NEC	--	8.0	8.0	25.8	--	9.0	9.0	23.0
Other U.S.	.1	--	.1	.3	.1	--	.1	.3
Other Non-U.S.	--	2.2	2.2	7.2	.2	2.5	2.7	6.9
TOTAL	8.4	22.6	31.0	100.0	13.7	25.4	39.1	100.0

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

FIXED DISK DRIVES, OVER 1 GIGABYTE

1987 DISK/TREND REPORT

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

14" disk diameter

Control Data	9772-13G
Hitachi	DKU-85I, DKU-98I
Ibis	1400, 2812
IBM	3380-AJ4, 3380-CJ2, 3380-BK4
Memorex	3680, 3682
NEC	N7765
Storage Technology	8380-B4, 8380-BE4, 8380P
Unisys	9494-12, 9494-24

10.5" disk diameter

Fujitsu	F6425M4/N4

9" disk diameter

Control Data	9715-1000
Hitachi	DK815-10
NEC	D2367, D2377

8" disk diameter

Control Data	Sabre 1230

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

The other 14" and 10.5" drives in this group are intended for mainframe and supermini applications similar to IBM's, and most use technology

similar to IBM's 3380 drives, relying on oxide coated disks and thin film heads. The exceptions are a few drives using ferrite heads, plus the Ibis drives, which use plated disks and offer 12 megabyte/second transfer rates for supercomputer and high-end imaging applications through parallel transfer electronics.

The 8" and 9" drives, both captive and OEM, also utilize advanced Winchester technology, and are used typically in small mainframe, supermini and imaging applications. It is likely that some will also be utilized in multiple-spindle arrays for PCM applications starting in 1988.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1986	1987	1988	1989	1990
U.S. manufacturers	3,891.7	4,599.4	5,158.2	6,909.6	8,669.5
All manufacturers	4,552.9	5,591.6	6,354.0	8,594.2	10,786.6

Fixed drives with more than 1 gigabyte capacity per spindle is a new product group for the DISK/TREND Report this year. Shipments of IBM 3380 series drives and compatible equivalent drives dominate the group. 72.6% of estimated worldwide 1987 revenues for the group will be generated by IBM drives for mainframe applications and 13.8% by plug compatible competitors.

This year's significant development in the mainframe disk drive market was IBM's introduction of the triple density 3380K. It is believed that IBM's management has been dissatisfied with the shipment rate for the 3380E drives introduced in 1985. It also seems clear that many IBM customers have been dissatisfied with the value offered by the 3380E, and they have been deluged for over a year with rumors of pending improvements.

The movement to triple density will provide a major improvement in price per megabyte, which IBM hopes will overcome the user attitude that the price improvement offered with the double density 3380E was unimpressive. By staying with the same transfer rate and track capacity, keeping price-per-box increases to a minimum, and making the new drives usable with existing controllers, IBM has set the stage for early market acceptance of the 3380K.

Current DISK/TREND estimates for IBM shipments, recently revised, place worldwide IBM 3380E shipments for 1985 at 30,300 spindles, rising to 46,000 in 1986 and 52,000 in 1987 -- which is probably the last year of significant production. Despite the inevitable difficulties in ramping up production of new high-end disk drives, 1987 worldwide shipments of 3380K are projected at 9,000 spindles.

IBM's single density 3380D is being replaced by the new single density 3380J, which lowers average head positioning time to 12 milliseconds, and which should be well received by some IBM users which can't get to the data fast enough with existing drives. This drive will help to keep up IBM's shipments of single density 3380s to an estimated 35,000 spindles in 1987, following shipments of 62,600 spindles in 1985 and 39,000 in 1986.

Hitachi held a 41.8% share of worldwide non-captive worldwide unit shipments for 1986, representing 13,500 spindles, with Fujitsu at 19.2% and Storage Technology at 17.3%. IBM's OEM sales of 3380s to Siemens and Honeywell are included in the "Other U.S." totals in Table 57. All shipments in 1986 were 14" drives, and the non-captive totals for Hitachi and Fujitsu include both PCM and OEM shipments. The PCM product mix was less than one third double capacity 3380s in 1986, but is expected to move to two thirds double capacity models in 1987.

Marketing trends

Despite significant enlargement of the role of other captive and OEM drives in this product group during the next few years, DISK/TREND projections indicate IBM still holding almost 62% of the group's worldwide $10.7 billion revenues in 1990. However, products not yet introduced are expected to provide a major share of IBM's projected $6.6 billion revenue in 1990.

Two key assumptions underlie the current projections: (1) That IBM will ship in the second half of 1988 a new 10.25" drive designed for optimum high performance, and (2) that IBM will ship in the second half of 1989 a new 5.25" drive designed for use in multiple spindle arrays to achieve improved cost per megabyte. The impact on IBM's current product mix by these moves will be to displace a high percentage of single density 3380 shipments with the 10.25" drive and to provide a cost effective replacement for triple density 3380s.

As usual, the PCM suppliers which survive all of these changes will be those which are able to react quickly to compete with IBM's new drives. The first order of business will be to match the 3380J and 3380K drives now starting to ship, and this is expected by mid-1988, with 10,500 spindles projected for 1988 shipment.

IBM's 10.25" drive is expected to be a tougher target, with new heads, motors and head positioning systems which the independents will probably take 18-24 months to match, and some may not choose to do so, considering the more specialized nature of the market opportunity. However, the IBM 5.25" drive will be the future mainstream disk drive for mainframes, and all companies staying in the PCM market will need to have an equivalent product, the first of which is expected in 1990.

A rapid movement to 8"/9" drives is expected from U.S. producers of captive drives, led by the RA90 9" model from DEC in 1988, plus several other drives from established captive drive manufacturers, with shipments building to 43,000 spindles in 1990. Japanese manufacturers of 8"/9" OEM drives are expected to hold the lead established with lower capacity 8"/9" drives, placing competitive emphasis on existing applications and customers, despite exchange rate disadvantages. Similarly, U.S. producers of OEM 5.25" drives will probably lead, with first shipments in 1989.

Technical trends

The future new IBM drives envisioned for this product group will introduce new technical challenges for other manufacturers. Both the 10.25" and 5.25" drives are expected to use rotational speeds 50% faster than today's typical 3600 RPM, intensifying problems with heat and power. Head positioning speeds are also expected to improve, embodying new actuator designs and advanced magnetic materials.

There is the possibility that the very high performance 10.25" drive may utilize multiple head sliders, creating larger logical cylinders and allowing fewer head movements, but introducing new considerations in head design, flying characteristics and controller logic. The end result, however, will be a new generation of drives for high-end applications which are smaller, quieter, cheaper, faster and require less power.

Forecasting assumptions

1. IBM will ship a new 10.25" high performance drive in the second half of 1988 and will ship a new multiple spindle disk array using high capacity 5.25" drives in second half of 1989.
2. PCM vendors will match IBM's new drives starting in 1990, and 5.25" OEM drives in this group will ship in 1989.

TABLE 51

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1986		Forecast							
	Revenues		1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	2,057.0	3,532.5	2,461.4	4,058.9	2,617.0	4,267.9	3,317.7	5,303.9	4,186.2	6,671.8
Other U.S. Captive	29.3	48.8	44.9	72.9	277.9	392.9	615.1	960.2	773.8	1,208.7
TOTAL U.S. CAPTIVE	2,086.3	3,581.3	2,506.3	4,131.8	2,894.9	4,660.8	3,932.8	6,264.1	4,960.0	7,880.5
PCM	118.2	161.9	212.5	289.1	227.9	301.9	316.8	422.4	365.2	486.1
OEM	74.8	148.5	102.7	178.5	136.8	195.5	161.8	223.1	227.0	302.9
TOTAL U.S. NON-CAPTIVE	193.0	310.4	315.2	467.6	364.7	497.4	478.6	645.5	592.2	789.0
TOTAL U.S. REVENUES	2,279.3	3,891.7	2,821.5	4,599.4	3,259.6	5,158.2	4,411.4	6,909.6	5,552.2	8,669.5
Non-U.S. Manufacturers										
Captive	--	187.9	--	347.6	--	498.5	--	697.6	--	904.0
PCM	200.0	422.8	222.2	481.7	205.2	427.7	271.0	492.8	288.2	490.6
OEM	--	50.5	48.0	162.9	135.5	269.6	285.5	494.2	449.5	722.5
TOTAL NON-U.S. REVENUES	200.0	661.2	270.2	992.2	340.7	1,195.8	556.5	1,684.6	737.7	2,117.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,479.3	4,552.9	3,091.7	5,591.6	3,600.3	6,354.0	4,967.9	8,594.2	6,289.9	10,786.6
OEM Average Price ($000)	31.1	27.6	13.3	16.1	10.6	12.3	9.2	10.5	7.5	8.3

TABLE 52

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1986		Forecast							
	Shipments		1987		1988		1989		1990	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	49.1	85.0	58.1	96.0	55.8	91.0	89.0	143.0	156.9	254.0
Other U.S. Captive	1.2	2.0	1.5	2.5	11.0	15.4	24.8	38.7	33.5	52.3
TOTAL U.S. CAPTIVE	50.3	87.0	59.6	98.5	66.8	106.4	113.8	181.7	190.4	306.3
PCM	5.3	7.4	8.1	11.2	7.7	10.2	9.0	12.0	19.0	24.2
OEM	2.4	5.2	5.3	8.3	9.5	12.5	14.3	18.4	29.8	38.0
TOTAL U.S. NON-CAPTIVE	7.7	12.6	13.4	19.5	17.2	22.7	23.3	30.4	48.8	62.2
TOTAL U.S. SHIPMENTS	58.0	99.6	73.0	118.0	84.0	129.1	137.1	212.1	239.2	368.5
Non-U.S. Manufacturers										
Captive	--	5.7	--	10.7	--	14.8	--	19.9	--	24.5
PCM	8.3	17.7	8.2	18.9	7.1	14.8	7.7	14.0	12.6	21.8
OEM	--	2.0	6.0	12.9	16.0	25.2	34.0	49.7	60.1	84.3
TOTAL NON-U.S. SHIPMENTS	8.3	25.4	14.2	42.5	23.1	54.8	41.7	83.6	72.7	130.6
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	66.3	125.0	87.2	160.5	107.1	183.9	178.8	295.7	311.9	499.1
Cumulative Shipments										
IBM	194.3	336.9	252.4	432.9	308.2	523.9	397.2	666.9	554.1	920.9
Non-IBM	41.6	101.8	70.7	166.3	122.0	259.2	211.8	411.9	366.8	657.0
WORLDWIDE TOTAL	235.9	438.7	323.1	599.2	430.2	783.1	609.0	1,078.8	920.9	1,577.9

TABLE 53

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1986 Revenues	1987		1988		1989			1990		
	14"	14"	8"	14"	8"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS											
IBM Captive	3,532.5	4,058.9	--	4,267.9	--	4,991.4	--	312.5	5,046.8	--	1,625.0
Other U.S. Captive	48.8	72.9	--	142.2	250.7	237.9	722.3	--	279.9	928.8	--
PCM	161.9	289.1	--	301.9	--	422.4	--	--	373.3	--	112.8
OEM	148.5	171.0	7.5	175.1	20.4	184.2	26.3	12.6	188.4	28.4	86.1
TOTAL U.S. REVENUES	3,891.7	4,591.9	7.5	4,887.1	271.1	5,835.9	748.6	325.1	5,888.4	957.2	1,823.9
NON-U.S. MANUFACTURERS											
Captive	187.9	325.6	22.0	465.5	33.0	643.8	53.8	--	820.0	84.0	--
PCM	422.8	481.7	--	427.7	--	492.8	--	--	415.4	--	75.2
OEM	50.5	86.9	76.0	119.6	150.0	200.2	294.0	--	251.1	442.0	29.4
TOTAL NON-U.S. REVENUES	661.2	894.2	98.0	1,012.8	183.0	1,336.8	347.8	--	1,486.5	526.0	104.6
WORLDWIDE RECAP											
Captive	3,769.2 -8.7%	4,457.4 +18.3%	22.0 --	4,875.6 +9.4%	283.7 --	5,873.1 +20.5%	776.1 +173.6%	312.5 --	6,146.7 +4.7%	1,012.8 +30.5%	1,625.0 +420.0%
PCM	584.7 +11.0%	770.8 +31.8%	-- --	729.6 -5.3%	-- --	915.2 +25.4%	-- --	-- --	788.7 -13.8%	-- --	188.0 --
OEM	199.0 +48.6%	257.9 +29.6%	83.5 --	294.7 +14.3%	170.4 +104.1%	384.4 +30.4%	320.3 +88.0%	12.6 --	439.5 +14.3%	470.4 +46.9%	115.5 +816.7%
Total Revenues	4,552.9 -4.9%	5,486.1 +20.5%	105.5 --	5,899.9 +7.5%	454.1 +330.4%	7,172.7 +21.6%	1,096.4 +141.4%	325.1 --	7,374.9 +2.8%	1,483.2 +35.3%	1,928.5 +493.2%
ANNUAL SHARE, BY DIAMETER	100.0%	98.2%	1.8%	93.0%	7.0%	83.6%	12.8%	3.6%	68.5%	13.8%	17.7%

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

TABLE 54

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1986 Shipments	1987		1988		1989			1990		
	14"	14"	8"	14"	8"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS											
IBM Captive	85.0	96.0	--	91.0	--	118.0	--	25.0	124.0	--	130.0
Other U.S. Captive	2.0	2.5	--	4.5	10.9	7.7	31.0	--	9.3	43.0	--
PCM	7.4	11.2	--	10.2	--	12.0	--	--	12.2	--	12.0
OEM	5.2	7.3	1.0	8.5	4.0	9.8	5.6	3.0	10.7	6.3	21.0
TOTAL U.S. SHIPMENTS	99.6	117.0	1.0	114.2	14.9	147.5	36.6	28.0	156.2	49.3	163.0
NON-U.S. MANUFACTURERS											
Captive	5.7	9.7	1.0	13.3	1.5	17.4	2.5	--	20.5	4.0	--
PCM	17.7	18.9	--	14.8	--	14.0	--	--	13.8	--	8.0
OEM	2.0	3.4	9.5	5.2	20.0	7.7	42.0	--	9.3	68.0	7.0
TOTAL NON-U.S. SHIPMENTS	25.4	32.0	10.5	33.3	21.5	39.1	44.5	--	43.6	72.0	15.0
WORLDWIDE RECAP											
Captive	92.7	108.2	1.0	108.8	12.4	143.1	33.5	25.0	153.8	47.0	130.0
	-16.1%	+16.7%	--	+.6%	--	+31.5%	+170.2%	--	+7.5%	+40.3%	+420.0%
PCM	25.1	30.1	--	25.0	--	26.0	--	--	26.0	--	20.0
	-.8%	+19.9%	--	-16.9%	--	+4.0%	--	--	--	--	--
OEM	7.2	10.7	10.5	13.7	24.0	17.5	47.6	3.0	20.0	74.3	28.0
	+38.5%	+48.6%	--	+28.0%	+128.6%	+27.7%	+98.3%	--	+14.3%	+56.1%	+833.3%
Total Shipments	125.0	149.0	11.5	147.5	36.4	186.6	81.1	28.0	199.8	121.3	178.0
	-11.3%	+19.2%	--	-1.0%	+216.5%	+26.5%	+122.8%	--	+7.1%	+49.6%	+535.7%
ANNUAL SHARE, BY DIAMETER	100.0%	92.9%	7.1%	80.3%	19.7%	63.2%	27.4%	9.4%	40.1%	24.3%	35.6%

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

TABLE 55

WORLDWIDE SHIPMENTS OF IBM AND PCM FIXED DISK DRIVES FOR MAINFRAMES

PRODUCT MIX ANALYSIS

	DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000 SPINDLES)									
	1986		FORECAST							
	---Shipments--		-----1987-----		-----1988-----		-----1989-----		-----1990-----	
	US	WW	US	WW	US	WW	US	WW	US	WW
PCM 3350 Type (317 MB)*	.6	6.0	--	--	--	--	--	--	--	--
IBM 3370 (729 MB)	8.8	22.0	4.0	10.0	3.2	8.0	--	--	--	--
IBM 3375 (819 MB)	.9	2.0	--	--	--	--	--	--	--	--
IBM 9335 (856 MB)	3.5	5.0	17.6	32.0	25.0	48.0	27.5	55.0	29.8	62.0
3380D/J Type (1260 MB)										
IBM	21.5	39.0	21.0	35.0	13.0	20.0	7.6	12.0	5.4	9.0
PCM**	9.1	17.3	3.9	9.5	2.5	5.5	--	--	--	--
TOTAL	30.6	56.3	24.9	44.5	15.5	25.5	7.6	12.0	5.4	9.0
3380E Type (2520 MB)										
IBM	27.6	46.0	31.2	52.0	--	--	--	--	--	--
PCM**	4.5	7.8	12.4	20.6	5.4	9.0	--	--	--	--
TOTAL	32.1	53.8	43.6	72.6	5.4	9.0	--	--	--	--
3380K Type (3780 MB)										
IBM	--	--	5.9	9.0	41.0	69.0	46.8	78.0	42.0	70.0
PCM**	--	--	--	--	6.3	10.5	15.6	26.0	10.8	18.0
TOTAL	--	--	5.9	9.0	47.3	79.5	62.4	104.0	52.8	88.0
Not yet announced										
IBM 10.25 INCH (1500 MB)	--	--	--	--	1.4	2.0	19.6	28.0	31.5	45.0
PCM 10.25 INCH (1500 MB)	--	--	--	--	--	--	--	--	5.6	8.0
TOTAL 10.25 INCH	--	--	--	--	1.4	2.0	19.6	28.0	37.1	53.0
IBM 5.25 INCH (1100 MB)	--	--	--	--	--	--	15.0	25.0	78.0	130.0
PCM 5.25 INCH (1100 MB)	--	--	--	--	--	--	--	--	12.0	20.0
TOTAL 5.25 INCH	--	--	--	--	--	--	15.0	25.0	90.0	150.0
TOTAL SPINDLES	76.5	145.1	96.0	168.1	97.8	172.0	132.1	224.0	215.1	362.0
TOTAL CAPACITY (Terabytes)		230.3		307.7		405.2		524.7		641.6
		+7%		+34%		+32%		+29%		+22%

*Includes 10.5" drives in 317 MB 3350 format.
**Includes: Some 14" drives, counted as equivalent to IBM 3380 (two 14" spindles = one IBM 3380 spindle).
Some 10.5" drives, counted as equivalent to IBM 3380 (two 10.5" spindles = one IBM 3380 spindle).
Some 8" drives, counted as equivalent to IBM 3380 (various spindle counts = one IBM 3380 spindle).

TABLE 56

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1986 Estimate Units (000)	1986 Estimate %	1990 Projection Units (000)	1990 Projection %
MAINFRAME/SUPERMINI General purpose	123.0	98.4	446.7	89.5
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	--	--	20.0	4.0
MICROCOMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	--	--	--	--
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	2.0	1.6	32.4	6.5
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	125.0	100.0	499.1	100.0

TABLE 57

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1986 Net Shipments					
	To United States Destinations			Worldwide		
	Units (000)		%	Units (000)		%
Drive Manufacturers	14"	Total		14"	Total	
HITACHI	4.0	4.0	25.0	13.5	13.5	41.8
FUJITSU	4.3	4.3	26.9	6.2	6.2	19.2
STORAGE TECHNOLOGY	3.9	3.9	24.4	5.6	5.6	17.3
Other U.S.	3.8	3.8	23.7	7.0	7.0	21.7
Other Non-U.S.	--	--	--	--	--	--
TOTAL	16.0	16.0	100.0	32.3	32.3	100.0

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

RIGID DISK DRIVE SPECIFICATIONS

RIGID MAGNETIC DISK DRIVE SPECIFICATIONS

1987 DISK/TREND product groups for rigid magnetic disk drives

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

Coverage

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

Specifications on drive models sold by computer system manufacturers, but purchased on an OEM basis from others, have been included in some cases, for identification purposes. Not listed in most cases are captive drives which are similar to OEM models made by the same manufacturer.

Generic type

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

Technology type

IBM drive model numbers are also used as a general guide to type of heads and recording disks when appropriate, using a broad interpretation

of IBM specifications. The term "3370 (ferrite)" indicates heads with the shape of IBM's 3370/3380 sliders, but using ferrite cores.

Interfaces

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

OEM prices

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

Capacities

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

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.

MANUFACTURER	ALPHA DATA	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	Atlas 520	DRM010A	DRM020A	DRM020D	DRP020A
DISK/TREND GROUP	7	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	Special	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite*
Interface	ESMD	ST412,SCSI	ST412,SCSI	SCSI	ALPS
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 520	U: 12.75	U: 25.5	F: 21.4	U: 25.5
REMOVABLE		--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 10,416	U: 10,416	F: 8,704	U: 20,832
Data surfaces per spindle	7.6	2	4	4	4
Heads per data surface	10	1	1	1	2
Tracks per surface	2250	615	615	615	615
Track density (TPI)	1000	880	880	880	880
Maximum linear density (BPI)	11700	12720	12720	12,720	27,022 BPI** 18,015 FCI
Rotational speed (RPM)	3600	3545	3545	3545	2640
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	18	75 (including settling)	75 (including settling)	75 (including settling)	75 (including settling)
Average rotational delay (msec)	8.3	8.46	8.46	8.46	11.4
Average access time (msec)	26.3	83.46	83.46	83.46	86.4
Data transfer rate (KBytes/sec)	1800	625	625	625	937.5
FIRST CUSTOMER SHIPMENT	2Q86	10/85	1986	1987	1987
U.S. OEM PRICE FOR 100 UNITS	$7,495	--	--	--	--
COMMENTS	8 Parallel channel version available	41 mm High	41 mm High	41 mm High	25 mm High *Metal in Gap **2,7 RLL Code

MANUFACTURER	ALPS ELECTRIC	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES
DRIVE	DRP020D	BT8085	BT8128	BT8170E	BT8170S
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	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	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite*	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 20.9	U: 85.3	U: 127.9	U: 170.6	F: 150.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	U: 10,416	U: 15,624	U: 20,832	F: 18,432
Data surfaces per spindle	2	8	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	615	1024	1024	1024	1024
Track density (TPI)	880	1053	1053	1053	1053
Maximum linear density (BPI)	27,022 BPI** 18,015 FCI	9290	13935 BPI* 9250 FCI	18580 BPI* 12387 FCI	18580 BPI* 12387 FCI
Rotational speed (RPM)	2640	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, DC Motor	Rotary, DC Motor	Rotary, DC Motor	Rotary, DC Motor
Average positioning time (msec)	75 (including settling)	25	25	22	22
Average rotational delay (msec)	11.4	8.3	8.3	8.3	8.3
Average access time (msec)	86.4	33.3	33.3	30.3	30.3
Data transfer rate (KBytes/sec)	937.5	625	937.5	1250	1250
FIRST CUSTOMER SHIPMENT	1987	2Q87	2Q87	4Q87	1Q88
U.S. OEM PRICE FOR 100 UNITS	--	$675 (1000)	$725 (1000)	$970 (1000)	$1,050 (1000)
COMMENTS	30 mm High *Metal in Gap **2,7 RLL Code		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CENTURY DATA	CENTURY DATA
DRIVE	F3053 Classic	F3080 Classic	F3127 Classic	AMCODYNE 7110	AMCODYNE 7130
DISK/TREND GROUP	4	4	5	1	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	8" Cartridge	8" Cartridge
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	200 mm OD	200 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	ST412	ESDI, SCSI	ESDI, SCSI	SMD,SCSI	SMD,SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 53.3	U: 80.0	U: 127.5	U: 26.9	U: 80.9
REMOVABLE				U: 26.9	U: 26.9
Capacity per track (Bytes)	U: 10,416	U: 15,624	U: 20,832	U: 20,928	U: 20,928
Data surfaces per spindle	5	5	5	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1224	644	644
Track density (TPI)	1200	1200	1389	555	555
Maximum linear density (BPI)	14330	21495 BPI* 14330 FCI	29557 BPI* 19704 FCI	10986 BPI* 7324 FCI	10986 BPI* 7324 FCI
Rotational speed (RPM)	3600	3600	3600	3523	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	20	20	20	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.45	8.3
Average access time (msec)	28.3	28.3	28.3	33.45	33.3
Data transfer rate (KBytes/sec)	625	937.5	1250	1229	1229
FIRST CUSTOMER SHIPMENT	12/87	12/87	11/87	1Q83	1/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	$3,275	$3,845
COMMENTS	41 mm High	41 mm High *2,7 RLL code	41 mm High *2,7 RLL code	Embedded Servo *2,7 RLL Code	Embedded Servo *2,7 RLL Code

MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
DRIVE	AMCODYNE 7130E	T306	T472	CAST 10304	CAST 10305
DISK/TREND GROUP	1	2	2	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	8" Cartridge	3336-11	3336-11	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3330-11	3330-11	3370	3370
Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SMD	SMD	Modified SMD	ESDI/SCSI	ESDI/SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 120.16	--	--	U: 87	U: 110
REMOVABLE	U: 40.05	U: 315.2	U: 472.8	--	--
Capacity per track (Bytes)	U: 21,582	U: 20,160	U: 30,240	U: 20,880	U: 20,880
Data surfaces per spindle	8	19	19	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	928	823	823	1050	1050
Track density (TPI)	743	384	384	1050	1050
Maximum linear density (BPI)	11526 BPI* 7684 FCI	6060	9090*	19405 BPI* 12937 FCI	19405 BPI* 12937 FCI
Rotational speed (RPM)	3416	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	27	30	26.5	28	28
Average rotational delay (msec)	8.78	8.3	8.3	8.3	8.3
Average access time (msec)	35.78	38.3	34.8	36.3	36.3
Data transfer rate (KBytes/sec)	1229	1209	1814	1250	1250
FIRST CUSTOMER SHIPMENT	4/86	8/76	3Q87	11/85	11/85
U.S. OEM PRICE FOR 100 UNITS	$4,150	$9,100	$10,200	$995	$1,200
COMMENTS	Embedded Servo *2,7 RLL Code		*2,7 RLL Code	41 mm High *2,7 RLL Code	51 mm High *2,7 RLL Code

MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
DRIVE	CAST 14404	CAST 14405	CAST 14406	AMS 315	C2400
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Hi Dens Oxide
DRIVE: Technology type	3370	3370	3370	Modified 3350	3370
Heads	Thin Film	Thin Film	Thin Film	Ferrite	Thin Film
Interface	ESDI/SCSI	ESDI/SCSI	ESDI/SCSI	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 114	F: 140	F: 170	U: 315.2	U: 408.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,880	F: 20,880	F: 20,880	U: 20,160	U: 20,160
Data surfaces per spindle	4	5	6	9.5	12
Heads per data surface	1	1	1	2	2
Tracks per surface	--	--	--	1646	1690
Track density (TPI)	1440	1440	1440	712	960
Maximum linear density (BPI)	19405 BPI* 12937 FCI	19405 BPI* 12937 FCI	19405 BPI* 12937 FCI	6363	9500
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	25	25	25	25	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	33.3	33.3	23.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1209	1209
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	3Q87	11/82	5/85
U.S. OEM PRICE FOR 100 UNITS	$1,355	$1,575	$1,845	$6,610	$5,835
COMMENTS	41 mm High *2,7 RLL Code Embedded Servo	41 mm High *2,7 RLL Code Embedded Servo	41 mm High *2,7 RLL Code Embedded Servo		

MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
DRIVE	C2476	TECSTOR 3005	TECSTOR 3010	TECSTOR 3020	AMS 513
DISK/TREND GROUP	6	6	6	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	14"	14"	14"	14"
Recording medium	Hi Dens Oxide	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	Modified SMD	Modified SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 475.9	U: 331.8	U: 331.8	U: 331.8	U: 513.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 28,160	U: 20,160	U: 20,160	U: 20,160	U: 32,064
Data surfaces per spindle	10	10	10	10	9.5
Heads per data surface	2	2	2	2	2
Tracks per surface	1690	1646	1646	1646	1690
Track density (TPI)	1143	680	680	680	712
Maximum linear density (BPI)	17900*	6450	6450	6450	10000
Rotational speed (RPM)	3961	3600	3600	3600	2400
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	29	29	29	25
Average rotational delay (msec)	7.57	8.3	8.3	8.3	12.5
Average access time (msec)	22.57	37.3	37.3	37.3	37.5
Data transfer rate (KBytes/sec)	1859	6050	12100	24200	1280
FIRST CUSTOMER SHIPMENT	3/85	1Q85	1Q85	1Q85	1/83
U.S. OEM PRICE FOR 100 UNITS	$6,235	$20,500	$21,500	$22,500	$7,200
COMMENTS	*2,7 RLL Code	5 track parallel data transfer	10 track parallel data transfer	20 track parallel data transfer	

MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	COGITO SYSTEMS	COGITO SYSTEMS
DRIVE	AMS 571	C2600	C2800	PT 925 PT 925R	PT 925E
DISK/TREND GROUP	7	7	7	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Hi Dens Oxide	Thin Film	Thin Film	Oxide/Thin Film
DRIVE: Technology type	3370	3370	3370	Modified 3350	Modified 3350
Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	Modified SMD	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 615	U: 613	U: 830	U: 25.52	U: 25.52
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 33,012	U: 30,240	U: 40,960	U: 10,416	U: 10,416
Data surfaces per spindle	9.5	12	12	4	4
Heads per data surface	2	2	2	1	1
Tracks per surface	1882	1690	845	615	615
Track density (TPI)	800	1143	1400	527	527
Maximum linear density (BPI)	10295	19200*	21382*	10200	10200
Rotational speed (RPM)	3600	3600	3600	3612	3612
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	19	15	15	85 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	27.3	23.3	23.3	93.3	48.3
Data transfer rate (KBytes/sec)	1980	1813	2400	625	625
FIRST CUSTOMER SHIPMENT	8/83	3Q85	8/86	2Q86	1987
U.S. OEM PRICE FOR 100 UNITS	$8,570	$6,850	$9,995	$230	--
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	41 mm High	41 mm High

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	CP340	CP3100	9710 RSD	9762 SMD	9766 SMD
DISK/TREND GROUP	4	5	2	2	2
MARKET	OEM	OEM	OEM	OEM, Captive	OEM, Captive
MEDIA: Generic type	Fixed	Fixed	Removable Storage Drive	Storage Module Drive	3336-11
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	230 mm OD 100 mm ID	14"	14"
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	3330-11	3330-11
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	SMD	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 40	F: 100	--	--	--
REMOVABLE	--	--	U: 82.9	U: 82.9	U: 315.2
Capacity per track (Bytes)	F: 13,312	F: 16,896	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	4	8	5	5	19
Heads per data surface	1	1	1	1	1
Tracks per surface	752	748	823	823	823
Track density (TPI)	1000	1150	550	384	384
Maximum linear density (BPI)	21379 BPI* 14253 FCI	23280 BPI* 15520 FCI	10000*	6038	6038
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	29	25	30	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.3	33.3	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	1000	1250	1209	1209	1209
FIRST CUSTOMER SHIPMENT	8/86	3Q87	1Q83	3/75	3/76
U.S. OEM PRICE FOR 100 UNITS	--	--	$4,915	$6,715	$12,355
COMMENTS	38 mm High *2,7 RLL Code Embedded Servo	41 mm High *2,7 RLL Code Embedded Servo	*2,7 RLL Code		

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	94155-48 Wren II	94155-67 Wren II	94155-85 Wren II	94155-86 Wren II	94156-48 Wren II
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	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 48.1	U: 67.4	U: 85.3	U: 86.7	U: 48.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	5	7	8	9	5
Heads per data surface	1	1	1	1	1
Tracks per surface	925	925	1024	925	925
Track density (TPI)	960	960	980	960	960
Maximum linear density (BPI)	9540	9540	9400	9540	9540
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	30	28	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	36.3	38.3	38.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	2Q84	2Q84	1986	2Q84	2Q84
U.S. OEM PRICE FOR 100 UNITS	$735 (250)	$805 (250)	$885 (250)	$885 (250)	$1,270
COMMENTS					

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	94156-67 Wren II	94156-86 Wren II	94205 Wren II HH	94166-101 Wren III	94166-141 Wren III
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	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ST412	ESDI, SCSI	ESDI, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 67.4	U: 86.7	U: 51.5	U: 101	U: 141
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 20,880	U: 20,880
Data surfaces per spindle	7	9	5	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	925	925	989	969	969
Track density (TPI)	960	960	960	960	960
Maximum linear density (BPI)	9540	9540	9400	19058*	19058*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	30	28	16.4	16.4
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	36.3	24.7	24.7
Data transfer rate (KBytes/sec)	625	625	625	1250	1250
FIRST CUSTOMER SHIPMENT	2Q84	2Q84	1Q86	2Q86	2Q86
U.S. OEM PRICE FOR 100 UNITS	$1,455	$1,640	$695 (250)	$1,240 (250)	$1,355 (250)
COMMENTS			41 mm High	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	94166-182 Wren III	Wren III HH	9715-160 FSD	94171 Wren IV	9715-300 FSD
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	3370	3380
Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ESDI, SCSI	ESDI, SCSI	SMD	SCSI	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 182	U: 106	U: 165.9	F: 301.9	U: 315
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,880	U: 20,880	U: 20,160	F: 24,576	U: 20,160
Data surfaces per spindle	9	5	10	9	9.5
Heads per data surface	1	1	1	1	2/1
Tracks per surface	969	969	823	1365	1646
Track density (TPI)	960	960	550	1280	1040
Maximum linear density (BPI)	19058*	19058*	9500*	19058*	10040*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	16.4	18	30	16.5	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.7	26.3	38.3	24.8	28.3
Data transfer rate (KBytes/sec)	1250	1250	1209	Up to 3000	1209
FIRST CUSTOMER SHIPMENT	2Q86	2/87	4Q82	3/87	4Q85
U.S. OEM PRICE FOR 100 UNITS	$1,465 (250)	$1,100 (250)	$4,650	$1,860 (250)	$5,290
COMMENTS	*2,7 RLL Code	41 mm High *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	9715-340 FSD	Sabre 368	9715-500 FSD	9771 XMD-I	9772 XMD-II
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	230 mm OD 100 mm ID	210 mm OD 100 mm ID	230 mm OD 100 mm ID	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3380	3380	3380	3380	3380
Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD	SMD,SMD-E,SCSI	Mod.SMD,IPI-2	Modified SMD	SMD-E
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 344.0	U: 368.0	U: 516.0	U: 825.0	U: 858.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 30,240	U: 30,240	U: 50,400	U: 50,400
Data surfaces per spindle	12	10	12	8	8
Heads per data surface	2	1	2	2	2
Tracks per surface	1422	1217	1422	2128	2128
Track density (TPI)	960	960	960	960	960
Maximum linear density (BPI)	10027*	15185*	15159*	15400*	15400*
Rotational speed (RPM)	3600	3600	3600	2160	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	18	18	18	16	16
Average rotational delay (msec)	8.3	8.3	8.3	13.89	8.3
Average access time (msec)	26.3	26.3	26.3	29.89	24.3
Data transfer rate (KBytes/sec)	1209	1815	1825	1825	3000
FIRST CUSTOMER SHIPMENT	4Q83	11/85	4Q83	3Q83	10/85
U.S. OEM PRICE FOR 100 UNITS	$5,815	$3,155	$6,165	$9,000	$9,000
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	9775 FMD	97704-700 Hydra	Sabre 500	Sabre 736	Sabre 850
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	Captive, OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed Module Drive	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3380	3380	3380	3380
Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD	ISI	Mod.SMD, SCSI	Mod.SMD, SCSI	Mod.SMD, IPI-2
CAPACITY/RECORDING DENSITY	1.9 MB Fixed Head Option				
Total capacity (MBytes) FIXED	U: 675.0	U: 703	U: 500	U: 741	U: 850
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 49,728	U: 41,088	U: 30,240	U: 41,088
Data surfaces per spindle	20	8	10	15	15
Heads per data surface	2	2	1	1	1
Tracks per surface	1686	1776	1217	1635	1381
Track density (TPI)	660	800	960	1289	1089
Maximum linear density (BPI)	6350	15200*	19816*	14981*	19816*
Rotational speed (RPM)	3600	3620	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	16	18	16	16
Average rotational delay (msec)	8.3	8.29	8.3	8.3	8.3
Average access time (msec)	33.3	24.29	26.3	24.3	24.3
Data transfer rate (KBytes/sec)	1209	12000	2465	1815	2465
FIRST CUSTOMER SHIPMENT	4/80	2Q86	2Q87	2Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	$15,155	$27,500	$3,740	$4,440	$4,615
COMMENTS		*2,7 RLL Code 4 track parallel data transfer	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	DATA GENERAL	DATA GENERAL
DRIVE	9715-1000 FSD-III	9772-13G XMD-III	Sabre 1230	6060	6122
DISK/TREND GROUP	8	8	8	2	2
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	3336-1	3336-11
Nominal disk diameter	230 mm OD 100 mm ID	14"	210 mm OD 100 mm ID	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Technology type	3380	3380	3370	3330-1	3330-11
Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	Mod.SMD, IPI-2	Mod.SMD, IPI-2	SMD,SCSI,IPI-2	Data General	Data General
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 1,030	U: 1,359	U: 1,236	--	--
REMOVABLE	--	--	--	F: 95.957	F: 277.491
Capacity per track (Bytes)	U: 41,088	U: 50,400	U: 50,400	F: 12,288	F: 17,920
Data surfaces per spindle	13	9.5	15	19	19
Heads per data surface	2	2	1	1	1
Tracks per surface	1930	2840	1635	411	815
Track density (TPI)	1283	1280	1289	192	370
Maximum linear density (BPI)	20254*	15400*	25264*	4040	6060
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	14	16	16	35	35
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	24.3	24.3	43.3	43.3
Data transfer rate (KBytes/sec)	2460	3000	3.0	806	1209
FIRST CUSTOMER SHIPMENT	1Q87	12/86	2Q88	1976	1Q80
U.S. OEM PRICE FOR 100 UNITS	$7,540	$11,000	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code		

MANUFACTURER	DATA GENERAL	DATA GENERAL	DATA-TECH MEMORIES	DATA-TECH MEMORIES	DIGITAL EQUIPMENT CORPORATION
DRIVE	6236 6237	6239 6290 6240 6350	DTM 853	DTM 885	RC25
DISK/TREND GROUP	6	7	4	4	1
MARKET	Captive	Captive	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Special Cartridge
Nominal disk diameter	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	8"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Data General	Data General	ST412, SCSI	ST412, SCSI	DEC
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 354.1	F: 592.2	U: 53.32	U: 85.32	F: 26
REMOVABLE	--	--	--	--	F: 26
Capacity per track (Bytes)	F: 28,672	F: 38,400	U: 10,416	U: 10,416	F: 15,872
Data surfaces per spindle	8	8	8	8	4
Heads per data surface	2	2	1	1	1
Tracks per surface	1572	1956	640	1024	821
Track density (TPI)	714	800	1173	1173	1000
Maximum linear density (BPI)	10438*	14154*	9074	9074	12350
Rotational speed (RPM)	3000	2940	3573	3573	2850
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Band, Torque Motor	Rotary, Band, Torque Motor	Rotary, Voice Coil
Average positioning time (msec)	20	21	30	30	35
Average rotational delay (msec)	10	10.2	8.4	8.4	10.5
Average access time (msec)	30	31.2	38.4	38.4	45.5
Data transfer rate (KBytes/sec)	1680	2200	625	625	1250
FIRST CUSTOMER SHIPMENT	9/83	2/85	1/87	1/87	4Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	$575	$675	--
COMMENTS	*2,7 RLL Code 6237-3 Spindles	*2,7 RLL Code 6239-1 Spindle 6290-2 Spindles 6240-3 Spindles 6350-9 Spindles	Embedded Servo	Embedded Servo	Embedded Servo

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	RL02	RA60	RA70	RA80	RM80
DISK/TREND GROUP	1	2	5	5	5
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	5440	Special Disk Pack	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	130 mm OD 40 mm ID	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Technology type	3330-1	Modified 3330	3370	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite/T.F.	Ferrite	Ferrite
Interface	DEC	DEC	DEC	DEC	DEC
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	--	F: 280	F: 121.0	F: 124.0
REMOVABLE	F: 10.48	F: 205.0	--	--	--
Capacity per track (Bytes)	F: 10,240	F: 21,504	F: 16,896	F: 15,872	F: 16,384
Data surfaces per spindle	2	6	11	7	7
Heads per data surface	1	1	1	2	2
Tracks per surface	512	1600	1507	1092	1122
Track density (TPI)	250	779	1355	478	478
Maximum linear density (BPI)	3725	9668 BPI* 7251 FCI	22437 BPI* 16828 FCI	6339	6339
Rotational speed (RPM)	2400	3600	4000	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	55	41.7	19.5	25	25
Average rotational delay (msec)	12.5	8.3	7.5	8.3	8.3
Average access time (msec)	67.5	50.0	27.0	33.3	33.3
Data transfer rate (KBytes/sec)	512.5	1980	1450	1200	1200
FIRST CUSTOMER SHIPMENT	1979	3Q83	12/87	1/82	1981
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo		

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DMA TECHNOLOGIES	FUJI ELECTRIC
DRIVE	RA81	RA82	SA482	360	FK305-26
DISK/TREND GROUP	6	7	7	1	3
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	"Micro-Magnum"	Fixed
Nominal disk diameter	14"	14"	14"	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	DEC	DEC	DEC	ST506	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 456.0	F: 622	F: 622	U: 12.75	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,112	F: 29,184	F: 29,184	U: 10,416	U: 10,416
Data surfaces per spindle	7	8	8	2	4
Heads per data surface	2	2	2	1	1
Tracks per surface	2496	2764	2764	612	615
Track density (TPI)	960	1063	1063	612	753
Maximum linear density (BPI)	11400 BPI* 8550 FCI	12545	12545	10894	15600
Rotational speed (RPM)	3600	3600	3600	3473	3350
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	28	24	24	98(including settling)	65(including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.6	8.96
Average access time (msec)	36.3	32.3	32.3	106.6	73.96
Data transfer rate (KBytes/sec)	2200	2400	2400	625	625
FIRST CUSTOMER SHIPMENT	9/82	4Q87	1Q87	5/84	9/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Embedded Servo		Drive consists of 4 spindles Total 2,488 MB	41 mm High Embedded Servo	41 mm High

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK309-26	FK303-52	FK305-39	FK305-39R	FK305-58R
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.6	U: 51.2	U: 38.4	U: 38.4*	U: 57.6*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 15,624*	U: 15,624*
Data surfaces per spindle	4	8	6	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	615
Track density (TPI)	753	753	753	753	753
Maximum linear density (BPI)	15600	15600	15600	23400 BPI* 15600 FCI	23400 BPI* 15600 FCI
Rotational speed (RPM)	3350	3350	3350	3350	3350
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	65(including settling)	40(including settling)	65(including settling)	65(including settling)	65(including settling)
Average rotational delay (msec)	8.96	8.96	8.96	8.96	8.96
Average access time (msec)	73.96	48.96	73.96	73.96	73.96
Data transfer rate (KBytes/sec)	625	625	625	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	4/87	8/87	9/86	11/86	11/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High	41 mm High	41 mm High	41 mm High *With RLL controller	41 mm High *With RLL controller

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	FK308S-39R	FK308S-58R	FK309-39R	M2223AD	M2225AD/SA
DISK/TREND GROUP	4	4	4	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ST412	ST412	ST412/SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 30.2	F: 45.3	U: 38.4*	U: 12.81	U: 25.62
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,288	F: 12,288	U: 15,624*	U: 10,416	U: 10,416
Data surfaces per spindle	4	6	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	615
Track density (TPI)	753	753	753	846	846
Maximum linear density (BPI)	23300 BPI* 15500 FCI	23300 BPI* 15500 FCI	23400 BPI* 15600 FCI	13330	13330
Rotational speed (RPM)	3500	3500	3350	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Rotary, Band Stepping Motor	Rotary, Band Stepping Motor
Average positioning time (msec)	65(including settling)	65(including settling)	65(including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.57	8.57	8.96	8.3	8.3
Average access time (msec)	73.57	73.57	73.96	93.3	93.3
Data transfer rate (KBytes/sec)	937.5	937.5	937.5*	625	625
FIRST CUSTOMER SHIPMENT	12/86	5/87	4/87	4Q86	4Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High *2,7 RLL Code	41 mm High *2,7 RLL Code	41 mm High *With RLL controller	41 mm High	41 mm High

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2225D	M2230AS/B	M2230AT M2230BT	M2233AS/B	M2233AT M2233BT
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	Captive,OEM	OEM	Captive,OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	AS=ST412 B=SA4000	ST412/SA4000	AS=ST412 B=SA4000	ST412/SA4000
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.6	U: 6.66	U: 6.66	U: 13.3	U: 13.33
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	2	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	320	320	320	320
Track density (TPI)	834	300	300	300	300
Maximum linear density (BPI)	14845	10200	10200	10200	10200
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	40	83 (including settling)	95 (including settling)	83 (including settling)	95 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	91.3	103.3	91.3	103.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	2Q87	4/83	5/84	4/83	5/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High		41 mm High		41 mm High

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2234AS/B	M2235AS/B	M2225DR	M2226AD/SA	M2226D
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	AS=ST412 B=SA4000	AS=ST412 B=SA4000	ST412	ST412/SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 20.0	U: 26.66	U: 38.43*	U: 38.43	U: 38.43
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 15,624*	U: 10,416	U: 10,416
Data surfaces per spindle	6	8	4	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	615	615	615
Track density (TPI)	300	300	834	846	834
Maximum linear density (BPI)	10200	10200	22267 BPI* 14845 FCI	13330	14845
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	83 (including settling)	83 (including settling)	35	85 (including settling)	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	91.3	91.3	43.3	93.3	48.3
Data transfer rate (KBytes/sec)	625	625	937.5*	625	625
FIRST CUSTOMER SHIPMENT	4/83	10/83	2Q87	4Q86	1Q87
U.S. OEM PRICE FOR 100 UNITS	--	$585	--	--	$525
COMMENTS			41 mm High *with RLL controller	41 mm High	41 mm High

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2226DR	M2227D	M2227DR	M2241AS M2241B	M2242AS M2242B
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	Captive,OEM	Captive,OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412, SA4000	ST412, SA4000
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 57.65*	U: 51.24	U: 76.86*	U: 31.4	U: 54.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 10,416	U: 15,624*	U: 10,416	U: 10,416
Data surfaces per spindle	6	8	8	4	7
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	754	754
Track density (TPI)	834	834	834	760	760
Maximum linear density (BPI)	22267 BPI* 14845 FCI	14845	22267 BPI* 14845 FCI	10200	10200
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	35	40	35	33	33
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	43.3	48.3	43.3	41.3	41.3
Data transfer rate (KBytes/sec)	937.5*	625	937.5*	625	625
FIRST CUSTOMER SHIPMENT	2Q87	1Q87	2Q87	5/84	5/84
U.S. OEM PRICE FOR 100 UNITS	$575	$595	$655	--	$1,210
COMMENTS	41 mm High *with RLL controller	41 mm High	41 mm High *with RLL controller		

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2243AS M2243B	M2243T	M2244E	M2311K/S	M2312K/S
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive,OEM	OEM	Captive,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	200 mm OD 100 mm ID	200 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412, SA4000	ST412	ESDI	SMD, SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 86.3	U: 86.7	U: 85.8	U: 48.25	U: 84.44
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 20,864	U: 20,480	U: 20,480
Data surfaces per spindle	11	7	5	4	7
Heads per data surface	1	1	1	1	1
Tracks per surface	754	1185	823	589	589
Track density (TPI)	760	1226	850	720	720
Maximum linear density (BPI)	10200	10200	20400*	9550	9550
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	33	25	25	20	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	41.3	33.3	33.3	28.3	28.3
Data transfer rate (KBytes/sec)	625	625	1,250	1229	1229
FIRST CUSTOMER SHIPMENT	5/84	3Q87	3Q85	4/81	4/81
U.S. OEM PRICE FOR 100 UNITS	$1,350	$1,000	$1,400	--	--
COMMENTS		41 mm High	*2,7 RLL Code		

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2321K/S	M2243R	M2245E	M2246E	M2246S
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	Captive,OEM	Captive,OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD, SCSI	ST412	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 84.2	U: 129*	U: 120.2	U: 171.7	F: 160.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	U: 15,624*	U: 20,864	U: 20,864	F: 19,456
Data surfaces per spindle	5	7	7	10	10
Heads per data surface	1	1	1	1	1
Tracks per surface	823	1185	823	823	823
Track density (TPI)	683	1226	850	850	850
Maximum linear density (BPI)	9867	15300 BPI* 10200 FCI	20400*	20400*	20400*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	25	25	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	33.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	1229	937.5*	1,250	1,250	1250
FIRST CUSTOMER SHIPMENT	11/83	3Q87	3Q85	3Q85	4Q86
U.S. OEM PRICE FOR 100 UNITS	--	$1,150	$1,530	$1,595	$1,720
COMMENTS		41 mm High *with RLL controller	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2247E	M2248E	M2284	M2322K/S	M2331K/KS
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	SMD	SMD, SCSI	MOD SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 181.5	U: 285.3	U: 168.6	U: 168.5	U: 168.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	U: 20,864	U: 20,480	U: 20,480	U: 40,960
Data surfaces per spindle	7	11	5	10	5
Heads per data surface	1	1	2	1	1
Tracks per surface	1243	1243	1646	823	823
Track density (TPI)	1267	1267	680	683	683
Maximum linear density (BPI)	19295*	19295*	6580	9867	19734*
Rotational speed (RPM)	3600	3600	2964	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	27	20	20
Average rotational delay (msec)	8.3	8.3	10.12	8.3	8.3
Average access time (msec)	26.3	26.3	37.12	28.3	28.3
Data transfer rate (KBytes/sec)	1250	1250	1012	1229	2458
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	4Q79	11/83	11/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	$3,450	--
COMMENTS	*1,7 RLL Code	*1,7 RLL Code			*2,7 RLL Code

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	F6421	M2249E	M2294K/N	M2333K/KS/P	M2343K/KS
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	130 mm OD 40 mm ID	14"	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	Modified 3350	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Fujitsu	ESDI	SMD	SMD,SCSI,IPI-2	Mod. SMD, SCSI
CAPACITY/RECORDING DENSITY	1.607 or 1.144 MB Fixed Head Option				
Total capacity (MBytes) FIXED	F: 446/317.5	U: 389	U: 335.5	U: 337.1	U: 383.38
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,793/ 19,069	U: 20,864	U: 20,480	U: 40,960	U: 40,960
Data surfaces per spindle	10	15	8	10	7.5
Heads per data surface	2	1	2	1	2/1
Tracks per surface	1680	1243	2048	823	1248
Track density (TPI)	880	1267	858	683	846
Maximum linear density (BPI)	12790	19295*	6500	19734*	20767*
Rotational speed (RPM)	3961	3600	2964	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	27	20	16
Average rotational delay (msec)	7.5	8.3	10.12	8.3	8.3
Average access time (msec)	25.5	26.3	37.12	28.3	24.3
Data transfer rate (KBytes/sec)	1859	1250	1012	2458	2458
FIRST CUSTOMER SHIPMENT	3Q81	3Q87	5/83	11/84	2/87
U.S. OEM PRICE FOR 100 UNITS	--	$2,995	--	$4,425	--
COMMENTS	Drive has four spindles	*1,7 RLL Code		*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2350A	M2351A	F6425	F6425K4/L4	M2298K/N
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Special	Special	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	Fujitsu	Fujitsu	Modified SMD
CAPACITY/RECORDING DENSITY		1.69 MB Fixed Head Option			
Total capacity (MBytes) FIXED	U: 474.2	U: 474.2	F: 630.0	F: 630.0	U: 671
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 28,160	U: 28,160	F: 47,476	F: 47,476	U: 40,960
Data surfaces per spindle	10	10	8	8	8
Heads per data surface	2	2	2	2	2
Tracks per surface	1684	1684	1770	1770	2048
Track density (TPI)	880	880	905	905	858
Maximum linear density (BPI)	12790	12790	24420*	24420*	13000 BPI* 8667 FCI
Rotational speed (RPM)	3961	3961	3620	3620	2722
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	15	15	27
Average rotational delay (msec)	7.5	7.5	8.3	8.3	11
Average access time (msec)	25.5	25.5	23.3	23.3	38
Data transfer rate (KBytes/sec)	1859/7436/9295	1859	3000	3,000	1859
FIRST CUSTOMER SHIPMENT	2/84	3/82	3Q83	3Q86	10/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Parallel data transfer, 4 or 5 channels		*2,7 RLL Code Drive has four spindles	*2,7 RLL Code Drive has four spindles	*2,7 RLL Code

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	HEWLETT-PACKARD
DRIVE	M2344K/KS	M2360A	M2361A	F6425M4/N4	7907A
DISK/TREND GROUP	7	7	7	8	1
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	8" Cartridge
Nominal disk diameter	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Sputtered	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	Special	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Mod. SMD, SCSI	Modified SMD	Modified SMD	Fujitsu	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 690.1	U: 689.8	U: 689.8	F: 1,260.0	F: 20.5
REMOVABLE	--	--	--	--	F: 20.5
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 40,960	F: 47,476	F: 16,384
Data surfaces per spindle	13.5	10	10	12	4
Heads per data surface	2/1	2	2	2	1
Tracks per surface	1248	1684	1684	2360	644
Track density (TPI)	846	880	880	1160	550
Maximum linear density (BPI)	20767*	18620*	18620*	24989*	10986 BPI* 7324 FCI
Rotational speed (RPM)	3600	3673	3600	3620	3523
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	16	18	18	17	30
Average rotational delay (msec)	8.3	8.17	8.3	8.3	8.45
Average access time (msec)	24.3	26.17	26.3	25.3	38.45
Data transfer rate (KBytes/sec)	2458	2507 - 12537	2,458	3,000	1229
FIRST CUSTOMER SHIPMENT	2Q87	3Q86	2Q85	3Q86	7/85
U.S. OEM PRICE FOR 100 UNITS	$8,400	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code Parallel Data Transfer, 4 or 5 channels	*2,7 RLL Code	*2,7 RLL Code Drive has four spindles	*2,7 RLL Code Embedded Servo Disk Drive Mfg. By Amcodyne

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97501B	7957A	7958A	97532E	97532S
DISK/TREND GROUP	3	4	5	5	5
MARKET	Captive, OEM	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370	3370
Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	HP	HPIB	HPIB	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 20	F: 81.7	F: 130.7	U: 129.68	F: 101.71
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 7,168	F: 16,128	F: 16,128	U: 20,480	F: 16,384
Data surfaces per spindle	2	5	8	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1400	1013	1013	1583	1552
Track density (TPI)	1850	1000	1000	1590	1590
Maximum linear density (BPI)	12700	19794*	19794*	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI
Rotational speed (RPM)	3000	3600	3600	3350	3350
PERFORMANCE					
Actuator type	Rotary, Band Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	75 (including settling)	29.0	29.0	17	17
Average rotational delay (msec)	10	8.3	8.3	8.95	8.95
Average access time (msec)	85	37.3	37.3	25.95	25.95
Data transfer rate (KBytes/sec)	500	1250	1250	1250	1500 Max.
FIRST CUSTOMER SHIPMENT	12/85	4Q86	4Q86	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	$605	--	--	--	--
COMMENTS	51 mm High Embedded Servo	*2,7 RLL Code Disk Drive Mfg by Micropolis	*2,7 RLL Code Disk Drive Mfg by Micropolis	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97533E	97533S	97536E	97536S	7936H
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370	3370	3370	3370	3370 (Ferrite)
Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 194.52	F: 152.57	U: 389.04	F: 305.14	F: 307.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	F: 16,384	U: 20,480	F: 16,384	F: 31,488
Data surfaces per spindle	6	6	12	12	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1583	1552	1583	1552	1396
Track density (TPI)	1590	1590	1590	1590	1121
Maximum linear density (BPI)	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	18800 BPI* 14101 FCI
Rotational speed (RPM)	3350	3350	3350	3350	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	17	17	17	17	20.5
Average rotational delay (msec)	8.95	8.95	8.95	8.95	8.3
Average access time (msec)	25.95	25.95	25.95	25.95	28.8
Data transfer rate (KBytes/sec)	1250	1500 Max.	1250	1500 Max.	2351
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	3Q87	3Q87	4Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*Variable Length Frequency Modulation Embedded Servo

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	7937H	7937S	DK301-1	DK301-2	DK302-2
DISK/TREND GROUP	7	7	3	3	3
MARKET	Captive	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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	HPIB	SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 571.4	F: 571.4	U: 12.7	U: 19.1	U: 25.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 31,488	F: 31,488	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	13	13	4	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1396	1396	306	306	615
Track density (TPI)	1121	1121	485	485	822
Maximum linear density (BPI)	18800 BPI* 14101 FCI	18800 BPI* 14101 FCI	12600	12600	13700
Rotational speed (RPM)	3600	3600	3600	3600	3550
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	20.5	20.5	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.45
Average access time (msec)	28.8	28.8	93.3	93.3	93.45
Data transfer rate (KBytes/sec)	2351	2351	625	625	625
FIRST CUSTOMER SHIPMENT	4Q86	4Q86	6/85	6/85	9/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*Variable Length Frequency Modulation Embedded Servo	*Variable Length Frequency Modulation Embedded Servo	41 mm High	41 mm High	41 mm High

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK502-1	DK502-2	DK502-3	DK503-1	DK503-2
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 13.3	U: 20.0	U: 26.6	U: 6.7	U: 13.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	6	8	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	320	320	320
Track density (TPI)	360	360	360	360	360
Maximum linear density (BPI)	9260	9260	9260	9260	9260
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	93.3	93.3	93.3	93.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	10/83	10/83	10/83	10/83	10/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Mfg. by Tokico	Mfg. by Tokico	Mfg. by Tokico	41 mm High Mfg. by Tokico	41 mm High Mfg. by Tokico

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK505-2	DK811-2	DK302-3	DK511-3	DK511-5
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	95 mm OD 25 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: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	Modified SMD	ST506/412	ST412, SCSI	ST412, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.62	U: 24.0 F: 20.0	U: 38.2	U: 36.4	U: 51.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 12,800	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	3	6	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	615	521	615	699	699
Track density (TPI)	650	480	822	784	784
Maximum linear density (BPI)	9490	7495	13700	9340	9340
Rotational speed (RPM)	3550	3521	3550	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	25	85	30	30
Average rotational delay (msec)	8.45	8.5	8.45	8.3	8.3
Average access time (msec)	93.45	33.5	93.45	38.3	38.3
Data transfer rate (KBytes/sec)	625	904	625	625	625
FIRST CUSTOMER SHIPMENT	3/85	10/80	9/86	1Q84	1Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High Mfg. by Tokico		41 mm High		

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK511-8	DK512-8	DK512C-8	DK521-5	DK811-4
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	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412, SCSI	ESDI, SMD	SCSI	ST412	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 85.7	U: 86.1	F: 73.3	U: 51.4	U: 48.0 F: 40.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,944	F: 17,920	U: 10,416	F: 12,800
Data surfaces per spindle	10	5	5	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	819	823	521
Track density (TPI)	925	925	925	960	480
Maximum linear density (BPI)	9250	18500*	18500*	9300	7495
Rotational speed (RPM)	3600	3482	3482	3600	3521
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	23	23	23	25	25
Average rotational delay (msec)	8.3	8.6	8.6	8.3	8.5
Average access time (msec)	31.3	31.6	31.6	33.3	33.5
Data transfer rate (KBytes/sec)	625	1209	1500 Max.	625	904
FIRST CUSTOMER SHIPMENT	--	3/85	1/87	12/86	10/80
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	41 mm High	

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK811-8	DK812S-5	DK812S-8	DK512-12	DK512-17
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	210 mm OD	210 mm OD	210 mm OD	130 mm OD	130 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	3350	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	SMD	SMD	ESDI, SMD	ESDI, SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 89.1 F: 71.1	U: 51	U: 85	U: 120.6	U: 172.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,800	U: 20,672	U: 20,672	U: 20,944	U: 20,944
Data surfaces per spindle	11	3	5	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	526	823	823	823	823
Track density (TPI)	480	760	760	925	925
Maximum linear density (BPI)	7495	9650 BPI* 6433 FCI	9650 BPI* 6433 FCI	18500*	18500*
Rotational speed (RPM)	3521	3510	3510	3482	3482
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	25	23	23
Average rotational delay (msec)	8.5	8.5	8.5	8.6	8.6
Average access time (msec)	33.5	33.5	33.5	31.6	31.6
Data transfer rate (KBytes/sec)	904	1209	1209	1209	1209
FIRST CUSTOMER SHIPMENT	3/82	7/83	7/83	3/85	3/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK512C-12	DK512C-17	DK522-10	DK522C-10	DK812S-12
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ESDI	SCSI	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 102.3	F: 146.7	U: 103.4	F: 87.5	U: 119
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 17,920	U: 20,944	F: 17,920	U: 20,672
Data surfaces per spindle	7	10	6	6	7
Heads per data surface	1	1	1	1	1
Tracks per surface	819	819	823	819	823
Track density (TPI)	925	925	960	960	760
Maximum linear density (BPI)	18500*	18500*	18500*	18500*	9650 BPI* 6433 FCI
Rotational speed (RPM)	3482	3482	3600	3600	3510
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	23	23	25	25	25
Average rotational delay (msec)	8.6	8.6	8.3	8.3	8.5
Average access time (msec)	31.6	31.6	33.3	33.3	33.5
Data transfer rate (KBytes/sec)	1500 Max.	1500 Max.	1250	1500 Max.	1209
FIRST CUSTOMER SHIPMENT	1/87	1/87	12/86	1/87	6/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	41 mm High *2,7 RLL Code	41 mm High *2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK812S-17	DK814S-17	DK814S-24	DK514-38	DK814S-34
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	210 mm OD	210 mm OD	130 mm OD	210 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	Modified SMD	Modified SMD	ESDI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 170.1	U: 170	U: 238	U: 382.3	U: 340
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,672	U: 32,768	U: 32,768	U: 30,240	U: 32,768
Data surfaces per spindle	10	5	7	14	10
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	823	903	823
Track density (TPI)	760	800	800	1033	800
Maximum linear density (BPI)	9650 BPI* 6433 FCI	18500*	18500*	26000 BPI* 17333 FCI	18500*
Rotational speed (RPM)	3510	2632	2632	3600	2632
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	20	20	16	20
Average rotational delay (msec)	8.5	11.4	11.4	8.3	11.4
Average access time (msec)	33.5	31.4	31.4	24.3	31.4
Data transfer rate (KBytes/sec)	1209	1815	1815	1815	1815
FIRST CUSTOMER SHIPMENT	6/83	12/84	12/84	3Q87	12/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	$2,700	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code SCSI and Mod. SMD interfaces also available	*2,7 RLL Code

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DKU-80	DK815-5	DKU-85I-D14 DKU-85I-D24	DKU-97I	DKU-97S
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	224 mm OD 100 mm ID	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type		3370 (Ferrite)	3380 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM, SMD	Modified SMD	IBM	IBM	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 427.7	U: 525.38	F: 630	F: 635.0	U: 697.059
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 26,880	U: 30,240	F: 47,476	F: 19,069	U: 20,672
Data surfaces per spindle	13	14	**	20	20
Heads per data surface	2	1	2	2	2
Tracks per surface	1224	1241	**	1666	1682
Track density (TPI)		860	**	720	720
Maximum linear density (BPI)		14585*	**	6425	6425
Rotational speed (RPM)	3000	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual Rotary, Voice Coil	Dual Rotary, Voice Coil
Average positioning time (msec)	18	18	15	20/18	20
Average rotational delay (msec)	10.0	8.3	8.3	8.3	8.3
Average access time (msec)	28.0	26.3	23.3	28.3/26.3	28.3
Data transfer rate (KBytes/sec)	1344	1815	3000	1198	1240
FIRST CUSTOMER SHIPMENT	11/83	11/84	4/86	1/81	9/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		*2,7 RLL Code	Drive has four spindles ** not announced	Drive has two spindles	

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	H-6555	H-8576-12 H-8576-22	DK815-10	DKU-85I-E14 DKU-85I-E24 H-6585-14 H-6585-24	DKU-98I H-8598-12 H-8598-22
DISK/TREND GROUP	7	7	8	8	8
MARKET	Captive	Captive	OEM	Captive	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	224 mm OD 100 mm ID	14"	224 mm OD 100 mm ID	14"	14"
Recording medium	Hi Dens Oxide	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	Modified 3350	3380	3380 (Ferrite)	3380
Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	Hitachi	IBM	Mod SMD, IPI-II	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 500	F: 635.0	U: 1,067	F: 1,260	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 28,884	F: 19,069	U: 40,960	F: 47,476	F: 47,476
Data surfaces per spindle	14	20	15	**	20
Heads per data surface	1	2	1	2	2
Tracks per surface	1237	1666	1737	**	1328 (Physical)
Track density (TPI)	860	720	1160	**	600
Maximum linear density (BPI)	14585*	6425	20000*	**	15240*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Dual Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Dual Rotary, Voice Coil
Average positioning time (msec)	18	20	15	17	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	28.3	23.3	25.3	24.3
Data transfer rate (KBytes/sec)	1815	1198	2460	3000	3000
FIRST CUSTOMER SHIPMENT	1Q85	4Q80	1Q87	12/85	4Q82
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Drive has 1 to 4 spindles	Drive has two spindles	*1,7 RLL Code	Drive has four spindles ** not announced	*2,7 RLL Code Drive has two spindles 2 actuators per spindle

MANUFACTURER	IBIS	IBIS	IBM	IBM	IBM
DRIVE	1400	2812	5525-021 5525-031	WD-325	4956-G10 H10
DISK/TREND GROUP	8	8	3	3	4
MARKET	OEM	OEM	Captive	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	210 mm OD 100 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Special	3380	Piccolo	Modified 3350	Modified 3350
Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	Custom,ISI,VME	Custom, ISI	IBM	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 1,409.0	U: 2,830.0	F: 29.3	U: 25.5	F: 40
REMOVABLE	--		--	--	--
Capacity per track (Bytes)	U: 49,728	U: 99,840	F: 16,384	U: 10,416	F: 8,704
Data surfaces per spindle	16	16	5	4	7
Heads per data surface	2	2	1	1	1
Tracks per surface	1776	1776	359	612	733
Track density (TPI)	769	769	450	850	815
Maximum linear density (BPI)	15294	32000	8530	13400	9398
Rotational speed (RPM)	3600	3600	3125	3600	3600
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	16	16	27	80 (including settling)	40
Average rotational delay (msec)	8.3	8.3	9.6	8.3	8.3
Average access time (msec)	24.3	24.3	36.6	88.3	48.3
Data transfer rate (KBytes/sec)	12000	12000	1031	625	625
FIRST CUSTOMER SHIPMENT	4Q83	4Q87	2/80	5/86	9/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Drive has one spindle, with two actuators. Up to 4 track parallel data transfer.	Drive has one spindle with two actuators. Two track parallel data transfer	5520 Admin. System	41 mm High	Series/1

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4963-58A	4963-64A 4963-64B	5170-319 5170-339 5170-839 5170-849	5364-001	5364-003 5364-004 5364-023 5364-024
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Piccolo	Piccolo	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ST412	IBM, ST412	ESDI
CAPACITY/RECORDING DENSITY	0.131 MB Fixed Heads				
Total capacity (MBytes) FIXED	F: 58.6	F: 64.5	F: 31.9	F: 41.92	F: 65.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 8,704	F: 8,192	F: 16,640
Data surfaces per spindle	11	11	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	359	359	733	733	580
Track density (TPI)	450	450	815	815	648
Maximum linear density (BPI)	8530	8530	9398	9398	18942*
Rotational speed (RPM)	3125	3125	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	27	40	40	30
Average rotational delay (msec)	9.6	9.6	8.3	8.3	8.3
Average access time (msec)	36.6	36.6	48.3	48.3	38.3
Data transfer rate (KBytes/sec)	1031	1031	625	625	1250
FIRST CUSTOMER SHIPMENT	2/79	2/79	10/85	6/85	2/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Series/1	Series/1	System unit for PC AT	System Unit for System/36 PC	System Unit for System/36 PC *2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5381- All Models	5525-032 5525-051	6150-4735	6150-6941	667-85
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive	Captive	Captive	Captive	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	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: Technology type	Piccolo	Piccolo	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ST412	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 64.5	F: 64.5	F: 44.6	F: 73.0	U: 85.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 8,704	F: 17,920	U: 20,833
Data surfaces per spindle	11	11	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	359	359	733	582	582
Track density (TPI)	450	450	815	648	648
Maximum linear density (BPI)	8530	8530	9398	18942*	18942*
Rotational speed (RPM)	3125	3125	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	27	40	30	30
Average rotational delay (msec)	9.6	9.6	8.3	8.3	8.3
Average access time (msec)	36.6	36.6	48.3	38.3	38.3
Data transfer rate (KBytes/sec)	1031	1031	625	1250	1250
FIRST CUSTOMER SHIPMENT	8/79	11/80	3/86	9/86	9/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	System/38 5381 Processor available with up to six disk spindles	5520 Admin. System -051 Model is Dual Spindle	RT PC	RT PC *2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8101-A23	8130-A23 8130-B23 8140-A33 A43, A53 A63, A73	8560-041 8580-041	8560-071 8580-071	669
DISK/TREND GROUP	4	4	4	4	5
MARKET	Captive	Captive	Captive	Captive	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	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: Technology type	Piccolo	Piccolo	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ST412	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 64.5	F: 64.5	F: 44.6	F: 70	U: 133
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 8,704	F: 18,432	U: 20,833
Data surfaces per spindle	11	11	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	359	359	733	583	915
Track density (TPI)	450	450	815	648	1000
Maximum linear density (BPI)	8530	8530	9398	18942*	19159*
Rotational speed (RPM)	3125	3125	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	27	40	30	28
Average rotational delay (msec)	9.6	9.6	8.3	8.3	8.3
Average access time (msec)	36.6	36.6	48.3	38.3	36.3
Data transfer rate (KBytes/sec)	1031	1031	625	1250	1250
FIRST CUSTOMER SHIPMENT	8/79	3Q79	2Q87	2Q87	4Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	8100 System -A25 model is two spindles	8100 System	PS/2 Model 60 and Model 80	PS/2 Model 60 and Model 80 *2,7 RLL code	*2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	671-181	671-284	678-200	3272	4967-2CA 4967-2CB
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	IPI-3, SCSI	ESDI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 181	U: 284	U: 238.3 F: 200.3	F: 114	F: 200.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 21,080	U: 21,080	U: 44,252 F: 37,376*	F: 17,920	F: 25,088
Data surfaces per spindle	7	11	4	7	7
Heads per data surface	1	1	1	1	2
Tracks per surface	1225	1225	1346	915	1140
Track density (TPI)	1168	1168	1096	1000	485
Maximum linear density (BPI)	21384*	21384*	23110**	19159*	9751
Rotational speed (RPM)	3283	3283	3119	3600	2964
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	23	23	19.5	28	25
Average rotational delay (msec)	9.14	9.14	9.62	8.3	10.1
Average access time (msec)	32.14	32.14	29.12	36.3	35.1
Data transfer rate (KBytes/sec)	1250	1250	2500	1250	1500
FIRST CUSTOMER SHIPMENT	1Q88	1Q88	6/86	4Q87	7/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*Outer 893 Tr. **1,7 RLL Code Embedded Servo	RT PC Models 125 + B25 *2,7 RLL code	Series/1 384 KB Cache

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5360-BXX	8102-A15	8580-111	9332-240 9332-250	9332-A11
DISK/TREND GROUP	5	5	5	5	5
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	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 Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Piccolo	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ESDI	SCSI	IPI-3
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 200.2	F: 129.7	F: 115	F: 200.3	F: 200.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	F: 16,384	F: 18,432	F: 37,376	F: 37,376
Data surfaces per spindle	7	11	7	4	4
Heads per data surface	2	1	1	1	1
Tracks per surface	1140	720	915	1346	1346
Track density (TPI)	485	850	1000	1096	1096
Maximum linear density (BPI)	9751	8770	19159*	23100 *	23100*
Rotational speed (RPM)	2964	3125	3600	3119	3119
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	25	27	28	19.5	19.5
Average rotational delay (msec)	10.1	9.6	8.3	9.62	9.62
Average access time (msec)	35.1	36.6	36.3	29.12	29.12
Data transfer rate (KBytes/sec)	1500	1031	1250	2500	2500
FIRST CUSTOMER SHIPMENT	7/83	4/84	4Q87	2Q87	8/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	System/36 5360-BX4 uses 2 spindles,with total 400.4 MB	8100 System -A17 model is two spindles	PS/2 Model 60 and Model 80 *2,7 RLL code	RT PC *1,7 RLL Code Embedded Servo	System/36 System/38 *1,7 RLL Code Embedded Servo

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4967-3CA 3CB	5360-BXA BXB C2X	671-387	678-400	8580-311
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Thin Film
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ESDI	IPI-3, SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 358	F: 359.6	U: 387	U: 476.5 F: 400.6	F: 314
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	F: 25,088	U: 21,080	U: 44,252 F: 37,376*	F: 17,408
Data surfaces per spindle	7	7	15	8	15
Heads per data surface	1	2	1	1	1
Tracks per surface	2048	2048	1225	1346	1225
Track density (TPI)	869	869	1168	1096	1168
Maximum linear density (BPI)	9751	9751	21384*	23110**	21384*
Rotational speed (RPM)	2964	2964	3283	3119	3283
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	23	19.5	23
Average rotational delay (msec)	10.1	10.1	9.14	9.62	9.14
Average access time (msec)	35.1	35.1	32.14	29.12	32.14
Data transfer rate (KBytes/sec)	1500	1500	1250	2500	1250
FIRST CUSTOMER SHIPMENT	9/86	2/86	1Q88	6/86	1Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Series/1	System/36 System uses multiple spindles	*2,7 RLL Code	*Outer 893 Tr. **1,7 RLL Code Embedded Servo	PS/2 Model 80 *2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9332-440 9332-450	9332-A12	3370-A02 3370-A12 3370-B02 3370-B12	3375-A1 3375-B1 3375-D1	685-B01
DISK/TREND GROUP	6	6	7	7	8
MARKET	Captive	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370	3370	3380
Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	SCSI	IPI-3	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 400.6	F: 400.6	F: 729.8	F: 819.7	U: 1,043.1 F: 855.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 37,376	F: 37,376	F: 31,744	F: 35,616	U: 44,280 F: 36,352
Data surfaces per spindle	8	8	12	12	6
Heads per data surface	1	1	2	2	2
Tracks per surface	1346	1346	1916	1918	3926
Track density (TPI)	1096	1096	800	800	1600
Maximum linear density (BPI)	23100 *	23100*	12134 BPI* 8128 FCI	12134 BPI* 8128 FCI	16200*
Rotational speed (RPM)	3119	3119	2964	2964	3623
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Rotary, Voice Coil
Average positioning time (msec)	19.5	19.5	19	19	18
Average rotational delay (msec)	9.62	9.62	10.1	10.1	8.28
Average access time (msec)	29.12	29.12	29.1	29.1	26.28
Data transfer rate (KBytes/sec)	2500	2500	1859	1859	3000
FIRST CUSTOMER SHIPMENT	2Q87	8/86	2Q84	3Q81	6/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	RT PC *1,7 RLL Code Embedded Servo	System/36 System/38 *1,7 RLL Code Embedded Servo	*2,7 RLL Code 4341 4361 4381 System/38	*2,7 RLL Code 4331 4341 303X Series	*2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	3380-AD4 3380-BD4	3380-AE4 3380-BE4	3380-AJ4 3380-BJ4 3380-CJ2	3380-AK4 3380-BK4	9335-B01
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	*	*	Oxide Coated
DRIVE: Technology type	3380	3380 x 2	3380 x 3	3380 x 3	3380
Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 1,260.4	F: 2,520.9	F: 1,260.4	F: 3,781.4	F: 855.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 47,476	F: 36,352
Data surfaces per spindle	15	15	15	15	6
Heads per data surface	2	2	2	2	2
Tracks per surface	1770	3540	1770	5310	3924
Track density (TPI)	*	1386	*	*	1600
Maximum linear density (BPI)	*	16200	*	*	16200*
Rotational speed (RPM)	3620	3620	3620	3620	3623
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Rotary, Voice Coil
Average positioning time (msec)	15	17	12	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.28
Average access time (msec)	23.3	25.3	24.3	24.3	26.28
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	2/85	7/85	10/87 (A,B)	10/87	8/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*not announced Drive has two spindles	Drive has two spindles	*Not announced AJ4 & BJ4 have two spindles	*Not announced Drive has two spindles	System/38 *2,7 RLL Code Embedded Servo

MANUFACTURER	ISOT	ISOT	ISOT	ISOT	ISOT
DRIVE	CM 5400-00 CM 5400-01	CM 5410	CM 5412	ES 5066 ES 5067.01 ES 5067.02	ES 5067
DISK/TREND GROUP	1	1	2	2	2
MARKET	OEM	Captive OEM	OEM	OEM	OEM
MEDIA: Generic type	5440	5440	SMD	3336-1	3336-11
Nominal disk diameter	14"	14"	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	2314	2314	3330-11	3330-1	3330-11
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Various Options	Various Options	SMD		
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 3.125	U: 5.75	--	--	--
REMOVABLE	U: 3.125	U: 5.75	U: 80	F: 100	F: 200
Capacity per track (Bytes)	U: 7,812	U: 7,812	U: 20,160	F: 13,030	F: 13,030
Data surfaces per spindle	4	4	5	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	204	406	823	411	815
Track density (TPI)	100	200	400	192	370
Maximum linear density (BPI)	2200	2200	6060	4040	4040
Rotational speed (RPM)	2400/1500	2400/1500	2400/3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	50	50	45	30	30
Average rotational delay (msec)	12.5/20	12.5	12.5/8.3	8.3	8.3
Average access time (msec)	62.5/70	62.5	57.5/53.3	38.3	38.3
Data transfer rate (KBytes/sec)	312/195	312/195	806/1209	806	806
FIRST CUSTOMER SHIPMENT	1979	1982	1983	1980	1981
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS					

MANUFACTURER	JOSEPHINE COUNTY TECHNOLOGY	JOSEPHINE COUNTY TECHNOLOGY	JOSEPHINE COUNTY TECHNOLOGY	JVC	JVC
DRIVE	JCT-100	JCT-105	JCT-110	JD-3812M	JD-3824R
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	JVC	JVC
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 5.2	U: 7.0	U: 14.0	F: 10.65	F: 21.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 11,504	U: 11,504	U: 11,504	F: 8,704	F: 17,408
Data surfaces per spindle	2	2	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	226	306	306	612	615
Track density (TPI)	200	270	270	849	849
Maximum linear density (BPI)	7690	7690	7690	13083	27410 BPI* 18273 FCI
Rotational speed (RPM)	3600	3600	3600	2322	2597
PERFORMANCE					
Actuator type	Linear, Band, Stepping Motor	Linear, Band, Stepping Motor	Linear, Band, Stepping Motor	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor
Average positioning time (msec)	110 (including settling)	150 (including settling)	150 (including settling)	78 (including settling)	78 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	12.9	11.6
Average access time (msec)	118.3	158.3	158.3	90.9	89.6
Data transfer rate (KBytes/sec)	625	625	625	400	937.5
FIRST CUSTOMER SHIPMENT	6/84	9/84	6/85	3Q87	2Q87
U.S. OEM PRICE FOR 100 UNITS	$230	$265	$295	--	--
COMMENTS	41 mm High	41 mm High	41 mm High	25.4 mm High Embedded Servo	28.9 mm High *2,7 RLL Code Embedded Servo

MANUFACTURER	KOVO (ARITMA)	KOVO (ARITMA)	KOVO (ZBROJOVKA BRNO)	LEXIKON	LEXIKON
DRIVE	Aritma 4080	Aritma 5080	KDP 724	HD 352	HD 362
DISK/TREND GROUP	2	2	1	3	3
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	3336-1	3336-11	2315	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3330-1	3330-11	2314	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM		ST412	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	--	U: 3.125	U: 25.5	F: 21.3
REMOVABLE	F: 100.0	F: 200.0	U: 3.125	--	--
Capacity per track (Bytes)	F: 13,030	F: 13,030	U: 7,812	U: 10,417	F: 8,704
Data surfaces per spindle	19	19	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	411	815	204	612	612
Track density (TPI)	192	370	100	800	800
Maximum linear density (BPI)	4040	4040	2200	13370	13370
Rotational speed (RPM)	3600	3600	2400	3573	3573
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor
Average positioning time (msec)	30	30	45	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	12.5	8.39	8.39
Average access time (msec)	38.3	38.3	57.5	93.39	93.39
Data transfer rate (KBytes/sec)	806	806	312.5	625	625
FIRST CUSTOMER SHIPMENT	1985	1986	1976	2/86	4/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS				41 mm High	41 mm High

MANUFACTURER	LEXIKON	LEXIKON	LEXIKON	LEXIKON	LEXIKON
DRIVE	HD 670	HDC 372	HD 674	LX 340	LX 360/S
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	PCM, OEM	Captive, OEM	OEM	OEM
MEDIA: Generic type	Fixed	Drive On Card	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	IBM PC	ST412	IBM	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.8	F: 21.3	U: 51.25	U: 51.2	F: 65.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 8,704	U: 10,416	U: 10,416	F: 13,056
Data surfaces per spindle	4	4	6	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	620	612	820	820	820
Track density (TPI)	690	800	765	1100	1100
Maximum linear density (BPI)	8952	13370	9940	14700	22050*
Rotational speed (RPM)	3573	3573	3518	3517	3517
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Stepping Motor	Band, Linear, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	40 (including settling)	85 (including settling)	40 (including settling)	28	28
Average rotational delay (msec)	8.39	8.39	8.53	8.5	8.5
Average access time (msec)	48.39	93.39	48.53	36.5	36.5
Data transfer rate (KBytes/sec)	625	625	625	625	937.5
FIRST CUSTOMER SHIPMENT	3Q85	5/86	8/86	6/87	9/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High	41 mm Thick	41 mm High	41 mm High	41 mm High *2,7 RLL Code

MANUFACTURER	LEXIKON	LEXIKON	LEXIKON	LEXIKON	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	LX 380/S	LXC 340	LXC 360	LX 580	JU-114
DISK/TREND GROUP	4	4	4	5	3
MARKET	OEM	PCM, OEM	PCM, OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Drive On Card	Drive On Card	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	IBM	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 85.6	F: 42.8	F: 65.5	U: 103.2	U: 13.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 8,704	F: 13,056	U: 10,416	U: 10,416
Data surfaces per spindle	6	6	6	8	2
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	820	1240	640
Track density (TPI)	1100	1100	1100	1115	800
Maximum linear density (BPI)	29400*	14700	22050*	10600	14423
Rotational speed (RPM)	3517	3517	3517	3517	3536
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor
Average positioning time (msec)	28	28	28	28	85 (including settling)
Average rotational delay (msec)	8.5	8.5	8.5	8.5	8.48
Average access time (msec)	36.5	36.5	36.5	36.5	93.48
Data transfer rate (KBytes/sec)	1250	625	937.5	625	625
FIRST CUSTOMER SHIPMENT	12/87	9/87	12/87	10/87	3Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High *2,7 RLL Code	41 mm Thick	41 mm High *2,7 RLL Code		

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	JU-116	JU-126	JU-614	JU-616	JU-662
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 26.6	U: 22.9	U: 13.3	U: 26.6	U: 6.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	3	4	8	2
Heads per data surface	1	1	1	1	1
Tracks per surface	640	733	320	320	320
Track density (TPI)	800	1019	360	360	360
Maximum linear density (BPI)	14423	13171	9100	9100	9280
Rotational speed (RPM)	3536	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Linear, DC Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	35	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.48	8.3	8.3	8.3	8.3
Average access time (msec)	93.48	43.3	93.3	93.3	93.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q86	2Q87	1Q84	1Q84	3Q84
U.S. OEM PRICE FOR 100 UNITS	$288	--	--	--	--
COMMENTS		41 mm High			41 mm High

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MAXTOR	MAXTOR
DRIVE	JU-664	JU-127	JU-128	XT-1085	LXT-170
DISK/TREND GROUP	3	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	ST412	ST412	ST412	ST412	ESDI, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 13.3	U: 38.17	U: 53.44	U: 85.32	U: 169.92
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 20,793
Data surfaces per spindle	4	5	7	8	9
Heads per data surface	1	1	1	1	1
Tracks per surface	320	733	733	1024	908
Track density (TPI)	360	1019	1019	1070	1360
Maximum linear density (BPI)	9280	13171	13171	9934	23897 BPI* 15931 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Linear, DC Motor	Linear, DC Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	35	35	28	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	43.3	43.3	36.3	28.3
Data transfer rate (KBytes/sec)	625	625	625	625	1250
FIRST CUSTOMER SHIPMENT	3Q84	2Q87	2Q87	2Q83	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	$495	$1,050	$1,100
COMMENTS	41 mm High	41 mm High	41 mm High		41 mm High *2,7 RLL Code

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	XT-1140	XT-2190	XT-4170E	XT-4170S	XT-4280S
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370	3370	3370
Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	ST412	ST412	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 143.42	U: 191.23	U: 179.45	F: 157.93	F: 248.17
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 20,940	F: 18,432	F: 18,432
Data surfaces per spindle	15	15	7	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	918	1224	1224	1224	1224
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI)	9280	11155	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	30	16	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	38.3	24.3	24.3	26.3
Data transfer rate (KBytes/sec)	625	625	1250	1500	1500
FIRST CUSTOMER SHIPMENT	2Q83	3Q84	2Q87	2/86	2/86
U.S. OEM PRICE FOR 100 UNITS	$2,350	$2,165	$1,495	$1,550	$2,390
COMMENTS			*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MEMOREX
DRIVE	XT-4380E	XT-4380S	XT-8380E	XT-8760E	3680
DISK/TREND GROUP	6	6	6	7	8
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Technology type	3370	3370	3370	3370	3380
Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI	ESDI	ESDI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 384.53	F: 338.41	U: 410.0	U: 768.9	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,940	F: 18,432	U: 31,410	U: 31,410	F: 47,476
Data surfaces per spindle	15	15	8	15	15
Heads per data surface	1	1	1	1	2
Tracks per surface	1224	1224	1632	1632	1,768
Track density (TPI)	1070	1070	1376	1376	806
Maximum linear density (BPI)	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI	31596 BPI* 21064 FCI	31596 BPI* 21064 FCI	15240*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual Linear, Voice Coil
Average positioning time (msec)	18	18	16	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	24.3	26.3	24.3
Data transfer rate (KBytes/sec)	1250	1500	1875	1875	3000
FIRST CUSTOMER SHIPMENT	2Q87	4Q87	1Q87	1Q87	8/83
U.S. OEM PRICE FOR 100 UNITS	$3,140	$3,025	$3,265	$5,535	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	PCM 3380 Drive has one spindle *2,7 RLL Code

MANUFACTURER	MEMOREX	MEMOREX	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	3680 HDP	3682	1333A	1335	1353
DISK/TREND GROUP	8	8	4	4	4
MARKET	PCM	PCM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Technology type	3380	3380 x 2	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 1,260	F: 2,520	U: 53.3	U: 85.3	U: 85.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	U: 10,416	U: 10,416	U: 20,832
Data surfaces per spindle	15	15	5	8	4
Heads per data surface	2	2	1	1	1
Tracks per surface	1768	3540	1024	1024	1024
Track density (TPI)	806	1386	1000	1000	1000
Maximum linear density (BPI)	15240*	16200*	9824	9824	19794*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	17	28	28	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	25.3	36.3	36.3	31.3
Data transfer rate (KBytes/sec)	3000	3000	625	625	1250
FIRST CUSTOMER SHIPMENT	3Q85	12/86	2Q84	2Q84	3Q85
U.S. OEM PRICE FOR 100 UNITS	--	--	$535 (1000)	$795 (1000)	$995 (1000)
COMMENTS	PCM 3380 *2,7 RLL Code Drive has eight spindles	PCM 3380E *2,7 RLL Code Drive has two spindles			*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1373	1373A	1353A	1355	1375
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 77.0	F: 96.3	U: 106.7	U: 170.6	F: 154.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,456	F: 19,456	U: 20,832	U: 20,832	F: 19,456
Data surfaces per spindle	4	5	5	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1016	1016	1024	1024	1016
Track density (TPI)	1000	1000	1000	1000	1000
Maximum linear density (BPI)	19794*	19794*	19794*	19794*	19794*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	23	23	23	23	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	31.3	31.3	31.3	31.3	31.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	1Q86	2/86	3Q85	3Q85	1Q86
U.S. OEM PRICE FOR 100 UNITS	$1,095 (1000)	$1,295 (1000)	$1,195 (1000)	$1,295 (1000)	$1,350 (1000)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	1554	1556	1558	HH-325	HH-725
DISK/TREND GROUP	5	6	6	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 280	U: 331	U: 382	U: 25.52	U: 25.52
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	U: 20,832	U: 10,416	U: 10,416
Data surfaces per spindle	11	13	15	4	4
Heads per data surface	1	1	1	1	2
Tracks per surface	1224	1224	1224	612	612
Track density (TPI)	1075	1075	1075	855	648
Maximum linear density (BPI)	*	*	*	13014	9680
Rotational speed (RPM)	3600	3600	3600	3550	3550
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	18	18	18	80 (including settling)	80 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.45	8.45
Average access time (msec)	26.3	26.3	26.3	88.45	88.45
Data transfer rate (KBytes/sec)	1250	1250	1250	625	625
FIRST CUSTOMER SHIPMENT	11/86	11/86	11/86	3/85	6/84
U.S. OEM PRICE FOR 100 UNITS	$1,595 (1000)	$1,695 (1000)	$2,195 (1000)	--	--
COMMENTS	SCSI version is Model 1574 *not announced	SCSI version is Model 1576 *not announced	SCSI version is Model 1578 *not announced	41 mm High Embedded Servo	41 mm High Embedded Servo

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	HH-825	HH-330	HH-738	HH-830	HH-1050
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	95 mm OD 25 mm OD	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.5	U: 38.28*	U: 38.28*	U: 38.28*	U: 51.04
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624*	U: 15,624*	U: 15,624*	U: 10,416
Data surfaces per spindle	4	4	4	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	612	612	612	612	1024
Track density (TPI)	648	855	648	648	960
Maximum linear density (BPI)	9680	13014*	14520*	14520*	10020
Rotational speed (RPM)	3550	3550	3550	3550	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Linear, Voice Coil
Average positioning time (msec)	65 (including settling)	80 (including settling)	105(including settling)	65 (including settling)	28
Average rotational delay (msec)	8.45	8.45	8.45	8.45	8.3
Average access time (msec)	73.45	88.45	113.45	73.45	36.3
Data transfer rate (KBytes/sec)	625	937.5*	937.5*	937.5*	625
FIRST CUSTOMER SHIPMENT	5/87	3/85	6/84	5/87	1/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High Embedded Servo	41 mm High *with RLL controller Embedded Servo	41 mm High *with RLL controller Embedded Servo	41 mm High *with RLL controller Embedded Servo	41 mm High

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	HH-1060	HH-1090	HH-1120	HH-2120	HH-3120
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 79.99*	U: 95.81	U: 143.71*	U: 144.06	F: 122.43
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 10,416	U: 15,664*	U: 15,664	F: 13,312
Data surfaces per spindle	5	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1314	1314	1314	1314
Track density (TPI)	960	1250	1250	1250	1250
Maximum linear density (BPI)	14935 BPI* 9957 FCI	9840	14760 BPI* 9840 FCI	14760 BPI* 9840 FCI	14760 BPI* 9840 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	28	28	28	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	36.3	36.3
Data transfer rate (KBytes/sec)	937.5*	625	937.5*	937.5	937.5
FIRST CUSTOMER SHIPMENT	2/86	9/87	10/87	1/88	11/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High *with RLL controller	41 mm High	41 mm High *with RLL controller	41 mm High *2,7 RLL Code	41 mm High *2,7 RLL Code

MANUFACTURER	MILTOPE	MILTOPE	MILTOPE	MILTOPE	MINISCRIBE
DRIVE	RDS-1500	RDS-3400	RDS-5000	RDS-1720	3425 Plus
DISK/TREND GROUP	3	4	4	5	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Special	Special	Special	Special	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	Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412/SCSI	ST412	SCSI	ESDI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 18.5	F: 30.8	F: 47.0	F: 159.3	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 9,216	F: 9,216	F: 9,216	F: 19,456	U: 10,416
Data surfaces per spindle	3	5	5	8	4
Heads per data surface	1	1	1	1	1
Tracks per surface	670	670	1024	1024	615
Track density (TPI)	680	1186	1000	960	588
Maximum linear density (BPI)	9890	11240	9824	20000*	10030
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor
Average positioning time (msec)	40	40	40	23	55 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	48.3	48.3	31.3	63.3
Data transfer rate (KBytes/sec)	625	625	625	1250	625
FIRST CUSTOMER SHIPMENT	5/84	4Q86	4Q86	3Q86	8/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	$205 (2500)
COMMENTS	Sold as militarized subsystem	Sold as militarized subsystem	Sold as militarized subsystem	Sold as militarized subsystem *2,7 RLL Code	41 mm High

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE	8425	8425F	8425S	8425X	SC20ATF
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
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	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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SCSI	IBM PC XT	IBM PC XT
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.6	U: 25.6	F: 21.3	F: 21.4	F: 21.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 8,704	F: 8,704	F: 8,704
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	612	615	615
Track density (TPI)	804	804	804	804	804
Maximum linear density (BPI)	13412	13412	13412	13412	13412
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	68 (including settling)	40 (including settling)	68 (including settling)	68 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	76.3	48.3	76.3	76.3	48.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q84	1Q87	3Q86	3Q86	3Q87
U.S. OEM PRICE FOR 100 UNITS	$225 (2500)	$275 (2500)	$296 (2500)	$296 (2500)	$400 (2500)
COMMENTS	41 mm High	41 mm High	41 mm High		41 mm Thick

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE	SCXT20	3053	3438 Plus	3650	6053
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Drive On Card	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	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM PC XT	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 21.4	U: 53.3	U: 38.4*	U: 50.5	U: 53.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	U: 10,416	U: 15,624*	U: 10,416	U: 10,416
Data surfaces per spindle	4	5	4	6	5
Heads per data surface	1	1	1	1	1
Tracks per surface	615	1024	615	809	1024
Track density (TPI)	804	1000	588	763	1000
Maximum linear density (BPI)	13412	10200	15048 BPI* 10030 FCI	10124	9950
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Linear, Voice Coil
Average positioning time (msec)	68 (including settling)	25	55 (including settling)	61 (including settling)	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	76.3	33.3	63.3	69.3	36.3
Data transfer rate (KBytes/sec)	625	625	937.5*	625	625
FIRST CUSTOMER SHIPMENT	3Q86	2Q87	3Q84	1Q87	4Q84
U.S. OEM PRICE FOR 100 UNITS	$320 (2500)	$440 (2500)	$215 (2500)	$265 (2500)	$475 (2500)
COMMENTS	41 mm Thick	41 mm High	41 mm High *with RLL controller	41 mm High	

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE	6079	6085	8438	8438F	SC30ATF
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Drive On Card
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	IBM PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 79.9*	U: 85.3	U: 38.4*	U: 38.4*	F: 32.7*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 10,416	U: 15,624*	U: 15,624*	F: 13,312*
Data surfaces per spindle	5	8	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	615	615	615
Track density (TPI)	1000	1000	804	804	804
Maximum linear density (BPI)	14925*	9950	19900 BPI* 13412 FCI	19900 BPI* 13412 FCI	19900 BPI* 13412 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rack & Pinion Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	28	28	68 (including settling)	40 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	76.3	48.3	48.3
Data transfer rate (KBytes/sec)	937.5*	625	937.5*	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	3Q87	4Q84	4Q85	1Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	$580 (2500)	$650 (2500)	$240 (2500)	$290 (2500)	$410 (2500)
COMMENTS	*with RLL controller		41 mm High *with RLL controller	41 mm High *with RLL controller	41 mm Thick *with RLL controller

MANUFACTURER	MINISCRIBE	MINISCRIBE	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	SCXT30 SCAT30	6128	MR321	MR322	MR521
DISK/TREND GROUP	4	5	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Drive On Card	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film/Oxide
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM PC XT/AT	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 32.7	U: 128.0*	U: 12.75	U: 25.5	U: 12.75
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 15,624*	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	8	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	1024	615	615	612
Track density (TPI)	804	1000	821	821	690
Maximum linear density (BPI)	19900 BPI* 13412 FCI	14925*	13840	13840	9201
Rotational speed (RPM)	3600	3600	3536	3536	3536
PERFORMANCE					
Actuator type	Rack & Pinion Stepping Motor	Linear, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	68 (including settling)	28	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.48	8.48	8.48
Average access time (msec)	76.3	36.3	93.48	93.48	93.48
Data transfer rate (KBytes/sec)	937.5	937.5*	625	625	625
FIRST CUSTOMER SHIPMENT	3Q86	3Q87	2Q86	2Q86	4/84
U.S. OEM PRICE FOR 100 UNITS	AT$370/XT$330**	$775 (2500)	--	--	--
COMMENTS	41 mm Thick *2,7 RLL Code **(2500)	*with RLL controller	41 mm High Embedded Servo	41 mm High	41 mm High

MANUFACTURER		MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE		MR522	MR533	MR535	M4870F	MR5310
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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
	Recording medium	Thin Film/Oxide	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE:	Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	3370 (Ferrite)
	Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	Interface	ST412	ST412, SCSI	ST412, SCSI	SMD	SCSI/EDSI
CAPACITY/RECORDING DENSITY						
Total capacity (MBytes)	FIXED	U: 25.5	U: 30.3	U: 50.55	U: 251.4	U: 101.1
	REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)		U: 10,416	U: 10,416	U: 10,416	U: 20,480	U: 20,832
Data surfaces per spindle		4	3	5	12	5
Heads per data surface		1	1	1	1	1
Tracks per surface		612	971	971	1023	971
Track density (TPI)		690	1028	1028	1000	1028
Maximum linear density (BPI)		9201	9358	9358	10000	18716*
Rotational speed (RPM)		3536	3600	3600	3544	3600
PERFORMANCE						
Actuator type		Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)		85 (including settling)	30	30	20	30
Average rotational delay (msec)		8.48	8.3	8.3	8.47	8.3
Average access time (msec)		93.48	38.3	38.3	28.47	38.3
Data transfer rate (KBytes/sec)		625	625	625	1209	1250
FIRST CUSTOMER SHIPMENT		6/84	3Q86	3Q86	4/84	4Q86
U.S. OEM PRICE FOR 100 UNITS		--	--	--	--	--
COMMENTS		41 mm High	41 mm High	41 mm High		53 mm High *2,7 RLL Code

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	NEC	NEC	NEC	NEC
DRIVE	M4875	N7745	D3126	D5124	D5126
DISK/TREND GROUP	6	2	3	3	3
MARKET	OEM	Captive	OEM, Captive	OEM, Captive	OEM
MEDIA: Generic type	Fixed	3336-11	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	14"	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370	3330-11	Modified 3350	Modified 3350	Modified 3350
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	NEC	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 408.5	--	U: 25.62	U: 12.91	U: 25.49
REMOVABLE	--	F: 200	--	--	--
Capacity per track (Bytes)	U: 30,720	F: 13,030	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	13	19	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1023	815	615	310	615
Track density (TPI)	1000	370	750	350	700
Maximum linear density (BPI)	14100*	4040	15000	9000	9000
Rotational speed (RPM)	3544	3600	3564	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Band, Stepping Motor	Linear, Band, Stepping Motor	Linear, Band, Stepping Motor
Average positioning time (msec)	20	30	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.47	8.3	8.4	8.3	8.3
Average access time (msec)	28.47	38.3	93.4	93.3	93.3
Data transfer rate (KBytes/sec)	1814	806	625	625	625
FIRST CUSTOMER SHIPMENT	3Q85	11/75	7/85	3/84	10/84
U.S. OEM PRICE FOR 100 UNITS	--	--	$387 (1000)	$350 (1000)	$430 (1000)
COMMENTS	*2,7 RLL Code			41 mm High	41 mm High

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5126H	D5127	D5127H	D5146	D5146H
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	Captive, OEM	Captive, OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.49	U: 38	U: 38	U: 51.24	U: 51.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624	U: 15,624	U: 10,416	U: 10,416
Data surfaces per spindle	4	4	4	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	615
Track density (TPI)	700	700	700	700	700
Maximum linear density (BPI)	9000	13500*	13500*	9000	9000
Rotational speed (RPM)	3600	3564	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Torque Motor	Linear, Band, Stepping Motor	Linear, Torque Motor	Linear, Band, Stepping Motor	Linear, Torque Motor
Average positioning time (msec)	40	85 (including settling)	40	85 (including settling)	40
Average rotational delay (msec)	8.3	8.4	8.3	8.3	8.3
Average access time (msec)	48.3	93.4	48.3	93.3	48.3
Data transfer rate (KBytes/sec)	625	937.5	937.5	625	625
FIRST CUSTOMER SHIPMENT	4/86	4/87	4/87	6/85	4/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	$717 (1000)
COMMENTS	41 mm High	*2,7 RLL Code	*2,7 RLL Code	41 mm High	41 mm High

MANUFACTURER		NEC	NEC	NEC	NEC	NEC
DRIVE		D5147H	D5452	D2257 N7729	D5652	D5852
DISK/TREND GROUP		4	4	5	5	5
MARKET		Captive, OEM	OEM	OEM	OEM	Captive, OEM
MEDIA:	Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
	Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
	Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE:	Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)
	Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	Interface	ST412	ST412	SMD	ESDI	SCSI
CAPACITY/RECORDING DENSITY						
Total capacity (MBytes)	FIXED	U: 75	U: 85.72	U: 167.7	U: 172.76	F: 147
	REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)		U: 15,624	U: 10,416	U: 20,480	U: 20,992	F: 17,920
Data surfaces per spindle		8	10	8	10	10
Heads per data surface		1	1	1	1	1
Tracks per surface		615	823	1024	823	823
Track density (TPI)		700	926	720	926	925
Maximum linear density (BPI)		13500*	9307	9420	18758*	18759*
Rotational speed (RPM)		3600	3600	3510	3573	3573
PERFORMANCE						
Actuator type		Linear, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)		40	28	20	23	23
Average rotational delay (msec)		8.3	8.3	8.55	8.4	8.4
Average access time (msec)		48.3	36.3	28.55	31.4	31.4
Data transfer rate (KBytes/sec)		937.5	625	1198	1250	1250
FIRST CUSTOMER SHIPMENT		5/87	4/86	5/83	2/86	5/87
U.S. OEM PRICE FOR 100 UNITS		--	--	$3,087	$1,825 (1000)	--
COMMENTS		*2,7 RLL Code		N7729 has two spindles per drive	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2268	D2268H	D2332 N7737	D2352 N7738	D2352H
DISK/TREND GROUP	6	6	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Captive, OEM	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	Modified SMD	SMD	Modified SMD	Mod.SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 337.1	U: 337.1	U: 337.1	U: 520	U: 520
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 20,480	U: 36,288	U: 36,288
Data surfaces per spindle	10	10	10	9.5	9.5
Heads per data surface	1	1	2	2/1	2/1
Tracks per surface	823	823	1646	1520	1520
Track density (TPI)	780	780	1080	1020	1020
Maximum linear density (BPI)	18900*	18900*	10500	18600*	18600*
Rotational speed (RPM)	2720	3600	3544	3070	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	20	15	15	15
Average rotational delay (msec)	11	8.3	8.47	9.8	8.3
Average access time (msec)	31	28.3	23.47	24.8	23.3
Data transfer rate (KBytes/sec)	1859	2460	1209	1859	2180
FIRST CUSTOMER SHIPMENT	6/85	11/85	6/85	1/85	11/85
U.S. OEM PRICE FOR 100 UNITS	$4,326	$4,405	--	$7,890	$8,058
COMMENTS	*2,7 RLL Code	*2,7 RLL Code		*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2362	D2366	D2462	N7755	N7756
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	Captive, OEM	Captive, OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	14"	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	IPI-2	SCSI	NEC	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 800	U: 800	F: 737	F: 635.0	F: 486.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	F: 37,888	F: 19,069	F: 32,288
Data surfaces per spindle	11.5	11.5	11.5	15	9.5
Heads per data surface	2/1	2/1	2/1	2	2/1
Tracks per surface	1700	1700	1700	2244	1520
Track density (TPI)	1070	1070	1070	960	1000
Maximum linear density (BPI)	21400*	21400*	21400*	6400	18600*
Rotational speed (RPM)	3600	3600	3600	3600	3070
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	15	15	15	20	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	9.8
Average access time (msec)	23.3	23.3	23.3	28.3	24.8
Data transfer rate (KBytes/sec)	2460	2460	2460	1198	1860
FIRST CUSTOMER SHIPMENT	2/86	1Q87	2Q87	1979	3Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	Drive has two spindles	*2,7 RLL Code Drive has two spindles

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	N7761	D2363	D2367	D2373	D2377
DISK/TREND GROUP	7	8	8	8	8
MARKET	Captive	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3380	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	NEC	Modified SMD	IPI-2	SMD-E	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 672.2	U: 1,132	U: 1,132	U: 1,415	U: 1,415
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	U: 40,960	U: 40,960	U: 51,200	U: 51,200
Data surfaces per spindle	5	13.5	13.5	13.5	13.5
Heads per data surface	2	2/1	2/1	2/1	2/1
Tracks per surface	1770	2048	2048	2048	2048
Track density (TPI)	800	1290	1290	1290	1290
Maximum linear density (BPI)	15300*	21400*	21400*	26800*	26800*
Rotational speed (RPM)	3620	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	15	15	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	23.3	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	3000	2460	2460	3070	3070
FIRST CUSTOMER SHIPMENT	1983	1Q87	3Q87	3Q87	4Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code 4 spindles per drive	*2,7 RLL code	*2,7 RLL code	*1,7 RLL Code	*1,7 RLL Code

MANUFACTURER		NEC	NEC	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA
DRIVE		D2463	N7765	NDR 340 Penny	NDR 1065	NDR 1085
DISK/TREND GROUP		8	8	4	4	4
MARKET		Captive, OEM	Captive	OEM	OEM	OEM
MEDIA:	Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
	Nominal disk diameter	230 mm OD 100 mm ID	14"	95 mm OD 25 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:	Technology type	3370 (Ferrite)	3380	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
	Heads	Ferrite	Thin Film	Ferrite	Ferrite	Ferrite
	Interface	SCSI	NEC	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY						
Total capacity (MBytes)	FIXED	F: 1,044	F: 1,344.9	U: 51.2	U: 66.93	U: 85.33
	REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)		F: 37,888	F: 47,476	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle		13.5	6	8	7	8
Heads per data surface		2/1	2	1	1	1
Tracks per surface		2048	2982	615	918	1024
Track density (TPI)		1290	1200	980	995	995
Maximum linear density (BPI)		21400*	16100*	12673	9280	9934
Rotational speed (RPM)		3600	3620	3600	3600	3600
PERFORMANCE						
Actuator type		Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)		15	17	39	25	26
Average rotational delay (msec)		8.3	8.3	8.3	8.3	8.3
Average access time (msec)		23.3	25.3	47.3	33.3	34.3
Data transfer rate (KBytes/sec)		2460	3000	625	625	625
FIRST CUSTOMER SHIPMENT		3Q87	9/86	1986	4Q84	1Q86
U.S. OEM PRICE FOR 100 UNITS		--	--	--	--	--
COMMENTS		*2,7 RLL code	*2,7 RLL Code 4 spindles per drive	41 mm High	Licensed from Maxtor	Licensed from Maxtor

MANUFACTURER	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA
DRIVE	NDR 1105	NDR 1140	NDR 2190	NDR 3170S	NDR 3280S
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370	3370
Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ST412	ST412	ST412	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 105.18	U: 143.43	U: 191.24	F: 146.64	F: 244.41
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	F: 13,312	F: 13,312
Data surfaces per spindle	11	15	15	9	15
Heads per data surface	1	1	1	1	1
Tracks per surface	918	918	1224	1224	1224
Track density (TPI)	995	995	1022	1020	1020
Maximum linear density (BPI)	9280	9280	11155	16732 BPI* 11155 FCI	16732 BPI* 11155 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	28	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	36.3	36.3	36.3
Data transfer rate (KBytes/sec)	625	625	625	1250	1250
FIRST CUSTOMER SHIPMENT	4Q84	4Q84	1Q86	2Q87	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Licensed from Maxtor	Licensed from Maxtor	Licensed from Maxtor	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NORTHERN TELECOM	NORTHERN TELECOM
DRIVE	NDR 4175	NDR 4380	NDR 4380S	8204X	8208X
DISK/TREND GROUP	5	6	6	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370	3370	3370	3370 (Ferrite)	3370 (Ferrite)
Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	ESDI	ESDI	SCSI	SMD, SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 179.38	U: 384.4	F: 319.61	U: 93.7	SCSI(F):142.0 U: 187.3
REMOVABLE	--	--	--	-	--
Capacity per track (Bytes)	U: 20,937	U: 20,937	F: 17,408	U: 21,912	U: 21,912
Data surfaces per spindle	7	15	15	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	1224	1069	1069
Track density (TPI)	1020	1020	1020	1039	1039
Maximum linear density (BPI)	21975 BPI* 14650 FCI	21975 BPI* 14650 FCI	21975 BPI* 14650 FCI	10238	10238
Rotational speed (RPM)	3600	3600	3600	3313.5	3313.5
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	28	28	28	19.5 (256 Byte sector)	19.5(256 Byte sector)
Average rotational delay (msec)	8.3	8.3	8.3	9.0	9.0
Average access time (msec)	36.3	36.3	36.3	28.5	28.5
Data transfer rate (KBytes/sec)	1875	1875	1875	1209	1209
FIRST CUSTOMER SHIPMENT	2Q87	2Q87	4Q87	9/83	9/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	$2,000	$3,040
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	Embedded Servo	Embedded Servo

MANUFACTURER	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
DRIVE	8210X	8212X	8308	8312	8412
DISK/TREND GROUP	5	6	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370	3370	3370
Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	SMD, SCSI	SMD, SCSI	H/P-SMD, SCSI	H/P-SMD, SCSI	Mod.SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	SCSI(F):177.5 U: 234.2	SCSI(F):265.6 U: 350.2	SCSI(F): 323 U: 394.8	SCSI(F): 529 U: 592.2	U: 820
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 21,912	U: 21,912	U: 34,300	U: 34,300	U: 41,778
Data surfaces per spindle	10	12	8	12	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1069	1332	1439	1439	1496
Track density (TPI)	1039	1203	1236	1236	1312
Maximum linear density (BPI)	10238	10238	16200 BPI* 10800 FCI	16200 BPI* 10800 FCI	20043 BPI* 13362 FCI
Rotational speed (RPM)	3313.5	3313.5	3313.5	3313.5	3656
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	19.5(256 Byte sector)	21 (256 Byte sector)	20	18	18
Average rotational delay (msec)	9.0	9.0	9.0	9.0	8.2
Average access time (msec)	28.5	30.0	29.0	27.0	26.2
Data transfer rate (KBytes/sec)	1209	1209	1895	1895	2550
FIRST CUSTOMER SHIPMENT	9/83	6/85	6/85	12/85	1/87
U.S. OEM PRICE FOR 100 UNITS	$3,350	$3,800	$3,950	$4,990	$5,900
COMMENTS	Embedded Servo	Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo

MANUFACTURER	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY
DRIVE	PT-225	PT-238R	PT-338	PT-351	PT-357R
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.6	U: 38.4	U: 38.4	U: 51.2	U: 57.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624	U: 10,416	U: 10,416	U: 15,624
Data surfaces per spindle	4	4	6	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	820	615
Track density (TPI)	983	983	983	983	983
Maximum linear density (BPI)	12218	18327 BPI* 12218 FCI	12218	14479	18327 BPI* 12218 FCI
Rotational speed (RPM)	3517	3517	3517	3517	3517
PERFORMANCE					
Actuator type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)
Average rotational delay (msec)	8.5	8.5	8.5	8.5	8.5
Average access time (msec)	43.5	43.5	43.5	43.5	43.5
Data transfer rate (KBytes/sec)	625	937.5	625	625	937.5
FIRST CUSTOMER SHIPMENT	3Q86	3Q86	3Q86	9/87	3Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High Embedded Servo	41 mm High Embedded Servo *2,7 RLL Code	41 mm High Embedded Servo	41 mm High Embedded Servo	41 mm High Embedded Servo *2,7 RLL Code

MANUFACTURER	PERTEC	PERTEC	PERTEC	PERTEC	PERTEC
DRIVE	DX199	DX265	DX332	DX368	DX375
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	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	SMD,SCSI,ESDI	SMD,SCSI,ESDI	SMD,SCSI,ESDI	SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 199	U: 265	U: 332	U: 368	U: 374.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 20,160	U: 30,240	U: 40,320
Data surfaces per spindle	6	8	10	10	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1649	1649	1649	1217	845
Track density (TPI)	1083	1083	1083	1083	1083
Maximum linear density (BPI)	12022*	12022*	12022*	16000*	40320*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	22	22	22	18	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	30.3	30.3	30.3	26.3	22.3
Data transfer rate (KBytes/sec)	1208	1208	1208	1815	2418
FIRST CUSTOMER SHIPMENT	4/85	4/85	4/85	1Q86	4Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	$3,350	$3,500	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	PERTEC	PERTEC	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT
DRIVE	DX548	DX731	Hardcard	Hardcard 20	Hardcard 40
DISK/TREND GROUP	7	7	3	3	4
MARKET	OEM	OEM	PCM, OEM	PCM, OEM	PCM, OEM
MEDIA: Generic type	Fixed	Fixed	Drive On Card	Drive On Card	Drive On Card
Nominal disk diameter	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Hi Dens Oxide	Hi Dens Oxide	Thin Film
DRIVE: Technology type	3370	3370	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SMD	Modified SMD	IBM PC	IBM PC	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 548.5	U: 731	F: 10.5	F: 21.2	F: 42.26
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 40,320	F: 8,704	F: 8,704	F: 14,336 and 17,408
Data surfaces per spindle	11	11	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1649	1649	612	615	612
Track density (TPI)	1083	1083	812	812	812
Maximum linear density (BPI)	18000*	40320*	13917 BPI* 9278 FCI	13917 BPI* 9278 FCI	21524 and 22392*
Rotational speed (RPM)	3600	3600	3600	3600	3000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Voice Coil
Average positioning time (msec)	20	18	65 (including settling)	49 (including settling)	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	10
Average access time (msec)	28.3	26.3	73.3	57.3	50
Data transfer rate (KBytes/sec)	1815	2418	625	625	843.7/1031
FIRST CUSTOMER SHIPMENT	2Q86	4Q87	10/85	6/86	5/87
U.S. OEM PRICE FOR 100 UNITS	$4,700	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE	803	7050	V150 V160	V185	514
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 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	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Priam, SMD	Priam, SMD	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 85.68	U: 70.49	U: 60.7	U: 85.0	U: 140.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 13,400	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	5	5	5	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	850	1049	1166	1166	1224
Track density (TPI)	960	960	1047	1047	1070
Maximum linear density (BPI)	9167	6597	10526	10526	10924
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	35	42	28	28	22
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	43.3	50.3	36.3	36.3	30.3
Data transfer rate (KBytes/sec)	1209	806	625	625	625
FIRST CUSTOMER SHIPMENT	9/83	4Q81	2Q87	3Q84	1Q86
U.S. OEM PRICE FOR 100 UNITS	$2,950	$2,850	$925	$1,205	$2,200
COMMENTS					

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE	519	617	628	717	728
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ESDI	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 191.2	U: 178.6	U: 280.7	F: 163.6	F: 258.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,832	U: 20,832	F: 19,456	F: 19,456
Data surfaces per spindle	15	7	11	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1225	1225	1225	1225
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI)	10924	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	22	20	20	20	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	30.3	28.3	28.3	28.3	28.3
Data transfer rate (KBytes/sec)	625	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	1Q86	4Q86	4Q86	1Q87	4Q86
U.S. OEM PRICE FOR 100 UNITS	$2,475	$1,840	$2,265	$1,980	$2,405
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE	806	15450	638	738	807
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	200 mm OD 63.5 mm ID	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Priam,SMD,SCSI	Priam, SMD	ESDI	SCSI	Priam,SMD,SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 227	U: 158.5	U: 382.7	F: 353.5	U: 344
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 20,832	F: 19,456	U: 20,160
Data surfaces per spindle	11	3.5	15	15	11
Heads per data surface	1	2/1	1	1	1
Tracks per surface	1023	2242	1225	1225	1552
Track density (TPI)	1040	960	1070	1070	1040
Maximum linear density (BPI)	9167	6430	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI	12096
Rotational speed (RPM)	3600	3100	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	20	46	20	20	25
Average rotational delay (msec)	8.3	9.7	8.3	8.3	8.3
Average access time (msec)	28.3	55.7	28.3	28.3	33.3
Data transfer rate (KBytes/sec)	1210	1040	1250	1250	1210
FIRST CUSTOMER SHIPMENT	5/84	3Q81	3Q86	4Q86	6/84
U.S. OEM PRICE FOR 100 UNITS	$3,280	$3,895	$2,690	$2,830	$4,105
COMMENTS			*2,7 RLL Code	*2,7 RLL Code	

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	Q520	Q2010	Q2020	Q250	Q280
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	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	3350	3350	3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SA1000	SA1000	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 21.33	U: 10.66	U: 21.33	F: 53.4	F: 80.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,400	U: 10,400	F: 16,384	F: 16,384
Data surfaces per spindle	4	2	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	512	512	512	815	815
Track density (TPI)	591	345	345	876	876
Maximum linear density (BPI)	9200	6600	6600	20000 BPI* 15000 FCI	20000 BPI* 15000 FCI
Rotational speed (RPM)	3529	3000	3000	3600	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	45	50	55	26	26
Average rotational delay (msec)	8.5	10	10	8.3	8.3
Average access time (msec)	53.5	60	65	34.3	34.3
Data transfer rate (KBytes/sec)	625	543	543	1250	1250
FIRST CUSTOMER SHIPMENT	4/83	1Q81	1Q81	4/86	4/86
U.S. OEM PRICE FOR 100 UNITS	$895 (1000)	$1,150 (1000)	$1,440 (1000)	$850 (1000)	$950 (1000)
COMMENTS				41 mm High *1,7 RLL Code Embedded Servo	41 mm High *1,7 RLL Code Embedded Servo

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	RICOH
DRIVE	Q530	Q540	Q2030	Q2040	RH5130
DISK/TREND GROUP	4	4	4	4	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	5.25" Cartridge
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3350	3350	3350	3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SA1000	SA1000	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 31.99	U: 42.66	U: 32.0	U: 42.66	--
REMOVABLE	--	--	--	--	U: 12.75
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,400	U: 10,400	U: 10,416
Data surfaces per spindle	6	8	6	8	2
Heads per data surface	1	1	1	1	1
Tracks per surface	512	512	512	512	612
Track density (TPI)	591	591	345	345	612
Maximum linear density (BPI)	9200	9200	6600	6600	10894
Rotational speed (RPM)	3529	3529	3000	3000	3473
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	45	45	60	65	98 (including settling)
Average rotational delay (msec)	8.5	8.5	10	10	8.6
Average access time (msec)	53.5	53.5	70	75	106.6
Data transfer rate (KBytes/sec)	625	625	543	543	625
FIRST CUSTOMER SHIPMENT	4/83	4/83	1Q81	1Q81	3Q85
U.S. OEM PRICE FOR 100 UNITS	$995 (1000)	$1,095 (1000)	$1,700 (1000)	$1,960 (1000)	--
COMMENTS					41 mm High Embedded Servo DMA License

MANUFACTURER	RICOH	RODIME	RODIME	RODIME	RODIME
DRIVE	RH5260 RH5261	R0652A	R03045	R03055	R03057S
DISK/TREND GROUP	1	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	5.25" Cartridge	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	96 mm OD 40 mm ID	96 mm OD 40 mm ID	96 mm OD 40 mm ID	96 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	Modified 3350	3370	3370	3370	3370
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST506/SCSI	SCSI	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	F: 21.3	U: 45.42	U: 54.5	F: 45.3
REMOVABLE	U: 25.5	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 17,408	U: 10,417	U: 10,417	F: 13,312
Data surfaces per spindle	1	4	5	6	4
Heads per data surface	2	1	1	1	1
Tracks per surface	1224	306	872	872	872
Track density (TPI)	1222	600	1040	1040	1040
Maximum linear density (BPI)	10894	22100 BPI 14700 FCI	15072	15072	22608*
Rotational speed (RPM)	3473	2750	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	98 (including settling)	85 (including settling)	28	28	28
Average rotational delay (msec)	8.6	10.9	8.3	8.3	8.3
Average access time (msec)	106.6	95.9	36.3	36.3	36.3
Data transfer rate (KBytes/sec)	625	937	625	625	937
FIRST CUSTOMER SHIPMENT	1987	4Q85	1Q87	1Q87	1Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High Embedded Servo RH5261 has SCSI interface	41 mm High	41 mm High	41 mm High	41 mm High *2,7 RLL Code

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE	R03085S	R05090	R05125S	R05180S	R08067
DISK/TREND GROUP	4	4	5	5	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	96 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370	3370	3370	3370	3370
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	SCSI	ST412	SCSI	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 69.6	U: 89.2	F: 102.98	F: 144.17	U: 674
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 10,417	F: 16,896	F: 16,896	U: 40,960
Data surfaces per spindle	6	7	5	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	872	1224	1219	1219	1646
Track density (TPI)	1040	1100	1100	1100	1200
Maximum linear density (BPI)	22608*	10024	20050*	20050*	20240*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	28	28	28	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	36.3	26.3
Data transfer rate (KBytes/sec)	937	625	1250	1250	2458
FIRST CUSTOMER SHIPMENT	3Q87	2Q87	2Q87	2Q87	1Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High *2,7 RLL Code	41 mm High	41 mm High *2,7 RLL Code	41 mm High *2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	SAGEM	SAGEM	SAGEM	SAGEM	SEAGATE TECHNOLOGY
DRIVE	MSA 240-25	MSA 240-50	MSA 250-50	MSA 250-100	ST125
DISK/TREND GROUP	3	4	4	5	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Special	Special	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	SCSI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 25	F: 50	--	--	U: 25.6
REMOVABLE	--	--	F: 50	F: 100	--
Capacity per track (Bytes)	F: 14,848	F: 14,848	F: 14,848	F: 14,848	U: 10,416
Data surfaces per spindle	4	8	8	16	4
Heads per data surface	8	8	8	8	1
Tracks per surface	464	464	464	464	615
Track density (TPI)	600	600	600	600	824
Maximum linear density (BPI)	13000	13000	13000	13000	15500
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Stepping Motor
Average positioning time (msec)	10	10	10	10	30 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	18.3	18.3	18.3	18.3	38.3
Data transfer rate (KBytes/sec)	1500	1500	1500	1500	625
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	1Q87	1Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	$305 (500)
COMMENTS	Militarized Subsystem	Militarized Subsystem	Militarized Subsystem Removable Head/Disk Module	Militarized Subsystem Removable Head/Disk Module	41 mm High

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST213	ST225	ST225N	ST4026	ST138
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 12.8	U: 25.6	F: 21.4	U: 25.6	U: 38.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 8,704	U: 10,416	U: 10,416
Data surfaces per spindle	2	4	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	615
Track density (TPI)	588	588	588	625	824
Maximum linear density (BPI)	9827	9827	9827	9617	15500
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Linear, Voice Coil	Rotary, Stepping Motor
Average positioning time (msec)	65 (including settling)	65 (including settling)	65 (including settling)	40	30 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	73.3	73.3	73.3	48.3	38.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	4Q85	10/84	4Q85	11/84	3Q87
U.S. OEM PRICE FOR 100 UNITS	$250 (500)	$260 (500)	$355 (500)	$490 (500)	$350 (500)
COMMENTS	41 mm High	41 mm High	41 mm High		41 mm High

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST138N	ST138R	ST157N	ST157R	ST238R
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 32.3	U: 38.4*	F: 48.6	U: 57.7*	U: 38.4*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 15,624*	F: 13,312	U: 15,624*	U: 15,624*
Data surfaces per spindle	4	4	6	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	613	615	613	615	615
Track density (TPI)	824	824	824	824	588
Maximum linear density (BPI)	23250 BPI* 15500 FCI	23250 BPI* 15500 FCI	23250 BPI* 15500 FCI	23250 BPI* 15500 FCI	14740 BPI* 9827 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	30 (including settling)	30 (including settling)	30 (including settling)	30 (including settling)	65 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	38.3	38.3	73.3
Data transfer rate (KBytes/sec)	937.5	937.5*	937.5	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	3Q87	3Q87	1Q86
U.S. OEM PRICE FOR 100 UNITS	$425 (500)	$325 (500)	$525 (500)	$460 (500)	$265 (500)
COMMENTS	41 mm High *2,7 RLL code	41 mm High *with RLL controller	41 mm High *2,7 RLL code	41 mm High *with RLL controller	41 mm High *With RLL Controller

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST251	ST251-1	ST251N	ST251R	ST277N
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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SCSI	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 51.2	U: 51.2	F: 43.1	U: 51.2*	F: 64.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 13,312	U: 15,624*	F: 13,312
Data surfaces per spindle	6	6	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	818	820	818
Track density (TPI)	777	777	777	777	777
Maximum linear density (BPI)	9935	9935	14902 BPI* 9935 FCI	14902 BPI* 9935 FCI	14902 BPI* 9935 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	40 (including settling)	30 (including settling)	40 (including settling)	40 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	38.3	48.3	48.3	48.3
Data transfer rate (KBytes/sec)	625	625	937.5	937.5*	937.5
FIRST CUSTOMER SHIPMENT	2Q86	3Q87	1/87	3Q87	1/87
U.S. OEM PRICE FOR 100 UNITS	$450 (500)	$520 (500)	$520 (500)	$425 (500)	$565 (500)
COMMENTS	41 mm High	41 mm High	41 mm High *2,7 RLL Code	41 mm High *with RLL controller	41 mm High *2,7 RLL Code

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST277R	ST296N	ST4038	ST4051	ST4096
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	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 76.9*	F: 85.0	U: 38.2	U: 50.9	U: 96.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	F: 17,408	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	6	6	5	5	9
Heads per data surface	1	1	1	1	1
Tracks per surface	820	818	733	977	1024
Track density (TPI)	777	777	750	960	1031
Maximum linear density (BPI)	14902 BPI* 9935 FCI	19869 BPI* 13246 FCI	9617	9720	9792
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	40 (including settling)	30 (including settling)	40	40	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	38.3	48.3	48.3	36.3
Data transfer rate (KBytes/sec)	937.5*	1250	625	625	625
FIRST CUSTOMER SHIPMENT	3Q86	4Q87	1/85	1/85	1Q86
U.S. OEM PRICE FOR 100 UNITS	$465 (500)	$950	$560 (500)	$605 (500)	$880 (500)
COMMENTS	41 mm High *with RLL controller	41 mm High *2,7 RLL Code			

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEIKO EPSON
DRIVE	ST4096N	ST4144N	ST4144R	ST4192N	HMD-710
DISK/TREND GROUP	4	5	5	5	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ST412	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 83.9	F: 126.2	U: 144.0	F: 168.5	U: 12.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	U: 15,624*	F: 18,432	U: 10,416
Data surfaces per spindle	4	6	9	8	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1147	1147	1024	1147	615
Track density (TPI)	1047	1047	1031	1047	910
Maximum linear density (BPI)	20078 BPI* 13385 FCI	20078 BPI* 13385 FCI	14688 BPI* 9792 FCI	20078 BPI* 13385 FCI	12900
Rotational speed (RPM)	3600	3600	3600	3600	3528
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Stepping Motor
Average positioning time (msec)	17	17	28	17	69 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.5
Average access time (msec)	25.3	25.3	36.3	25.3	77.5
Data transfer rate (KBytes/sec)	1250	1250	937.5*	1250	625
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	3Q87	3Q87	3Q86
U.S. OEM PRICE FOR 100 UNITS	$1,000 (500)	$1,100 (500)	$1,000 (500)	$1,200 (500)	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*With RLL controller	*2,7 RLL Code	41 mm High

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON
DRIVE	HMD-720	HMD-725X	HMD-726A	HMD-946	HMD-976
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Drive On Card	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: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	IBM PC XT	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.5	F: 21.4	F: 20.8	F: 42.5	F: 70.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 8,704	F: 8,448	F: 13,824	F: 13,824
Data surfaces per spindle	4	4	4	3	5
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	1025	1025
Track density (TPI)	910	910	910	1275	1275
Maximum linear density (BPI)	12900	13791	13791	22548*	22548*
Rotational speed (RPM)	3528	3358	3300	3662	3662
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	69 (including settling)	80 (including settling)	80 (including settling)	29	29
Average rotational delay (msec)	8.5	8.9	9.1	8.2	8.2
Average access time (msec)	77.5	88.9	89.1	37.2	37.2
Data transfer rate (KBytes/sec)	625	625	625	1000	1000
FIRST CUSTOMER SHIPMENT	3Q86	4Q86	4Q86	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm High	41 mm Thick	41 mm High	41 mm High *2,7 RLL Code	41 mm High *2,7 RLL Code

MANUFACTURER	SHINWA DIGITAL INDUSTRY	SHINWA DIGITAL INDUSTRY	SHINWA DIGITAL INDUSTRY	SHINWA DIGITAL INDUSTRY	SIEMENS
DRIVE	D110	D220	D3510	D3520	1200
DISK/TREND GROUP	3	3	3	3	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	ST412	ST412	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 12.75	U: 25.5	U: 12.75	U: 25.5	U: 207
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 21,280
Data surfaces per spindle	2	4	2	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	612	612	612	612	1216
Track density (TPI)	608	608	830	830	1207
Maximum linear density (BPI)	10262	10262	13555	13555	19330 BPI* 12887 FCI
Rotational speed (RPM)	3333	3333	3333	3333	3571
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)	25
Average rotational delay (msec)	9	9	9	9	8.5
Average access time (msec)	94	94	94	94	33.5
Data transfer rate (KBytes/sec)	625	625	625	625	1250
FIRST CUSTOMER SHIPMENT	2/86	2/86	3Q87	3Q87	1Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	$1,325
COMMENTS	41 mm High	41 mm High	41 mm High	41 mm High	*2,7 RLL Code

MANUFACTURER	SIEMENS	SIEMENS	SIEMENS	SONY	SONY
DRIVE	2200	2300	1300	SRD1020C	SRD1040C
DISK/TREND GROUP	5	5	6	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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: Technology type	3370	3370	3370	3370 (Ferrite)	3370 (Ferrite)
Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SCSI	SCSI	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 174.3	F: 261.4	U: 310	F: 20.1	F: 40.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 17,920	U: 21,280	F: 8,704	F: 8,704
Data surfaces per spindle	8	12	12	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1216	1216	1216	1224	1224
Track density (TPI)	1207	1207	1207	1060	1060
Maximum linear density (BPI)	19331 BPI* 12887 FCI	19331 BPI* 12887 FCI	19330 BPI* 12887 FCI	12000	12000
Rotational speed (RPM)	3524	3524	3571	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	25	40	40
Average rotational delay (msec)	8.5	8.5	8.5	8.3	8.3
Average access time (msec)	33.5	33.5	33.5	48.3	48.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1500 Max.	1500 Max.
FIRST CUSTOMER SHIPMENT	4/87	4/87	1Q86	1Q87	1Q87
U.S. OEM PRICE FOR 100 UNITS	$1,325	$2,170	$2,170	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	41 mm High	41 mm High

MANUFACTURER	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	8380-A4 8380-AA4 8380-B4	8380-BE4	8380P	SQ306RD	SQ312RD
DISK/TREND GROUP	8	8	8	1	1
MARKET	PCM, OEM	PCM, OEM	PCM, OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	3.9" Cartridge	3.9" Cartridge
Nominal disk diameter	14"	14"	14"	100 mm OD 40 mm ID	100 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	3380	3380 x 2	3380	Modified 3350	Modified 3350
Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	IBM	IBM	IBM	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 1,260	F: 2,520.97	F: 1,260	--	--
REMOVABLE	--	--		U: 6.38	U: 12.75
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	U: 10,416	U: 10,416
Data surfaces per spindle	15	15	15	2	2
Heads per data surface	2	2	2	1	1
Tracks per surface	1770	3540	1770	306	615
Track density (TPI)	800	*	800	435	741
Maximum linear density (BPI)	15240 BPI* 10160 FCI	*	15240 BPI* 10160 FCI	12186	12608
Rotational speed (RPM)	3620	3620	3620	3547	3545
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	16	17	12.0	90 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.46	8.46
Average access time (msec)	24.3	25.3	20.3	98.46	93.46
Data transfer rate (KBytes/sec)	3000	3000	3000	625	625
FIRST CUSTOMER SHIPMENT	1983	6/86	12/87	9/82	7/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	$575 (1000)	$550 (1000)
COMMENTS	*2,7 RLL Code PCM 3380 Drive has two spindles	PCM 3380-BE4 *not announced Drive has two spindles	*2,7 RLL code PCM 3380 drive has two spindles	41 mm High 4.8" Wide Embedded Servo	41 mm High 4.8" Wide Embedded Servo

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	TANDON	TANDON	TANDON
DRIVE	SQ319	SQ555	Businesscard 21	TM262	TM362
DISK/TREND GROUP	1	1	3	3	3
MARKET	OEM, PCM	OEM	PCM, OEM	OEM	OEM
MEDIA: Generic type	3.9" Cartridge	Syquest Q-Pak	Fixed-Card	Fixed	Fixed
Nominal disk diameter	100 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: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM PC	SCSI	IBM PC	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	--	F: 21.3	U: 25.58	U: 25.58
REMOVABLE	U: 19.1	F: 44.5	--	--	--
Capacity per track (Bytes)	U: 15,048	F: 17,408	F: 8,704	U: 10,416	U: 10,416
Data surfaces per spindle	2	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	1278	612	615	615
Track density (TPI)	741	1086	804	804	804
Maximum linear density (BPI)	18912	23316 BPI* 15544 FCI	13739	13810	13739
Rotational speed (RPM)	3545	3280	3568	3568	3568
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	85 (including settling)	25	80 (including settling)	80 (including settling)	80 (including settling)
Average rotational delay (msec)	8.46	9.15	8.4	8.4	8.4
Average access time (msec)	93.46	34.15	88.4	88.4	88.4
Data transfer rate (KBytes/sec)	937.5	1250	625	625	625
FIRST CUSTOMER SHIPMENT	7/86	3Q87	1/86	4/85	4/85
U.S. OEM PRICE FOR 100 UNITS	$770	$610 (1000)	$425 (2500)	$260 (2500)	$260 (2500)
COMMENTS	Includes controller, software, and mounting hardware	41 mm High *2,7 RLL Code Embedded Servo		41 mm High TM362 in half high 5.25" package	41 mm High

MANUFACTURER	TANDON	TANDON	TANDON	TANDON	TANDON
DRIVE	TM362R	TM2085	TM3085	DATA PAC	TM344
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	OEM	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Data Pac	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	ST412	Tandon	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 24.6*	U: 85.3	U: 85.3	--	U: 49.2*
REMOVABLE	--	--	--	U: 38.44*	--
Capacity per track (Bytes)	U: 15,800*	U: 10,416	U: 10,416	U: 15,624*	U: 15,800*
Data surfaces per spindle	2	8	8	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	782	1004	1024	615	782
Track density (TPI)	1013	1029	1029	804	1013
Maximum linear density (BPI)	20608 BPI* 13739 FCI	9716	9716	20608 BPI* 13739 FCI	20608 BPI* 13739 FCI
Rotational speed (RPM)	3568	3600	3600	3600	3568
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	85 (including settling)	25	25	40 (including settling)	37 (including settling)
Average rotational delay (msec)	8.4	8.3	8.3	8.3	8.4
Average access time (msec)	93.4	33.3	33.3	48.3	45.4
Data transfer rate (KBytes/sec)	937.5*	625	625	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	3/87	3Q86	3Q85	3Q86	3Q87
U.S. OEM PRICE FOR 100 UNITS	$230 (2500)	$1,015	$815	--	$325 (2500)
COMMENTS	41 mm High *with RLL controller			*with RLL controller	41 mm High *with RLL controller

MANUFACTURER	TANDON	TANDON	TANDON	TANDON	TEAC
DRIVE	TM346	TM364	TM2128	TM2170	SD-540
DISK/TREND GROUP	4	4	5	5	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SCSI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 73.8*	U: 49.2*	U: 128.0	U: 170.6	U: 51.25
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,800*	U: 15,800*	U: 15,624	U: 15,624	U: 10,416
Data surfaces per spindle	6	4	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	782	782	1004	1344	615
Track density (TPI)	1013	1013	1029	1373	690
Maximum linear density (BPI)	20608 BPI* 13739 FCI	20608 BPI* 13739 FCI	14574 BPI* 9716 FCI	14574 BPI* 9716 FCI	8940
Rotational speed (RPM)	3568	3568	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor
Average positioning time (msec)	37 (including settling)	85 (including settling)	25	25	40 (including settling)
Average rotational delay (msec)	8.4	8.4	8.3	8.3	8.3
Average access time (msec)	45.4	93.4	33.3	33.3	48.3
Data transfer rate (KBytes/sec)	937.5*	937.5*	937.5	937.5	625
FIRST CUSTOMER SHIPMENT	4Q87	3/87	3Q86	3Q86	1986
U.S. OEM PRICE FOR 100 UNITS	$475 (2500)	$275 (2500)	$1,170	$1,375	--
COMMENTS	41 mm High *with RLL controller	41 mm High *with RLL controller	*2,7 RLL Code	*2,7 RLL Code	41 mm High

MANUFACTURER	TOKICO	TOKICO	TOKICO	TOKICO	TOKICO
DRIVE	DK502-3	DK503-2 TD5013	DK505-2 TD5025	TD5046 TD5046H	TD5087
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	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: Technology type	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST506/412	ST506/412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 26.6	U: 13.33	U: 25.5	U: 51.24	U: 96.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	8	4	4	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	612	615	1152
Track density (TPI)	360	360	670	650	1000
Maximum linear density (BPI)	9260	9260	9490	9500	10676
Rotational speed (RPM)	3600	3600	3600	3550	3550
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Linear, Band, Torque Motor	Linear, Band, Torque Motor
Average positioning time (msec)	85 (including settling)	85 (including settling)	85 (including settling)	40	35
Average rotational delay (msec)	8.3	8.3	8.3	8.45	8.45
Average access time (msec)	93.3	93.3	93.3	48.45	43.45
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	10/83	10/83	3/85	4/86	10/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		41 mm High	41 mm High	41 mm High H version has 28 ms average positioning time	41 mm High

MANUFACTURER	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION
DRIVE	MK-132FA	MK-53FB	MK-54FB	MK-56FB	MK-133FA
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 22.9	U: 43.2	U: 60.5	U: 86.5	U: 38.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	3	5	7	10	5
Heads per data surface	1	1	1	1	1
Tracks per surface	733	830	830	830	733
Track density (TPI)	930	900	900	900	930
Maximum linear density (BPI)	14600	9383	9383	9383	14600
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	25	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q87	3/85	3/85	3/85	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	$895	$1,020	$1,190	--
COMMENTS	41 mm High				41 mm High

MANUFACTURER	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION
DRIVE	MK-134FA	MK-153FA	MK-153FB	MK-182FB	MK-154FA
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ESDI	SCSI	SMD	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 53.4	U: 86.5	F: 74.8	U: 83.0	U: 121.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,832	F: 18,432	U: 20,160	U: 20,832
Data surfaces per spindle	7	5	5	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	733	830	830	823	830
Track density (TPI)	930	900	900	900	900
Maximum linear density (BPI)	14600	18766 BPI* 12510 FCI	18766 BPI* 12510 FCI	9,000 BPI* 6,000 FCI	18766 BPI* 12510 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	25	18	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	33.3	26.3	33.3
Data transfer rate (KBytes/sec)	625	1250	1250	1210	1250
FIRST CUSTOMER SHIPMENT	3Q87	4/86	9/86	2Q83	4/86
U.S. OEM PRICE FOR 100 UNITS	$790	$1,325	$1,435	$2,275	$1,430
COMMENTS	41 mm High	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION
DRIVE	MK-154FB	MK-156FA	MK-156FB	MK-184FB	MK-186FB
DISK/TREND GROUP	5	5	5	5	5
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	210 mm OD	210 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 105.2	U: 172.9	F: 150.8	U: 116.1	U: 165.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 20,832	F: 18,432	U: 20,160	U: 20,160
Data surfaces per spindle	7	10	10	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	830	830	830	823	823
Track density (TPI)	900	900	900	900	900
Maximum linear density (BPI)	18766 BPI* 12510 FCI	18766 BPI* 12510 FCI	18766 BPI* 12510 FCI	9,000 BPI* 6,000 FCI	9,000 BPI* 6,000 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	25	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	33.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1210	1210
FIRST CUSTOMER SHIPMENT	9/86	4/86	9/86	2Q83	4Q83
U.S. OEM PRICE FOR 100 UNITS	$1,535	$1,535	$1,675	$2,395	$2,635
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION
DRIVE	MK-283FC	MK-284FC	MK-256FA	MK-256FD	MK-285FC
DISK/TREND GROUP	5	5	6	6	6
MARKET	Captive, OEM	Captive, 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	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	ESDI	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 170.1	U: 238.2	U: 382.5	F: 338.4	U: 340.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 41,340	U: 41,340	U: 31,248	F: 27,648	U: 41,340
Data surfaces per spindle	5	7	10	10	10
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	1224	1224	823
Track density (TPI)	765	765	1330	1330	765
Maximum linear density (BPI)	19300 BPI* 12867 FCI	19300 BPI* 12867 FCI	27872 BPI* 18581 FCI	27872 BPI* 18581 FCI	19300 BPI* 12867 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	2480	2460	1875	1875	2460
FIRST CUSTOMER SHIPMENT	4/86	4/86	1Q88	1Q88	9/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code	*2,7 RLL Code

MANUFACTURER	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOYO SODA
DRIVE	MK-286FC	MK-287FC	MK-288FC	MK-388FA	Dart 130
DISK/TREND GROUP	6	6	7	7	5
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	Modified SMD	SMD	ESDI, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 374.3	U: 442.3	U: 510.3	U: 719.9	U: 129.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 41,340	U: 41,340	U: 41,340	U: 41,240	U: 20,160
Data surfaces per spindle	11	13	15	15	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	823	1161	916
Track density (TPI)	765	765	765	1000	1000
Maximum linear density (BPI)	19300 BPI* 12867 FCI	19300 BPI* 12867 FCI	19300 BPI* 12867 FCI	19528 BPI* 13019 FCI	18534
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	18	18	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	2460	2460	2460	2480	1209
FIRST CUSTOMER SHIPMENT	4/86	4/86	4/86	12/87	3Q87
U.S. OEM PRICE FOR 100 UNITS	$3,235	--	$4,195	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	

MANUFACTURER	TOYO SODA	TULIN	TULIN	TULIN	TULIN
DRIVE	Dart 170	TL226	TL240	TL326	TL340
DISK/TREND GROUP	5	3	3	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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: Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI, SCSI	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 166.2	U: 26.7	U: 40.0	U: 26.7	U: 40.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	9	4	6	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	916	640	640	640	640
Track density (TPI)	1000	656	656	656	656
Maximum linear density (BPI)	18534	10000	10000	10000	10000
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, band stepping motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	18	85 (including settling)	85 (including settling)	40 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	93.3	93.3	48.3	48.3
Data transfer rate (KBytes/sec)	1814	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q87	3/84	3/84	1986	1986
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		41 mm High Embedded Servo	41 mm High Embedded Servo	41 mm High Embedded Servo	41 mm High Embedded Servo

MANUFACTURER	UNISYS	UNISYS	UNISYS	UNISYS	UNISYS
DRIVE	9484-13	MD-3	MD-4	MD-8	9494-12
DISK/TREND GROUP	2	5	5	5	8
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	3336-11	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3330-11	Modified 3350	Modified 3350	Modified 3350	3380
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	Burroughs	Burroughs	Burroughs	Modified SMD	Burroughs
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	(3 Spindles) F: 405	(4 Spindles) F: 528	F: 250	F: 870
REMOVABLE	F: 252	--	--	--	--
Capacity per track (Bytes)	F: 16,200	F: 16,384	F: 16,000	F: 30,600	F: 32,781
Data surfaces per spindle	19	10	10	10	15
Heads per data surface	1	1	1	1	2
Tracks per surface	815	833	833	822	1768
Track density (TPI)	384	900	900	683	806
Maximum linear density (BPI)	6060	9000	9000	19734*	15240
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear Voice Coil
Average positioning time (msec)	28.50	28	28	18	16
Average rotational delay (msec)	8.33	8.3	8.3	8.3	8.3
Average access time (msec)	36.83	36.3	36.3	26.3	24.3
Data transfer rate (KBytes/sec)	1209	1210	1210	2400	3000
FIRST CUSTOMER SHIPMENT	1Q83	12/84	12/84	4Q86	1Q85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	B2900 B7900 B7800 B4900 A3,A9,A15 V300	XE5XX Mfg. by Toshiba	A3,A9,V300 B4500 Mfg. by Toshiba	*2,7 RLL Code Mfg.by Toshiba	B7900 B4900 A9,A10, A15,V300 Drive has two spindles

MANUFACTURER	UNISYS	VERMONT RESEARCH	XEBEC	XEBEC	YE DATA
DRIVE	9494-24	7030	Owl II	Owl 40X	3540
DISK/TREND GROUP	8	7	3	4	4
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Technology type	3380 x 2	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Burroughs	SMD	SASI	SASI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 1,740	U: 625.4	F: 21.3	F: 40	U: 53.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,781	U: 35,714	F: 8,704	F: 11,264	U: 10,416
Data surfaces per spindle	15	11	4	4	7
Heads per data surface	2	2	1	1	1
Tracks per surface	3538	1592	612	888	731
Track density (TPI)	1386	1217	736	800	1019
Maximum linear density (BPI)	16200*	20859 BPI* 13906 FCI	8845	13120	13200
Rotational speed (RPM)	3600	3000	3600	3662	3600
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Linear, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, DC Motor
Average positioning time (msec)	17	16**	65 (including settling)	65 (including settling)	29
Average rotational delay (msec)	8.3	10	8.3	8.2	8.3
Average access time (msec)	25.3	26	73.3	73.2	37.3
Data transfer rate (KBytes/sec)	3000	1800	625	625	625
FIRST CUSTOMER SHIPMENT	6/87	4Q87	4/86	8/87	--
U.S. OEM PRICE FOR 100 UNITS	--	$7,235	--	--	--
COMMENTS	*2,7 RLL Code Drive has two spindles	*2,7 RLL Code Embedded Servo **Maximum positioning time 22 ms.	41 mm High	41 mm High	41 mm High

MANUFACTURER	YE DATA				
DRIVE	3541				
DISK/TREND GROUP	4				
MARKET	OEM				
MEDIA: Generic type	Fixed				
Nominal disk diameter	95 mm OD 25 mm ID				
Recording medium	Thin Film				
DRIVE: Technology type	3370 (Ferrite)				
Heads	Ferrite				
Interface	SCSI				
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 44.9				
REMOVABLE	--				
Capacity per track (Bytes)	F: 7,680				
Data surfaces per spindle	8				
Heads per data surface	1				
Tracks per surface	731				
Track density (TPI)	1019				
Maximum linear density (BPI)	13200				
Rotational speed (RPM)	3600				
PERFORMANCE					
Actuator type	Rotary, DC Motor				
Average positioning time (msec)	29				
Average rotational delay (msec)	8.3				
Average access time (msec)	37.3				
Data transfer rate (KBytes/sec)	625				
FIRST CUSTOMER SHIPMENT	4Q87				
U.S. OEM PRICE FOR 100 UNITS	--				
COMMENTS	41 mm High Embedded Servo				

MANUFACTURER PROFILES

1987 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 "1986 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. "1986 total net sales" covers the fiscal year ending December 31, 1986, for each firm unless noted otherwise, or for the parent company if the disk drive manufacturer is a subsidiary. Northern Telecom is listed with U.S. firms for convenience.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars is given below. The average exchange rate for 1986 is used, as reported by the U.S. Federal Reserve Bulletin and rounded to three significant figures.

Country	Currency	Currency units per U.S. dollar
Canada	Dollar	1.39
France	Franc	6.93
Italy	Lira	1491.00
Japan	Yen	168.00
Korea	Won	885.00
Taiwan	Dollar	37.8
United Kingdom	Pound	0.681
West Germany	Deutsch mark	2.170

U.S. Manufacturers

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

Alpha Data is a privately held manufacturer of head-per-track disk drives. The firm has been trying for several years to develop the market for an unusual 14" moving head drive using plated disks. The current version has 520 megabytes capacity and 18 ms average access time, achieved by using 10 heads per data surface.

AMCODYNE
Division of Century Data Inc.
1301 South Sunset Street
Longmont, CO 80501

Organized in 1981 by a group of industry veterans with high performance disk drive experience at Storage Technology, Amcodyne started first shipments of its 8" disk cartridge drive (26 MB fixed/26 MB removable) in early 1983. The firm's second product, an 8" fixed disk drive with 224 megabytes capacity, was discontinued in 1985 before deliveries were started, in order to concentrate on the disk cartridge drive market. Because the market for Amcodyne's products was relatively small, the company had difficulty in generating enough revenue to support the development of new products, and in 1986 Amcodyne was acquired by Century Data.

AMPEX CORPORATION
401 Broadway
Redwood City, CA 94063

1986 total net sales: $11,749,000,000 Net income: $605,000

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

ATASI CORPORATION
2075 Zanker Road
San Jose, CA 95131

Atasi was started in 1981 by disk industry veterans to manufacture high capacity 5.25" Winchester fixed drives. The company was first to estab-

lish quantity production of voice coil 5.25" drives and managed to secure an attractive market share. However, initial design was costly compared to competitive products which followed, and Atasi failed to hold its initial lead. Atasi's agreed upon acquisition by Seagate fell through early in 1984, followed by a management reorganization. As cash problems became severe, the company entered Chapter 11 in August, 1985, but maintained operations with a small staff. Atasi emerged from Chapter 11 in 1986 and in the spring of 1987, Atasi was acquired by Tandon. In the future, Tandon plans to manufacture the Atasi line at its Singapore facilities.

BRAND TECHNOLOGIES, INC.
6140 Variel Avenue
Woodland Hills, CA

Brand Technologies was formed in 1986 to develop high performance 5.25" Winchester drives by Avi Brand, a veteran of Pertec and Computer Memories. 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. Current products include 85 and 128 megabyte full height drives. In mid 1987, Brand concluded an agreement with Hyosung Computer, a Korean firm, in which Hyosung obtained a 25% interest in Brand. In addition, Hyosung will manufacture drives for Brand in Korea and distribute the drives in the Far East on an exclusive basis.

CARDIFF PERIPHERALS CORPORATION
5421 Avenida Encinas
Carlsbad, CA 92008

Cardiff Peripherals was formally organized in 1987 with Canadian financial backing, the result of several years of product development activity by industry veteran Frank Lutz, first with 5.25" drives, later with 3.5" drives. The firm is introducing in the fall of 1987 a family of high performance 3.5" drives with up to 127 megabytes capacity.

CENTURY DATA, INC.
2055 Gateway Place
San Jose, CA 95110

1986 disk sales: $20,400,000

After several years of flat sales, Century Data Systems was sold in mid-1986 by Xerox to Cybernex Corporation. Cybernex had been restructured after a agreement with IBM, which included divestiture of all head manufacturing operations, and has evolved into Century Data, Inc, parent company for Century Data Systems and Cybernex Advanced Storage Technology (CAST), plus other companies since acquired: Amcodyne, Tecstor, and Ford-

Higgins, a subsystem producer. The Century Data Systems product line has been in transition for years, as newer fixed disk drives gradually replaced products in production before the acquisition by Xerox in 1979. Century is pinning its future hopes on higher capacity fixed disk drives introduced during the past three years, including 8" drives with capacities up to 830 megabytes, plus product lines of the newly acquired firms.

COGITO (See Asian Manufacturers)

COMPUTER MEMORIES, INC.
9233 Eton Avenue
Chatsworth, CA 91311

1986 disk sales: $11,300,000

CMI started shipments of 5.25" fixed Winchester drives in 1981. IBM became CMI's largest customer in 1984, with major purchases of 20 megabyte drives used in the PC AT. During 1985 and 1986 CMI's IBM business sometimes exceeded 80% of the firm's total. The burden of keeping IBM happy proved to be too much for CMI -- development of future products suffered badly. When IBM stopped buying at the end of 1985, CMI had few products suitable for the 1986 OEM market. The firm also found it necessary to settle an expensive patent infringement lawsuit with Quantum, with the payment of $6 million and an agreement to discontinue certain disk drives. After struggling for several months with the problem, CMI's management announced in June, 1986, that the firm had dropped all disk drive manufacturing. In March, 1987, the firm announced its intention to merge with Hemdale, a film producer, and henceforth be known by that name.

CONNER PERIPHERALS, INC.
2221 Old Oakland Road
San Jose, CA 95131

Conner Peripherals is pioneering the market for high performance 3.5 inch Winchester disk drives. The firm is headed by Finis Conner, co-founder of Seagate Technology, and the firm's first product was designed by a development company organized by John Squires, until early 1985 a key member of the Miniscribe technical staff. The company has attracted a minority investment by Compaq Computer and has installed a high-volume production facility in San Jose, with first shipments in August, 1986, of a 40 megabyte 3.5" drive. By mid-1987, shipments, mostly to Compaq, had reached high levels, and facilities were already being expanded. In addition to adding another facility at the original site, Conner has acquired a second plant to manufacture a newly announced 100 megabyte 3.5" drive, and is also planning to start production in Singapore.

CONTROL DATA CORPORATION
8100 - 34th Avenue South
Minneapolis, MN 55440

1986 disk sales: $1,192,800,000
1986 total net sales: $3,347,000,000 Net income: ($264,500,000)

Control Data is now the second largest producer of OEM rigid disk drives, after the firm's share of worldwide OEM revenues fell to 15.3% in 1986, after a continuing decline from 1980's peak of 55%. But after seven years of watching its role as the leader in OEM disk drives gradually evaporate, Control Data appears to have stabilized its position. During the last three years CDC has managed to maintain a flow of major new 14", 9", 8", 5.25" and 3.5" drives, to replace those which have been declining in shipments. The company became the dominant OEM drive supplier in the 1970's on the strength of successful product lines in 14" disk cartridges, storage module drives, large disk pack drives, plus mid-range and large fixed disk drives. But many of the older OEM drives peaked in shipments years ago, and CDC went through a long dry spell, before management changes refocused resources on new product start up activities. Disk drives sold by Control Data are designed and manufactured by Magnetic Peripherals, Inc., a joint venture. In 1987, CDC purchased Unisys' 13% interest in MPI, which now gives CDC an 80% share. Honeywell retains its 14% share and Bull a 6% share. Control Data manages the joint venture and has exclusive responsibility for sales of its products in the OEM market. Drives made by MPI for sale with any of the parent company's systems are considered captive CDC drives for the purposes of DISK/TREND statistics, and captive drives for parent companies are a significant portion of MPI shipments. Control Data was a participant in the plug compatible disk drive market for several years, but its late start in the 3380 market prompted the firm to phase out of the PCM market in 1985. Until 1986, CDC also was the managing partner in Optical Storage International, an optical disk joint venture with Philips. However, this organization has now been renamed, with majority control in Philips' hands.

DATA GENERAL CORPORATION
4400 Computer Drive
Westboro, MA 01581

1986 disk sales: $120,000,000
1986 total net sales: $1,268,000,000 (FY ending 9/30/86) Net income: $5,700,000

Data General manufactured all disk drive requirements internally for years, covering its requirements with several captive disk cartridge, disk pack and 14" Winchester drives. Despite the addition to its product line of several drives purchased from outside disk drive manufacturers, Data General has continued with introduction of internally developed drives, adding low end 8" drives in 1982, plus a 354 megabyte 14" fixed drive in 1983, subsequently extended to 592 megabytes in late 1984. Disk drive manufacturing is now located in a new facility at Durham, New Hampshire.

DATA-TECH MEMORIES, INC.
2350 Shasta Way
Simi Valley, CA 93065

Data-Tech Memories was founded by Leonard Caprino, a former engineering manager at Computer Memories, to concentrate on low cost 85 megabyte 5.25" drives. The firm made its first shipments in early 1987, and currently plans to expand production capability at its facility in Simi Valley, California.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1986 disk sales: $629,900,000
1986 total net sales: $7,590,000,000 (FY ending 6/30/86) Net income: $617,000,000

Until the 1980s, most revenues from DEC's internally manufacturerd disk drives were derived from disk cartridge drives, notably the high volume RL02 and its predecessors. However, in 1981 a new family of 14" Winchester drives appeared. The RA81, a 14" rack mounted Winchester drive with a formatted capacity of 456 megabytes has been the big revenue producer for DEC in recent years. The other drive in the group is the RA60, a rack mounted disk pack drive with 205 megabytes formatted capacity. These were DEC's first internally designed and produced high end disk drives, and the manufacturing startup for the drives and their controller was painful, but significant to the firm's profitability. Starting in early 1987, the company has been delivering the follow-on to the RA81, the 622 megabyte RA82, initially only in a four spindle version, later in a single spindle model. In late 1983, DEC started shipping the RC25 "Aztec", a long-delayed 8" disk cartridge drive, superseding the 14" RL02 -- perhaps too late to maintain the company's disk cartridge drive market at its previous size. DEC became a major customer for voice coil actuator 5.25" drives manufactured by both Micropolis and Maxtor, but is now producing the captive RA70, expected to be only the first model in a series of high-end 5.25" drives to come during future years.

DISC TECH ONE
849 Ward Drive
Santa Barbara, CA 93111

In 1982 Disc Tech One acquired from M/A-Com the Ohio Scientific disk drive operation (previously owned by Okidata). In 1984 the firm merged with Lifetech Industries Corporation, a San Diego hearing aid manufacturer, but Disc Tech One was later re-established as a separate company. The firm is now devoting most of its resources to development and manufacture of disk subsystems for personal computers, and in 1986, ceased manufacturing disk drives to concentrate upon subsystems and drive repairs.

DMA TECHNOLOGIES
601 Pine Avenue
Goleta, CA 93117

DMA Systems started shipments of its 5.25" 5/5 MB 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. Later, capacities were doubled on the fixed/removable drives, and an 11 MB half high was introduced. Manufacturing licenses were sold to Memorex, which later discontinued all OEM disk drive operations, and also to Newbury Data, Ricoh, and MFM, all of which are producing drives. However, the market was slower to respond to DMA's product and pricing than the firm had anticipated. DMA ran out of funds and was forced to cease operations by its bank, in August, 1985, but re-established production a few months later. By mid-1986, the bank had been paid off and the firm has restarted operations as DMA Technology.

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

1986 disk sales: $251,400,000
1986 total net sales: $7,102,000,000 (FY ending 10/31/86) Net income: $516,000,000

Hewlett-Packard has an extensive manufacturing operation for captive disk drives at Boise, Idaho, established in 1977 and since expanded, supplemented in mid-1983 with a new $50 million facility in Bristol, England, and by production of 3.5" Winchester drives at Greeley, Colorado. H-P makes disk cartridge, disk pack, and fixed Winchester disk drives at Boise, which is also the firm's development facility for advanced head and disk technology. During 1987 H-P introduced 5.25" drives with capacities up to 389 megabytes and 8" drives with up to 571 megabytes. The sputtered disks used in 3.5", 5.25" and 8" drives are produced at Boise. Also during 1987, the company launched an OEM sales program for rigid disk drives, spearheaded by the new 5.25" and 8" models.

IBIS SYSTEMS, INC.
5775 North Lindero Canyon Drive
Westlake Village, CA 91360

1986 disk sales: $40,000,000

Ibis was one of the most ambitious of the industry's many start up companies from the early 1980's, with a plan to make OEM and PCM versions of a 3380 equivalent drive. After finding that the technical complexities of such a project are very real, and having learned the extent of the resources needed to launch an adequate sales and service organization, Ibis changed its strategy to concentrate on a parallel data transfer version of the drive. This plan has paid off, and Ibis is now the leader in parallel transfer drives used with supercomputers and high end imaging systems.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1986 disk sales: $6,519,400,000
1986 total net sales: $51,250,000,000 Net income: $4,789,000,000

IBM is now manufacturing 14", 8", 5.25" and 3.5" fixed disk drives at several factories in the United States, Europe, Japan and Brazil. The revenue leader in all of this activity is clearly the 3380 family, with single capacity (1981), double capacity (1985) and triple capacity (1987) models all still in production. Positioned below the 3380, IBM introduced the 9335, a 14" drive with 855 megabytes, and the 9332, two 8" models with 200 or 400 megabytes, in mid-1986 to replace the older 3370/3375 series. The newest drive is a 314 megabyte 5.25" model announced for delivery with high-end personal computers in early 1988. IBM's first significant OEM sales of disk drives were made in 1984, and involved the 3380 -- both Siemens and Honeywell are buying the drive. For disk drives broadly sold on an OEM basis, it will be more difficult for IBM to establish a significant OEM disk drive business due to tough competition and a rapidly changing market -- but the firm is making a strenuous effort to sell newer models to major system manufacturers and is quoting low prices. IBM has begun to use industry standard interfaces for products that have some OEM potential, but it is a two edged sword. While making IBM products more saleable, it improves the ability of other vendors to sell drives that can attach to IBM systems.

IBM is still a significant buyer of OEM disk drives, primarily small diameter drives for personal computer systems, but the totals are down from the peak of a few years ago. IBM is still buying large quantities to supplement apparent shortfalls in its own production, but internal manufacturing for small diameter disk drives has gone into high gear at IBM: The firm made a large portion of its requirements for 5.25" drives for the PC XT and PC AT, and is making all of its 3.5" drives for the PS/2 product series. 30, 40 and 70 megabyte voice coil 5.25" drives are now in production, and 115 and 314 megabyte drives have been announced. Internal production of stepping motor 5.25" drives was phased out in the autumn of 1986.

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

Josephine County Technology was started by disk drive industry veterans trying to escape the smog of San Fernando Valley. The firm started production at the close of 1984 with half high 5.25" Winchester drives, designed to be produced at extremely low cost. The company's activities have been on a small scale, so far, limited by a lack of financing, but production is slowly increasing.

LAPINE TECHNOLOGY CORPORATION
182 Topaz Avenue
Milpitas, CA 95035

1986 disk sales: $24,900,000

LaPine Technology was formed in July, 1983, to develop 3.5" Winchester drives. The company was a case study in creative financing for the disk drive industry, during a period of scarce venture capital funding. The repertoire of financing techniques included limited R&D partnerships, inventory financing (Prudential Bache), and an offshore partner for manufacturing and further equity investment (Kyocera). LaPine's 3.5" drives were produced by Kyocera in Japan. In mid-1987, LaPine shut down almost all activities as a result of legal disputes between LaPine and Kyocera, and it is expected that the firm will cease all operations by the end of 1987.

MAXTOR CORPORATION
150 River Oaks Parkway
San Jose, CA 95134

1986 disk sales: $148,300,000
1986 total net sales: $175,299,000 (FY ending 3/31/87) Net income: $34,609,000

Maxtor startled its competitors in 1982 by announcing a family of 5.25" drives with up to 140 megabyte capacity. These drives went into production in mid-1983, later joined by 190 megabyte drives in 1984 and 380 megabyte drives in 1985. Maxtor became the first company to find space in the standard 5.25" form factor for eight disks, and thus was able to achieve up to 190 megabytes while maintaining the standard Seagate transfer rate of five megabits per second -- a strategy which proved successful in making available an immediate market 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 de facto interface standard, now widely used for high performance 5.25" drives. Maxtor is now the leader in high end 5.25" Winchesters despite early skepticism by competitors, and has maintained its place in the spotlight by announcing a 765 megabyte 5.25" drive, which started shipping in 1987, and a 170 megabyte 3.5" drive, currently promised for mid-1988. In 1987, the firm received wide attention in the industry for shipment delays in newer models of its 380 and 765 megabyte drives, caused by a shortfall in promised deliveries of thin film heads. Maxtor has added another thin film head supplier, and hopes to get back on plan by early 1988.

MEMOREX CORPORATION
611 South Milpitas Boulevard
Milpitas, CA 95035

Memorex was acquired by Burroughs in late 1981, and Burroughs placed all disk drive development and manufacturing responsibility for the entire company in the Memorex organization. In late 1986, however, Burroughs sold the disk drive sales and service operations of Memorex to a group of senior Memorex executives, retaining only the rigid disk development and manufacturing operations. Memorex, now headquartered in London, includes PCM marketing operations, the Memorex Communications Division, and the flexible media operations.

MFM, INC.
360 Merrimack Street
Lawrence, MA 01843

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

MICROCOMPUTER MEMORIES, INC.
6855 Vineland Avenue
North Hollywood, CA 91605

1986 disk sales: $3,100,000

MMI was formed quietly in 1982 to develop a 3.5" Winchester drive, and managed to go public in January, 1984, before the big 1984 decline in technology stocks. The firm started shipping a 10 megabyte drive in 1984 and a 4-platter 20 megabyte version in 1985. After a year of growing shipments, mostly to personal computer subsystem manufacturers, the firm ran out of cash and filed Chapter 11 bankruptcy proceedings in May, 1986. Attempts to refinance were unsuccessful and MMI filed final bankruptcy proceedings under Chapter 7 in 1987.

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1986 disk sales: $210,800,000
1986 total net sales: $213,000,000 Net income: $18,300,000

Known as the originator of high capacity 5.25" flexible disk drives, Micropolis entered the 8" Winchester disk drive market in 1979, and became a factor in the marketplace, after the usual Winchester early production

problems. The company has embarked on an ambitious development program for small high performance Winchester disk drives, and has become a market leader in high capacity 5.25" drives -- the first firm to establish volume deliveries of 85 megabyte models. Micropolis has been the 5.25" industry leader at 85 megabytes and 170 megabytes, and is also expected to be in contention for leadership at 380 megabytes.

MICROSCIENCE INTERNATIONAL CORPORATION
777 Palomar Avenue
Sunnyvale, CA 94086

1986 disk sales: $63,600,000

Microscience International was formed early in 1982 by experienced disk drive engineering managers. The firm started shipments in mid-1983 for its half high 5.25" 10 megabyte drive, and added a 20 megabyte version in mid-1984, both using plated disks, and with several innovative design features intended to improve reliability. 3.5" drives were also added to the line, including both OEM and card-mounted versions. A half high voice coil 5.25" drive with 50 megabytes capacity was added in early 1986, followed by drives with up to 144 megabytes capacity. The firm has joined with the Wearnes organization to establish a manufacturing facility in Singapore, now in production on stepping motor drives, and has started production in Taiwan for voice coil drives.

MICRO STORAGE CORPORATION
2986 Oakmead Village Court
Santa Clara, CA 95051

Micro Storage was formed in 1984 to produce a 5.25" half high disk cartridge drive, with founders from Santa Clara Valley and funding from Omron Tateisi Electronics Company Ltd, Kyoto. First production shipments were made in mid-1985, with manufacturing by Omron. However, Omron withdrew funding from the venture as a result of unfavorable exchange rates, and Micro Storage ceased operations in December, 1986.

MILTOPE CORPORATION
1770 Walt Whitman Road
Melville, NY 11747

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

MINISCRIBE CORPORATION
1871 Lefthand Circle
Longmont, CO 80501

1986 disk sales: $175,400,000
1986 total net sales: $184,861,000 Net income: $6,102,000

Production of Miniscribe's 5.25" Winchester drives started in late 1981, stayed at modest levels through most of 1982, then soared in late 1982 as IBM started taking 5.25" Winchester deliveries for the personal computer program. Other major OEM customers were subsequently added, and the company has maintained a strong position in non-captive shipments of 5.25" Winchester drives below 30 megabytes. It's not been an easy life, however, with drastic changes in IBM's procurements in 1984, coupled with the adverse fortunes of some of Miniscribe's customers which lost market share in the personal computer wars to IBM. Miniscribe started shipping half high 5.25" drives in the first half of 1983, and added 20 megabyte 3.5" drives in late 1984 and 85 megabyte 5.25" drives in 1985. As of mid-1987, the product line extended to 380 megabytes.

But in spite of Miniscribe's success in new product development, business problems caused by loss of IBM's purchases in early 1985 led to the departure of the founding management, to be replaced by a trouble-shooting team installed by Hambrecht & Quist, the investment banking firm which led a rescue financing operation. The new management focused on new products, with a tough cost control program, and recent quarterly results show that Miniscribe has returned to profitability. Concurrently, Miniscribe has succeeded in introducing extensive robotics into its production lines, resulting in a very efficient assembly process. Production facilities are in Singapore and Colorado.

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

1986 disk sales: $19,600,000
1986 total net sales: $4,384,000,000 Net income: $313,000,000

Northern Telecom's Memory Systems Division in Ann Arbor, Michigan, is shipping a family of high performance 8" Winchester drives, with capacities now up to 563 megabytes. These drives are used for captive applications with Northern Telecom and are supported with an active OEM sales program.

PERIPHERAL TECHNOLOGY, INC.
685 East Cochran Street
Simi Valley, CA 93065

Peripheral Technology was founded in 1985 to develop and market a high capacity 3.5" Winchester drive first shipped in the second half of 1986, with founders who had worked together at Dataproducts, then acquired various disk drive experience. 70% of PTI was owned by Haitai International, a Korean consumer products company, but in mid-1987, this interest was sold to Live Systems, a Japanese company serving the medical market. Production will be done in a Korean facility, with initial production runs contracted to Oriental Precision. OPC will also serve as a second source once PTI's own Korean production begins. Additional production will be done in the U.S. in existing facilities.

PERTEC PERIPHERALS CORPORATION
Subsidiary of Digital Development Corp
20400 Plummer Street
Chatsworth, CA 91311

1986 disk sales: $5,200,000

Pertec, a pioneer manufacturer of OEM 14" disk cartridge drives, was acquired by Triumph Adler in early 1980. After struggling to bring its disk drive line up to date, the initial 8" Winchester drives announced a few years ago were dropped in favor of a new series of 8" high capacity drives which now extends to 731 megabytes capacity. The disk cartridge line has been phased out. Olivetti purchased Triumph Adler in 1986 and sold Pertec to Digital Development Corp almost immediately thereafter.

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

The Plus Hardcard is an innovative plug-in card for the IBM personal computer aftermarket, combining a 3.5" Winchester and all controller electronics on a single add-in card. The original version, first shipped in October, 1985, was 10 megabytes, supplemented in 1986 with a 20 megabyte model and in 1987 by a 40 megabyte model. The Hardcard has attracted a flood of competition, both from other disk drive manufacturers and from firms specializing in the personal computer aftermarket. Both types of competitors were able to quickly enter the market, by combining controller boards with 3.5" drives already in production. Quantum set up Plus as a separately operated subsidiary, in order to provide concentration on the special design requirements involved and to establish a specialized marketing and sales organization targeted at the PC market. Manufacturing has been contracted out to Matsushita Kotobuki Electronics.

PRIAM CORPORATION
20 West Montague Expressway
San Jose, CA 95134

1986 disk sales: $120,000,000
1986 total net sales: $128,756,000 (FY ending 6/30/86) Net income: $59,000,000

Priam became a significant supplier of OEM Winchester disk drives in 1981, as volume production was achieved for the firm's original line of mid-range 14" drives and shipments of 8" drives got underway. 8" Winchesters with capacities up to 344 megabytes eventually became the firm's leading products. After abortive efforts to enter the high capacity 5.25" market, Priam acquired Vertex Peripherals in early 1985, with its successful 5.25" product line. However, Priam was slow to penetrate the market for high end 5.25" drives and the firm's management was reorganized in 1986, apparently in an attempt to focus on this area. The 5.25" product line now extends to 380 megabytes. In 1987, Priam began manufacturing drives in Taiwan, the largest U.S. disk drive manufacturer yet to do so.

QUANTUM CORPORATION
1804 McCarthy Boulevard
Milpitas, CA 95035

1986 disk sales: $115,000,000
1986 total net sales: $120,760,000 (FY ending 3/31/87) Net income: $8,806,000

Quantum's original game plan was to provide a low-cost upgrade to the Shugart Associates 8" Winchester drives. The Quantum plan worked very well, and 5.25" drives with capacities up to 40 megabytes were added in 1983, becoming the company's major product. As the Quantum full size 40 megabyte 5.25" drives peaked, the firm announced half high OEM 5.25" drives with up to 80 megabytes capacity, for delivery before the end of 1985. First shipment of these drives was late, however, and Quantum's sales growth has flattened out for the moment. In 1985, the company established Plus Development as a wholly owned subsidiary to pioneer development and marketing of unique 3.5" drives for the personal computer market, and Plus products have provided the majority of Quantum's revenues in recent quarters. In 1987, Quantum announced that it would terminate its 160 megabyte 5.25" development effort because it was still behind schedule. The 3.5" high-end market is Quantum's new target.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1986 disk sales: $708,300,000
1986 total net sales: $958,065,000 Net income: $139,741,000
(FY ending 6/30/87)

The term "Seagate compatible" has become part of the industry's language. In 1981, Seagate shipped two thirds of the 5.25" drives produced worldwide, with 35,000 units -- and another de facto standard was created. In 1982, Seagate's many new competitors nibbled the company's worldwide share of low end 5.25" Winchesters down to 40%, and by 1985 the Seagate market share was down to 24.4%. Seagate has taken 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 has stayed profitable, rebuilt its revenues, and in 1986 became the worldwide leader in OEM disk drive revenues.

Seagate is attempting to diversify into higher capacity 5.25" drives, but during the last two years a major part of the firm's growth has come from the personal computer aftermarket. After IBM cut back purchases of Seagate stepping motor drives in favor of internal captive production, Seagate launched a successful campaign to take the business away from IBM at the dealer level, with phenomenal success. The company remains vulnerable to the changes IBM has made in the PC attachment opportunity for disk drives, by "bundling" hard disk drives with systems at the factory instead of giving dealers an easy opportunity to upgrade with independent disk drives. However, Seagate has already demonstrated the resiliency likely to be necessary for future survival.

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

1986 disk sales: $129,500,000
1986 total net sales: $696,000,000 Net income: $17,000,000

After great success in the second half of the 1970's as the leader in plug compatible disk drives, STC's shipments dropped in 1982/1983, as IBM 3380 shipments started in earnest. STC's volume shipments of 3380 equivalent drives didn't start until early 1984, too late to save the company from failures in its other new business areas. The firm's management had launched expensive programs to build mainframe computers and optical disk drives -- and had acquired firms in other areas, with extensive bank borrowing. In October, 1984, the bankers wouldn't wait, and the company was thrown into Chapter 11. Disk drive order rates have suffered because of the loss of credibility brought on by bankruptcy, but improved with the availability of the STC double capacity 3380 equivalent drive in mid-1986.

After a series of complex negotiations with creditors, the firm emerged from bankruptcy in mid-1987. Orders for STC's innovative 1/2" tape cartridge library system have been very strong, and if this program is executed well, it will go a long way to restoring STC's position in the storage products industry.

SYQUEST TECHNOLOGY
47923 Warm Springs Boulevard
Fremont, CA 94538

1986 disk sales: $28,600,000

SyQuest was started in early 1982 to make disk drives using 3.9" (100 mm) plated disks, in both fixed and removable disk configurations. SyQuest's plan was extremely ambitious, but the firm didn't get into volume production with a reliable drive until late 1983. After initial early emphasis on the personal computer aftermarket, SyQuest has established significant OEM sales, with major shipments to the segment of the PC market controlled by governmental security requirements. The firm is now emphasizing a new removable 5.25" drive with formatted capacity of 44 megabytes, using an embedded SCSI controller.

TANDON CORPORATION
20320 Prairie Street
Chatsworth, CA 91311

1986 disk sales: $176,300,000
1986 total net sales: $214,080,000 (FY ending 6/30/86) Net income: ($62,773,000)

Tandon's growth rate in flexible disk drives made the company the world's largest manufacturer of floppy drives in the early 1980's, and the firm launched a bid to become a major supplier of 5.25" Winchester drives, eventually supplemented with 3.5" drives. Consistent with the firm's philosophy of maximum practical vertical integration, Tandon internally manufactures a very high proportion of its drives' content, including plated disks. In contrast to its largest 5.25" Winchester competitors, Seagate and Miniscribe, Tandon was not able to sell these products to IBM, and was late in establishing production for half high models. Tandon underwent a drastic change in company strategy during 1985-86, and attempted to establish itself as a major personal computer manufacturer. In early 1987, Tandon introduced a removable 3.5" Winchester disk drive for use with personal computers, and in April, 1987, acquired Atasi to broaden its product line with voice coil 5.25" high capacity drives.

TECSTOR, INC.
16161 Gothard Street
Huntington Beach, CA 92647

Tecstor acquired rights in 1981 to a 14" Winchester drive developed by BASF in Europe, but never placed in quantity production. Tecstor's shipments started at the end of 1981, with a family of high performance 14" fixed disk drives offering capacities in the 300 megabyte range. After concluding that the modest production level available for this product line was not adequate to maintain profitability, Tecstor concentrated its resources in a line of parallel transfer drives using the same head disk assemblies. The firm was acquired in 1987 by Century Data, Inc.

TULIN CORPORATION
2393 Qume Drive
San Jose, CA 95131

1986 disk sales: $11,100,000

Tulin started production shipments of its family of half high 5.25" Winchester disk drives in March, 1984, with capacities up to 40 megabytes. Though the founders had disk drive industry background and were well funded by ITT, the relatively slow 85 millisecond average access time of the initial models hurt sales. The management eventually bought out ITT's interest in the firm, and established a licensing and contract manufacturing arrangement with Oki Electric, in order to step up production for the planned faster drives. This arrangement was the victim of rapid changes in the dollar/yen exchange rate, which made Tulin's landed cost for drives made under the Oki Electric contract prohibitively expensive. Tulin retreated into Chapter 11, and the Oki Electric contracts were abrogated in the bankruptcy proceedings. Tulin is now manufacturing disk drives with a skeleton crew at the original San Jose facility.

UNISYS CORPORATION
Burroughs Place
Detroit, MI 48232

1986 disk sales: $233,500,000
1986 total net sales: $7,432,000,000 Net income: ($43,000,000)

After many years of captive disk drive production, Burroughs acquired Memorex in late 1981. All Burroughs disk drive operations were then consolidated in the firm's Memorex subsidiary, including production of captive drives. Internally manufactured drives sold with Burroughs systems on a captive basis consist of 3330 and 3380 plug compatible models from the Memorex product line, now equipped with controllers for use with Burroughs systems. First deliveries of the firm's 3380 equivalent drive were made in mid-September, 1983, as promised -- but various technical problems kept the production level below plan. One of the first major projects at

Memorex under Burroughs management, already satisfactorily completed, was development of controllers to make possible the use of large Memorex disk drives with Burroughs systems -- thus creating another sizeable market for Memorex drives, a captive one.

The 1986 acquisition of Sperry by Burroughs has led to changes in the combined company's strategy toward data storage; while the disk drive manufacturing operations were retained, flexible media and the plug compatible marketing and service operations of Memorex were sold to the operation's management. Unisys then sold its 13% interest in the Magnetic Peripherals, Inc., joint venture to Control Data, the managing parter. In late 1986, the firm trimmed several U.S. manufacturing operations, but in 1987 Unisys announced a plant in Singapore, which will make large disk drives.

VERMONT RESEARCH CORPORATION
Precision Park
North Springfield, VT 05156

1986 total net sales: $4,600,000 (FY ending 9/30/86) Net income: ($3,260)

VRC has been primarily a manufacturer of head-per-track disk drives and magnetic drum memories, with manufacturing both in Vermont and England. Lower demand for these memory devices has caused flat sales and a shrinkage in the company's staff. A 14" high capacity disk cartridge drive with embedded servo was produced for several years for militarized computer systems. In 1983, VRC started shipping fixed/removable and removable-only disk cartridge drives using the Dysan 8" disk cartridge. Because both of these product lines had very small sales, the company has stopped production and has announced a high performance 625 megabyte 8" drive for late 1987 availability.

WESTERN DYNEX CORPORATION
3536 West Osborn Road
Phoenix, AZ 85019

Western Dynex managed to stay profitable in the 14" disk cartridge drive business longer than most others, because of its highly efficient, low cost manufacturing operation. But OEM shipments of disk cartridge drives below 12 megabytes capacity are almost only a memory, and Western Dynex elected to enter the 5.25" disk cartridge race. The drive used the Dysan 5.25" cartridge, and was originally intended to be Seagate compatible. Rather than emphasize OEM sales, Western Dynex developed subsystems aimed at specific vertical markets, and has since stopped manufacturing the drive.

XEBEC
3579 Highway 50 East
Carson City, NV 89701

1986 disk sales: $6,500,000
1986 total net sales: $116,000,000 Net income: ($3,500,000)

Xebec's management has been looking for an entry point into the disk drive manufacturing business for years, as an extension of the firm's success in producing high-volume controllers. In 1984, several programs were launched, including purchase of the Datapoint Sunnyvale operations, the Epelo start-up for high performance 5.25" disk drives, and the Owl, an internally manufactured half high 5.25" drive with an embedded SASI interface. However, Xebec ran short on the cash required to fund all of its expansion programs, and only the Owl remains currently active.

Asian Manufacturers

(All fiscal years end in March, 1986 unless otherwise noted. Firms are in Japan unless otherwise noted.)

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

1986 total net sales: $2,141,125,000 Net income: $53,351,000

Alps Electric is a high growth manufacturer of electronic components and sub-assemblies for television, audio, instruments and computer applications. The firm builds floppy disk drives on an OEM basis, notably for Apple Computer, and started production in the U.S. in 1987. In 1985, Alps introduced a line of 5.25" half-high and 3.5" rigid disk drives. In 1986, Alps became the first manufacturer to announce a 30mm high 3.5" drive. A 25.4 mm high, 20 megabyte drive was announced in 1987. A variant of this product is used as a removable disk drive that fits in a half high 5.25" enclosure.

COGITO SYSTEMS CORPORATION
Subsidiary of Ching Fong Investment Co., Ltd.
180 Chung Hsiao E. Rd., Sec. 4
Taipei, Taiwan

Cogito started operations in 1982 in California with funding from Ching Fong Investments, Ltd., a Taiwan organization which also owns Magnex, a head manufacturer. Cogito's first products have been low-end half high 5.25" Winchester drives. Production started in mid-1983, but shipments remained small, and all operations are now located in Taiwan.

EPSON (See Seiko Epson)

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

1986 disk sales: $21,300,000
1986 total net sales: $3,132,571,000 Net income: $31,333,000

Fuji Electric was established in 1923 and is the firm from which Fujitsu was born in 1935. Fuji Electric still owns about 16% of Fujitsu. The firm manufactures power generating equipment, electrical equipment for the transportation sector, vending machines and instrumentation. Data storage products include sputtered media and 3.5" disk drives. Fuji Electric has

provided contract manufacturing services to Fujitsu and Nippon Peripherals for 5.25" and 3.5" drives. The firm began selling 3.5" drives under its own name in 1985.

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

1986 disk sales: $1,104,100,000
1986 total net sales: $10,070,392,000 Net income: $231,702,000

Fujitsu derives about 72% 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 has skillfully managed a transition from older removable disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters.

Fujitsu has aggressively marketed most of its captive drives in OEM versions, using industry standard OEM interfaces, and is now a leader in the U.S. market for OEM rigid disk drives. Particularly effective in the OEM market have been the high performance 8" 48/84/168/337/690 megabyte drives, and the 10.5" "Eagle" series of high performance drives with up to 3.0 MB/sec transfer rate. Fujitsu is also a major factor in the IBM plug compatible disk drive market with sales of Eagle series drives through Amdahl. Fujitsu has begun manufacturing its high performance drives at a new facility near Portland, Oregon, and is expected to increase the output of this factory at a rapid rate.

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

1986 disk sales: $642,300,000
1986 total net sales: $29,824,160,000 Net income: $892,154,000

Hitachi is Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. The firm currently makes a wide range of Winchester technology fixed disk drives which are sold as captive drives with Hitachi computer systems and, in several cases, as OEM drives. In addition to significant OEM sales of smaller capacity fixed disk drives, Hitachi also sells IBM compatible 3380 equivalent drives to National Advanced Systems for distribution with NAS systems in the U.S., and in 1983 started selling 3380 equivalent drives for distribution in the European PCM market through BASF, and currently through Comparex, the joint venture PCM vendor owned by BASF and Siemens. Hitachi was the first independent disk drive supplier to ship a double capacity product equivalent to the IBM 3380E. In the spring of 1987,

Hitachi began shipping rigid disk drives from a manufacturing facility in Norman, Oklahoma. It will make 8" and 14" rigid drives and a line of 5.25" optical disk drives. Also in 1987, Hitachi announced a 380 megabyte 5.25" drive as well as filling in its line with several lesser capacity half height 5.25" drives.

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

1986 disk sales: $24,000,000
1986 total net sales: $4,167,636,000 Net income $64,833,000

JVC's revenues are generated mostly by consumer electronics products. The firm has been the beneficiary of sharp growth in the home video recorder market and VTRs now account for almost 62% of total revenues. Matsushita Electric Industrial holds 50.6% ownership. JVC is now expanding into computer peripherals, starting in 1984 with 5.25" floppy disk drives, a program since de-emphasized due to small market share and unfavorable exchange rates. 3.5" rigid drives were first shipped in 1985, and the present 3.5" product line includes a 25.4 mm high drive aimed at the portable computer market. JVC began to ship CD-ROM drives in 1987.

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

1986 total net sales: $1,661,327,000 Net income: $109,434,000

Kyocera is the world's largest manufacturer of ceramic packages for integrated circuits, and also makes a variety of electronic and optical components. As the result of an investment and manufacturing agreement with LaPine Technology, Kyocera started production in 1986 of LaPine's 3.5" drives and shipped significant quantities until mid-1987. In late 1986, Kyocera and Prudential Bache, both of which had been minority shareholders in Lapine, purchased the remainder of the firm, with Kyocera obtaining one third ownership and Prudential Bache two thirds. Due to the shifting exchange rate, Kyocera was not able to meet Lapine's quantity requirements profitably, and a shortfall in shipments occurred. Inability of the partners to agree on a mutually satisfactory course of action resulted in a suit against Kyocera by Lapine. Lapine's operations were subsequently halted, but the corporate shell remains, under Prudential Bache control, to prosecute the Kyocera suit.

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

1986 disk sales: $17,800,000
1985 total net sales: $1,791,410,000 (FY ending 11/30/85) Net income: $64,392,000

Matsushita Communication Industrial is a member of the Matsushita Electric industrial group, a worldwide giant in appliances and electronics. MCI was the licensee for Shugart Associates' flexible disk drives in Japan and most of the Shugart floppy models for the Japanese OEM market. In 1981, MCI added several Winchester technology fixed disk drives, including low end 5.25" drives. 3.5" Winchesters were added to the product line in 1985. MCI has also acquired the U.S. distribution rights for the 5.25" half height floppy disk drive made under the Shugart license. As of mid-1987, the 3.5" line extends to 53 megabytes and the 5.25" half height line to 117 megabytes.

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

1986 disk sales: $54,100,000
1986 total net sales: $12,556,446,000 Net income: $178,851,000

In addition to being one of Japan's largest electronic and electrical products manufacturers, Mitsubishi Electric is a leader in the domestic small business systems market. The company is ending production of a variety of removable disk types and has begun making small and mid-range Winchester technology drives at a highly automated facility near Osaka. Captive shipments have been the major portion of Mitsubishi's disk drive shipments, but the firm is now emphasizing OEM business in small diameter Winchester drives. 3.5" low end drives, 5.25" low end and midrange drives, and 8" drives to 408 megabytes are in production as of mid-1987.

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

1986 disk sales: $1,047,700,000
1986 total net sales: $13,896,833,000 Net income: $161,815,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 40% of the firm's total revenues. Current disk drive production involves fixed disk drives, from large to small configurations, for both captive and OEM markets. Fixed disk drives include 14", 9", 8", 5.25" and 3.5" disk diameters, with large scale production for several small diameter drives. Sales of the smaller

drives have been very strong as a result of success in the OEM market and the strong position of NEC in the Japanese personal computer market. NEC, Fujitsu, and NTT have jointly developed a 2.2 gigabyte drive using thin film technology. The drives will be packaged to make up capacities as large as 8.8 gigabytes using multiple spindles.

NIPPON ELECTRIC INDUSTRY CO., LTD.
19-18, Tsutsumi-dori 1-chome
Sumida-ku, Tokyo 131

1986 disk sales: $9,000,000
1986 total net sales: $143,809,000 Net income: 33,416,000

Nippon Electric Industry (NEC owns 34.5% of the firm) is known in Japan by its tradename, Densei. The company produces power supplies for communications and computer equipment, automatic control systems and other electronic equipment. Recent efforts have centered upon office and factory automation equipment made for NEC. It manufactured magnetic drum memories for several years. Densei entered the OEM disk drive market with 5.25" Winchesters of its own design, and introduced half high models. However, since December, 1986, production has been dedicated to NEC.

NIPPON PERIPHERALS LIMITED
660 Miyamae, Fujisawa-shi
Kanagawa-ken 251

1986 disk sales: $38,700,000

Fujitsu and Hitachi owned NPL equally as a joint venture. NPL's charter was to develop advanced disk drives and other magnetic peripherals, and developed its own versions of most IBM new disk drives introduced since the 3340. In recent years, Fujitsu and Hitachi de-emphasized the role of NPL, and the firm was shut down in the Spring of 1987. The major portion of NPL's independent sales were to BASF, for resale as PCM drives in Europe, and to Memorex, which marketed 3370 equivalent drives in Europe and the U.S. These shipments were treated as PCM shipments by NPL in DISK/TREND statistics to avoid distortion of PCM market totals.

NIPPON SYSTEMHOUSE CO., LTD.
Nakajima Building
1-8-1, Kitashinjuku
Shinjuku-ku, Tokyo

Nippon Systemhouse acquired a license in late 1983 to manufacture the SyQuest line of fixed and removable 3.9" disk drives, and to market them in Japan. The firm is a manufacturer of medical systems, and terminals produced for Burroughs in Japan. The executive staff includes a number of

ex-Burroughs managers. Nippon Systemhouse started disk drive production in 1984 and concentrated on the subsystems market in Japan. Drive production has been nominal.

OKI ELECTRIC INDUSTRY CO., LTD.
1-17-12, Toranomon
Minato-ku, Tokyo 105

1986 total net sales: $2,336,952,000 Net income: ($5,755,000)

Oki is a diversified manufacturer of electronic communications and data processing equipment, and also has a major role in the Japanese market as a terminal producer. For several years, the firm emphasized floppy drives, and made 8" one sided floppy drives for captive use and 5.25" one third high drives for both OEM and captive use. In 1985, Oki obtained rights from Tulin to manufacture and market the Tulin 5.25" half high rigid disk line on a worldwide basis. Production began in early 1986 on a captive basis for Tulin, but as a result of the strong yen, the price to Tulin increased to the point where the firm was non-competitive and had to file for Chapter 11 protection. A bankruptcy court subsequently terminated the Oki/Tulin supply contract, although Oki has continued to supply a few drives to meet warranty requirements. As a result, Oki is now considering other methods of distributing its rigid disk products.

OMRON TATEISI ELECTRONICS CO.
10, Hanazono-Tsuchidocho
Ukyoku, Kyoto 616

1986 total net sales: $1,449,988,000 Net income: $15,327,000

Omron is best known as a manufacturer of electronic controls and electronic fund transfer systems. The firm attempted to make an entry into the data storage products industry through an investment in Micro Storage Corporation, which had designed a 5.25" cartridge disk drive. The drive was to have been made in volume by Omron, which began shipments to Micro Storage in mid-1986, but unfavorable exchange rates and the limited size of the market forced a termination of the effort in January, 1987.

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

OPC, founded in 1953, is one of Korea's pioneering firms in the electronics industry. It is a major supplier of telecommunications equipment, video systems, and a volume producer of CRT terminals. OPC is producing a 3.9" cartridge disk drive on a contract manufacturing basis for SyQuest, plus 3.5" drives for Peripheral Technology, and is actively seeking additional manufacturing business.

OTARI ELECTRIC CO., LTD.
29-18, Minami Ogikubo 4-chome
Suginami-ku, Tokyo 167

Otari is a specialized manufacturer of professional audio tape decks and high speed tape duplicating systems. Shortly before its acquisition by CCT, Rotating Memory Systems (later Disctron) entered into a manufacturing agreement with Otari to produce the 5.25" Winchester drives for sale in Japan. Otari started production of the orginal RMS full size drive in 1983, and has since added half high models on its own. Otari production in 1986 was nominal.

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

1986 disk sales: $8,800,000
1986 total net sales: $3,534,875,000 Net income: $92,000,000

Copiers, sensitized papers and photographic equipment provide the major portion of Ricoh's revenues, but the firm has been investing in a growing line of data processing equipment since 1979. Its first products were 8" floppy drives made under a license from Calcomp, but the expanding line now includes several types of printers, plus 5.25" and 3.5" floppy disk drives used in both captive and OEM applications. In 1985, Ricoh obtained a license to make the DMA 5.25" cartridge disk drive design, and production began in 1986. An expanded capacity version has since been introduced. When DMA encountered major financial difficulties, Ricoh became the major source for the drive. Ricoh has also been successful with a write-once+ optical drive marketed in the U.S. by Maxtor.

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

1986 disk sales: $86,500,000

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also control Japan's Seiko companies, known for watches and electronics. Epson is best known for its dot-matrix printers, but also manufactures a portable computer, displays, line printers, paper tape equipment and floppy disk drives. In 1985, Epson introduced a line of half-high 5.25" rigid disks with capacity to 20 megabytes. Epson has since broadened its product line to include 3.5" drives, plus 40 and 80 megabyte 5.25" drives.

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

Shinwa Digital is a manufacturer of electronic components and equipment, including cash registers, calculators, medical systems, printers and keyboards. The company started shipping half high 5.25" drives in 1986, and added 3.5" drives in 1987.

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

1986 total net sales: $8,012,398,000 Net income: $249,333,000

Sony's growth in the consumer electronics market has become more difficult as saturation looms in sectors of the market, and the firm's management has made it clear that expansion in office products is a major company objective. Several computer systems have been announced in recent years, and the company has achieved a worldwide impact with the 3.5" microfloppy, which has become an industry standard. Sony's microfloppy drive and media shipments have grown, first as Hewlett-Packard selected the drive for its personal computers, then as Apple chose the drive for its Macintosh systems. Sony proposed a 2.0 megabyte 3.5" media standard in 1985, which has also become an industry standard, with help from IBM, which selected the media standard, but not Sony's drives, for the PS/2 product line. The firm's first entry into the rigid disk drive market came last year, with half high 5.25" SCSI drives offering up to 40 megabytes formatted.

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

In 1986, Tatung began shipments under its own name of 5.25" half high Winchester disk drives made under license from Xebec. The firm has been making similar drives for Xebec under a contract manufacturing agreement. Relatively few have been produced to date, and most of these have been shipped to Xebec.

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

1986 total net sales: $457,083,000 (FY ending 9/30/86) Net income: ($595,000)

TEAC has taken steps in recent years to expand into computer peripherals, in recognition of slow growth in the worldwide market for quality audio tape decks, its previous major product area. Computer peripherals now

account for about 66% of sales, mostly in floppy disk drives. TEAC has shipped 5.25" flexible disk drives since 1978. In 1982, TEAC acquired a manufacturing license from Seagate Technology for its 5.25" Winchester disk drives, with rights to market the drives in Japan and the Far East. The firm added a 12 megabyte half high drive in 1983, followed by a 25 megabyte version in 1985 and 50 megabytes in 1986. Concentration in floppy disks and the strong dollar have combined to hurt TEAC: in the last two years, the firm operated at a loss.

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

1986 disk sales: $32,500,000
1986 total net sales: $607,964,000 Net income: $12,327,000

Tokico, a member of the Hitachi group, is a manufacturer of automotive equipment, including shock absorbers, brakes and air compressors. Factory automation is a newly developed product area. The company is manufacturing a 5.25" Winchester fixed disk drive similar to the NPL NP05, with versions of the Tokico drive sold separately by Hitachi and by the Hitachi group trading company, Nissei Sangyo. A half high version went into production in late 1983. As of mid-1987, the product line extended to drives of 51 megabytes capacity. Tokico has begun to market its disk drive products under its own name.

TOKYO ELECTRIC CO., LTD
2-6, Naka-Meguro
Meguro-ku, Tokyo 153

1986 total net sales: $1,214,726,000 Net income: $21,773,000

Tokyo Electric is a member of the Toshiba group (Toshiba has 50.6% ownership), and manufactures electronic cash registers, POS systems, household appliances and a growing family of data processing products, notably printers. In 1982, the firm started producing 5.25" floppy drives and added 3.5" floppy drives in 1984. The first 5.25" Winchesters were shipped in 1985, but the firm was unable to establish itself as a major Winchester disk drive producer and the program has been discontinued.

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

1986 disk sales: $132,000,000
1986 total net sales: $20,077,113,000 Net income: $353,809,000

Toshiba is a major factor in consumer electric and electronic products, plus a wide range of industrial electronic products and heavy electric power equipment. The company also has a leading position in the Japanese

office computer market. Disk drives supplied by Toshiba include rigid, floppy and optical drives. Rigid disk drive production is concentrated in captive products, primarily newer Winchester technology fixed disk drives in low and mid-range capacities, in 8", 5.25", and 3.5" disk diameters. Toshiba's presence in the U.S. OEM rigid disk market was strongly enhanced when it acquired the OEM disk drive operations of Memorex from Burroughs, and Toshiba has continued to strengthen its U.S. operations. Still uncertain in mid-1987 is the impact of possible U.S. Congressional retaliatory tariffs imposed in response to shipments to the U.S.S.R. of sensitive equipment by a Toshiba subsidiary

TOYO SODA MANUFACTURING CO., LTD.
1-7-7 Akasaka
Minato-ku, Tokyo 107

1986 total net sales: $1,467,642,000 Net income: $27,619,000

Toyo Soda is a manufacturer of materials for use in the electronics industry, including sputtered thin film media for 3.5" and 5.25" rigid disk drives. The firm is also preparing to begin manufacturing in mid-1987 a drive based upon the designs of now defunct Applied Information Memories. 130, 170, and 250 megabyte drives have been announced, but production of the 250 megabyte unit has been deferred to a later date.

YE DATA, INC.
Subsidiary of Yaskawa Electric Mfg. Co., Ltd.
1-1 Higashi-Ikebukuro 3-chome
Toshima-ku, Tokyo 170

1986 total net sales: $240,214,000 Net income: $6,101,000

Yaskawa Electric produces primarily heavy electrical machinery and automation equipment. YE Data is best known for its line of floppy disk drives, with the firm's biggest success coming in 1984 when it was selected by IBM as supplier for the 1.6 megabyte 5.25" drive used in the PC AT. At the 1986 NCC show, YE Data's 3.5" 50 megabyte drive was introduced by C. Itoh Electronics, a major importer of Japanese electronic industry products for the U.S. market. Floppy drives remain the largest part of YE Data's business.

European Manufacturers

BASF AG
D-6700 Ludwigshafen
West Germany

1986 disk sales: $11,600,000
1986 total net sales: $19,840,000,000 Net income: $419,000,000

BASF is one of the world's chemical giants, and a pioneer manufacturer of magnetic recording media. Since the early 1970's, BASF has been a disk drive manufacturer, starting with a license from the old Century Data Systems to make 2314 type drives. Even after dropping production of drives for the mainframe market, the company continued to be a significant factor in the European PCM market by reselling 3350 and 3380 equivalent drives made by Hitachi. In late 1986, Siemens and BASF agreed to create a joint venture company, Comparex Informationssysteme GmbH, to market the plug compatible peripherals that BASF and Siemens were purchasing from Japanese manufacturers and remarketing in Europe. Comparex began operations in January, 1987. Internal BASF manufacturing of rigid drives, limited to 5.25" and 3.5" in the last few years, will cease in 1987.

BULL PERIPHERALS
94, Avenue Gambetta
75960 Paris Cedex 20
France

1986 disk sales: $44,900,000
1986 total net sales: $2,569,400,000 Net income: $39,100,000

In 1982, France's socialist government established control of Cii-Honeywell Bull by taking over Compagnie de Saint-Gobain, which held a majority interest. Honeywell Information Systems' previous 47% share of Cii-HB was reduced to 19.9%, and Compagnie des Machines Bull became the parent company for several operating units in the Bull Group, including Bull Peripherals. In April, 1987, Bull, Honeywell, and NEC concluded an agreement whereby Honeywell sold off its computer operations to create a jointly owned venture, Honeywell Bull, to be headquartered in Minneapolis. At present, Bull and Honeywell each own 42.5%, and NEC owns 15%. During recent years, Bull's production of its unusual 10.5" "Cynthia" rigid disk drives continued, but 5.25" drives have been emphasized. Production in France of 5.25" Winchester drives started in 1982, for captive and OEM distribution in Europe. A 5.25" disk cartridge drive was added in 1983. Bull has a cross-licensing arrangement with Vertex (now Priam) under which the organization has been manufacturing high capacity 5.25" drives. In mid-1986, Bull decided to cease marketing disk drives in the U.S., due to unfavorable exchange rates and a generally weak position in the market, and in 1987, Bull decided to end its disk drive manufacturing activities.

COMPAREX INFORMATIONSSYSTEME GMBH
Joint venture of BASF and Siemens
Gottlieb-Daimler-Strasse 10
D-6800 Mannheim
West Germany

Comparex became operational at the beginning of January, 1987, as a new joint venture operation comprising the former BASF and Siemens PCM businesses. The joint venture will market systems and peripherals made by Fujitsu and Hitachi. Current disk drive activities involve only PCM 3380 equivalent drives produced by Hitachi.

ISOT
51, Chapaev St.
Sofia, Bulgaria

1986 disk sales: $148,800,000

Disk drives manufactured by ISOT, the Bulgarian state computer organization, are exported throughout Eastern Bloc countries by Isotimpex, the foreign trade organization for Bulgarian computer equipment and other electronic products. Isotimpex is currently marketing drives compatible with IBM 2314 and 3330 disk pack drives, plus disk cartridge drives and 14" 80, 100, and 200 megabyte disk pack drives. ISOT, which operates disk drive factories with perhaps the highest level of vertical integration to be found anywhere in the disk drive industry, began production of 14", 8" and 5.25" Winchester drives in late 1985.

KOVO
Jankovcova 2
17088 Praha 7
Czechoslovakia

KOVO is the Czechoslovakian import/export agency with jurisdiction over that country's trade in computers and related products. Included in the current product line are computers and peripheral equipment manufactured by Zbrojovka Brno and Aritma, both diversified manufacturing operations. 14" disk cartridge and disk pack drives are produced in small quantities.

LEXICON S.P.A. (Previously Olivetti Peripheral Equipment)
Subsidiary of Ing. C. Olivetti & C., S.p.A.
via Torina, 603
10090 S. Bernardo d'Ivrea (Torino)
Italy

1986 disk sales: $185,100,000
1986 total net sales: $4,908,000,000 Net income: $379,000,000

Olivetti's current management has undertaken numerous changes to modernize the company's product lines and delete older lines. The Olivetti

Peripheral Equipment organization represented a consolidation of the firm's printer and disk memory activities in 1980. This organization has established production for 5.25" and 3.5" Winchester disk drives at Ivrea, with both captive and OEM markets in mind. The biggest impact on Olivetti during the past few years was purchase of a 25% share in the company by American Telephone and Telegraph, and adoption of an Olivetti-designed personal computer for distribution by AT&T. Production of small disk drives for this program has been underway at Ivrea, resulting in rapid growth in rigid disk drive production. All portions of the Rotating memories Division of OPE were combined to form a new subsidiary, Lexicon, in February, 1987.

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

1986 disk sales: $14,700,000

Newbury Data is the current name for the organization known previously as Data Recording Equipment, or DRE. Disk drives were manufactured for several years by a joint venture company owned by DRI, its parent firm, and Magnetic Peripherals, Inc., the U.S. disk drive development and manufacturing firm managed by Control Data. When the joint venture was dissolved in 1983, DRI regained ownership. Newbury Data is now placing emphasis on newer disk drives, some produced under manufacturing licenses with U.S. firms. Newbury Data has produced 5.25" disk cartridge drives under a DMA Systems license, and is also in production on Maxtor high capacity 5.25" drives under a license from that firm. In 1986, Newbury began shipments of a 3.5" drive with 50 megabytes capacity.

NIXDORF COMPUTER AG
Furstenallee 7
4790 Paderborn
West Germany

1986 total net sales: $2,075,000,000 Net income: $102,300,000

Nixdorf has maintained a high rate of overall company growth during recent years, and the firm has undertaken various programs to control costs through internal manufacturing programs. Nixdorf manufactured storage module drives in Berlin, West Germany, under a license from Control Data, for captive shipment with Nixdorf systems until 1987, and is starting production for its own internally developed 8" and 5.25" Winchester drives. The smaller drives will receive emphasis in the future.

RODIME LIMITED
Nasmyth Road
Southfield Industrial Estates
Glenrothes, Fife KY6 2SD
Scotland

1986 disk sales: $87,400,000
1986 total net sales: $96,000,000 (FY ending 9/30/86) Net income: ($1,200,000)

Rodime is a rare European phenomenon: A successful 5.25" OEM disk drive start up company, which proceeded to become the first disk drive manufacturer to achieve large volume production of 3.5" Winchester drives. 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 have increasingly relied on shipments of 3.5" drives, which it was the first to ship in 1983. The company has announced 170 megabyte half-high 5.25" drives and high capacity 8" and 3.5" models, but has been slow to establish production. Perhaps as a way of offsetting disappointing sales, Rodime surprised the industry by obtaining patent coverage on the concept of a 3.5" drive -- claiming no new technology, only a reduction in size. The firm then sued Miniscribe and Conner Peripherals for patent infringement. When IBM announced the PS/2 family, which uses 3.5" drives, it sued Rodime to invalidate the patent, and Rodime bravely met the challenge by countersuing IBM for patent infringement.

SAGEM
(Societe d'Applications Generales d'Electricite et de Mecanique)
6 Avenue d'lena
75783 Paris CEDEX 16
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.

SIEMENS AG
Communications Group
St. Martin-strasse 76
D-8000 Munchen 80
West Germany

1986 total net sales: $21,659,000,000 (FY ending 9/30/86) Net income: $691,000,000

After many years of producing rigid disk drives of its own design for captive use with its mainframe systems, Siemens has now closed out its 14" disk drive manufacturing program in Munich. Several disk pack drives and

a large fixed disk drive for captive use were phased out in favor of outside purchases of high performance drives, including IBM's 3380. In the meantime, Siemens has developed a 5.25" Winchester disk drive with capacities up to 300 megabytes, and started deliveries in early 1986. Siemens is selling the drive in the U.S. and European OEM disk drive markets, and has set up a marketing organization to pioneer the high-end 5.25" disk drive market. In late 1986, Siemens and BASF agreed to create a joint venture company, Comparex Informationssysteme GmbH, to market the plug compatible peripherals that BASF and Siemens were purchasing from Japanese manufacturers and remarketing in Europe. Comparex began operations in January, 1987.