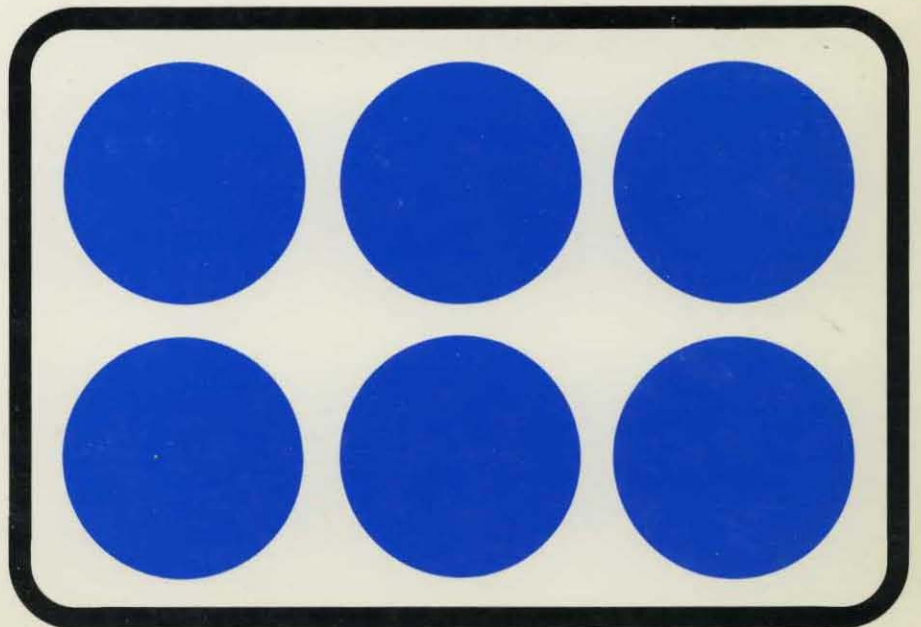


1988 DISK/TREND[®] REPORT

RIGID
DISK
DRIVES



1988 DISK/TREND[®] REPORT

RIGID DISK DRIVES

October, 1988

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

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

© Copyright 1988 by DISK/TREND, Inc. All rights reserved. No portion of this report may be reproduced in whole or in part without written permission. All information included is believed to be reliable but cannot be guaranteed to be complete or correct. DISK/TREND is a trademark registered in the United States Patent and Trademark Office.

FOREWORD

The conventional wisdom in the disk drive industry holds that the number of participating companies is destined to shrink as the total annual revenue builds to new heights. However, in 1988 actual events haven't followed this plan.

A number of companies have dropped out of the disk drive business. But six companies from the United States have entered the industry, together with two each from Japan and South Korea. All together, there are 63 active rigid disk drive manufacturers this year, compared to 60 last year. Perhaps we'll lose a few more next year, but if not the theory may have to be revised.

This is the twelfth year of the DISK/TREND Report, which 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

	<u>Page</u>
INTRODUCTION	SUM-1
SUMMARY	SUM-2
Industry size	SUM-2
Marketing channels	SUM-4
Product mix	SUM-6
OEM market	SUM-10
TECHNICAL REVIEW	SUM-16
Competing technologies	SUM-16
Disk drive enhancements	SUM-25
DEFINITIONS	SUM-29
DISK CARTRIDGE DRIVES	DT1-1
DISK PACK DRIVES	DT2-1
FIXED DISK DRIVES, LESS THAN 30 MEGABYTES	DT3-1
FIXED DISK DRIVES, 30-60 MEGABYTES	DT4-1
FIXED DISK DRIVES, 60-100 MEGABYTES	DT5-1
FIXED DISK DRIVES, 100-300 MEGABYTES	DT6-1
FIXED DISK DRIVES, 300-500 MEGABYTES	DT7-1
FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE	DT8-1
FIXED DISK DRIVES, MORE THAN 1 GIGABYTE	DT9-1
RIGID MAGNETIC DISK DRIVE SPECIFICATIONS	RSPEC-1
MANUFACTURER PROFILES	MFGR-1
DISK/TREND ON DISK	DTDISK-1

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1 CONSOLIDATED WORLDWIDE REVENUES, All Rigid Magnetic Disk Drive Groups	SUM-3
2 CONSOLIDATED WORLDWIDE REVENUES, Rigid Magnetic Disk Drives, Market Class Review	SUM-5
3 CONSOLIDATED WORLDWIDE REVENUES, Rigid Magnetic Disk Drives, Product Category Review	SUM-8
4 CONSOLIDATED WORLDWIDE SHIPMENTS, Rigid Magnetic Disk Drives, Product Category Review	SUM-9
5 OEM WORLDWIDE REVENUES, Rigid Magnetic Disk Drives, Product Category Review	SUM-12
6 OEM WORLDWIDE SHIPMENTS, Rigid Magnetic Disk Drives, Product Category Review	SUM-13
7 1986 MARKET SHARES, Manufacturers of Rigid Magnetic Disk Drives	SUM-14
8 CURRENT PRODUCT LINES, Manufacturers of Rigid Magnetic Disk Drives	SUM-15
9 DISK CARTRIDGE DRIVES Revenue Summary	DT1-7
10 DISK CARTRIDGE DRIVES Unit Shipment Summary	DT1-8
11 DISK CARTRIDGE DRIVES Revenue Breakdown by Disk Diameter	DT1-9
12 DISK CARTRIDGE DRIVES Shipment Breakdown by Disk Diameter	DT1-10
13 DISK CARTRIDGE DRIVES Applications Summary	DT1-11

LIST OF TABLES (Continued)

<u>Table</u>	<u>Page</u>
14 DISK CARTRIDGE DRIVES Market Share Summary, Non-Captive Drives	DT1-12
15 DISK PACK DRIVES Revenue Summary	DT2-5
16 DISK PACK DRIVES Unit Shipment Summary	DT2-6
17 DISK PACK DRIVES Revenue Breakdown by Disk Diameter	DT2-7
18 DISK PACK DRIVES Shipment Breakdown by Disk Diameter	DT2-8
19 DISK PACK DRIVES Application Summary	DT2-9
20 DISK PACK DRIVES Market Share Summary, Non-Captive Drives	DT2-10
21 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES, Revenue Summary	DT3-9
22 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES, Unit Shipment Summary	DT3-10
23 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES, Revenue Breakdown by Disk Diameter	DT3-11
24 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES, Shipment Breakdown by Disk Diameter	DT3-12
25 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES, Application Summary	DT3-13
26 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES, Market Share Summary, Non-Captive Drives	DT3-14
27 FIXED DISK DRIVES, 30-60 MEGABYTES, Revenue Summary	DT4-9
28 FIXED DISK DRIVES, 30-60 MEGABYTES, Unit Shipment Summary	DT4-10
29 FIXED DISK DRIVES, 30-60 MEGABYTES, Revenue Breakdown by Disk Diameter	DT4-11

LIST OF TABLES (Continued)

<u>Table</u>	<u>Page</u>
30 FIXED DISK DRIVES, 30-60 MEGABYTES, Shipment Breakdown by Disk Diameter	DT4-12
31 FIXED DISK DRIVES, 30-60 MEGABYTES, Application Summary	DT4-13
32 FIXED DISK DRIVES, 30-60 MEGABYTES, Market Share Summary, Non-Captive Drives	DT4-14
33 FIXED DISK DRIVES, 60-100 MEGABYTES, Revenue Summary	DT5-7
34 FIXED DISK DRIVES, 60-100 MEGABYTES, Unit Shipment Summary	DT5-8
35 FIXED DISK DRIVES, 60-100 MEGABYTES, Revenue Breakdown by Disk Diameter	DT5-9
36 FIXED DISK DRIVES, 60-100 MEGABYTES, Shipment Breakdown by Disk Diameter	DT5-10
37 FIXED DISK DRIVES, 60-100 MEGABYTES, Application Summary	DT5-11
38 FIXED DISK DRIVES, 60-100 MEGABYTES, Market Share Summary, Non-Captive Drives	DT5-12
39 FIXED DISK DRIVES, 100-300 MEGABYTES, Revenue Summary	DT6-7
40 FIXED DISK DRIVES, 100-300 MEGABYTES, Unit Shipment Summary	DT6-8
41 FIXED DISK DRIVES, 100-300 MEGABYTES, Revenue Breakdown by Disk Diameter	DT6-9
42 FIXED DISK DRIVES, 100-300 MEGABYTES, Shipment Breakdown by Disk Diameter	DT6-10
43 FIXED DISK DRIVES, 100-300 MEGABYTES, Application Summary	DT6-11
44 FIXED DISK DRIVES, 100-300 MEGABYTES, Market Share Summary, Non-Captive Drives	DT6-12
45 FIXED DISK DRIVES, 300-500 MEGABYTES, Revenue Summary	DT7-7

LIST OF TABLES (Continued)

<u>Table</u>	<u>Page</u>
46 FIXED DISK DRIVES, 300-500 MEGABYTES, Unit Shipment Summary	DT7-8
47 FIXED DISK DRIVES, 300-500 MEGABYTES, Revenue Breakdown by Disk Diameter	DT7-9
48 FIXED DISK DRIVES, 300-500 MEGABYTES, Shipment Breakdown by Disk Diameter	DT7-10
49 FIXED DISK DRIVES, 300-500 MEGABYTES, Application Summary	DT7-11
50 FIXED DISK DRIVES, 300-500 MEGABYTES, Market Share Summary, Non-Captive Drives	DT7-12
51 FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE, Revenue Summary	DT8-7
52 FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE, Unit Shipment Summary	DT8-8
53 FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE, Revenue Breakdown by Disk Diameter	DT8-9
54 FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE, Shipment Breakdown by Disk Diameter	DT8-10
55 FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE, Application Summary	DT8-11
56 FIXED DISK DRIVES, 500 MEGABYTES-1 GIGABYTE, Market Share Summary, Non-Captive Drives	DT8-12
57 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE, Revenue Summary	DT9-7
58 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE, Unit Shipment Summary	DT9-8
59 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE, Revenue Breakdown by Disk Diameter	DT9-9
60 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE, Shipment Breakdown by Disk Diameter	DT9-10
61 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE, IBM and PCM Disk Drives, Product Mix	DT9-11

LIST OF TABLES (Continued)

<u>Table</u>	<u>Page</u>
62 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE, Application Summary	DT9-12
63 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE, Market Share Summary, Non-Captive Drives	DT9-13

FIGURES

<u>Figure</u>	<u>Page</u>
1 CHANGING PRODUCT MIX, Consolidated Rigid Disk Drive Shipments	SUM-7

INTRODUCTION

One of the DISK/TREND product groups has been split 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 are now doing so, for the second consecutive year. Somehow, when we reorganized several DISK/TREND product groups last year, we didn't quite finish the job. The previous 30-100 megabyte group was getting crowded, and it failed to differentiate between the separate clusters of drives in high and low ends of the group. So the old product group has been split into two new groups, at the 60 megabyte level. No other product groups are affected.

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, 30-60 megabytes
5. Fixed disk drives, 60-100 megabytes
6. Fixed disk drives, 100-300 megabytes
7. Fixed disk drives, 300-500 megabytes
8. Fixed disk drives, 500 megabytes - 1 gigabyte
9. Fixed disk drives, more than 1 gigabyte

This information will help you use the report

- * All disk drive revenues are reported at the level of the first public sale, at the estimated transaction price, whether the sale occurs at the captive end user, PCM or OEM levels.
- * All unit totals are given in spindles. A disk drive containing two spindles is counted in DISK/TREND statistics as two spindles, except for some plug compatible drives which are counted in units equivalent in capacity to corresponding IBM drive models.
- * 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 DRIVESIndustry size

Many manufacturers have been buffeted during 1988 by undercapacity to produce rising new products and overcapacity to make sinking old products, as well as the continuing difficulties with component sourcing, exchange rates, and finding cash for expansion. Nevertheless, the industry's growth continues, even if the rewards are not distributed evenly among the participants. Total rigid disk drive revenue for 1987 was \$16.6 billion, with 1991 forecasted at \$30.6 billion, averaging 16.7% per year.

The 1987 revenue total fell \$1.5 billion below last year's forecast, with the shortfall primarily in older captive models from IBM and other U.S. captive drive manufacturers. But even with the forecasting shortfall, 1987's revenue total was 13.7% above the previous year, due mostly to solid growth for OEM drives.

1988's revenue increase is expected to be up again, 23.2% higher than 1987. U.S. captive revenues are climbing again, with production increases for several new models from IBM, Digital Equipment, Hewlett-Packard and Data General. OEM drive revenues also continue to grow, reflecting this year's 36.8% boost in worldwide unit shipments, to 14,192,200 drives.

The excellent outlook through 1991 for total revenues will favor some segments of the industry over others. New captive drives yet to be announced by IBM and other U.S. companies will keep U.S. captive revenues growing faster than the industry average. Some of these same new drives, however, will help to continue the seesaw sales pattern for plug compatible models, as PCM producers scramble to keep up with IBM. As usual, OEM drive growth will continue, favoring those with major new products.

TABLE 1
CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		-----Forecast-----							
	Revenues		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	4,186.7	6,727.7	5,774.4	8,961.8	7,336.3	11,269.5	8,548.3	13,176.8	9,780.0	15,104.4
Other U.S. Captive	828.6	1,445.7	961.8	1,599.4	1,372.2	2,318.0	1,689.5	2,809.5	1,753.3	2,955.4
TOTAL U.S. CAPTIVE	5,015.3	8,173.4	6,736.2	10,561.2	8,708.5	13,587.5	10,237.8	15,986.3	11,533.3	18,059.8
PCM	168.6	232.8	148.4	232.7	84.4	160.9	103.5	192.0	173.9	286.4
OEM	2,659.1	3,681.3	3,067.0	4,619.5	3,512.8	5,279.9	3,715.1	5,618.4	3,940.0	6,026.3
TOTAL U.S. NON-CAPTIVE	2,827.7	3,914.1	3,215.4	4,852.2	3,597.2	5,440.8	3,818.6	5,810.4	4,113.9	6,312.7
TOTAL U.S. REVENUES	7,843.0	12,087.5	9,951.6	15,413.4	12,305.7	19,028.3	14,056.4	21,796.7	15,647.2	24,372.5
Non-U.S. Manufacturers										
Captive	206.3	2,422.7	132.1	2,601.0	305.8	2,534.2	421.1	2,615.7	538.2	2,606.9
PCM	176.7	412.7	194.5	430.7	323.3	639.8	374.0	701.7	502.5	831.8
OEM	641.7	1,687.5	741.9	2,016.7	940.3	2,490.6	1,035.9	2,759.2	1,068.0	2,805.3
TOTAL NON-U.S. REVENUES	1,024.7	4,522.9	1,068.5	5,048.4	1,569.4	5,664.6	1,831.0	6,076.6	2,108.7	6,244.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	8,867.7	16,610.4	11,020.1	20,461.8	13,875.1	24,692.9	15,887.4	27,873.3	17,755.9	30,616.5

Marketing channels

Reversing a long term trend, the number of disk drive manufacturers has actually increased in 1988. This edition of the DISK/TREND Report lists 63 companies now in production or with announced products, compared with the 60 included last year.

The U.S. disk drive manufacturers now number 35, an increase of one over 1987. There are actually six new names on the list, with deletions due to the departure of companies with negligible production or sale of a product line, as in the case of Tandon's sale of its disk drive product line to Western Digital. Most of the new entrants, both U.S. and non-U.S. firms, are concentrating on small diameter low-end drives. The Asian manufacturer list has increased by two, with the drop-outs having little or no production. New Asian firms include Samsung Electronics and Goldstar Telecommunications, from South Korea, plus Kyocera and Mitsumi Electric, from Japan.

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.

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.

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

WORLDWIDE REVENUES BY MANUFACTURER TYPE	-----1987-----		-----1988-----		-----1989-----		Forecast-----1990-----		-----1991-----	
	Revenues \$M	%	\$M	%	\$M	%	\$M	%	\$M	%
U.S. Manufacturers -----										
IBM Captive	6,727.7 +4.8%	40.5%	8,961.8 +33.2%	43.7%	11,269.5 +25.8%	45.6%	13,176.8 +16.9%	47.2%	15,104.4 +14.6%	49.3%
Other U.S. Captive	1,445.7 -24.0%	8.7%	1,599.4 +10.6%	7.8%	2,318.0 +44.9%	9.3%	2,809.5 +21.2%	10.0%	2,955.4 +5.2%	9.6%
PCM	232.8 +43.8%	1.4%	232.7 --	1.1%	160.9 -30.9%	.6%	192.0 +19.3%	.6%	286.4 +49.2%	.9%
OEM	3,681.3 +47.8%	22.1%	4,619.5 +25.5%	22.5%	5,279.9 +14.3%	21.3%	5,618.4 +6.4%	20.1%	6,026.3 +7.3%	19.6%
Total U.S. Manufacturers	12,087.5 +10.1%	72.7%	15,413.4 +27.5%	75.1%	19,028.3 +23.5%	76.8%	21,796.7 +14.5%	77.9%	24,372.5 +11.8%	79.4%
Non-U.S. Manufacturers -----										
Captive	2,422.7 +31.4%	14.5%	2,601.0 +7.4%	12.7%	2,534.2 -2.6%	10.2%	2,615.7 +3.2%	9.3%	2,606.9 -.3%	8.5%
PCM	412.7 -11.4%	2.4%	430.7 +4.4%	2.1%	639.8 +48.5%	2.5%	701.7 +9.7%	2.5%	831.8 +18.5%	2.7%
OEM	1,687.5 +27.5%	10.4%	2,016.7 +19.5%	10.1%	2,490.6 +23.5%	10.5%	2,759.2 +10.8%	10.3%	2,805.3 +1.7%	9.4%
Total Non-U.S. Manufacturers	4,522.9 +24.5%	27.3%	5,048.4 +11.6%	24.9%	5,664.6 +12.2%	23.2%	6,076.6 +7.3%	22.1%	6,244.0 +2.8%	20.6%
Worldwide Recap -----										
Captive	10,596.1 +4.2%	63.8%	13,162.2 +24.2%	64.3%	16,121.7 +22.5%	65.3%	18,602.0 +15.4%	66.7%	20,666.7 +11.1%	67.5%
PCM	645.5 +2.9%	3.9%	663.4 +2.8%	3.2%	800.7 +20.7%	3.2%	893.7 +11.6%	3.2%	1,118.2 +25.1%	3.7%
OEM	5,368.8 +40.8%	32.3%	6,636.2 +23.6%	32.5%	7,770.5 +17.1%	31.5%	8,377.6 +7.8%	30.1%	8,831.6 +5.4%	28.8%
Total All Manufacturers	16,610.4 +13.7%	100.0%	20,461.8 +23.2%	100.0%	24,692.9 +20.7%	100.0%	27,873.3 +12.9%	100.0%	30,616.5 +9.8%	100.0%

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

Product mix

After reaching a peak of 77% of worldwide unit shipments in 1984, fixed disk drives less than 30 megabytes are expected to provide only 43.4% of 1988's unit shipment volume. Actual shipments are still growing, and are expected to continue increasing through 1991, but the share of unit shipments held by this product group is forecasted to slump to 33.2% by 1991.

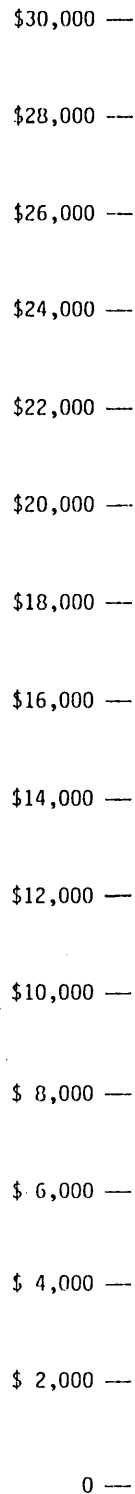
The main application for low-end drives is the personal computer market, and while there is enough overall growth in PCs to sustain modest increases for this group, higher capacity drives are faring better, due to greater software complexity and heightened user sophistication.

Among other fixed disk drive groups, 30-60 megabyte drives have enjoyed boom times in the last few years, pushed by popularity of 286/386-based PCs, but are also expected to decline slightly in percentage share, to 28.1% in 1991. On the other hand, all of the fixed disk drive product groups with capacities over 60 megabytes will increase their share of the total through 1991, driven by increasing data storage demand for high-end personal computers, technical workstations and minicomputers.

Although much of the industry has been preoccupied with low-end and mid-range drives in recent years, the majority of revenues still are generated by drives in the higher capacity ranges. Even though unit shipments of models with capacities over 300 megabytes were less than 5% of the total for all rigid disk drives, they provided 57.2% of 1987 revenues, with 1991 forecasted at 63.1%. Most of the increase is expected to come from new drives, especially for mainframe applications, with major new drives expected from IBM next year.

Figure 1
 CHANGING PRODUCT MIX
 CONSOLIDATED WORLDWIDE RIGID DISK DRIVE REVENUES

Worldwide Revenues (Millions)



1987

1991

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

WORLDWIDE REVENUES ALL MANUFACTURERS	-----1987-----		-----1988-----		-----1989-----		-----Forecast-----		-----1991-----	
	Revenues \$M	%	\$M	%	\$M	%	\$M	%	\$M	%
DISK CARTRIDGE DRIVES	112.2 -43.3%	.7%	80.0 -28.7%	.4%	77.6 -3.0%	.3%	67.1 -13.5%	.2%	48.4 -27.9%	.2%
DISK PACK DRIVES	273.0 -46.3%	1.6%	205.3 -24.8%	1.0%	141.5 -31.1%	.6%	77.4 -45.3%	.3%	39.2 -49.4%	.1%
FIXED DISK DRIVES less than 30 Megabytes	2,252.0 +2.5%	13.6%	2,320.4 +3.0%	11.3%	2,175.7 -6.2%	8.8%	2,160.9 -.7%	7.8%	2,140.3 -1.0%	7.0%
FIXED DISK DRIVES 30 - 60 Megabytes	1,968.6 +70.5%	11.9%	2,121.4 +7.8%	10.4%	2,425.4 +14.3%	9.8%	2,594.5 +7.0%	9.3%	2,637.4 +1.7%	8.6%
FIXED DISK DRIVES 60-100 Megabytes	1,151.2 +7.5%	6.9%	1,584.2 +37.6%	7.7%	2,067.8 +30.5%	8.4%	2,485.3 +20.2%	8.9%	2,893.2 +16.4%	9.4%
FIXED DISK DRIVES 100 - 300 Megabytes	1,350.0 +8.3%	8.1%	2,201.2 +63.1%	10.8%	2,613.1 +18.7%	10.6%	2,894.5 +10.8%	10.4%	3,543.5 +22.4%	11.6%
FIXED DISK DRIVES 300 - 500 Megabytes	2,035.3 +8.0%	12.3%	2,416.2 +18.7%	11.8%	2,852.2 +18.0%	11.6%	3,219.3 +12.9%	11.5%	3,498.4 +8.7%	11.4%
FIXED DISK DRIVES 500 Megabytes to 1 GB	2,413.7 +34.4%	14.5%	3,540.1 +46.7%	17.3%	4,095.1 +15.7%	16.6%	4,418.5 +7.9%	15.9%	3,608.4 -18.3%	11.8%
FIXED DISK DRIVES more than 1 Gigabyte	5,054.4 +11.0%	30.4%	5,993.0 +18.6%	29.3%	8,244.5 +37.6%	33.3%	9,955.8 +20.8%	35.7%	12,207.7 +22.6%	39.9%
Total Worldwide Revenue	16,610.4 +13.7%	100.0%	20,461.8 +23.2%	100.0%	24,692.9 +20.7%	100.0%	27,873.3 +12.9%	100.0%	30,616.5 +9.8%	100.0%
% U.S. Mfg.	72.7%		75.3%		77.0%		78.1%		79.6%	

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	-----1987-----		-----Forecast-----							
	---Shipments---		-----1988-----		-----1989-----		-----1990-----		-----1991-----	
	Units	%	Units	%	Units	%	Units	%	Units	%
DISK CARTRIDGE DRIVES	90.9 -12.6%	.7%	77.9 -14.3%	.4%	101.5 +30.3%	.5%	116.9 +15.2%	.5%	97.7 -16.4%	.3%
DISK PACK DRIVES	33.8 -42.2%	.3%	25.5 -24.6%	.1%	17.2 -32.5%	.1%	10.9 -36.6%	--	6.3 -42.2%	--
FIXED DISK DRIVES less than 30 Megabytes	6,769.0 +33.1%	51.3%	7,582.4 +12.0%	43.5%	8,335.0 +9.9%	38.2%	9,110.0 +9.3%	35.2%	9,840.0 +8.0%	33.2%
FIXED DISK DRIVES 30 - 60 Megabytes	4,147.9 +223.3%	31.4%	5,765.6 +39.0%	33.0%	7,033.1 +22.0%	32.2%	7,948.0 +13.0%	30.7%	8,345.0 +5.0%	28.1%
FIXED DISK DRIVES 60-100 Megabytes	1,043.9 +40.1%	7.9%	1,703.5 +63.2%	9.8%	2,744.0 +61.1%	12.6%	3,730.0 +35.9%	14.4%	5,056.0 +35.5%	17.0%
FIXED DISK DRIVES 100 - 300 Megabytes	528.8 +108.8%	4.0%	1,264.8 +139.2%	7.2%	1,922.1 +52.0%	8.8%	2,564.0 +33.4%	9.9%	3,336.0 +30.1%	11.2%
FIXED DISK DRIVES 300 - 500 Megabytes	240.2 +34.1%	1.8%	541.4 +125.4%	3.1%	941.4 +73.9%	4.3%	1,324.7 +40.7%	5.1%	1,654.0 +24.9%	5.6%
FIXED DISK DRIVES 500 Megabytes to 1 GB	193.7 +107.8%	1.5%	303.3 +56.6%	1.7%	481.9 +58.9%	2.2%	642.0 +33.2%	2.5%	717.0 +11.7%	2.4%
FIXED DISK DRIVES more than 1 Gigabyte	143.7 +15.0%	1.1%	185.0 +28.7%	1.1%	260.0 +40.5%	1.1%	413.0 +58.8%	1.6%	605.1 +46.5%	2.0%
Total Worldwide Shipments	13,191.9 +66.4%	100.0%	17,449.4 +32.3%	100.0%	21,836.2 +25.1%	100.0%	25,859.5 +18.4%	100.0%	29,657.1 +14.7%	100.0%
% U.S. Mfg.	78.2%		79.9%		76.2%		74.6%		75.1%	

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

OEM market

Seagate's sales of slightly over one billion dollars in 1987 improved the company's share of the OEM disk drive market to 19.8% of the 1987 worldwide total. Imprimis (formerly Control Data's Data Storage Products Group) continued to hold second place, with 14.9%, almost the same share as the previous year. New management at Imprimis has brought renewed growth to the long-term leader in OEM disk drives, which held 55.1% of 1980 worldwide OEM revenues.

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 unit shipments for many years, U.S. manufacturers dropped to 66.7% in 1985, but gained in 1986 and reached 78.4% in 1987. The U.S. percentage share of OEM unit shipments is expected to decline after 1988, as shipments of low-end drives by non-U.S. manufacturers to their domestic markets increases. 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.

OEM drive producers have led the way in the industry's movement to drives with smaller disks, and no end is in sight. Starting with the first shipment of the Seagate 5.25" 6 megabyte drive in 1980, OEM drive manufacturers have been pushing 5.25" drives into higher and higher capacity ranges, currently capped by 760 megabyte drives promised for shipment this year by several manufacturers, following Maxtor's lead.

The full size 5.25" form factor, in turn, is losing ground to half high 5.25" drives. 98.5% of 5.25" fixed drives less than 30 megabytes are now half high models, as are 93% of the 30-60 megabyte drives. After introduction in 1983, the rapid rise of 3.5" drives for personal computer applications has now captured more than half of all unit shipments for drives below 60 megabytes, and the impact of the 3.5" format is starting to be felt in capacities above 60 megabytes. Further proof of the vitality of this trend is found in the introduction this year of 2.5" drives, which are expected to be produced in substantial quantities starting in 1989 for the laptop personal computer market.

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 36.1% of 1987 worldwide OEM revenues were generated by drives over 100 megabytes, but 1991's OEM revenue level for this capacity range is forecasted at 47.2% of the worldwide total.

5.25" drives will continue to work their way into increasingly higher capacity ranges. 5.25" drives are already leading in unit shipments as of this year for the 300-500 megabyte group, and 5.25" drives are expected to assume shipment leadership by 1990 in the 500 megabyte to 1 gigabyte group, then by 1991 in the over 1 gigabyte group.

3.5" drives will also participate in the advance to higher areal densities and total capacity per drive. The current DISK/TREND forecast predicts that 84.5% 100-300 megabyte drives will be 3.5" models in 1991. The first 3.5" drives with capacities over 300 megabytes are expected next year, growing to 23% of the world total by 1991.

TABLE 5
 OEM WORLDWIDE REVENUES
 RIGID DISK DRIVES
 PRODUCT CATEGORY REVIEW
 REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	-----1987-----		-----1988-----		-----1989-----		-----Forecast-----		-----1991-----	
	Revenues \$M	%	\$M	%	\$M	%	1990 \$M	%	\$M	%
DISK CARTRIDGE DRIVES	77.4 -7.9%	1.4%	64.0 -17.3%	1.0%	68.2 +6.6%	.9%	63.2 -7.3%	.8%	48.4 -23.4%	.5%
DISK PACK DRIVES	178.8 -23.0%	3.4%	139.2 -22.1%	2.1%	94.5 -32.1%	1.2%	59.6 -36.9%	.7%	35.0 -41.3%	.4%
FIXED DISK DRIVES less than 30 Megabytes	1,239.3 +1.6%	23.2%	1,359.9 +9.7%	20.6%	1,372.8 +0.9%	17.8%	1,435.4 +4.6%	17.2%	1,447.0 +0.8%	16.5%
FIXED DISK DRIVES 30 - 60 Megabytes	1,329.3 +150.0%	24.7%	1,579.8 +18.8%	23.8%	1,736.7 +9.9%	22.3%	1,787.7 +2.9%	21.3%	1,752.7 -2.0%	19.9%
FIXED DISK DRIVES 60-100 Megabytes	590.0 +1.6%	11.0%	629.6 +6.7%	9.4%	882.6 +40.2%	11.4%	1,087.1 +23.2%	13.0%	1,373.9 +26.4%	15.5%
FIXED DISK DRIVES 100 - 300 Megabytes	590.5 +67.5%	11.0%	902.4 +52.8%	13.6%	1,196.3 +32.6%	15.4%	1,318.4 +10.2%	15.8%	1,462.5 +10.9%	16.6%
FIXED DISK DRIVES 300 - 500 Megabytes	461.5 +17.7%	8.6%	814.8 +76.6%	12.3%	1,000.0 +22.7%	12.8%	1,090.7 +9.1%	13.0%	1,117.4 +2.4%	12.6%
FIXED DISK DRIVES 500 Megabytes to 1 GB	569.2 +156.7%	10.6%	642.3 +12.8%	9.7%	851.3 +32.5%	11.0%	884.2 +3.9%	10.5%	871.3 -1.5%	9.9%
FIXED DISK DRIVES more than 1 Gigabyte	332.8 +67.2%	6.1%	504.2 +51.5%	7.5%	568.1 +12.7%	7.2%	651.3 +14.6%	7.7%	723.4 +11.1%	8.1%
Total Worldwide Revenues	5,368.8 +40.8%	100.0%	6,636.2 +23.6%	100.0%	7,770.5 +17.1%	100.0%	8,377.6 +7.8%	100.0%	8,831.6 +5.4%	100.0%
% U.S. Mfg.	68.5%		69.6%		67.9%		67.0%		68.2%	

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	-----1987-----		-----Forecast-----				-----1991-----			
	---Shipments--- Units	%	-----1988----- Units	%	-----1989----- Units	%	-----1990----- Units	%	-----1991----- Units	%
DISK CARTRIDGE DRIVES	85.9 -1.4%	.8%	75.9 -11.6%	.5%	100.3 +32.1%	.6%	116.4 +16.1%	.6%	97.7 -16.1%	.4%
DISK PACK DRIVES	26.7 -35.2%	.3%	20.4 -23.6%	.2%	13.6 -33.3%	--	9.5 -30.1%	--	6.0 -36.8%	.1%
FIXED DISK DRIVES less than 30 Megabytes	5,313.8 +25.0%	51.3%	6,211.2 +16.9%	43.8%	7,040.0 +13.3%	40.2%	7,817.0 +11.0%	38.4%	8,501.0 +8.8%	37.5%
FIXED DISK DRIVES 30 - 60 Megabytes	3,419.8 +254.1%	32.9%	5,250.4 +53.5%	37.0%	6,270.1 +19.4%	35.6%	6,943.0 +10.7%	34.1%	7,131.0 +2.7%	31.4%
FIXED DISK DRIVES 60-100 Megabytes	842.9 +25.9%	8.2%	1,129.1 +34.0%	8.0%	1,759.5 +55.8%	10.0%	2,299.0 +30.7%	11.3%	3,074.0 +33.7%	13.5%
FIXED DISK DRIVES 100 - 300 Megabytes	432.7 +138.3%	4.1%	921.9 +113.1%	6.5%	1,390.5 +50.8%	7.9%	1,820.0 +30.9%	8.9%	2,195.0 +20.6%	9.7%
FIXED DISK DRIVES 300 - 500 Megabytes	135.6 +62.8%	1.3%	385.5 +184.3%	2.7%	647.7 +68.0%	3.7%	872.7 +34.7%	4.3%	1,070.0 +22.6%	4.7%
FIXED DISK DRIVES 500 Megabytes to 1 GB	103.9 +245.2%	1.0%	151.7 +46.0%	1.1%	297.0 +95.8%	1.7%	398.0 +34.0%	1.9%	460.0 +15.6%	2.0%
FIXED DISK DRIVES more than 1 Gigabyte	16.0 +122.2%	.1%	46.1 +188.1%	.2%	71.8 +55.7%	.3%	119.1 +65.9%	.5%	171.4 +43.9%	.7%
Total Worldwide Shipments	10,377.3 +64.3%	100.0%	14,192.2 +36.8%	100.0%	17,590.5 +23.9%	100.0%	20,394.7 +15.9%	100.0%	22,706.1 +11.3%	100.0%
% U.S. Mfg.	78.4%		79.7%		74.5%		72.0%		72.0%	

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

TABLE 7
1987 ESTIMATED MARKET SHARES
WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1987 rates)

	CAPTIVE		PCM		OEM		TOTAL INDUSTRY	
	\$M	%	\$M	%	\$M	%	\$M	%
U.S. MANUFACTURERS								
Century Data	--	--	--	--	42.1	.8	42.1	.3
Conner Peripherals	--	--	--	--	113.0	2.1	113.0	.7
Data General	156.1	1.5	--	--	--	--	156.1	.9
Digital Equipment	724.9	6.8	--	--	--	--	724.9	4.4
Hewlett-Packard	318.3	3.0	--	--	9.8	.2	328.1	2.0
Ibis	--	--	--	--	50.4	.9	50.4	.3
IBM	6,727.5	63.5	--	--	116.9	2.2	6,844.4	41.2
Imprimis (Control Data)	50.0	.5	--	--	798.7	14.9	848.7	5.1
LaPine	--	--	--	--	26.4	.5	26.4	.2
Maxtor	--	--	--	--	228.6	4.3	228.6	1.4
Memorex	--	--	53.4	8.3	--	--	53.4	.3
Micropolis	--	--	--	--	287.8	5.4	287.8	1.7
Microscience International	--	--	--	--	151.6	2.8	151.6	.9
Miniscribe	--	--	--	--	361.1	6.7	361.1	2.2
Plus Development	--	--	--	--	72.8	1.4	72.8	.4
Priam	--	--	--	--	116.6	2.2	116.6	.7
Quantum	--	--	--	--	105.1	2.0	105.1	.6
Seagate Technology	--	--	--	--	1,065.7	19.8	1,065.7	6.4
Storage Technology	--	--	179.4	27.8	--	--	179.4	1.1
SyQuest	--	--	--	--	22.9	.4	22.9	.1
Tandon	140.7	1.3	--	--	79.3	1.5	220.0	1.3
Unisys	54.8	.5	--	--	--	--	54.8	.3
Other U.S.	1.1	--	--	--	32.5	.6	33.6	.2
U.S. Total	8,173.4	77.1	232.8	36.1	3,681.3	68.6	12,087.5	72.8
NON-U.S. MANUFACTURERS								
Fuji Electric	--	--	--	--	35.0	.7	35.0	.2
Fujitsu	756.9	7.1	197.4	30.6	528.4	9.8	1,482.7	8.9
Hitachi	238.2	2.2	215.2	33.3	186.4	3.5	639.8	3.9
ISOT	27.2	.3	--	--	127.8	2.4	155.0	.9
JVC (Victor Company)	--	--	--	--	80.5	1.5	80.5	.5
Mitsubishi Electric	55.6	.5	--	--	6.2	.1	61.8	.4
NEC	914.9	8.6	--	--	356.9	6.6	1,271.8	7.7
Newbury Data	--	--	--	--	29.3	.5	29.3	.2
Northern Telecom	27.7	.3	--	--	22.0	.4	49.7	.3
Olivetti	129.0	1.2	--	--	7.7	.1	136.7	.8
Rodime	--	--	--	--	109.8	2.0	109.8	.7
Seiko Epson	36.0	.3	--	--	12.6	.2	48.6	.3
Siemens	42.8	.4	--	--	22.3	.4	65.1	.4
Tokico	48.6	.5	--	--	20.8	.4	69.4	.4
Toshiba	104.7	1.0	--	--	58.5	1.1	163.2	1.0
Other Non-U.S.	41.1	.4	.1	--	83.3	1.6	124.5	.7
Non-U.S. Total	2,422.7	22.9	412.7	63.9	1,687.5	31.4	4,522.9	27.2
WORLDWIDE TOTAL	10,596.1	100.0	645.5	100.0	5,368.8	100.0	16,610.4	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: 2 = 2.5" C = Captive
 3 = 3"-3.9" P = PCM
 5 = 5.25" O = OEM
 8 = 8"-9.5"
 10 = 10.5"
 14 = 14"

TABLE 8
 CURRENT PRODUCT LINES
 MANUFACTURERS OF RIGID MAGNETIC DISK DRIVES

DISK/TREND PRODUCT GROUP:		1	2	3	4	5	6	7	8	9
U.S. Manufacturers	Type	Disk Cartridge Drives	Disk Pack Drives	Fixed Disk Drives <30 MB	Fixed Disk Drives 30-60 MB	Fixed Disk Drives 60-100 MB	Fixed Disk Drives 100-300 MB	Fixed Disk Drives 300-500 MB	Fixed Disk Drives 500 MB-1 GB	Fixed Disk Drives >1 GB
Alpha Data	0								14	
Areal Technology	0				3		3			
Brand Technologies	0				3	3,5	3,5			
Cardiff Peripherals	0				3	3	3			
Century Data	0,P	8	14			5	5	8,14	8	8
Comport	0				3	3				
Conner Peripherals	0			3	3		3			
Data General	C		14					14	8,14	
DDC Pertec	0						8	8	8	8
Digital Equipment	C	8	14					5,14	14	8
DMA Technologies	0	5								
Hewlett-Packard	C,0			3		5	5	5,8	8	
Ibis	0									14
IBM	C,0			3,8	3,5	3,5,8	3,5,8,14	5,8,14	8,14	14
Imprimis (Control Data)	0,C		8,14		5	5	3,5,8	5,8	5,8,14	8,14
Josephine County Technology	0			5						
Kalok	0			3	3					
Magnum Technology	0					5	5	8		
Maxtor	0					5	3,5	5	5	
MFM Technology	0	5								
Micropolis	0				5	5	5	5	5	
Microscience International	0			3,5	3,5	5	3,5			
Miltope	0			5	3,5		5			
Miniscribe	0			3,5	3,5	5	5	5	5	
Northern Telecom	0						8	8	8	8
Plus Development	P,0			3	3					
PrairieTek	0			2						
Priam	0					5,8	5,8,14	5,8	5	
Quantum	0				3,5	3,5	3			
Seagate Technology	0			3,5	3,5	5	5			
Storage Technology	P,0									14
SyQuest Technology	0	3,5								
Unisys	C		14						14	14
Xebec	0			5	5					
Western Digital	P,0			3	3					
Asian Manufacturers										
Alps Electric	0			3	3					
Fuji Electric	0			3	3					
Fujitsu	C,0,P			3,5	3,5,8	3,5,8	3,5,8,14	5,8,10,14	5,8,10,14	8,10
Goldstar Telecommunication	C,0			5	5					
Hitachi	C,0,P			3,5	3,5,8	5,8	5,8	5,8	5,8,14	8,14
JVC (Victor Company)	0			3	3					
Kyocera	0			3	3					
Matsushita Com. Ind.	0			3,5	3	3				
Mitsubishi Electric	C,0			3	3,5	5	5,8	8	8	
Mitsumi Electric	0			3						
NEC	C,0		14	3,5	3,5	5	3,5,8	5,8	8,14	8,14
Peripheral Technology	0			3	3	3	3			
Ricoh	C,0	5								
Samsung Electronics	C,0				3					
Seiko Epson	C,0			3	3	3				
Shinwa Digital	0			5	3					
Teac	0			5	5					
Tokico	C,0			5	3,5	3,5				
Toshiba	C,0			3	3,5	5,8	5,8	5,8	8	
Y-E Data	0				3	3				
European Manufacturers										
ISOT	C,0	14	14	5,8				14		
Kovo	C,0	14	14							
Lexikon	C,0			3	3		3			
Newbury Data	0					5	5	5		
Nixdorf	C					5	8			
Rodime	0			3	3	3,5	3,5		8	
Sagem	0			5	5		5			
Siemens	C,0						5	5	5	

TECHNICAL REVIEW

Competing technologies

Rigid magnetic disk drive technology continues to advance, providing ever improved performance and lower costs. However, it is becoming clear that alternate technologies are approaching the point where they will soon be able to challenge rigid disk drive technology in selected, specific application niches. The most significant of these competitors include:

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

All have already established themselves in some applications where characteristics such as speed, removability, or environmental tolerance give them unique advantages. Semiconductor memory, in particular, has advanced down the learning curve at a faster rate than rigid magnetic drive technology, but progress is slowing as the complexity of product and process technology increases.

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

Great competitive strength is now derived from the size of the worldwide magnetic disk drive industry, which includes scores of well estab-

lished 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, 3M, Eastman Kodak and Digital Equipment Corp. Whereas the initial products manufactured were 12" in diameter, the trend is increasingly to 5.25" diameter drives. 4.72" drives should enter production status in 1989.

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 five gigabytes. Some systems, such as Eastman Kodak's 14" drive, provide several gigabytes on a single removable disk. However, the current technology cannot provide performance equivalent to magnetic disk technology, nor can optical drives yet compete on a product cost basis.

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 slower 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 Laser Magnetic Storage, Laserdrive, Ricoh, 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 modified, and for which a write-once system would not be at a disadvantage -- such as stock market history, legal files, seismic data, engineering design records, 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 non-reversibility. 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 attractive for engineering design firms, banks, insurance companies and other organizations with massive records that must be easily accessed. Library systems are needed in order to make optical storage practical in a larger system environment. But the markets will be specialized, with system manufacturers slow to act. Manufacturers of 5.25" optical drives have yet to show that they can make products that will stand up to extended periods of hard mechanical wear and tear when used in automated libraries.

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 rewritable optical disk systems, when cost-effective drives with improved performance are available. Magneto-optical recording has seen development activity for more than twenty years, and "phase change" optical recording has attracted considerable attention during the past few years. The performance of magneto-optical drives exceeds that of write-once drives. Because it takes somewhat less laser power to change the state of a bit than required by write-once drives, the drive can rotate somewhat faster for a given laser power, reducing latency and improving data transfer rate. However, it will be years before rewritable optical technology can approach the best magnetic drive technology.

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 can be more reliable than magnetic disk drives due to the increased head to 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, and low-end optical drives for personal computer systems could displace low-end tape backup systems beginning in the early 1990s.

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

Phase change optical recording involves a different type of amorphous coating, in which individual spots on the disk are changed by polarized light from a crystalline state, during which light is reflected, to a non-crystalline state, during which light is absorbed. Fujitsu has revealed a comparable process in which different crystalline states are used to vary reflectivity.

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, but there are applications, such as backup, where this is not a major disadvantage. In mid-1988, Tandy Corporation announced its intention to supply such a drive in the future. Individual firms are also working on other proposed reversible optical recording technologies, but none of them have overcome all of the problems, which have included: Slow completion of the reversal cycle, limitations on the number of reversals before degradation, poor shelf life, and low recording density.

Magneto-optical storage is entering the manufacturing stage. Most of the technical problems have been overcome by some of the U.S., Japanese and 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 numerous firms, and several firms, including Sony, Maxtor, and Olympus are expected to be manufacturing magneto-optical drives and media by the end of 1988. Others are expected to begin in 1989. 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-1988, 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 manu-

facturing by Western Electric, lagged 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 megabit chips, the introduction of support circuits and a guaranteed future price reduction policy. The company attracted a variety of customers in specialized and harsh environment applications -- at least sufficient to establish quantity production and start down the learning curve. However, Intel elected to withdraw from the business during the recent semiconductor market slump in order to concentrate resources on more critical areas, and sold its magnetic bubble business to MemTech Technology Corp. in 1986.

Bubble memories for both military and industrial applications are also manufactured by Magnesys, which was formed in 1983. In 1988, Magnesys licensed Science Applications International Corp. (SAIC), a defense contractor, as a second manufacturing source for its bubble memories. Magnesys has begun offering bubble cartridge storage systems in 360 and 720 kilobyte configurations, but the price is 10 to 15 times that of equivalent flexible disk drives.

The non-volatility of magnetic bubbles and their suitability for capacities too small to be cost effective for magnetic disk drives has proven to be attractive to system manufacturers for applications such as industrial control systems, robots, point of sale terminals, portable computers, medical instrumentation, avionic systems and militarized systems. Although bubble memory densities are approaching 4 megabits per device, they are still not cost competitive with magnetic disk technology.

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. In the industrial sector, Magnesys has begun commercial development of VBL memory technology.

- * High capacity flexible disk drives: It is within the capabilities of today's technology to fabricate a 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 20 megabyte range have been announced by Brier Technology and Insite Peripherals, and several firms in Japan are working on 16 megabyte floppy disk drives. The 20 megabyte versions would be more acceptable to end users because they allow a 20 megabyte rigid drive to easily be backed up.

The 12 megabyte 5.25" floppy disk drive announced by Eastman Kodak and DTC, and the 10 megabyte drive offered by Konica and Citizen, were aimed at applications with specialized systems needs and the personal computer add-on market. Future products from these firms may double capacities to 24 megabytes, or shift to a 3.5" format. DTC announced a 24 megabyte, 5.25" drive at the 1988 spring Comdex conference, and Iomega has previously announced a 5.25", 20 megabyte Bernoulli disk drive and has the technical capability to offer the same capacity in a 3.5" drive version.

Perpendicular recording for flexible disks has the potential to increase capacity without any significant increases in track density. By using a sputtered thin film on a Mylar substrate, perpendicular recording disks could achieve linear densities of at least 50,000 BPI. Higher track densities achieved through embedded servo techniques or optical tracking methods could increase capacities by a factor of four or more. Toshiba has designed a 4 megabyte, 3.5" drive based on barium ferrite as the recording material and is offering manufacturing licenses. 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. Such "isotropic" particles, in coatings with conventional binder systems, could result in coatings 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. 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 or a major licensee, SSR still has the potential to be a major commercial technology. As of mid-1988, reports of a joint development program between 3M and Sony were appearing in the trade press.

- * Semiconductor memory: The fast response time of semiconductor memory has already won it a role in large and small systems where it serves as a substitute for rigid drives where very fast access to data or programs is required. Even personal computer operating systems allow part of their memory to be designated for use as a virtual disk. However, semiconductor memory is expensive, ranging from a few hundred to a few thousand dollars per megabyte, which limits its use to situations where its high speed is vitally necessary for the system to meet requirements.

Memory chips, now increasingly available in 1 megabit configurations, are expected to become available in 4 megabit sizes in the early 1990s and in 16 megabit configurations by the mid 1990s. The arrival of 64 megabit chips, not expected until the very late 1990s, is expected to signal the first real opportunity for semiconductor memory to compete with magnetic disks across a broader range of applications. Until that point, the cost and performance of the rigid magnetic drive will have improved enough to keep its solid state competitor at bay.

It is probably a mistake to assume that progress in semiconductor technology over the next ten years can proceed at the rate of improvement shown in the last 20 years. Because the complexity of the product has increased, the investment in time and capital required to produce succeeding generations has also increased. As a result, the rate of improvement will decline.

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 heads patterned after IBM's 3350 designs dominated in early Winchester disk drives. During recent years, PCM drives using heads designed to compete against IBM's 3370, 3375, 3380, and other new drives with ferrite heads having sliders with 3370 contours have been more common. 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 captive and OEM drives, while thin film heads gradually reach high production levels and become price competitive with Winchester heads. 1984 saw the beginning of thin film head shipments for small diameter OEM disk drives. Production has overcome startup disasters and is increasing as more vendors start to master the process and gain control of process yields.

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

- * Recording disks: As 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 fixed 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. Existing 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 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.

- * Head positioning methods: The industry is not moving forward rapidly with TPI improvements. Several of the highest performance small drives operate at over 1,000 TPI, but such precision is costly. The industry still has plenty of room for innovation in this area. IBM introduced a triple density version of the 3380 in the last half of 1987 that uses an estimated 2,100 TPI. It will be influential in moving the rest of the industry to higher track densities. Some firms are investigating the use of optical tracking techniques to obtain higher TPI, and IBM has shown the feasibility of creating media with very narrow tracks. However, considerable work will have to be done to develop heads capable of working with such narrow track widths.
- * Perpendicular recording: Today's disk drives all use longitudinal recording, making use of magnetic domains oriented parallel to the surface of the recording medium. 100,000 BPI could theoretically be resolved by recording heads if magnetization

were oriented in a plane perpendicular to the recording surface, and TPI could also be sharply increased.

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

Early developers of perpendicular recording discovered that the high bit densities implicit in perpendicular recording resulted in very high data transfer rates that available controllers for small disk drives couldn't handle. Censtor, a startup firm working with perpendicular recording, avoided this problem by improving track density as well as bit density, permitting the use of current controller technology. This approach required Censtor to develop both heads and media and to completely manage the head/disk interface. Censtor has been working with an OEM customer to put its process into production.

- * 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.

Most of the pioneering in development of disk arrays has been done to satisfy fault-tolerant requirements for on-line transaction systems, and it is believed that the OLTP markets will continue to drive most array development. Drive manufacturers considering supplying complete multi-spindle arrays have discovered that most of their prospective customers would prefer to buy the drives and design and manufacture arrays themselves for value-added considerations and because of sensitive interrelationships with system software.

- * Performance: Significant improvements in data transfer rate and average access time are expected during the next few years. The

single most important factor in initiating these improvements will be the increase in disk rotation rate, which both decreases latency and increases data transfer rate. A secondary, but significant technique will be the use of multiple heads per surface and/or multiple heads per slider to permit parallel access to large amounts of data without head movement.

Drives having rotation rates in the range of 5400 RPM are likely to appear in the next year or two. Hitachi has already announced a 5.25", 600 megabyte drive operating at 4876 RPM and other firms are understood to be designing drives operating at this speed or higher.

The use of parallel transfer from multiple heads to achieve data rates to 12 megabytes per second has been a practice for several years, with such drives typically used for supercomputers and high-end imaging applications. Drives with data transfer rates of 24 megabytes per second are in demand for supercomputing applications and are expected soon.

- * Form factor: Sub-3.5" drives will become an increasingly significant part of the market. Driven by the demands of manufacturers of lap-top computers and portable word processing equipment, small footprint, low power drive designs will proliferate over the next several years. The first of these, a 2.5", 20 megabyte drive from PrairieTek, has already been announced. Other firms, both U.S. and Japanese, have active design programs underway.

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 IBM, Hewlett-Packard or Toshiba to computer system end users are considered captive, if internally manufactured.
- * In the case of a joint venture disk drive manufacturer, such as Magnetic Peripherals, Inc. (until 1987 MPI was 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. MPI shipments were credited to Control Data, the managing partner, but starting with 1987 data, all shipments to the former MPI co-owners are treated as OEM sales by Control Data. With the 1988 establishment of Imprimis as a separate Control Data subsidiary, Imprimis drives sold with Control Data systems will be considered captive product sales.

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 NEC are non-captive, except for drives sold with systems made by the parent company or other subsidiaries.
- * Shipments by Siemens are non-captive if not used in Siemens 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 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 or more 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 1988 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:

- * Seagate and Microscience International are considered U.S. manufacturers, even though each firm manufactures some of its disk drives in non-U.S. locations.
- * Northern Telecom is considered a non-U.S. manufacturer, since it is owned by a non-U.S. organization.

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 AS/400, HP 3000.

Personal computers: Business and professional computers normally used by a single user. Examples: IBM PS/2 model 70, 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 DRIVESCoverage

Examples of disk drives in this group include:

14" disk diameter

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

8" disk diameter

Century Data	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 DISK/TREND Reports through 1986, disk cartridge drives were divided into two groups according to capacity.

The number of disk cartridge drives in production continues to shrink, as older models are discontinued. None of the companies which led in shipments of 14" OEM disk cartridge drives during the heyday of this group -- Control Data, Diablo or Western Dynex -- are currently represented with products. In fact, 14" drives have been phased out, except for Eastern Bloc production.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	58.1	42.7	51.3	52.8	37.9
All manufacturers	112.2	80.0	77.6	67.1	48.4

Revenues for disk cartridge drives continued to decline in 1987, dropping more than expected for both captive and OEM markets. Worldwide total revenues for all disk cartridge drives were \$112,200,000, down 43.3%, while worldwide captive and OEM revenues dropped 69.5% and 7.9%, respectively.

Older 14" and 8" captive disk cartridge drive programs by Digital Equipment and Control Data are being phased out, accounting for the continuing sharp drop in captive revenues. OEM revenues have been depressed by lower than anticipated non-U.S. sales.

Unfortunately, the growth expectations of several years ago for 8" and 5.25" drives have been largely unfulfilled. Disk cartridge drives are more difficult to design and manufacture than fixed disk drives of the same capacity and disk diameter, due to increased mechanical complexity and greater risk of contamination. The extent of these problems was not clearly recognized by most would-be producers of 8" and 5.25" drives, resulting in long delays for availability of announced products, shipment of many unreliable disk drives, and several failed programs.

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

SyQuest continued to dominate shipments of non-captive disk cartridge drives in 1987, with 53,000 units, mostly 3.9" models, which accounted for 61.6% of all unit shipments for the product group. In 1988, however, the pattern is changing. It is estimated that this year's shipments of 3.9" drives will be down to 24,000 units, representing only 30.6% of all disk cartridge drive shipments. 5.25" worldwide drive shipments are expected to jump to 40,100 units in 1988, more than half of the product group total, driven by demand for more capacity.

Marketing trends

As in previous years, 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 remaining production for larger drives is concentrated in Eastern Bloc countries and will be phased out by 1991.

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 which utilize

exchangable data bases and some personal computer users with specialized requirements.

Shipments of 3.9" drives were flat in 1987 as expected, but the decline underway in 1988 is destined to continue, with 5.25" drives assuming strong growth leadership for the product group. The markets still available to 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 1991 worldwide shipments are expected to be 5.25" drives.

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 the higher areal densities already in use with high capacity fixed disk drives, heads must fly at lower altitudes, increasing the need for lower contamination levels.

It is possible to increase density in removable disk drives, 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 starting in 1988, with good acceptance.

TABLE 9
DISK CARTRIDGE DRIVES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----Revenues-----Forecast-----									
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	8.8	21.6	4.0	8.0	3.1	5.4	1.5	2.3	--	--
TOTAL U.S. CAPTIVE	8.8	21.6	4.0	8.0	3.1	5.4	1.5	2.3	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	33.3	36.5	31.5	34.7	41.3	45.9	45.8	50.5	35.2	37.9
TOTAL U.S. NON-CAPTIVE	33.3	36.5	31.5	34.7	41.3	45.9	45.8	50.5	35.2	37.9
TOTAL U.S. REVENUES	42.1	58.1	35.5	42.7	44.4	51.3	47.3	52.8	35.2	37.9
Non-U.S. Manufacturers	-----									
Captive	--	13.2	--	8.0	--	4.0	--	1.6	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	3.8	40.9	3.8	29.3	4.5	22.3	5.6	12.7	7.7	10.5
TOTAL NON-U.S. REVENUES	3.8	54.1	3.8	37.3	4.5	26.3	5.6	14.3	7.7	10.5
Worldwide Recap	-----									
TOTAL WORLDWIDE REVENUES	45.9	112.2	39.3	80.0	48.9	77.6	52.9	67.1	42.9	48.4
OEM Average Price (\$000)	.5	.9	.5	.8	.5	.6	.4	.5	.4	.4

TABLE 10
DISK CARTRIDGE DRIVES
UNIT SHIPMENT SUMMARY

-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----										
	1987		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
-----Shipments-----Forecast-----										
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	1.4	3.2	.5	1.0	.4	.7	.2	.3	--	--
TOTAL U.S. CAPTIVE	1.4	3.2	.5	1.0	.4	.7	.2	.3	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	60.4	65.7	57.7	60.1	79.2	85.8	95.0	103.4	77.5	82.7
TOTAL U.S. NON-CAPTIVE	60.4	65.7	57.7	60.1	79.2	85.8	95.0	103.4	77.5	82.7
TOTAL U.S. SHIPMENTS	61.8	68.9	58.2	61.1	79.6	86.5	95.2	103.7	77.5	82.7
Non-U.S. Manufacturers										
Captive	--	1.8	--	1.0	--	.5	--	.2	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	4.8	20.2	4.8	15.8	6.0	14.5	8.0	13.0	11.0	15.0
TOTAL NON-U.S. SHIPMENTS	4.8	22.0	4.8	16.8	6.0	15.0	8.0	13.2	11.0	15.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	66.6	90.9	63.0	77.9	85.6	101.5	103.2	116.9	88.5	97.7
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	990.7	1,722.0	1,053.7	1,799.9	1,139.3	1,901.4	1,242.5	2,018.3	1,331.0	2,116.0
WORLDWIDE TOTAL	1,044.0	1,801.0	1,107.0	1,878.9	1,192.6	1,980.4	1,295.8	2,097.3	1,384.3	2,195.0

TABLE 11
 DISK CARTRIDGE DRIVES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1987				1988				Forecast				1990			1991	
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	8"	5.25"
U.S. MANUFACTURERS																	
Captive	4.4	17.2	--	--	--	8.0	--	--	--	5.4	--	--	--	2.3	--	--	--
OEM	--	10.4	3.7	22.4	--	5.2	19.9	9.6	--	4.7	38.0	3.2	--	3.6	46.9	1.8	36.1
TOTAL U.S. REVENUES	4.4	27.6	3.7	22.4	--	13.2	19.9	9.6	--	10.1	38.0	3.2	--	5.9	46.9	1.8	36.1
NON-U.S. MANUFACTURERS																	
Captive	11.2	2.0	--	--	8.0	--	--	--	4.0	--	--	--	1.6	--	--	--	--
OEM	34.0	1.8	5.1	--	24.5	--	4.8	--	16.3	--	6.0	--	5.0	--	7.7	--	10.5
TOTAL NON-U.S. REVENUES	45.2	3.8	5.1	--	32.5	--	4.8	--	20.3	--	6.0	--	6.6	--	7.7	--	10.5
WORLDWIDE RECAP																	
Captive	15.6	19.2	--	--	8.0	8.0	--	--	4.0	5.4	--	--	1.6	2.3	--	--	--
	-63.6%	-71.0%	--	--	-48.7%	-58.3%	--	--	-50.0%	-32.5%	--	--	-60.0%	-57.4%	--	--	--
OEM	34.0	12.2	8.8	22.4	24.5	5.2	24.7	9.6	16.3	4.7	44.0	3.2	5.0	3.6	54.6	1.8	46.6
	-13.9%	+14.0%	-17.8%	-3.0%	-27.9%	-57.4%	+180.7%	-57.1%	-33.5%	-9.6%	+78.1%	-66.7%	-69.3%	-23.4%	+24.1%	-50.0%	-14.7%
Total Revenues	49.6	31.4	8.8	22.4	32.5	13.2	24.7	9.6	20.3	10.1	44.0	3.2	6.6	5.9	54.6	1.8	46.6
	-39.7%	-59.2%	-35.8%	-10.0%	-34.5%	-58.0%	+180.7%	-57.1%	-37.5%	-23.5%	+78.1%	-66.7%	-67.5%	-41.6%	+24.1%	-69.5%	-14.7%
ANNUAL SHARE, BY DIAMETER	44.3%	28.0%	7.8%	19.9%	40.7%	16.5%	30.9%	11.9%	26.3%	13.0%	56.7%	4.0%	9.8%	8.8%	81.4%	3.7%	96.3%

Note: 8 inch totals include 10.5 inch drives.

TABLE 12
 DISK CARTRIDGE DRIVES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987				1988				Forecast				1990			1991	
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	8"	5.25"
U.S. MANUFACTURERS																	
Captive	1.1	2.1	--	--	--	1.0	--	--	--	.7	--	--	--	.3	--	--	--
OEM	--	5.0	4.7	56.0	--	2.0	34.1	24.0	--	1.8	76.0	8.0	--	1.4	102.0	.7	82.0
TOTAL U.S. SHIPMENTS	1.1	7.1	4.7	56.0	--	3.0	34.1	24.0	--	2.5	76.0	8.0	--	1.7	102.0	.7	82.0
NON-U.S. MANUFACTURERS																	
Captive	1.4	.4	--	--	1.0	--	--	--	.5	--	--	--	.2	--	--	--	--
OEM	13.6	.4	6.2	--	9.8	--	6.0	--	6.5	--	8.0	--	2.0	--	11.0	--	15.0
TOTAL NON-U.S. SHIPMENTS	15.0	.8	6.2	--	10.8	--	6.0	--	7.0	--	8.0	--	2.2	--	11.0	--	15.0
WORLDWIDE RECAP																	
Captive	2.5	2.5	--	--	1.0	1.0	--	--	.5	.7	--	--	.2	.3	--	--	--
	-63.8%	-70.2%	--	--	-60.0%	-60.0%	--	--	-50.0%	-30.0%	--	--	-60.0%	-57.1%	--	--	--
OEM	13.6	5.4	10.9	56.0	9.8	2.0	40.1	24.0	6.5	1.8	84.0	8.0	2.0	1.4	113.0	.7	97.0
	-8.1%	+68.8%	-27.8%	+3.7%	-27.9%	-63.0%	+267.9%	-57.1%	-33.7%	-10.0%	+109.5%	-66.7%	-69.2%	-22.2%	+34.5%	-50.0%	-14.2%
Total Shipments	16.1	7.9	10.9	56.0	10.8	3.0	40.1	24.0	7.0	2.5	84.0	8.0	2.2	1.7	113.0	.7	97.0
	-25.8%	-31.9%	-32.3%	+2.6%	-32.9%	-62.0%	+267.9%	-57.1%	-35.2%	-16.7%	+109.5%	-66.7%	-68.6%	-32.0%	+34.5%	-58.8%	-14.2%
ANNUAL SHARE, BY DIAMETER	17.7%	8.7%	12.0%	61.6%	13.9%	3.9%	51.6%	30.6%	6.9%	2.5%	82.9%	7.7%	1.9%	1.5%	96.6%	.7%	99.3%

Note: 8 inch totals include 10.5 inch drives.

TABLE 13
 CARTRIDGE DISK DRIVES
 APPLICATIONS SUMMARY
 Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	19.7	21.7	11.7	12.0
PERSONAL COMPUTERS Business and professional, single user	21.0	23.1	20.5	21.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	9.8	10.8	7.8	8.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	40.4	44.4	57.7	59.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	90.9	100.0	97.6	100.0

TABLE 14
 DISK CARTRIDGE DRIVES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
	14"	8"	5.25"	<5.25"	Total		14"	8"	5.25"	<5.25"	Total	
SYQUEST	--	--	1.0	52.0	53.0	81.3	--	--	1.0	56.0	57.0	66.4
RICOH	--	--	4.8	--	4.8	7.4	--	--	6.0	--	6.0	7.0
CENTURY DATA	--	4.1	--	--	4.1	6.3	--	4.3	--	--	4.3	5.0
Other U.S.	--	.6	2.7	--	3.3	5.0	--	.7	3.7	--	4.4	5.1
Other Non-U.S.	--	--	--	--	--	--	13.6	.4	.2	--	14.2	16.5
TOTAL	--	4.7	8.5	52.0	65.2	100.0	13.6	5.4	10.9	56.0	85.9	100.0

Note: 8 inch totals include 10.5 inch drives.

DISK PACK DRIVESCoverage

Examples of disk drives in this group include:

14" disk diameter

Century Data	T306
Data General	6060, 6122
Digital Equipment	RA60
Imprimis (Control Data)	9762, 9766
ISOT	ES 5066, ES 5067
Kovo (Aritma)	4080, 5080
NEC	N7745
Unisys	9484-13

9" disk diameter

Imprimis (Control Data)	9710
-------------------------	------

IBM's 1971 introduction of the 3330, with 19 data surfaces, set the physical model for larger disk pack drives. The Control Data 300 megabyte SMD is the major large disk pack drive still in production. Among the large disk pack files introduced in more recent years, the Digital Equipment RA60 (14" 205 MB using 6 data surfaces) is the sole survivor, except for Eastern Bloc products.

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 the industry standard for high performance OEM disk drives.

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

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

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1991</u>
U.S. manufacturers	189.7	122.0	69.7	26.6	3.5
All manufacturers	273.0	205.3	141.5	77.4	39.2

As expected, 1987 saw a major reduction in shipments of disk pack drives, continuing the trend which began with the introduction of Winchester technology in the mid-1970's. Worldwide 1987 shipments of all types of disk pack drives were 33,800 spindles, down 42.2%.

Despite its shrinking production of disk pack drives, Control Data remained the dominant worldwide producer of non-captive drives in 1987, with 9,000 14" SMD drives and 7,300 9" RSD drives. 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. 1991 worldwide OEM shipments of 9" drives are now forecasted to drop to 1,000 units. Disk pack drives of all types have 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.

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 were achieved by DEC's 1983 introduction of the RA60, partially through use of run length limited encoding. However, there are no known plans by any drive manufacturer to develop a new drive in this group using today's technology.

Forecasting assumptions

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

TABLE 15
DISK PACK DRIVES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		Forecast							
	Revenues		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	58.3	82.2	37.3	54.1	25.2	36.0	8.4	12.0	--	--
TOTAL U.S. CAPTIVE	58.3	82.2	37.3	54.1	25.2	36.0	8.4	12.0	--	--
PCM										
OEM	61.4	107.5	40.9	67.9	17.3	33.7	7.3	14.6	2.1	3.5
TOTAL U.S. NON-CAPTIVE	61.4	107.5	40.9	67.9	17.3	33.7	7.3	14.6	2.1	3.5
TOTAL U.S. REVENUES	119.7	189.7	78.2	122.0	42.5	69.7	15.7	26.6	2.1	3.5
Non-U.S. Manufacturers										
Captive	--	12.0	--	12.0	--	11.0	--	5.8	--	4.2
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	71.3	--	71.3	--	60.8	--	45.0	--	31.5
TOTAL NON-U.S. REVENUES	--	83.3	--	83.3	--	71.8	--	50.8	--	35.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	119.7	273.0	78.2	205.3	42.5	141.5	15.7	77.4	2.1	39.2
OEM Average Price (\$000)	5.9	6.6	6.0	6.8	5.9	6.9	5.2	6.2	3.5	5.8

TABLE 16
DISK PACK DRIVES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1987		Forecast							
	Shipments		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	4.6	6.5	3.1	4.5	2.1	3.0	.7	1.0	--	--
TOTAL U.S. CAPTIVE	4.6	6.5	3.1	4.5	2.1	3.0	.7	1.0	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	10.4	17.1	6.8	10.8	2.9	5.1	1.4	2.5	.6	1.0
TOTAL U.S. NON-CAPTIVE	10.4	17.1	6.8	10.8	2.9	5.1	1.4	2.5	.6	1.0
TOTAL U.S. SHIPMENTS	15.0	23.6	9.9	15.3	5.0	8.1	2.1	3.5	.6	1.0
Non-U.S. Manufacturers										
Captive	--	.6	--	.6	--	.6	--	.4	--	.3
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	9.6	--	9.6	--	8.5	--	7.0	--	5.0
TOTAL NON-U.S. SHIPMENTS	--	10.2	--	10.2	--	9.1	--	7.4	--	5.3
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	15.0	33.8	9.9	25.5	5.0	17.2	2.1	10.9	.6	6.3
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	519.1	935.8	529.0	961.3	534.0	978.5	536.1	989.4	536.7	995.7
WORLDWIDE TOTAL	560.4	1,008.4	570.3	1,033.9	575.3	1,051.1	577.4	1,062.0	578.0	1,068.3

TABLE 17
DISK PACK DRIVES
WORLDWIDE REVENUES (\$M)
BREAKDOWN BY DISK DIAMETER

	1987		Forecast							
	Revenues		1988		1989		1990		1991	
	14"	9"	14"	9"	14"	9"	14"	9"	14"	9"
<u>U.S. MANUFACTURERS</u>										
Captive	82.2	--	54.1	--	36.0	--	12.0	--	--	--
OEM	80.4	27.1	49.3	18.6	24.8	8.9	9.2	5.4	--	3.5
TOTAL U.S. REVENUES	162.6	27.1	103.4	18.6	60.8	8.9	21.2	5.4	--	3.5
<u>NON-U.S. MANUFACTURERS</u>										
Captive	12.0	--	12.0	--	11.0	--	5.8	--	4.2	--
OEM	71.3	--	71.3	--	60.8	--	45.0	--	31.5	--
TOTAL NON-U.S. REVENUES	83.3	--	83.3	--	71.8	--	50.8	--	35.7	--
<u>WORLDWIDE RECAP</u>										
Captive	94.2 -65.6%	--	66.1 -29.8%	--	47.0 -28.9%	--	17.8 -62.1%	--	4.2 -76.4%	--
OEM	151.7 -18.4%	27.1 -41.6%	120.6 -20.5%	18.6 -31.4%	85.6 -29.0%	8.9 -52.2%	54.2 -36.7%	5.4 -39.3%	31.5 -41.9%	3.5 -35.2%
Total Revenues	245.9 -46.5%	27.1 -44.5%	186.7 -24.1%	18.6 -31.4%	132.6 -29.0%	8.9 -52.2%	72.0 -45.7%	5.4 -39.3%	35.7 -50.4%	3.5 -35.2%
ANNUAL SHARE, BY DIAMETER	90.2%	9.8%	91.0%	9.0%	93.8%	6.2%	93.1%	6.9%	91.2%	8.8%

TABLE 18
 DISK PACK DRIVES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987 Shipments		Forecast							
	14"	9"	1988		1989		1990		1991	
	14"	9"	14"	9"	14"	9"	14"	9"	14"	9"
U.S. MANUFACTURERS										
Captive	6.5	--	4.5	--	3.0	--	1.0	--	--	--
OEM	9.8	7.3	5.8	5.0	2.7	2.4	1.0	1.5	--	1.0
TOTAL U.S. SHIPMENTS	16.3	7.3	10.3	5.0	5.7	2.4	2.0	1.5	--	1.0
NON-U.S. MANUFACTURERS										
Captive	.6	--	.6	--	.6	--	.4	--	.3	--
OEM	9.6	--	9.6	--	8.5	--	7.0	--	5.0	--
TOTAL NON-U.S. SHIPMENTS	10.2	--	10.2	--	9.1	--	7.4	--	5.3	--
WORLDWIDE RECAP										
Captive	7.1 -58.5%	--	5.1 -28.2%	--	3.6 -29.4%	--	1.4 -61.1%	--	.3 -78.6%	--
OEM	19.4 -31.4%	7.3 -43.4%	15.4 -20.6%	5.0 -31.5%	11.2 -27.3%	2.4 -52.0%	8.0 -28.6%	1.5 -37.5%	5.0 -37.5%	1.0 -33.3%
Total Shipments	26.5 -41.6%	7.3 -44.3%	20.5 -22.6%	5.0 -31.5%	14.8 -27.8%	2.4 -52.0%	9.4 -36.5%	1.5 -37.5%	5.3 -43.6%	1.0 -33.3%
ANNUAL SHARE, BY DIAMETER	78.5%	21.5%	80.5%	19.5%	86.1%	13.9%	86.3%	13.7%	84.2%	15.8%

TABLE 19
DISK PACK DRIVES
APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	6.8	20.1	.3	5.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	14.2	42.1	4.2	69.0
PERSONAL COMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	11.6	34.3	.3	5.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	1.2	3.5	1.3	21.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	33.8	100.0	6.2	100.0

FIXED DISK DRIVES, LESS THAN 30 MEGABYTESCoverage

Examples of disk drives in this group include:

8" disk diameter

IBM	5525-021/031
-----	--------------

5.25" disk diameter

Fujitsu	M2233AT*, M2235AS
Goldstar Telecommunication	GSH-520*
Hitachi	DK505-2*
Josephine County Technology	JCT-105, JCT-110
Matsushita Communication Ind.	JU-614
Microscience International	HH-825*
Miltope	RDS-1500
NEC	D5126H*
Seagate Technology	ST225*, ST225N*, ST4026
Shinwa Digital	D110*, D220*
Teac	SD-521*
Tokico	DK502-3, DK505-2*
Xebec	Owl II*

3.5" disk diameter

Alps Electric	DRM020A*, DRP020A*
Conner Peripherals	CP3022**
Fuji Electric	FK309-26*
Fujitsu	M2225D2*
Hewlett-Packard	97501B
Hitachi	DK302-2*
IBM	WD-325*
JVC (Victor)	JD-3824T**
Kalok	KL320*
Kyocera	KC20B
Matsushita Communication Ind.	JU-114*, JU-106**
Microscience International	HH-325*
Miniscribe	8425*, 8425S*, 8425F*
Mitsubishi Electric	MR321*, MR322*
NEC	D3126*
Peripheral Technology	PT-225*
Plus Development	Hardcard 20**, Passport*
Rodime	R0652*
Seagate Technology	ST125*
Seiko Epson	HMD-720*, HMD-726*
Toshiba	MK-132FA*
Western Digital	WD93028-A*

2.5" disk diameter

PrairieTek

220**

*Indicates drives with maximum 41.3 mm height, or less.

**Indicates drives with maximum 25.4 mm height, or less.

All drives in this group use variations of the technology loosely described as "Winchester". Some use 3340/3350-type ferrite heads, but most of the newer drives use "mini-slider" heads 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.

Utilizing the higher areal densities now possible with advanced heads and disks, one inch high 20 megabyte drives using single 3.5" disks have appeared, signaling a major future trend. The new two disk PrairieTek 2.5" drive is also probably the pathfinder for many drives to follow.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	1,466.5	1,705.2	1,559.9	1,494.6	1,430.1
All manufacturers	2,252.0	2,320.4	2,175.7	2,160.9	2,140.3

As the personal computer market moves to more powerful processors, demand has shifted in favor of disk drives with higher capacities, holding

1988 DISK/TREND REPORT

down the growth rate for this product group. Worldwide unit shipments increased 33.1% in 1987, to 6,769,000 drives, but the estimate for 1988 is up only 12%, a reduction in growth rate from last year's DISK/TREND forecast.

Total revenues for the product group increased only 2.5% in 1987, held down by lower prices for OEM drives and reduced captive drive manufacturing programs by both U.S. and Japanese manufacturers. These factors, plus slower growth in unit shipments, limit the 1988 revenue forecast to a nominal 3.0% increase.

The continuing shift to 3.5" drives continues, but has not proceeded as far as expected during 1988. It appears that IBM overestimated its influence on the personal computer market, in attempting to move too quickly in 1987 to the PS/2 product family. Unfortunately for IBM, too many users liked the older PC XT and PC AT systems and decided they wouldn't discard their old software, their expensive add-in cards and their 5.25" disk drives.

As a result, the older PC standard has continued to prosper without IBM, providing a strong residual market for low-end 5.25" disk drives through both clone manufacturers and the dealer aftermarket. And the many technical and legal delays faced by clone manufacturers in entering the PS/2 compatible market have slowed the growth of 3.5" drive shipments, up only 51.9% in 1988, a million units below the previous forecast.

But the rise of the 3.5" format continues, growing from 26.2% of the unit shipment total in 1986 for this product group to 48.1% in 1987, with 1988 estimated at 65.3%. The commercial impact of these changes in product mix has been excellent growth for U.S. based drive manufacturers with low cost 3.5" drive production capability. On the other hand, the

1988 DISK/TREND REPORT

continuing decline in 5.25" drive shipments has led to lower prices and increased inventories for firms late in developing appropriate 3.5" models.

Despite IBM's limited influence on the PC clone makers, the firm's requirements for 3.5" drives in this product group have grown immensely. Captive IBM shipments of 3.5" 20 megabyte drives, all manufactured at Fujisawa, started in 1986 with nominal quantities for specialized Asian personal computer models. But with the April, 1987, introduction of the PS/2 product line, IBM's shipments increased to an estimated 850,000 units -- not including, of course, the company's internal consumption of its own products. 1988 shipments are forecasted at 1,050,000 drives, down from last year's forecast for 1988, due to emphasis on new 30 and 60 megabyte drives on some PS/2 models and displacement of some requirements by outside purchase of 20 megabyte 3.5" drives from Seagate.

Usage of hard disk drives with personal computers has now become standard practice in most offices, and the personal computer market continues to be the dominant application area for drives in this product group, accounting for 89.6% of 1987 unit shipments. It is expected that the future will see a modest decline in usage with minicomputers and multi-user systems in favor of higher capacity drives, while a slight percentage increase in consumer and hobby computer applications will occur.

To the surprise of no one in the disk drive industry, Seagate shipped more than twice as many non-captive drives as any other competitor in this product group in 1987. The Seagate total was 2,224,000 drives, mostly 5.25", for 41.9% of the worldwide total. Miniscribe recorded the biggest increase, shipping 970,000 drives, the majority of which were 3.5", for

18.3% of the worldwide total. It should be noted that Table 26 includes shipments by Tandon and LaPine, both active in the disk drive industry in 1987, but not in 1988.

Marketing trends

The 20 megabyte 3.5" drive can expect another year or two of heady growth, but that growth is destined to flatten by 1991, suffering from tough competition from both smaller drives and higher capacity drives. The first 2.5" drives are expected to be shipped this year, and numerous higher capacity 3.5" drives are already available.

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 3.5" 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 with capacities below 30 megabytes are expected to decline starting in 1989, with the result that worldwide shipments are projected to increase only 14.8% in 1990.

But while 3.5" drives eventually lose momentum and 5.25" drives drop to less than 1% of shipments for the product group in 1991, 2.5" drives are expected to enjoy rapid growth, rising to almost 14% of unit shipments in this product group in 1991. Although the vitality of this market has

not yet been demonstrated with volume shipments, all of the prerequisites for success are present: A growing laptop computer market, availability of essential components, and a manufacturing kick-off by a well funded startup staffed by successful industry veterans.

The changes in product mix will be dramatic:

<u>Worldwide captive & OEM Unit shipments (000)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
5.25" full size	101.2 1.5%	39.3 .5%	25.0 .3%	32.0 .3%	45.0 .5%
5.25" half high	3,402.1 50.3%	2,581.7 34.1%	940.0 11.3%	253.0 2.8%	47.0 .5%
3.5"	3,264.0 48.2%	4,959.1 65.4%	7,172.0 86.0%	8,231.0 90.4%	8,373.0 85.1%
<3.5"	-- --	2.0 --	198.0 2.4%	594.0 6.5%	1,375.0 13.9%

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 1989.

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 high production volumes despite use of continually higher recording densities.

Although several initially available 3.5" drives used disks with 40 millimeter inner diameters, 25 millimeter has been more widely used, to increase the recording area per disk. The result is linear densities in the 13,000 bits per inch range for 3.5" 20 megabyte drives using two

disks, and up to 21,500 BPI for single disk models. The new 2.5" drives will also use two disks (65 millimeter OD, 20 millimeter ID) for 20 megabytes, recorded at 22,500 BPI. High density oxide disks are used by a few firms at the low end of the above range, but sputtered or plated are used by most drive manufacturers.

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

Embedded controllers will also make it possible to take the next step in recording density, since the physical characteristics of drives will be masked from systems. Most 3.5" floppy drives are already produced in one inch high configurations, and production of one inch high 3.5" rigid disk drives using only one disk has already commenced, offering the prospect of further reductions in 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, but with a reduction in shipments starting in 1989, in favor of higher capacity drives.
2. Drives with less than 3.5" disk diameter will achieve quantity production from multiple vendors in 1989 and will develop a major market with laptop portable applications.
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)-----									
	1987		-----Forecast-----							
	Revenues		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	357.0	510.0	428.4	630.0	363.0	550.0	308.0	475.0	262.8	405.0
Other U.S. Captive	41.8	62.2	9.6	24.0	9.0	18.0	12.6	23.1	29.3	46.5
TOTAL U.S. CAPTIVE	398.8	572.2	438.0	654.0	372.0	568.0	320.6	498.1	292.1	451.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	500.9	894.3	547.9	1,051.2	484.9	991.9	510.9	996.5	538.7	978.6
TOTAL U.S. NON-CAPTIVE	500.9	894.3	547.9	1,051.2	484.9	991.9	510.9	996.5	538.7	978.6
TOTAL U.S. REVENUES	899.7	1,466.5	985.9	1,705.2	856.9	1,559.9	831.5	1,494.6	830.8	1,430.1
Non-U.S. Manufacturers										
Captive	18.4	440.5	--	306.5	7.0	234.9	15.8	227.4	27.9	241.8
PCM	--	--	--	--	--	--	--	--	--	--
OEM	72.9	345.0	50.7	308.7	66.0	380.9	67.3	438.9	65.2	468.4
TOTAL NON-U.S. REVENUES	91.3	785.5	50.7	615.2	73.0	615.8	83.1	666.3	93.1	710.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	991.0	2,252.0	1,036.6	2,320.4	929.9	2,175.7	914.6	2,160.9	923.9	2,140.3
OEM Average Price (\$000)	.231	.233	.214	.219	.191	.195	.178	.184	.164	.170

TABLE 22
FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1987		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	595.0	850.0	714.0	1,050.0	660.0	1,000.0	616.0	950.0	584.0	900.0
Other U.S. Captive	155.0	210.7	6.0	15.0	9.0	18.0	18.0	33.0	50.0	79.0
TOTAL U.S. CAPTIVE	750.0	1,060.7	720.0	1,065.0	669.0	1,018.0	634.0	983.0	634.0	979.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	2,190.3	4,006.4	2,574.2	4,994.3	2,571.0	5,248.0	2,905.0	5,668.0	3,336.0	6,061.0
TOTAL U.S. NON-CAPTIVE	2,190.3	4,006.4	2,574.2	4,994.3	2,571.0	5,248.0	2,905.0	5,668.0	3,336.0	6,061.0
TOTAL U.S. SHIPMENTS	2,940.3	5,067.1	3,294.2	6,059.3	3,240.0	6,266.0	3,539.0	6,651.0	3,970.0	7,040.0
Non-U.S. Manufacturers	-----									
Captive	18.0	394.5	--	306.2	10.0	277.0	25.0	310.0	49.0	360.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	298.3	1,307.4	227.7	1,216.9	314.0	1,792.0	336.0	2,149.0	350.0	2,440.0
TOTAL NON-U.S. SHIPMENTS	316.3	1,701.9	227.7	1,523.1	324.0	2,069.0	361.0	2,459.0	399.0	2,800.0
Worldwide Recap	-----									
TOTAL WORLDWIDE SHIPMENTS	3,256.6	6,769.0	3,521.9	7,582.4	3,564.0	8,335.0	3,900.0	9,110.0	4,369.0	9,840.0
Cumulative Shipments	-----									
IBM	1,243.4	1,794.9	1,957.4	2,844.9	2,617.4	3,844.9	3,233.4	4,794.9	3,817.4	5,694.9
Non-IBM	10,644.8	17,920.0	13,452.7	24,452.4	16,356.7	31,787.4	19,640.7	39,947.4	23,425.7	48,887.4
WORLDWIDE TOTAL	11,888.2	19,714.9	15,410.1	27,297.3	18,974.1	35,632.3	22,874.1	44,742.3	27,243.1	54,582.3

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

1988 DISK/TREND REPORT

	1987			Forecast												
	Revenues			1988			1989			1990			1991			
	8"	5.25"	3.5"	8"	5.25"	3.5"	<3.5"	5.25"	3.5"	<3.5"	5.25"	3.5"	<3.5"	5.25"	3.5"	<3.5"
U.S. MANUFACTURERS																
IBM Captive	--	--	510.0	--	--	630.0	--	--	550.0	--	--	450.0	25.0	--	315.0	90.0
Other U.S. Captive	--	--	62.2	--	--	24.0	--	--	18.0	--	--	23.1	--	--	35.4	11.1
OEM	.7	602.6	291.0	--	456.4	594.3	.5	157.1	797.0	37.8	40.8	872.4	83.3	8.2	832.6	137.8
TOTAL U.S. REVENUES	.7	602.6	863.2	--	456.4	1,248.3	.5	157.1	1,365.0	37.8	40.8	1,345.5	108.3	8.2	1,183.0	238.9
NON-U.S. MANUFACTURERS																
Captive	--	262.4	178.1	--	155.9	150.6	--	66.9	168.0	--	34.8	179.4	13.2	35.0	171.0	35.8
OEM	.6	120.3	224.1	.6	36.8	271.3	--	15.9	361.0	4.0	16.4	407.4	15.1	19.3	393.1	56.0
TOTAL NON-U.S. REVENUES	.6	382.7	402.2	.6	192.7	421.9	--	82.8	529.0	4.0	51.2	586.8	28.3	54.3	564.1	91.8
WORLDWIDE RECAP																
Captive	--	262.4	750.3	--	155.9	804.6	--	66.9	736.0	--	34.8	652.5	38.2	35.0	521.4	136.9
	--	-62.7%	+208.8%	--	-40.6%	+7.2%	--	-57.1%	-8.5%	--	-48.0%	-11.3%	--	+6%	-20.1%	+258.4%
OEM	1.3	722.9	515.1	.6	493.2	865.6	.5	173.0	1,158.0	41.8	57.2	1,279.8	98.4	27.5	1,225.7	193.8
	-81.9%	-18.4%	+57.5%	-53.8%	-31.8%	+68.0%	--	-64.9%	+33.8%	--	-66.9%	+10.5%	+135.4%	-51.9%	-4.2%	+97.0%
Total Revenues	1.3	985.3	1,265.4	.6	649.1	1,670.2	.5	239.9	1,894.0	41.8	92.0	1,932.3	136.6	62.5	1,747.1	330.7
	-96.5%	-38.0%	+122.0%	-53.8%	-34.1%	+32.0%	--	-63.0%	+13.4%	--	-61.7%	+2.0%	+226.8%	-32.1%	-9.6%	+142.1%
ANNUAL SHARE, BY DIAMETER	.1%	43.9%	56.0%	--	28.1%	71.9%	--	11.0%	87.2%	1.8%	4.3%	89.5%	6.2%	2.9%	81.7%	15.4%

TABLE 24
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987			Forecast												
	Shipments			1988			1989			1990			1991			
	8"	5.25"	3.5"	8"	5.25"	3.5"	<3.5"	5.25"	3.5"	<3.5"	5.25"	3.5"	<3.5"	5.25"	3.5"	<3.5"
U.S. MANUFACTURERS																
IBM Captive	--	--	850.0	--	--	1,050.0	--	--	1,000.0	--	--	900.0	50.0	--	700.0	200.0
Other U.S. Captive	--	--	210.7	--	--	15.0	--	--	18.0	--	--	33.0	--	--	59.0	20.0
OEM	.7	2,817.6	1,188.1	--	2,365.3	2,627.0	2.0	873.0	4,195.0	180.0	233.0	4,985.0	450.0	47.0	5,204.0	810.0
TOTAL U.S. SHIPMENTS	.7	2,817.6	2,248.8	--	2,365.3	3,692.0	2.0	873.0	5,213.0	180.0	233.0	5,918.0	500.0	47.0	5,963.0	1,030.0
NON-U.S. MANUFACTURERS																
Captive	--	184.2	210.3	--	110.2	196.0	--	37.0	240.0	--	12.0	276.0	22.0	10.0	285.0	65.0
OEM	.3	501.5	805.6	.3	145.5	1,071.1	--	55.0	1,719.0	18.0	40.0	2,037.0	72.0	35.0	2,125.0	280.0
TOTAL NON-U.S. SHIPMENTS	.3	685.7	1,015.9	.3	255.7	1,267.1	--	92.0	1,959.0	18.0	52.0	2,313.0	94.0	45.0	2,410.0	345.0
WORLDWIDE RECAP																
Captive	--	184.2	1,271.0	--	110.2	1,261.0	--	37.0	1,258.0	--	12.0	1,209.0	72.0	10.0	1,044.0	285.0
	--	-68.3%	+408.2%	--	-40.2%	-.8%	--	-66.4%	-.2%	--	-67.6%	-3.9%	--	-16.7%	-13.6%	+295.8%
OEM	1.0	3,319.1	1,993.7	.3	2,510.8	3,698.1	2.0	928.0	5,914.0	198.0	273.0	7,022.0	522.0	82.0	7,329.0	1,090.0
	-81.1%	+5.0%	+83.5%	-70.0%	-24.4%	+85.5%	--	-63.0%	+59.9%	--	-70.6%	+18.7%	+163.6%	-70.0%	+4.4%	+108.8%
Total Shipments	1.0	3,503.3	3,264.7	.3	2,621.0	4,959.1	2.0	965.0	7,172.0	198.0	285.0	8,231.0	594.0	92.0	8,373.0	1,375.0
	-89.7%	-6.3%	+144.3%	-70.0%	-25.2%	+51.9%	--	-63.2%	+44.6%	--	-70.5%	+14.8%	+200.0%	-67.7%	+1.7%	+131.5%
ANNUAL SHARE, BY DIAMETER	--	51.9%	48.1%	--	34.7%	65.3%	--	11.6%	86.1%	2.3%	3.1%	90.5%	6.4%	.9%	85.2%	13.9%

TABLE 25
FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	246.4	3.6	39.4	.4
PERSONAL COMPUTERS Business and professional, single user	6061.7	89.6	8787.0	89.3
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	182.1	2.7	344.4	3.5
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	157.0	2.3	334.6	3.4
CONSUMER AND HOBBY COMPUTERS	111.0	1.6	314.9	3.2
OTHER APPLICATIONS	10.8	.2	19.7	.2
Total	6768.9	100.0	9840.1	100.0

TABLE 26
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	8"	5.25"	3.5"	Total		8"	5.25"	3.5"	Total	
SEAGATE	--	1507.3	7.6	1514.9	60.9	--	2209.8	14.2	2224.0	41.9
MINISCRIBE	--	280.0	100.0	380.0	15.3	--	400.0	570.0	970.0	18.3
NEC	--	52.0	3.0	55.0	2.2	--	366.0	114.0	480.0	9.0
TANDON	--	--	25.0	25.0	1.0	--	--	345.0	345.0	6.5
JVC	--	--	20.0	20.0	.8	--	--	230.0	230.0	4.3
MICROSCIENCE	--	58.5	2.0	60.5	2.4	--	195.0	5.0	200.0	3.8
RODIME	--	1.0	128.0	129.0	5.2	--	5.0	160.0	165.0	3.1
PLUS DEVELOPMENT	--	--	100.0	100.0	4.0	--	--	125.0	125.0	2.4
LAPINE	--	--	81.0	81.0	3.3	--	--	108.0	108.0	2.0
Other U.S.	.5	7.5	20.9	28.9	1.1	.7	12.8	20.9	34.4	.6
Other Non-U.S.	--	3.2	91.1	94.3	3.8	.3	130.5	301.6	432.4	8.1
TOTAL	.5	1909.5	578.6	2488.6	100.0	1.0	3319.1	1993.7	5313.8	100.0

FIXED DISK DRIVES, 30-60 MEGABYTESCoverage

Examples of disk drives in this group include:

8" disk diameter

Fujitsu	M2311K
Hitachi	DK812S-5

5.25" disk diameter

Fujitsu	M2241, M2242
Hitachi	DK511-5, DK521-5*
IBM	4956
Imprimis (Control Data)	94155-48
Micropolis	1333A
Microscience International	HH-1050*, HH-830*
Miltope	RDS-5000
Miniscribe	3650*, 3053*
Mitsubishi Electric	MR533*, MR535*
NEC	D5127H*, D5146H*
Quantum	Q250*
Sagem	MSA 240-50
Seagate Technology	ST4038, ST251*
Teac	SD-540*
Tokico	DK5046*
Toshiba	MK-53FB
Xebec	Owl 40AT*

3.5" disk diameter

Alps Electric	DRQ040A**
Areal Technology	BP 50**
Brand Technologies	BT9053*
Cardiff Peripherals	F3057*
Comport	2040*, 2041*
Conner Peripherals	CP340*, CP344*
Fuji Electric	FK303-52*, FK308S-58R*
Fujitsu	M2226D2*, M2611S**
Hitachi	DK302-3*
IBM	8550-031
JVC	JD-3848H*
Kalok	KL330*
Kyocera	KC 40C*
Matsushita Communication Ind.	JU-127*, JU-128*
Microscience International	HH-330*
Miltope	RDS-3040
Miniscribe	8438*, 8438F*
Mitsubishi Electric	MR335*

3.5" disk diameter (continued)

NEC	D3142*
Peripheral Technology	PT338*, PT357R*
Plus Development	Hardcard 40*
Quantum	40S*, 40AT*
Rodime	R03055*, R03065*
Samsung Electronics	SHD2040M*
Seagate Technology	ST138*, ST157N*
Seiko Epson	HMD-946*
Shinwa Digital	D440*
Tokico	TD3041C*, TD3042C**
Toshiba	MK-133FA*, MK-134FA*
Western Digital	WD93038-X*
Y-E Data	YD-3042*

*Indicates drives with maximum 41.3 mm height, or less.

**Indicates drives with maximum 25.4 mm height, or less.

1988 is the first year that the drives in this capacity range have been analyzed as a separate group. Through last year, they had been included in the broader 30-100 megabyte group in several previous editions of the DISK/TREND Report.

These are all nominally "Winchester" drives, but 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.

In the last two years, numerous 3.5" drives were introduced in this product group. Intense competition is developing at the 40 megabyte (formatted) level, which will lead to a variety of attempts to reduce product costs, affecting product design.

Conner Peripheral's 40 megabyte drive, currently the 3.5" shipment leader in this product group, uses only two disks, and provided the model for many later drive introductions by other firms. Taking the trend to higher densities a step further, Fujitsu has announced a 45 megabyte single disk 3.5" drive.

Perhaps providing a glimpse of the future, a new manufacturer, Areal Technology, has announced a 3.5" drive with 50 megabyte capacity, using only one side of a single 3.5" disk. Despite the manufacturing difficulties caused by such high areal densities, the potential cost advantages from reduced parts count and mechanical simplification will continue to stimulate further innovation.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	1,557.5	1,560.8	1,756.2	1,871.0	1,942.2
All manufacturers	1,968.6	2,121.4	2,425.4	2,594.5	2,637.4

1987 was a boom year for drives in this product group, as drive manufacturers responded to the demand by personal computer users for more disk capacity. Worldwide unit shipments rose 223.3% in 1987, to 4,147,900 drives, generating \$1.9 billion in revenue. However, 1988's growth in unit shipments is expected to be a modest 39%, reflecting more restrained growth in personal computer shipments and diversion of part of the PC upgrade business to drives with more than 60 megabyte capacity.

Full size 5.25" drives in this capacity range had their last big year in 1987 with worldwide shipments of 1,342,400 units, but are forecasted to drop to 191,700 drives this year, almost 80% of which will be produced by IBM. Full size drives had already been eclipsed by half high models in 1987, and the 2,581,800 half high drives estimated for this year will constitute 93% of the 5.25" total.

1988 DISK/TREND REPORT

3.5" drives enjoyed an outstanding production start-up year in 1987, with numerous manufacturers participating in worldwide unit shipments of 990,500 drives. Explosive growth in 1988 is expected to result in shipments of 2,991,600 3.5" drives, 51.8% of the worldwide total for drives of all sizes in this product group.

Captive shipments are still dominated by IBM's activities. While 1987 IBM shipments of full size 5.25" "Pixie" drives were an estimated 350,000 units, 1988's total is forecasted at only 150,000 drives. One of the reasons for this decline is IBM's new 30 megabyte 3.5" drive, with 1988 shipments projected at 250,000 drives. Tandon's large captive 1987 shipments of 3.5" drives in this product group do not appear in the 1988 statistics, due to the sale of this product line to Western Digital, and 1988 shipments to Tandon are considered to be OEM sales by Western Digital.

Non-captive 1987 shipments were dominated by Seagate's OEM sales of 5.25" drives, which constituted almost all of the company's 1,616,000 drives included in this product group. Seagate's 47.3% of the worldwide OEM unit shipment total was followed by 11.2% for Miniscribe (split between 5.25" and 3.5"), 8.1% for Imprimis (all 5.25"), 7.4% for Conner Peripherals (all 3.5"), and 7.3% for Microscience International (mostly 5.25").

87% of 1987 total worldwide shipments of drives in this product group were used in single user personal computer applications. The 6.1% used with minicomputers and multi-user micros in 1987 is expected to be cut in half by 1991, in favor of higher capacity drives, while modest increases are expected in dedicated application non-office markets and with home computers.

Marketing trends

Next year's growth in unit shipments for this group is expected to be up over 1.2 million drives, but the forecast is for more modest increases to follow, with 1991 up only 5%. The outlook for worldwide revenue growth is even lower, with annual increases averaging only 7.7% during 1989-91, and slumping to 1.7% in 1991.

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 continuous upward movement in the average capacity of disk drives used with personal computers. This product group has been benefiting from that trend during the last few years, and will suffer from the same trend in the future as average capacities move up.

The growth pattern for 3.5" drives is destined to continue, assisted by increases in IBM's captive production of 3.5" drives, but with OEM drives holding the overwhelming majority of total shipments:

<u>Worldwide captive & OEM Unit shipments (000)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
5.25" full size	1,342.4 32.4%	191.7 3.3%	57.0 .8%	-- --	-- --
5.25" half high	1,809.1 43.7%	2,581.8 44.8%	1,914.0 27.2%	728.0 9.2%	158.0 1.9%
3.5"	990.5 23.9%	2,991.6 51.9%	5,062.0 72.0%	7,220.0 90.8%	8,187.0 98.1%

A classic rivalry has been underway between 5.25" half high drives and 3.5" drives, which still continues. 5.25" half high drives were available in the marketplace in production quantities well before 3.5" drives, at

lower prices. But their main strength during the last year has been continuing momentum for shipments of PC AT clones. However, the movement to small footprint personal computers favors future growth for the 3.5" drives in this capacity range, and they are expected to provide 98% of the group's 1991 worldwide shipments.

Technical trends

The same technical developments that are pushing drives below 30 megabytes in capacity toward single disk configurations are having a similar impact on this product group: The pressure to cut costs by reducing the parts count. The first of the single disk drives in the 40-50 megabyte range have been announced, and many more participants are to be expected during the next few years as availability of suitable heads and disks is established.

In addition to lower costs, higher areal density will also have the effect of speeding the transition to intelligent embedded controllers. Higher recording densities mean higher transfer rates, and frequently will be used with multiple recording bands, each with different densities. In order to mask individual drive peculiarities, it is expected that most new drives will offer embedded controllers, with the choice of leading interfaces such as SCSI, PC AT and others.

Higher areal density will also make smaller box sizes practical. It is obvious that the new single disk 3.5" drives will be offered in one inch high packages, but further reductions in disk diameter may also appear. Although not forecasted separately in this edition of the DISK/TREND report, it would not be surprising to see the appearance of

2.5" drives in this product group, now that they have been introduced at the 20 megabyte capacity level.

Forecasting assumptions

1. IBM's production of 5.25" drives will stop in 1989, but continuous growth for 3.5" drives will occur. IBM will continue to rely primarily on internal manufacturing for drives in this group, but will supplement internal shortfalls with outside purchases.
2. The decline of OEM 5.25" drives will continue, replaced by the movement to 3.5" drives.

TABLE 27
FIXED DISK DRIVES, 30 - 60 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		Forecast							
	Revenues		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM Captive	249.9	367.5	244.4	356.3	337.0	498.0	408.8	618.8	448.0	700.0
Other U.S. Captive	14.0	85.3	1.2	1.2	2.2	2.4	3.0	4.0	2.4	4.0
TOTAL U.S. CAPTIVE	263.9	452.8	245.6	357.5	339.2	500.4	411.8	622.8	450.4	704.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	905.1	1,104.7	749.3	1,203.3	766.7	1,255.8	730.1	1,248.2	694.6	1,238.2
TOTAL U.S. NON-CAPTIVE	905.1	1,104.7	749.3	1,203.3	766.7	1,255.8	730.1	1,248.2	694.6	1,238.2
TOTAL U.S. REVENUES	1,169.0	1,557.5	994.9	1,560.8	1,105.9	1,756.2	1,141.9	1,871.0	1,145.0	1,942.2
<u>Non-U.S. Manufacturers</u>										
Captive	88.2	186.5	54.6	184.1	61.8	188.3	65.8	184.0	72.3	180.7
PCM	--	--	--	--	--	--	--	--	--	--
OEM	54.8	224.6	100.8	376.5	138.3	480.9	159.4	539.5	153.4	514.5
TOTAL NON-U.S. REVENUES	143.0	411.1	155.4	560.6	200.1	669.2	225.2	723.5	225.7	695.2
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE REVENUES	1,312.0	1,968.6	1,150.3	2,121.4	1,306.0	2,425.4	1,367.1	2,594.5	1,370.7	2,637.4
OEM Average Price (\$000)	.385	.389	.294	.301	.272	.277	.254	.257	.243	.246

TABLE 28
FIXED DISK DRIVES, 30 - 60 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1987		Forecast							
	Shipments		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	238.0	350.0	275.0	400.0	413.0	610.0	545.0	825.0	640.0	1,000.0
Other U.S. Captive	44.6	288.2	.8	.8	1.8	2.0	3.0	4.0	3.0	5.0
TOTAL U.S. CAPTIVE	282.6	638.2	275.8	400.8	414.8	612.0	548.0	829.0	643.0	1,005.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	2,345.2	2,907.1	2,593.5	4,163.3	2,880.0	4,715.0	2,928.0	5,005.0	2,894.0	5,159.0
TOTAL U.S. NON-CAPTIVE	2,345.2	2,907.1	2,593.5	4,163.3	2,880.0	4,715.0	2,928.0	5,005.0	2,894.0	5,159.0
TOTAL U.S. SHIPMENTS	2,627.8	3,545.3	2,869.3	4,564.1	3,294.8	5,327.0	3,476.0	5,834.0	3,537.0	6,164.0
Non-U.S. Manufacturers										
Captive	42.0	89.9	36.0	114.4	53.0	151.0	66.0	176.0	87.0	209.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	147.9	512.7	302.6	1,087.1	452.0	1,555.1	575.0	1,938.0	589.0	1,972.0
TOTAL NON-U.S. SHIPMENTS	189.9	602.6	338.6	1,201.5	505.0	1,706.1	641.0	2,114.0	676.0	2,181.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,817.7	4,147.9	3,207.9	5,765.6	3,799.8	7,033.1	4,117.0	7,948.0	4,213.0	8,345.0
Cumulative Shipments										
IBM	459.1	668.0	734.1	1,068.0	1,147.1	1,678.0	1,692.1	2,503.0	2,332.1	3,503.0
Non-IBM	3,971.0	5,772.5	6,903.9	11,138.1	10,290.7	17,561.2	13,862.7	24,684.2	17,435.7	32,029.2
WORLDWIDE TOTAL	4,430.1	6,440.5	7,638.0	12,206.1	11,437.8	19,239.2	15,554.8	27,187.2	19,767.8	35,532.2

TABLE 29
 FIXED DISK DRIVES, 30 - 60 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1987			Forecast									
	Revenues			1988			1989			1990		1991	
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS													
IBM Captive	--	367.5	--	--	150.0	206.3	--	50.0	448.0	--	618.8	--	700.0
Other U.S. Captive	--	9.4	75.9	--	1.2	--	--	2.4	--	4.0	--	4.0	--
OEM	7.3	926.0	171.4	--	661.7	541.6	--	449.8	806.0	154.4	1,093.8	29.8	1,208.4
TOTAL U.S. REVENUES	7.3	1,302.9	247.3	--	812.9	747.9	--	502.2	1,254.0	158.4	1,712.6	33.8	1,908.4
NON-U.S. MANUFACTURERS													
Captive	--	160.0	26.5	--	117.9	66.2	--	78.3	110.0	54.4	129.6	25.5	155.2
OEM	1.8	138.3	84.5	1.0	76.1	299.4	.2	58.6	422.1	23.6	515.9	5.4	509.1
TOTAL NON-U.S. REVENUES	1.8	298.3	111.0	1.0	194.0	365.6	.2	136.9	532.1	78.0	645.5	30.9	664.3
WORLDWIDE RECAP													
Captive	--	536.9	102.4	--	269.1	272.5	--	130.7	558.0	58.4	748.4	29.5	855.2
	--	-2.8%	--	--	-49.9%	+166.1%	--	-51.4%	+104.8%	-55.3%	+34.1%	-49.5%	+14.3%
OEM	9.1	1,064.3	255.9	1.0	737.8	841.0	.2	508.4	1,228.1	178.0	1,609.7	35.2	1,717.5
	-71.2%	+116.5%	--	-89.0%	-30.7%	+228.6%	-80.0%	-31.1%	+46.0%	-65.0%	+31.1%	-80.2%	+6.7%
Total Revenues	9.1	1,601.2	358.3	1.0	1,006.9	1,113.5	.2	639.1	1,786.1	236.4	2,358.1	64.7	2,572.7
	-90.9%	+53.4%	--	-89.0%	-37.1%	+210.8%	-80.0%	-36.5%	+60.4%	-63.0%	+32.0%	-72.6%	+9.1%
ANNUAL SHARE, BY DIAMETER	.5%	81.4%	18.1%	--	47.6%	52.4%	--	26.5%	73.5%	9.1%	90.9%	2.5%	97.5%

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

	1987			Forecast									
	Shipments			1988			1989			1990		1991	
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS													
IBM Captive	--	350.0	--	--	150.0	250.0	--	50.0	560.0	--	825.0	--	1,000.0
Other U.S. Captive	--	12.2	276.0	--	.8	--	--	2.0	--	4.0	--	5.0	--
OEM	5.0	2,443.8	458.3	--	2,383.1	1,780.2	--	1,730.0	2,985.0	630.0	4,375.0	124.0	5,035.0
TOTAL U.S. SHIPMENTS	5.0	2,806.0	734.3	--	2,533.9	2,030.2	--	1,782.0	3,545.0	634.0	5,200.0	129.0	6,035.0
NON-U.S. MANUFACTURERS													
Captive	--	71.9	18.0	--	56.4	58.0	--	41.0	110.0	32.0	144.0	15.0	194.0
OEM	.9	273.6	238.2	.5	183.2	903.4	.1	148.0	1,407.0	62.0	1,876.0	14.0	1,958.0
TOTAL NON-U.S. SHIPMENTS	.9	345.5	256.2	.5	239.6	961.4	.1	189.0	1,517.0	94.0	2,020.0	29.0	2,152.0
WORLDWIDE RECAP													
Captive	--	434.1	294.0	--	207.2	308.0	--	93.0	670.0	36.0	969.0	20.0	1,194.0
	--	+41.1%	--	--	-52.3%	+4.8%	--	-55.1%	+117.5%	-61.3%	+44.6%	-44.4%	+23.2%
OEM	5.9	2,717.4	696.5	.5	2,566.3	2,683.6	.1	1,878.0	4,392.0	692.0	6,251.0	138.0	6,993.0
	-68.9%	+193.6%	--	-91.5%	-5.6%	+285.3%	-80.0%	-26.8%	+63.7%	-63.2%	+42.3%	-80.1%	+11.9%
Total Shipments	5.9	3,151.5	990.5	.5	2,773.5	2,991.6	.1	1,971.0	5,062.0	728.0	7,220.0	158.0	8,187.0
	-79.2%	+155.6%	--	-91.5%	-12.0%	+202.0%	-80.0%	-28.9%	+69.2%	-63.1%	+42.6%	-78.3%	+13.4%
ANNUAL SHARE, BY DIAMETER	.1%	76.1%	23.8%	--	48.2%	51.8%	--	28.1%	71.9%	9.2%	90.8%	1.9%	98.1%

TABLE 31
 FIXED DISK DRIVES, 30 - 60 MEGABYTES
 APPLICATIONS SUMMARY
 Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	254.7	6.1	250.4	3.0
PERSONAL COMPUTERS Business and professional, single user	3610.4	87.0	7268.4	87.1
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	119.0	2.9	200.3	2.4
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	133.1	3.2	500.7	6.0
CONSUMER AND HOBBY COMPUTERS	23.6	.6	108.5	1.3
OTHER APPLICATIONS	7.1	.2	16.7	.2
Total	4147.8	100.0	8345.1	100.0

TABLE 32
 FIXED DISK DRIVES, 30 - 60 MEGABYTES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	8"	5.25"	3.5"	Total		8"	5.25"	3.5"	Total	
SEAGATE	--	1367.6	2.1	1369.7	54.9	--	1613.8	2.2	1616.0	47.3
MINISCRIBE	--	190.0	100.0	290.0	11.6	--	233.0	150.0	383.0	11.2
IMPRIMIS (CDC)	--	219.4	--	219.4	8.8	--	277.8	--	277.8	8.1
CONNER PERIPHERALS	--	--	248.0	248.0	9.9	--	--	254.0	254.0	7.4
MICROSCIENCE	--	120.0	4.0	124.0	5.0	--	240.0	10.0	250.0	7.3
NEC	--	17.0	1.0	18.0	.7	--	150.0	3.0	153.0	4.5
FUJITSU	--	1.8	14.7	16.5	.7	--	13.8	83.8	97.6	2.9
FUJI ELECTRIC	--	--	60.0	60.0	2.4	--	--	70.0	70.0	2.0
RODIME	--	3.5	20.0	23.5	1.0	--	35.0	25.0	60.0	1.8
Other U.S.	3.5	57.5	33.1	94.1	3.8	5.0	79.2	42.1	126.3	3.7
Other Non-U.S.	--	17.1	12.8	29.9	1.2	.9	74.8	56.4	132.1	3.8
TOTAL	3.5	1993.9	495.7	2493.1	100.0	5.9	2717.4	696.5	3419.8	100.0

FIXED DISK DRIVES, 60-100 MEGABYTESCoverage

Examples of disk drives in this group include:

8" disk diameter

Fujitsu	M2312K, M2321K
Hitachi	DK812S-8
IBM	4963-64A
Priam	7050, 803
Toshiba	MK-182FB

5.25" disk diameter

Brand Technologies	BT8085
Fujitsu	M2243
Hitachi	DK511-8, DK512-8
IBM	5364, 667-85
Imprimis (Control Data)	94155-85, 94205-77*
Magnum Technology	MT3085
Maxtor	XT-1085
Micropolis	1353, 1373
Microscience International	HH-1075*, HH-1090*
Miniscribe	6085, 3675*
Mitsubishi Electric	MR537S*
NEC	D5147H*, D5452
Newbury Data	NDR 1085
Priam	V185A
Quantum	Q280*
Rodime	R05090*
Seagate	ST277N*, ST4096
Tokico	DK5087*
Toshiba	MK-56FB

3.5" disk diameter

Brand Technologies	BT9075*
Cardiff Peripherals	F3096*
Comport	2082*
Fujitsu	M2612S**
IBM	8550-061
Kyocera	KC 80C*
Matsushita Communication Ind.	JU-1391*
Maxtor	LXT-100S*
Peripheral Technology	PT-4102S*
Quantum	80S*, 80AT*
Rodime	R03085A/S*
Seiko Epson	HMD-976*

3.5" disk diameter (continued)Tokico
Y-E DataTD3081E*
YD-3082*

*Indicates drives with maximum 41.3 mm height, or less.

**Indicates drives with maximum 25.4 mm height, or less.

60-100 megabyte drives have been split into a separate product group this year, instead of being included in the previous 30-100 megabyte group. Significant shipments in this product group got underway in 1981 with early entrants such as the 8" Priam and Fujitsu drives, which developed quick acceptance of the 8" form factor at this capacity level, and rapidly displaced earlier 14" drives.

During recent years, however, even more substantial displacement, this time of 8" models, followed the 1984 arrival of 85 megabyte 5.25" drives. By providing a major reduction in price and making possible the addition of higher disk capacities to desktop workstations, 85 megabyte 5.25" drives became one of the industry's classic success stories. Newer half high versions are continuing much of the same momentum.

1988 is also seeing the start of production shipments for 3.5" drives by many additional companies, plus several of the 5.25" drive producers. So far, the majority of the 3.5" drives are targeted at personal computer applications, with embedded controllers compatible with IBM PC AT standards, as well as SCSI, commonly offered.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	889.3	1,392.7	1,650.7	1,978.0	2,356.5
All manufacturers	1,151.2	1,584.2	2,067.8	2,485.3	2,893.2

1988 DISK/TREND REPORT

Disk drives in this capacity range have become an important part of the industry, led by the rapid growth of 85 megabyte 5.25" drives during the second half of this decade. Total shipments of all drives in the product group were 1,043,900 units in 1987, 97% of which were 5.25" models, and revenues topped \$1 billion.

But disk drive industry successes are temporary phenomena. 8" drive shipments in this group peaked in 1984, and total 5.25" shipments will top out this year, even though shipments of half high versions are expected to grow for another year. 3.5" drive shipments are off to a fast start, boosted by heavy shipments of IBM's new 60 megabyte drive for mid-range PS/2 models, providing over 75% of the estimated 3.5" shipment total for 1988. Numerous manufacturing programs for OEM 3.5" drives are also being established during 1988, facilitating rapid future growth.

The personal computer market bought 43.6% of the unit shipments for this group in 1987, and this share is forecasted to grow to 73.8% in 1991. Growing reliance on this application area set the stage for the pricing donnybrook which occurred in the U.S. market for 5.25" OEM drives in 1988. Although the market with traditional system manufacturers was in decline, drive manufacturers had discovered that the personal computer aftermarket was able to absorb most of their available production, as more and more users upgraded systems. Unfortunately for the traditional market leaders in this product group, Seagate eventually discovered the market, too. As a result, average prices for all OEM drives in the group dropped from \$700 in 1987 to \$558 in 1988, with much lower prices the norm in the PC aftermarket.

Micropolis maintained its lead in non-captive unit shipments in 1987 with 272,600 drives, 32.6% of the worldwide total. Quantum moved up to

1988 DISK/TREND REPORT

16.1% on the strength of its half high 5.25" drive, Imprimis held 11.8%, and Priam had 8.3%.

Marketing trends

1987's one million drive shipment total is forecasted to grow to five million drives in 1991, with worldwide revenues over \$2.8 billion. The major cause for growth will continue to be the expanding market for mid-range personal computers, and most of the growth will go to 3.5" drives. Average annual growth for 3.5" drives is estimated at 125.1% for 1989-91.

The only increases forecasted for 5.25" drives are in half high models, and that will continue only through 1989:

<u>Worldwide captive & OEM Unit shipments (000)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
5.25" full size	800.0 78.7%	765.1 45.6%	375.5 13.7%	155.0 4.1%	62.0 1.2%
5.25" half high	211.6 20.8%	403.5 24.0%	596.0 21.7%	517.0 13.9%	233.0 4.6%
3.5"	5.0 .5%	510.7 30.4%	1,771.0 64.6%	3,058.0 82.0%	4,761.0 94.2%

Almost 60% of 1991 unit shipments of 3.5" drives are expected to be OEM models, totaling 2.8 million units. Of the remaining 1.9 million captive units, IBM is forecasted to account for most of the total, with 1.8 million.

Technical trends

It is believed that technology employed for drives in this product group will be derived mostly from programs developed for the groups above and below it in capacity. The extensive development of 3.5" drives with

capacities above 100 megabytes will result in achievement of high areal densities, which will be employed with drives in this group as suitable heads, disks and other components become available through the pioneering at higher capacities. The packaging techniques developed for one inch high drives with lower capacities also will be adapted to this product group, taking advantage of the availability of miniaturized drive motors, head positioning mechanisms and electronic components.

Interfaces offered on future 3.5" drives in this group will also probably follow the patterns established on lower capacity drives. Because of the higher areal densities to be employed, embedded controllers will be used with most drives, to mask unique individual file organization, with most drive manufacturers offering an optional choice of most interfaces compatible with popular personal computers.

Forecasting assumptions

1. IBM's production of 8" drives will stop in 1988, and production of 5.25" drives will stop in 1989, while 3.5" shipments will build rapidly. IBM will rely on internal manufacturing for drives in this group, but will supplement internal shortfalls with outside purchases.
2. Growth for OEM 5.25" drives will end in 1988, except for continued growth for half high models through 1989, limited by movement to higher capacities, and by a movement to 3.5" drives.
3. Availability of OEM 3.5" drives will be adequate to satisfy growing demand.

TABLE 33
FIXED DISK DRIVES, 60-100 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		-----Forecast-----							
	Revenues		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	267.2	400.0	621.9	875.0	705.2	1,010.5	795.6	1,170.0	833.0	1,260.0
Other U.S. Captive	13.8	25.5	10.1	20.8	24.8	43.5	46.8	80.0	60.5	106.3
TOTAL U.S. CAPTIVE	281.0	425.5	632.0	895.8	730.0	1,054.0	842.4	1,250.0	893.5	1,366.3
PCM	--	--	--	--	--	--	--	--	--	--
OEM	363.4	463.8	376.5	496.9	441.4	596.7	547.4	728.0	698.3	990.2
TOTAL U.S. NON-CAPTIVE	363.4	463.8	376.5	496.9	441.4	596.7	547.4	728.0	698.3	990.2
TOTAL U.S. REVENUES	644.4	889.3	1,008.5	1,392.7	1,171.4	1,650.7	1,389.8	1,978.0	1,591.8	2,356.5
Non-U.S. Manufacturers										
Captive	48.0	135.7	--	58.8	3.6	131.2	7.8	148.2	18.0	153.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	52.0	126.2	61.9	132.7	154.5	285.9	189.9	359.1	183.3	383.7
TOTAL NON-U.S. REVENUES	100.0	261.9	61.9	191.5	158.1	417.1	197.7	507.3	201.3	536.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	744.4	1,151.2	1,070.4	1,584.2	1,329.5	2,067.8	1,587.5	2,485.3	1,793.1	2,893.2
OEM Average Price (\$000)	.681	.700	.541	.558	.495	.502	.470	.473	.446	.447

TABLE 34
FIXED DISK DRIVES, 60-100 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1987		Forecast							
	Shipments		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	108.0	160.0	402.0	550.0	632.0	905.0	884.0	1,300.0	1,190.0	1,800.0
Other U.S. Captive	3.5	8.6	2.3	4.4	16.5	27.5	34.0	56.0	49.0	84.0
TOTAL U.S. CAPTIVE	111.5	168.6	404.3	554.4	648.5	932.5	918.0	1,356.0	1,239.0	1,884.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	540.6	687.5	710.1	935.7	915.5	1,236.0	1,185.0	1,576.0	1,583.0	2,245.0
TOTAL U.S. NON-CAPTIVE	540.6	687.5	710.1	935.7	915.5	1,236.0	1,185.0	1,576.0	1,583.0	2,245.0
TOTAL U.S. SHIPMENTS	652.1	856.1	1,114.4	1,490.1	1,564.0	2,168.5	2,103.0	2,932.0	2,822.0	4,129.0
Non-U.S. Manufacturers										
Captive	12.0	32.4	--	20.0	2.0	52.0	6.0	75.0	15.0	98.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	69.2	155.4	99.7	193.4	288.1	523.5	383.0	723.0	395.0	829.0
TOTAL NON-U.S. SHIPMENTS	81.2	187.8	99.7	213.4	290.1	575.5	389.0	798.0	410.0	927.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	733.3	1,043.9	1,214.1	1,703.5	1,854.1	2,744.0	2,492.0	3,730.0	3,232.0	5,056.0
Cumulative Shipments										
IBM	349.1	526.0	751.1	1,076.0	1,383.1	1,981.0	2,267.1	3,281.0	3,457.1	5,081.0
Non-IBM	1,541.2	2,218.6	2,353.3	3,372.1	3,575.4	5,211.1	5,183.4	7,641.1	7,225.4	10,897.1
WORLDWIDE TOTAL	1,890.3	2,744.6	3,104.4	4,448.1	4,958.5	7,192.1	7,450.5	10,922.1	10,682.5	15,978.1

TABLE 35
FIXED DISK DRIVES, 60-100 MEGABYTES
WORLDWIDE REVENUES (\$M)
BREAKDOWN BY DISK DIAMETER

	1987			Forecast									
	Revenues			1988			1989			1990		1991	
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS													
IBM Captive	148.0	252.0	--	144.0	221.0	510.0	--	48.0	962.5	--	1,170.0	--	1,260.0
Other U.S. Captive	--	25.5	--	--	20.8	--	--	21.9	21.6	49.0	31.0	68.7	37.6
OEM	7.7	456.1	--	5.4	467.5	24.0	2.0	354.5	240.2	224.3	503.7	79.4	910.8
TOTAL U.S. REVENUES	155.7	733.6	--	149.4	709.3	534.0	2.0	424.4	1,224.3	273.3	1,704.7	148.1	2,208.4
NON-U.S. MANUFACTURERS													
Captive	6.0	129.7	--	--	57.0	1.8	--	98.8	32.4	93.6	54.6	63.0	90.0
OEM	6.2	116.5	3.5	3.3	87.9	41.5	1.0	92.5	192.4	72.9	286.2	30.0	353.7
TOTAL NON-U.S. REVENUES	12.2	246.2	3.5	3.3	144.9	43.3	1.0	191.3	224.8	166.5	340.8	93.0	443.7
WORLDWIDE RECAP													
Captive	154.0 -61.4%	407.2 +422.1%	--	144.0 -6.5%	298.8 -26.6%	511.8 --	--	168.7 -43.5%	1,016.5 +98.6%	142.6 -15.5%	1,255.6 +23.5%	131.7 -7.6%	1,387.6 +10.5%
OEM	13.9 -48.3%	572.6 +3.7%	3.5	8.7 -37.4%	555.4 -3.0%	65.5 --	3.0 -65.5%	447.0 -19.5%	432.6 +560.5%	297.2 -33.5%	789.9 +82.6%	109.4 -63.2%	1,264.5 +60.1%
Total Revenues	167.9 -60.5%	979.8 +55.4%	3.5	152.7 -9.1%	854.2 -12.8%	577.3 --	3.0 -98.0%	615.7 -27.9%	1,449.1 +151.0%	439.8 -28.6%	2,045.5 +41.2%	241.1 -45.2%	2,652.1 +29.7%
ANNUAL SHARE, BY DIAMETER	14.6%	85.2%	.2%	9.6%	54.0%	36.4%	.1%	29.9%	70.0%	17.7%	82.3%	8.3%	91.7%

Note: 8 inch totals include 10.5 inch drives.

TABLE 36
 FIXED DISK DRIVES, 60-100 MEGABYTES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987			Forecast									
	Shipments			1988			1989			1990		1991	
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS													
IBM Captive	20.0	140.0	--	20.0	130.0	400.0	--	30.0	875.0	--	1,300.0	--	1,800.0
Other U.S. Captive	--	8.6	--	--	4.4	--	--	9.5	18.0	25.0	31.0	37.0	47.0
OEM	4.0	683.5	--	2.7	893.0	40.0	1.0	745.0	490.0	481.0	1,095.0	175.0	2,070.0
TOTAL U.S. SHIPMENTS	24.0	832.1	--	22.7	1,027.4	440.0	1.0	784.5	1,383.0	506.0	2,426.0	212.0	3,917.0
NON-U.S. MANUFACTURERS													
Captive	.6	31.8	--	--	19.0	1.0	--	34.0	18.0	33.0	42.0	23.0	75.0
OEM	2.7	147.7	5.0	1.5	122.2	69.7	.5	153.0	370.0	133.0	590.0	60.0	769.0
TOTAL NON-U.S. SHIPMENTS	3.3	179.5	5.0	1.5	141.2	70.7	.5	187.0	388.0	166.0	632.0	83.0	844.0
WORLDWIDE RECAP													
Captive	20.6	180.4	--	20.0	153.4	401.0	--	73.5	911.0	58.0	1,373.0	60.0	1,922.0
	-59.7%	+667.7%	--	-2.9%	-15.0%	--	--	-52.1%	+127.2%	-21.1%	+50.7%	+3.4%	+40.0%
OEM	6.7	831.2	5.0	4.2	1,015.2	109.7	1.5	898.0	860.0	614.0	1,685.0	235.0	2,839.0
	-50.4%	+26.9%	--	-37.3%	+22.1%	--	-64.3%	-11.5%	+684.0%	-31.6%	+95.9%	-61.7%	+68.5%
Total Shipments	27.3	1,011.6	5.0	24.2	1,168.6	510.7	1.5	971.5	1,771.0	672.0	3,058.0	295.0	4,761.0
	-57.7%	+49.0%	--	-11.4%	+15.5%	--	-93.8%	-16.9%	+246.8%	-30.8%	+72.7%	-56.1%	+55.7%
ANNUAL SHARE, BY DIAMETER	2.6%	97.0%	.4%	1.4%	68.7%	29.9%	.1%	35.5%	64.4%	18.0%	82.0%	5.8%	94.2%

Note: 8 inch totals include 10.5 inch drives.

TABLE 37
 FIXED DISK DRIVES, 60 - 100 MEGABYTES
 APPLICATIONS SUMMARY
 Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	.9	.1	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	338.4	32.4	657.3	13.0
PERSONAL COMPUTERS Business and professional, single user	455.1	43.6	3731.3	73.8
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	48.1	4.6	192.1	3.8
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	201.4	19.3	455.0	9.0
CONSUMER AND HOBBY COMPUTERS	--	--	15.2	.3
OTHER APPLICATIONS	--	--	5.1	.1
Total	1043.8	100.0	5056.0	100.0

TABLE 38
 FIXED DISK DRIVES, 60-100 MEGABYTES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	8"	5.25"	3.5"	Total		8"	5.25"	3.5"	Total	
MICROPOLIS	--	209.3	--	209.3	34.3	--	272.6	--	272.6	32.4
QUANTUM	--	106.0	--	106.0	17.4	--	136.0	--	136.0	16.1
IMPRIMIS (CDC)	--	68.5	--	68.5	11.2	--	99.3	--	99.3	11.8
PRIAM	2.4	58.2	--	60.6	9.9	4.0	66.2	--	70.2	8.3
SEAGATE	--	49.5	--	49.5	8.1	--	52.2	--	52.2	6.2
RODIME	--	28.0	4.0	32.0	5.3	--	35.0	5.0	40.0	4.8
TOSHIBA	--	18.4	--	18.4	3.0	--	39.9	--	39.9	4.7
FUJITSU	.6	11.4	--	12.0	2.0	2.1	35.4	--	37.5	4.4
MINISCRIBE	--	30.2	--	30.2	5.0	--	35.7	--	35.7	4.2
Other U.S.	--	16.5	--	16.5	2.7	--	21.5	--	21.5	2.6
Other Non-U.S.	--	6.8	--	6.8	1.1	.6	37.4	--	38.0	4.5
TOTAL	3.0	602.8	4.0	609.8	100.0	6.7	831.2	5.0	842.9	100.0

Note: 8 inch totals include 10.5 inch drives.

FIXED DISK DRIVES, 100-300 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Fujitsu	M2284
IBM	4967-2CX, 5360-BXX
Priam	15450

9" disk diameter

Imprimis (Control Data)	9715-160
-------------------------	----------

8" disk diameter

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

5.25" disk diameter

Brand Technologies	BT8128, BT8170E/S
Century Data	14406*
Fujitsu	M2245E, M2243R*
Hewlett-Packard	97532S, 97533E
Hitachi	DK512-17, DK522C-10*
IBM	8580-111, 669
Imprimis (Control Data)	94166-182, 94221-190*
Maxtor	XT-1140, XT-2190
Micropolis	1554, 1674-7*
Microscience International	HH-1120*, HH-3120*
Miltope	RDS-1720
Miniscribe	6128, 3180E/S*
Mitsubishi Electric	MR5310E*
NEC	D5655*, D5852
Newbury Data	NDR 2190, NDR 4175E
Priam	519, 728
Rodime	R05180S*
Sagem	MSA 250-100
Seagate Technology	ST4144R, ST4192N
Siemens	2300
Toshiba	MK-154FA, MK-156FB

3.5" disk diameter

Areal Technology	BP 100**
Brand Technologies	BP9149E*
Cardiff Peripherals	F-3127*
Conner Peripherals	CP3100*, CP3114*
Fujitsu	M2614S**
IBM	8570-121
Imprimis (Control Data)	94354-200*
Maxtor	LXT-100S*, LXT-200S*
Microscience International	5100*
NEC	D3661*
Peripheral Technology	PT4102R*
Quantum	170S*
Rodime	R03130A*

*Indicates drives with maximum 41.3 mm height, or less.

**Indicates drives with maximum 25.4 mm height, or less.

Previously the exclusive domain of 14" drives, the 1980's have seen numerous introductions of drives using smaller diameter disks in this group. A parade of 8" drives was launched at the beginning of the decade, followed by numerous 5.25" drives in the middle of the decade -- and now by a wave of 3.5" drives since 1987.

These, as well as the older 14" drives, all use variations of Winchester technology. Disks used with the 14" and 8" drives are oxide coated, but disks used on the 5.25" and 3.5" drives are mostly plated or sputtered.

Heads are usually ferrite types on the 14" and 8" drives, and also on a majority of the smaller drives, usually "mini" types patterned after the 3370 slider. There is limited usage of thin film heads, except for 5.25" and 3.5" drives employing higher areal densities.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	884.1	1,545.8	1,860.7	2,038.8	2,628.6
All manufacturers	1,350.0	2,201.2	2,613.1	2,894.5	3,543.5

As recently as 1985, 5.25" drives provided only 6.4% of the revenues and 16.6% of the unit shipments for this product group. Only two years later, 1987 revenues for 5.25" drives were more than half of the group total, and 83.1% of the group's unit shipments were 5.25" drives.

However, the rapid migration to 5.25" drives reduced revenue growth in 1987, with total revenue for the group at \$1.35 billion, up only 8.3% over the previous year, while unit shipments at 528,800 drives were up 108.8%. Also tending to dampen total revenue growth was the shrinking production of captive 8"-14" drives, with typical prices much higher than smaller diameter drives.

U.S. manufacturers continue to win back the largest share of non-captive drive revenues in this product group by dominating shipments of 5.25" drives, holding 84% of 5.25" unit shipments in both 1987 and 1988. Japanese manufacturers continue to lead in 8" OEM drive shipments, but these products are now dropping rapidly. IBM's shipments of 14", 8", and 5.25" drives, plus a new 3.5" model, are estimated at 252,500 units for 1988, 73.6% of the captive worldwide unit shipment total.

Maxtor continued to claim leadership in non-captive unit shipments for 1987, with 130,000 drives, 30.1% of the worldwide total. In a close second place, Micropolis held 20.6% and Imprimis, 20.1%. Minicomputer and multiple user micros held 54.5% of unit shipments in 1987, but the big growth by 1991 is expected to come from personal computers.

1988 DISK/TREND REPORT

Marketing trends

This product group is clearly destined to enjoy excellent growth for many years, but with inevitable changes in product mix. Worldwide shipments are forecasted to grow from 1987's half million drives to 3,336,000 units in 1991, with revenues reaching \$3.5 billion.

Despite the fact that 5.25" drives have established great momentum in this capacity range, only the half high versions are expected to continue growing for a few more years after 1988, with full size drives peaking in 1988 with 664,600 estimated unit shipments:

<u>Worldwide captive & OEM Unit shipments (000)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
5.25" full size	410.4 90.9%	664.6 54.8%	538.0 28.4%	309.0 12.1%	154.0 4.6%
5.25" half high	28.4 6.3%	197.4 16.3%	407.0 21.5%	505.0 19.8%	362.0 10.9%
3.5"	12.5 2.8%	350.7 28.9%	950.5 50.1%	1,742.0 68.1%	2,820.0 84.5%

Underlying the expected decline in full size 5.25" drives is the movement by the minicomputer and technical workstations markets to higher capacity 5.25" models, above this product group. Half high 5.25" drives, in high volume production only during the last year, will be preferred for many workstation applications, but 3.5" drives are expected to pass up total 5.25" shipments by 1989, due to growth in sophisticated personal computers, preference for small footprint systems, and competitive prices.

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, involving up to five disks, new head suspensions, embedded controllers, and very fast actuators.

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

Most drive manufacturers are offering ESDI interfaces with 5.25" drives operating at 10 megabit/second transfer rates, and embedded SCSI controllers are also available from a growing list of manufacturers. It is not yet clear which interfaces will prevail with 3.5" drives in this range. But there are design advantages in masking a file organization optimized for high density behind an intelligent interface, so SCSI and embedded controllers compatible with specific personal computers will probably continue to predominate.

Forecasting assumptions

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

TABLE 39
FIXED DISK DRIVES, 100 - 300 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----Revenues-----Forecast-----									
IBM Captive	300.6	439.7	572.6	782.6	603.2	834.2	639.7	893.1	879.0	1,275.0
Other U.S. Captive	9.1	19.8	13.4	25.7	48.1	84.4	113.7	193.6	185.0	316.6
TOTAL U.S. CAPTIVE	309.7	459.5	586.0	808.3	651.3	918.6	753.4	1,086.7	1,064.0	1,591.6
PCM	--	--	--	--	--	--	--	--	--	--
OEM	337.7	424.6	576.1	737.5	714.4	942.1	701.8	952.1	732.3	1,037.0
TOTAL U.S. NON-CAPTIVE	337.7	424.6	576.1	737.5	714.4	942.1	701.8	952.1	732.3	1,037.0
TOTAL U.S. REVENUES	647.4	884.1	1,162.1	1,545.8	1,365.7	1,860.7	1,455.2	2,038.8	1,796.3	2,628.6
Non-U.S. Manufacturers	-----									
Captive	26.2	300.0	23.1	490.5	98.1	498.2	127.6	489.4	169.6	489.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	79.2	165.9	77.9	164.9	107.0	254.2	147.6	366.3	169.1	425.5
TOTAL NON-U.S. REVENUES	105.4	465.9	101.0	655.4	205.1	752.4	275.2	855.7	338.7	914.9
Worldwide Recap	-----									
TOTAL WORLDWIDE REVENUES	752.8	1,350.0	1,263.1	2,201.2	1,570.8	2,613.1	1,730.4	2,894.5	2,135.0	3,543.5
OEM Average Price (\$000)	1.3	1.3	.9	.9	.8	.8	.7	.7	.6	.6

TABLE 40
FIXED DISK DRIVES, 100 - 300 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1987		-----Forecast-----							
	Shipments		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	39.3	53.0	195.0	252.5	284.0	383.0	384.1	534.0	586.0	850.0
Other U.S. Captive	1.2	2.1	3.3	6.4	15.7	27.5	40.0	68.0	73.0	125.0
TOTAL U.S. CAPTIVE	40.5	55.1	198.3	258.9	299.7	410.5	424.1	602.0	659.0	975.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	267.5	340.0	598.8	775.0	838.3	1,110.5	980.0	1,330.0	1,111.0	1,574.0
TOTAL U.S. NON-CAPTIVE	267.5	340.0	598.8	775.0	838.3	1,110.5	980.0	1,330.0	1,111.0	1,574.0
TOTAL U.S. SHIPMENTS	308.0	395.1	797.1	1,033.9	1,138.0	1,521.0	1,404.1	1,932.0	1,770.0	2,549.0
Non-U.S. Manufacturers										
Captive	4.2	41.0	4.1	84.0	30.1	121.1	44.0	142.0	64.0	166.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	43.1	92.7	63.6	146.9	114.0	280.0	196.0	490.0	247.0	621.0
TOTAL NON-U.S. SHIPMENTS	47.3	133.7	67.7	230.9	144.1	401.1	240.0	632.0	311.0	787.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	355.3	528.8	864.8	1,264.8	1,282.1	1,922.1	1,644.1	2,564.0	2,081.0	3,336.0
Cumulative Shipments										
IBM	93.4	133.3	288.4	385.8	572.4	768.8	956.5	1,302.8	1,542.5	2,152.8
Non-IBM	690.7	1,110.7	1,360.5	2,123.0	2,358.6	3,662.1	3,618.6	5,692.1	5,113.6	8,178.1
WORLDWIDE TOTAL	784.1	1,244.0	1,648.9	2,508.8	2,931.0	4,430.9	4,575.1	6,994.9	6,656.1	10,330.9

TABLE 41
 FIXED DISK DRIVES, 100 - 300 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1987				Forecast													
	Revenues				1988				1989				1990			1991		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	
U.S. MANUFACTURERS																		
IBM Captive	315.1	46.6	78.0	--	210.1	90.5	212.0	270.0	87.6	70.4	123.7	552.5	34.0	27.1	832.0	--	1,275.0	
Other U.S. Captive	16.7	--	3.1	--	2.4	--	23.3	--	--	--	82.8	1.6	--	173.6	20.0	261.6	55.0	
OEM	16.5	16.2	378.2	13.7	12.2	5.3	551.3	168.7	6.0	1.3	509.1	425.7	--	375.3	576.8	177.0	860.0	
TOTAL U.S. REVENUES	348.3	62.8	459.3	13.7	224.7	95.8	786.6	438.7	93.6	71.7	715.6	979.8	34.0	576.0	1,428.8	438.6	2,190.0	
NON-U.S. MANUFACTURERS																		
Captive	--	111.0	189.0	--	--	112.0	378.5	--	--	32.6	399.6	66.0	10.0	361.8	117.6	299.4	190.0	
OEM	.8	82.8	82.3	--	--	31.0	113.3	20.6	--	17.6	121.1	115.5	6.6	107.4	252.3	54.3	371.2	
TOTAL NON-U.S. REVENUES	.8	193.8	271.3	--	--	143.0	491.8	20.6	--	50.2	520.7	181.5	16.6	469.2	369.9	353.7	561.2	
WORLDWIDE RECAP																		
Captive	331.8 -34.2%	157.6 -49.1%	270.1 +237.6%	--	212.5 -36.0%	202.5 +28.5%	613.8 +127.2%	270.0	87.6 -58.8%	103.0 -49.1%	606.1 -1.3%	620.1 +129.7%	44.0 -57.3%	562.5 -7.2%	969.6 +56.4%	561.0 -.3%	1,520.0 +56.8%	
OEM	17.3 -37.1%	99.0 -26.1%	460.5 +141.0%	13.7	12.2 -29.5%	36.3 -63.3%	664.6 +44.3%	189.3	6.0 -50.8%	18.9 -47.9%	630.2 -5.2%	541.2 +185.9%	6.6 -65.1%	482.7 -23.4%	829.1 +53.2%	231.3 -52.1%	1,231.2 +48.5%	
Total Revenues	349.1 -34.3%	256.6 -42.1%	730.6 +169.5%	13.7	224.7 -35.6%	238.8 -6.9%	1,278.4 +75.0%	459.3	93.6 -58.3%	121.9 -49.0%	1,236.3 -3.3%	1,161.3 +152.8%	50.6 -58.5%	1,045.2 -15.5%	1,798.7 +54.9%	792.3 -24.2%	2,751.2 +53.0%	
ANNUAL SHARE, BY DIAMETER	26.0%	19.0%	54.1%	.9%	10.2%	10.8%	58.2%	20.8%	3.6%	4.7%	47.4%	44.3%	1.7%	36.2%	62.1%	22.4%	77.6%	

Note: 8 inch totals include 9 inch drives.

TABLE 42
 FIXED DISK DRIVES, 100 - 300 MEGABYTES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987				1988				Forecast				1990			1991	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	18.0	5.0	30.0	--	12.0	10.5	80.0	150.0	5.0	8.0	45.0	325.0	4.0	10.0	520.0	--	850.0
Other U.S. Captive	1.4	--	.7	--	.2	--	6.2	--	--	--	27.0	.5	--	60.0	8.0	100.0	25.0
OEM	5.3	5.9	316.3	12.5	3.8	2.0	592.2	177.0	2.0	.5	635.0	473.0	--	506.0	824.0	251.0	1,323.0
TOTAL U.S. SHIPMENTS	24.7	10.9	347.0	12.5	16.0	12.5	678.4	327.0	7.0	8.5	707.0	798.5	4.0	576.0	1,352.0	351.0	2,198.0
NON-U.S. MANUFACTURERS																	
Captive	--	9.5	31.5	--	--	10.0	74.0	--	--	3.1	98.0	20.0	1.0	99.0	42.0	90.0	76.0
OEM	.2	32.1	60.4	--	--	13.6	109.6	23.7	--	8.0	140.0	132.0	3.0	139.0	348.0	75.0	546.0
TOTAL NON-U.S. SHIPMENTS	.2	41.6	91.9	--	--	23.6	183.6	23.7	--	11.1	238.0	152.0	4.0	238.0	390.0	165.0	622.0
WORLDWIDE RECAP																	
Captive	19.4	14.5	62.2	--	12.2	20.5	160.2	150.0	5.0	11.1	170.0	345.5	5.0	169.0	570.0	190.0	951.0
	-35.1%	-53.2%	+475.9%	--	-37.1%	+41.4%	+157.6%	--	-59.0%	-45.9%	+6.1%	+130.3%	-55.0%	-.6%	+65.0%	+12.4%	+66.8%
OEM	5.5	38.0	376.7	12.5	3.8	15.6	701.8	200.7	2.0	8.5	775.0	605.0	3.0	645.0	1,172.0	326.0	1,869.0
	-32.9%	-32.7%	+222.2%	--	-30.9%	-58.9%	+86.3%	--	-47.4%	-45.5%	+10.4%	+201.4%	-64.7%	-16.8%	+93.7%	-49.5%	+59.5%
Total Shipments	24.9	52.5	438.9	12.5	16.0	36.1	862.0	350.7	7.0	19.6	945.0	950.5	8.0	814.0	1,742.0	516.0	2,820.0
	-34.6%	-40.0%	+243.7%	--	-35.7%	-31.2%	+96.4%	--	-56.2%	-45.7%	+9.6%	+171.0%	-59.2%	-13.9%	+83.3%	-36.6%	+61.9%
ANNUAL SHARE, BY DIAMETER	4.7%	9.9%	83.1%	2.3%	1.3%	2.9%	68.3%	27.5%	.4%	1.0%	49.3%	49.3%	.3%	31.8%	67.9%	15.5%	84.5%

Note: 8 inch totals include 9 inch drives.

TABLE 43
 FIXED DISK DRIVES, 100 - 300 MEGABYTES
 APPLICATIONS SUMMARY
 Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	9.7	1.8	3.3	.1
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	288.6	54.6	1628.0	48.8
PERSONAL COMPUTERS Business and professional, single user	87.7	16.6	1034.2	31.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	33.2	6.3	66.7	2.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	108.7	20.6	600.5	18.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.9	.2	3.3	.1
Total	528.8	100.1	3336.0	100.0

TABLE 44
 FIXED DISK DRIVES, 100 - 300 MEGABYTES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	
MAXTOR	--	--	104.0	--	104.0	33.5	--	--	130.0	--	130.0	30.1
MICROPOLIS	--	--	59.4	--	59.4	19.1	--	--	89.1	--	89.1	20.6
IMPRIMIS (CDC)	--	.9	72.6	--	73.5	23.7	.5	1.3	85.3	--	87.1	20.1
FUJITSU	--	6.5	4.3	--	10.8	3.5	.2	20.0	19.3	--	39.5	9.1
PRIAM	4.8	3.7	6.1	--	14.6	4.7	4.8	4.6	7.6	--	17.0	3.9
HITACHI	--	3.2	5.1	--	8.3	2.7	--	3.6	12.4	--	16.0	3.7
Other U.S.	--	--	3.7	12.3	16.0	5.1	--	--	4.3	12.5	16.8	3.9
Other Non-U.S.	--	7.4	16.6	--	24.0	7.7	--	8.5	28.7	--	37.2	8.6
TOTAL	4.8	21.7	271.8	12.3	310.6	100.0	5.5	38.0	376.7	12.5	432.7	100.0

Note: 8 inch totals include 9 inch drives.

FIXED DISK DRIVES, 300-500 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

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

10.5" disk diameter

Fujitsu	M2350A, F6421
---------	---------------

9" disk diameter

Imprimis (Control Data)	9715-300, 9715-340
-------------------------	--------------------

8" disk diameter

Century Data	C2400, C2476
DDC Pertec	DX332, DX368
Fujitsu	M2333K
Hewlett-Packard	7936H
Hitachi	DKU-80, DK-814S-34
IBM	9332-A12, 678-400
Imprimis (Control Data)	9720-368
Magnum Technology	MT3000
Mitsubishi Electric	MR4875
NEC	D2268H
Northern Telecom	8308, 8212X
Priam	807
Toshiba	MK-286FC, MK-287FC

5.25" disk diameter

Digital Equipment	RA70
Fujitsu	M2249E/S
Hewlett-Packard	97536E/S
Hitachi	DK514-38
IBM	8580-311, 671-387
Imprimis (Control Data)	94171-344, 94186-442
Maxtor	XT-4380E/S, XT-8380E
Micropolis	1558-15
Miniscribe	9380E/S
NEC	D5662
Newbury Data	NDR 4380E, NDR 6380S

5.25" disk diameter (continued)

Priam	638, 738
Siemens	1300, 4410
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 several are still in production. Led by the successful Fujitsu 10.5" Eagle, other small drives included several 9" models by Control Data, followed by numerous 8" drives. The latest wave is a group of 5.25" drives, mostly in the 380 megabyte range, following the lead of Maxtor, the first to make production shipments of a drive in this capacity range, in 1986. Fourteen companies so far have announced 5.25" drives in this product group.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	1,501.7	1,729.0	2,119.5	2,478.5	2,759.3
All manufacturers	2,035.3	2,416.2	2,852.2	3,219.3	3,498.4

Worldwide revenues for 300-500 megabyte drives will top \$2.4 billion this year, and unit shipments will climb 125%, to 541,400 drives. Boosting the current growth is the 1988 increase in shipments of 380 megabyte 5.25" drives, more than 220,000 of which are being generated as the result of OEM drive shipments by U.S. manufacturers.

After first shipments in 1986, production of OEM 5.25" drives reached 39,600 units in 1987, as most of the current 14 producers established

early manufacturing capability, with many experiencing severe problems in finding consistent sources for critical components.

Recognizing the large latent market for high-end 5.25" drives, several producers set overly ambitious 1988 sales and production targets for themselves, and the industry is currently suffering from excess capacity. But despite the industry's planning problems, 1988 worldwide shipments of 5.25" drives in this group are expected to total 372,700 units, slightly higher than forecasted in the 1987 DISK/TREND Report.

In addition to the strong growth in OEM 5.25" drives, significant changes are also underway in captive shipments. IBM's shipments of the 400 megabyte 9332 8" drive are expected to peak this year at 35,000 units, and the 315 megabyte (formatted) "Lee" 5.25" drive is estimated at 50,000 units, for several system applications. IBM's estimated \$842 million in revenue for 1988 will provide more than half of the captive total for the 300-500 megabyte group. The other U.S. captive total for 1988 has been held down by declining production of older drives by Digital Equipment, Data General and Hewlett-Packard, now being phased out in favor of higher capacity models.

Fujitsu continued to lead in non-captive unit shipments for 1987, but the company's percentage share fell 15 points from the previous year, to 35.2% of the worldwide total. Fujitsu's non-captive shipments, consisting of 14", 10.5", 8" and 5.25" drives, totaled 47,700 units, only two thousand more than the previous year. Coming up behind was Imprimis, with 28.0%, and Maxtor, which led in 5.25" drives, with 11.1%.

Minicomputer and multi-user micro applications, including network file servers, held 46.3% of all unit shipments for the product group in 1987, and this share is expected to grow to 66% in 1991. Technical

1988 DISK/TREND REPORT

workstations will also take a growing share, but mainframes, which took 29.3% of the units shipped in 1987, will drop sharply.

Marketing trends

By 1991, worldwide revenues for 300-500 megabyte drives are forecasted to reach almost \$3.5 billion, with shipments at 1,654,000 units. While both 14" and 8"/9" drives continue to decline in worldwide shipment totals, 5.25" shipments are expected to more than double in 1989, and to continue growth at least through 1991, although with smaller increases.

The first 3.5" drives are expected in this group next year, with an introduction by IBM. First shipments of OEM 3.5" drives are shown in 1990 in the disk diameter tables later in this section, but could occur earlier if development activities are emphasized.

U.S. manufacturers are expected to continue dominance of the OEM 5.25" drive market, exploiting their head start and a favorable exchange rate, and are also likely to take the lead in shipments of 3.5" drives. Running counter to the worldwide trend, OEM shipments of 14" drives by non-U.S. manufacturers have been growing, and that growth is forecasted to continue through 1990 -- a trend caused entirely by growing Eastern Bloc shipments of 317 megabyte 3350-type drives for mainframe applications.

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 8" and 9" drives in the 300-500 megabyte range -- while intense activity is underway on smaller drives.

Maxtor was the lonely pioneer in 5.25" drives in the 300-500 megabyte range. The firm's successful production of such drives inspired a dozen competitors to take on the twin challenges of fitting enough disks into the standard 5.25" form factor and finding ways to improve head positioning time below the sub-20 millisecond average required to be competitive. The next stage is expected to be the introduction of 5.25" half high 380 megabyte drives, due to arrive on the scene in 1989, using the same areal density now being employed with 770 megabyte 5.25" drives.

While many manufacturers are still sweating out the design and manufacturing startup problems associated with 3.5" drives at the 200 megabyte level, it is predictable that most will eventually also offer drives above 300 megabytes, utilizing techniques such as higher areal density, zoned recording and closer packaging of disks.

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

Forecasting assumptions

1. Total shipments of 14", 9" and 8" drives will continue to decline.
2. Sustained growth for technical workstations, LANs, general purpose mini/micros and specialized systems will create significant growth for both captive and OEM 5.25" drives, as well as the 3.5" drives, which will first be introduced by IBM in 1989.

TABLE 45
FIXED DISK DRIVES, 300 - 500 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		Forecast							
	Revenues		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM Captive	411.0	596.6	598.5	842.0	893.8	1,223.0	1,025.2	1,431.6	1,101.5	1,630.5
Other U.S. Captive	375.3	679.4	204.4	388.9	163.9	280.7	207.0	346.5	228.0	384.0
TOTAL U.S. CAPTIVE	786.3	1,276.0	802.9	1,230.9	1,057.7	1,503.7	1,232.2	1,778.1	1,329.5	2,014.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	174.8	225.7	390.8	498.1	480.0	615.8	533.2	700.4	564.9	744.8
TOTAL U.S. NON-CAPTIVE	174.8	225.7	390.8	498.1	480.0	615.8	533.2	700.4	564.9	744.8
TOTAL U.S. REVENUES	961.1	1,501.7	1,193.7	1,729.0	1,537.7	2,119.5	1,765.4	2,478.5	1,894.4	2,759.3
<u>Non-U.S. Manufacturers</u>										
Captive	25.5	297.8	34.0	370.5	34.5	348.5	46.0	350.5	50.5	366.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	154.5	235.8	111.3	316.7	109.8	384.2	118.1	390.3	138.4	372.6
TOTAL NON-U.S. REVENUES	180.0	533.6	145.3	687.2	144.3	732.7	164.1	740.8	188.9	739.1
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE REVENUES	1,141.1	2,035.3	1,339.0	2,416.2	1,682.0	2,852.2	1,929.5	3,219.3	2,083.3	3,498.4
OEM Average Price (\$000)	3.2	3.4	1.7	2.1	1.3	1.5	1.0	1.2	.9	1.0

TABLE 46
FIXED DISK DRIVES, 300 - 500 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1987		-----Forecast-----							
	---Shipments---		-----1988-----		-----1989-----		-----1990-----		-----1991-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers -----										
IBM Captive	27.3	39.5	68.4	92.0	160.5	213.0	240.7	332.0	292.1	430.0
Other U.S. Captive	25.4	46.1	21.2	39.0	30.2	50.7	46.0	77.0	57.0	96.0
TOTAL U.S. CAPTIVE	52.7	85.6	89.6	131.0	190.7	263.7	286.7	409.0	349.1	526.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	56.6	70.7	233.4	293.7	383.5	491.2	512.3	671.7	622.0	820.0
TOTAL U.S. NON-CAPTIVE	56.6	70.7	233.4	293.7	383.5	491.2	512.3	671.7	622.0	820.0
TOTAL U.S. SHIPMENTS	109.3	156.3	323.0	424.7	574.2	754.9	799.0	1,080.7	971.1	1,346.0
Non-U.S. Manufacturers -----										
Captive	1.5	19.0	2.0	24.9	3.5	30.0	7.0	43.0	9.5	58.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	45.5	64.9	47.4	91.8	68.9	156.5	101.0	201.0	136.0	250.0
TOTAL NON-U.S. SHIPMENTS	47.0	83.9	49.4	116.7	72.4	186.5	108.0	244.0	145.5	308.0
Worldwide Recap -----										
TOTAL WORLDWIDE SHIPMENTS	156.3	240.2	372.4	541.4	646.6	941.4	907.0	1,324.7	1,116.6	1,654.0
Cumulative Shipments -----										
IBM	164.3	265.8	232.7	357.8	393.2	570.8	633.9	902.8	926.0	1,332.8
Non-IBM	430.5	728.3	734.5	1,177.7	1,220.6	1,906.1	1,886.9	2,898.8	2,711.4	4,122.8
WORLDWIDE TOTAL	594.8	994.1	967.2	1,535.5	1,613.8	2,476.9	2,520.8	3,801.6	3,637.4	5,455.6

TABLE 47
FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES (\$M)
BREAKDOWN BY DISK DIAMETER

	1987			Forecast															
	Revenues			1988			1989				1990				1991				
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	
U.S. MANUFACTURERS																			
IBM Captive	237.5	359.1	--	126.0	476.0	240.0	51.0	350.0	624.0	198.0	--	159.6	660.0	612.0	--	63.0	717.5	850.0	
Other U.S. Captive	636.4	41.0	2.0	265.2	21.1	102.6	34.0	6.7	240.0	--	--	--	346.5	--	--	--	384.0	--	
OEM	13.8	159.8	52.1	11.0	131.9	355.2	6.0	75.0	534.8	--	3.2	30.8	628.0	38.4	--	10.4	649.8	84.6	
TOTAL U.S. REVENUES	887.7	559.9	54.1	402.2	629.0	697.8	91.0	431.7	1,398.8	198.0	3.2	190.4	1,634.5	650.4	--	73.4	1,751.3	934.6	
NON-U.S. MANUFACTURERS																			
Captive	76.8	185.3	35.7	96.6	224.9	49.0	77.0	187.5	84.0	--	63.0	117.0	170.5	--	50.0	71.5	245.0	--	
OEM	88.1	120.9	26.8	163.7	77.9	75.1	185.0	43.2	156.0	--	180.0	18.4	181.5	10.4	136.0	6.6	192.0	38.0	
TOTAL NON-U.S. REVENUES	164.9	306.2	62.5	260.3	302.8	124.1	262.0	230.7	240.0	--	243.0	135.4	352.0	10.4	186.0	78.1	437.0	38.0	
WORLDWIDE RECAP																			
Captive	950.7	585.4	37.7	487.8	722.0	391.6	162.0	544.2	948.0	198.0	63.0	276.6	1,177.0	612.0	50.0	134.5	1,346.5	850.0	
	-11.3%	+54.9%	--	-48.7%	+23.3%	+938.7%	-66.8%	-24.6%	+142.1%	--	-61.1%	-49.2%	+24.2%	+209.1%	-20.6%	-51.4%	+14.4%	+38.9%	
OEM	101.9	280.7	78.9	174.7	209.8	430.3	191.0	118.2	690.8	--	183.2	49.2	809.5	48.8	136.0	17.0	841.8	122.6	
	-28.9%	+25.6%	+214.3%	+71.4%	-25.3%	+445.4%	+9.3%	-43.7%	+60.5%	--	-4.1%	-58.4%	+17.2%	--	-25.8%	-65.4%	+4.0%	+151.2%	
Total Revenues	1,052.6	866.1	116.6	662.5	931.8	821.9	353.0	662.4	1,638.8	198.0	246.2	325.8	1,986.5	660.8	186.0	151.5	2,188.3	972.6	
	-16.3%	+44.0%	+364.5%	-37.1%	+7.6%	+604.9%	-46.7%	-28.9%	+99.4%	--	-30.3%	-50.8%	+21.2%	+233.7%	-24.5%	-53.5%	+10.2%	+47.2%	
ANNUAL SHARE, BY DIAMETER	51.8%	42.6%	5.6%	27.5%	38.6%	33.9%	12.4%	23.2%	57.6%	6.8%	7.6%	10.1%	61.8%	20.5%	5.3%	4.3%	62.7%	27.7%	

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

TABLE 48
 FIXED DISK DRIVES, 300 - 500 MEGABYTES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987			1988				1989				Forecast				1991			
	Shipments																		
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	
U.S. MANUFACTURERS																			
IBM Captive	12.5	27.0	--	7.0	35.0	50.0	3.0	25.0	130.0	55.0	--	12.0	150.0	170.0	--	5.0	175.0	250.0	
Other U.S. Captive	41.8	3.9	.4	17.3	1.9	19.8	2.0	.7	48.0	--	--	--	77.0	--	--	--	96.0	--	
OEM	2.0	39.5	29.2	1.9	40.8	251.0	1.2	25.0	465.0	--	.7	11.0	628.0	32.0	--	4.0	722.0	94.0	
TOTAL U.S. SHIPMENTS	56.3	70.4	29.6	26.2	77.7	320.8	6.2	50.7	643.0	55.0	.7	23.0	855.0	202.0	--	9.0	993.0	344.0	
NON-U.S. MANUFACTURERS																			
Captive	3.2	10.7	5.1	4.2	13.7	7.0	3.5	12.5	14.0	--	3.0	9.0	31.0	--	2.5	6.5	49.0	--	
OEM	12.3	42.2	10.4	17.4	29.5	44.9	18.5	18.0	120.0	--	20.0	8.0	165.0	8.0	17.0	3.0	192.0	38.0	
TOTAL NON-U.S. SHIPMENTS	15.5	52.9	15.5	21.6	43.2	51.9	22.0	30.5	134.0	--	23.0	17.0	196.0	8.0	19.5	9.5	241.0	38.0	
WORLDWIDE RECAP																			
Captive	57.5	41.6	5.5	28.5	50.6	76.8	8.5	38.2	192.0	55.0	3.0	21.0	258.0	170.0	2.5	11.5	320.0	250.0	
	-8.9%	+59.4%	--	-50.4%	+21.6%	--	-70.2%	-24.5%	+150.0%	--	-64.7%	-45.0%	+34.4%	+209.1%	-16.7%	-45.2%	+24.0%	+47.1%	
OEM	14.3	81.7	39.6	19.3	70.3	295.9	19.7	43.0	585.0	--	20.7	19.0	793.0	40.0	17.0	7.0	914.0	132.0	
	-25.5%	+47.2%	+360.5%	+35.0%	-14.0%	+647.2%	+2.1%	-38.8%	+97.7%	--	+5.1%	-55.8%	+35.6%	--	-17.9%	-63.2%	+15.3%	+230.0%	
Total Shipments	71.8	123.3	45.1	47.8	120.9	372.7	28.2	81.2	777.0	55.0	23.7	40.0	1,051.0	210.0	19.5	18.5	1,234.0	382.0	
	-19.2%	+51.1%	+424.4%	-33.4%	-1.9%	+726.4%	-41.0%	-32.8%	+108.5%	--	-16.0%	-50.7%	+35.3%	+281.8%	-17.7%	-53.7%	+17.4%	+81.9%	
ANNUAL SHARE, BY DIAMETER	30.0%	51.3%	18.7%	8.8%	22.3%	68.9%	3.0%	8.6%	82.6%	5.8%	1.8%	3.0%	79.4%	15.8%	1.2%	1.1%	74.7%	23.0%	

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

TABLE 49
 FIXED DISK DRIVES, 300 - 500 MEGABYTES
 APPLICATIONS SUMMARY
 Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	70.4	29.3	99.2	6.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	111.2	46.3	1091.6	66.0
PERSONAL COMPUTERS Business and professional, single user	5.2	2.2	115.8	7.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	19.2	8.0	33.1	2.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	33.7	14.0	314.3	19.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.5	.2	--	--
Total	240.3	100.0	1654.0	100.0

TABLE 50
 FIXED DISK DRIVES, 300 - 500 MEGABYTES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
FUJITSU	6.3	26.8	.6	33.7	33.0	10.3	36.2	1.2	47.7	35.2
IMPRIMIS (CDC)	--	25.0	4.1	29.1	28.5	--	32.2	5.8	38.0	28.0
MAXTOR	--	--	13.0	13.0	12.7	--	--	15.0	15.0	11.1
PRIAM	--	5.0	2.6	7.6	7.4	--	6.3	3.2	9.5	7.0
SIEMENS	--	--	6.0	6.0	5.9	--	--	8.5	8.5	6.3
Other U.S.	1.3	.4	5.2	6.9	6.8	2.0	1.0	5.2	8.2	6.0
Other Non-U.S.	--	5.4	.4	5.8	5.7	2.0	6.0	.7	8.7	6.4
TOTAL	7.6	62.6	31.9	102.1	100.0	14.3	81.7	39.6	135.6	100.0

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

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTECoverage

Examples of disk drives in this group include:

14" disk diameter

Alpha Data	Atlas 520
Data General	6239, 6357
Digital Equipment	SA482, RA82
Fujitsu	M2298
Hitachi	DKU-97S, DKU-85I-D14
IBM	3370, 9335
Imprimis (Control Data)	9771, 9772, 9775
NEC	N7761, N7765

10.5" disk diameter

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

9" disk diameter

Hitachi	DK815-5
Imprimis (Control Data)	9715-500
Mitsubishi Electric	E1880B
NEC	D2352, D2462

8" disk diameter

Century Data	C2600, C2800
Imprimis (Control Data)	9720-736, 9720-850
Data General	6581
DDC Pertec	DX548, DX731
Fujitsu	M2344K/KS
Hewlett-Packard	7937H/S
IBM	9332-600
Northern Telecom	8312, 8412
Rodime	R08067
Toshiba	MK-288FC, 388FA

5.25" disk diameter

Fujitsu	M2263E
Hitachi	DK711S-60D
Imprimis (Control Data)	94181-638
Maxtor	XT-8760E
Micropolis	1568-15
Miniscribe	9789E/S
Priam	776
Siemens	5710, 5720

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

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	1,534.8	2,641.6	3,130.6	3,361.1	2,628.2
All manufacturers	2,413.7	3,540.1	4,095.1	4,418.5	3,608.4

During 1987 and 1988, 14" drives still maintain a strong lead in total revenue for this product group, and 8" drives continue to dominate unit shipments. Total shipments of all drives are expected to top 300 thousand units in 1988, up 56.6%, and revenues will exceed \$3.5 billion.

IBM's estimated \$1.4 billion in 1988 captive revenue will provide 49.5% of the worldwide captive total. IBM will ship an estimated 48,000 9335 14" drives this year, plus growing numbers of the 600 megabyte version of the 8" 9332, and a smaller number of the ten year old 3370, probably the last.

1988 is expected to be the peak production year for 14" drives in this product group, but 8" drives are increasing in shipments faster, up 58.3% in 1988, to 176,700 units. Shifting application patterns, plus the growing availability during the last few years of lower cost 8"/9" OEM drives in this capacity range, has changed the product mix.

Expanding usage of minicomputers and multi-user micros in distributed processing and in technical workstation markets has stimulated demand for 8"/9" drive models. But the clock is ticking: The first 5.25" drives above 500 megabytes were shipped in 1987, and several producers of 380 megabyte 5.25" drives have announced drives in this product group.

Imprimis non-captive shipments grew to 39,400 drives in 1987, mostly 8" models, for 37.9% of the worldwide total. NEC jumped to 27.9%, with growing shipments of 9" drives, and Fujitsu held 25.8%.

Mainframe and supermini markets received 69.1% of 1987 unit shipments, but this application area is expected to decrease in the future in percentage share, although growing in unit shipments, as minicomputer and multi-user micros increase demand.

Marketing trends

Unit shipment growth for this product group is expected to continue, averaging 34.6% per year in the 1989-91 period. However, the effect of rapid change in product mix, as lower cost 5.25" drives assume shipment leadership, will be to depress total revenues for the group. Worldwide 1991 total revenue is forecasted at \$3.6 billion, sinking almost to the 1988 level. Captive drive producers, including IBM, will be primarily affected by this impact, due to heavy current reliance on large diameter drives carrying comparatively high price tags.

Although just getting started in volume production, 5.25" drives are expected to rise to 34.1% of 1989 total unit shipments, and to actually provide a majority of OEM shipments in that year. By 1991, 5.25" drives are forecasted at 66.9% of all shipments, with 481,000 units. 8" drive production is expected to peak 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.

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

Technical trends

It is believed that the technical developments in this product group through 1991 will consist primarily of refinements to the basic products already introduced. 8"/9" drives have established high standards for performance and reliability, and the challenge will be for 5.25" drives to equal these standards.

The 16 millisecond average positioning time common in the 8"/9" group has been equalled or bettered by many of the new 5.25" drives, and performance will improve beyond this level in the following years. The 30,000

POH MTBF specification offered by several 8" and 9" drive vendors has also been matched by the newcomers.

Forecasting assumptions

1. IBM will continue production of 8" and 14" drives in this capacity range through 1991, but will also start shipments of a 5.25" drive in 1989.
2. Production of 8" and 9" drives will peak in 1990.
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 51
FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	452.1	875.8	760.2	1,431.1	941.7	1,737.3	991.3	1,884.9	695.3	1,273.1
Other U.S. Captive	275.8	417.3	554.7	892.5	540.3	893.4	557.8	929.2	483.7	804.4
TOTAL U.S. CAPTIVE	727.9	1,293.1	1,314.9	2,323.6	1,482.0	2,630.7	1,549.1	2,814.1	1,179.0	2,077.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	181.0	241.7	231.7	318.0	363.2	499.9	379.7	547.0	377.2	550.7
TOTAL U.S. NON-CAPTIVE	181.0	241.7	231.7	318.0	363.2	499.9	379.7	547.0	377.2	550.7
TOTAL U.S. REVENUES	908.9	1,534.8	1,546.6	2,641.6	1,845.2	3,130.6	1,928.8	3,361.1	1,556.2	2,628.2
Non-U.S. Manufacturers	-----									
Captive	--	551.4	15.0	574.2	61.8	613.1	112.5	720.2	147.2	659.6
PCM	--	--	--	--	--	--	--	--	--	--
OEM	205.6	327.5	208.4	324.3	236.2	351.4	219.6	337.2	197.2	320.6
TOTAL NON-U.S. REVENUES	205.6	878.9	223.4	898.5	298.0	964.5	332.1	1,057.4	344.4	980.2
Worldwide Recap	-----									
TOTAL WORLDWIDE REVENUES	1,114.5	2,413.7	1,770.0	3,540.1	2,143.2	4,095.1	2,260.9	4,418.5	1,900.6	3,608.4
OEM Average Price (\$000)	5.4	5.4	4.2	4.2	2.8	2.8	2.2	2.2	1.8	1.8

TABLE 52
 FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE
 UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1987		Forecast							
	Shipments		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	20.4	39.0	36.8	68.0	51.2	91.0	64.3	113.0	66.8	110.0
Other U.S. Captive	16.8	25.7	34.3	55.9	37.1	61.4	48.0	80.0	52.0	87.0
TOTAL U.S. CAPTIVE	37.2	64.7	71.1	123.9	88.3	152.4	112.3	193.0	118.8	197.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	31.6	42.9	52.0	70.5	134.6	183.7	181.0	260.0	216.0	313.0
TOTAL U.S. NON-CAPTIVE	31.6	42.9	52.0	70.5	134.6	183.7	181.0	260.0	216.0	313.0
TOTAL U.S. SHIPMENTS	68.8	107.6	123.1	194.4	222.9	336.1	293.3	453.0	334.8	510.0
Non-U.S. Manufacturers										
Captive	--	25.1	1.0	27.7	3.5	32.5	9.0	51.0	15.0	60.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	39.2	61.0	52.4	81.2	77.3	113.3	90.0	138.0	90.0	147.0
TOTAL NON-U.S. SHIPMENTS	39.2	86.1	53.4	108.9	80.8	145.8	99.0	189.0	105.0	207.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	108.0	193.7	176.5	303.3	303.7	481.9	392.3	642.0	439.8	717.0
Cumulative Shipments										
IBM	96.8	213.2	133.6	281.2	184.8	372.2	249.1	485.2	315.9	595.2
Non-IBM	234.8	452.1	374.5	687.4	627.0	1,078.3	955.0	1,607.3	1,328.0	2,214.3
WORLDWIDE TOTAL	331.6	665.3	508.1	968.6	811.8	1,450.5	1,204.1	2,092.5	1,643.9	2,809.5

TABLE 53

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE REVENUES (\$M)

BREAKDOWN BY DISK DIAMETER

	1987			Forecast											
	Revenues			1988			1989			1990			1991		
	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	875.8	--	--	1,186.6	244.5	--	1,226.5	456.4	54.4	1,293.4	387.5	204.0	703.5	147.0	422.6
Other U.S. Captive	187.7	229.6	--	587.5	305.0	--	481.1	391.3	21.0	365.2	432.0	132.0	179.3	429.0	196.1
OEM	68.0	170.1	3.6	25.5	250.1	42.4	4.7	265.2	230.0	--	224.0	323.0	--	168.2	382.5
TOTAL U.S. REVENUES	1,131.5	399.7	3.6	1,799.6	799.6	42.4	1,712.3	1,112.9	305.4	1,658.6	1,043.5	659.0	882.8	744.2	1,001.2
NON-U.S. MANUFACTURERS															
Captive	343.0	208.4	--	303.4	270.8	--	252.0	332.5	28.6	200.0	342.0	178.2	114.0	272.0	273.6
OEM	58.7	268.8	--	28.8	287.2	8.3	13.3	262.5	75.6	--	222.0	115.2	--	183.0	137.6
TOTAL NON-U.S. REVENUES	401.7	477.2	--	332.2	558.0	8.3	265.3	595.0	104.2	200.0	564.0	293.4	114.0	455.0	411.2
WORLDWIDE RECAP															
Captive	1,406.5	438.0	--	2,077.5	820.3	--	1,959.6	1,180.2	104.0	1,858.6	1,161.5	514.2	996.8	848.0	892.3
	+4%	+152.0%	--	+47.7%	+87.3%	--	-5.7%	+43.9%	--	-5.2%	-1.6%	+394.4%	-46.4%	-27.0%	+73.5%
OEM	126.7	438.9	3.6	54.3	537.3	50.7	18.0	527.7	305.6	--	446.0	438.2	--	351.2	520.1
	-5.3%	+399.3%	--	-57.1%	+22.4%	--	-66.9%	-1.8%	+502.8%	--	-15.5%	+43.4%	--	-21.3%	+18.7%
Total Revenues	1,533.2	876.9	3.6	2,131.8	1,357.6	50.7	1,977.6	1,707.9	409.6	1,858.6	1,607.5	952.4	996.8	1,199.2	1,412.4
	-.1%	+235.1%	--	+39.0%	+54.8%	--	-7.2%	+25.8%	+707.9%	-6.0%	-5.9%	+132.5%	-46.4%	-25.4%	+48.3%
ANNUAL SHARE, BY DIAMETER	63.6%	36.3%	.1%	60.3%	38.3%	1.4%	48.4%	41.7%	9.9%	42.2%	36.4%	21.4%	27.7%	33.2%	39.1%

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

TABLE 54
 FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987			Forecast											
	Shipments			1988			1989			1990			1991		
	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	39.0	--	--	53.0	15.0	--	55.0	28.0	8.0	58.0	25.0	30.0	35.0	10.0	65.0
Other U.S. Captive	10.1	15.6	--	33.4	22.5	--	28.3	30.1	3.0	22.0	36.0	22.0	11.0	39.0	37.0
OEM	7.7	34.2	1.0	3.2	53.0	14.3	.7	68.0	115.0	--	70.0	190.0	--	58.0	255.0
TOTAL U.S. SHIPMENTS	56.8	49.8	1.0	89.6	90.5	14.3	84.0	126.1	126.0	80.0	131.0	242.0	46.0	107.0	357.0
NON-U.S. MANUFACTURERS															
Captive	14.8	10.3	--	13.8	13.9	--	12.0	17.5	3.0	10.0	19.0	22.0	6.0	16.0	38.0
OEM	9.7	51.3	--	4.8	72.3	4.1	2.3	75.0	36.0	--	74.0	64.0	--	61.0	86.0
TOTAL NON-U.S. SHIPMENTS	24.5	61.6	--	18.6	86.2	4.1	14.3	92.5	39.0	10.0	93.0	86.0	6.0	77.0	124.0
WORLDWIDE RECAP															
Captive	63.9	25.9	--	100.2	51.4	--	95.3	75.6	14.0	90.0	80.0	74.0	52.0	65.0	140.0
	+15.8%	+227.8%	--	+56.8%	+98.5%	--	-4.9%	+47.1%	--	-5.6%	+5.8%	+428.6%	-42.2%	-18.7%	+89.2%
OEM	17.4	85.5	1.0	8.0	125.3	18.4	3.0	143.0	151.0	--	144.0	254.0	--	119.0	341.0
	+27.0%	+421.3%	--	-54.0%	+46.5%	--	-62.5%	+14.1%	+720.7%	--	+7.7%	+68.2%	--	-17.4%	+34.3%
Total Shipments	81.3	111.4	1.0	108.2	176.7	18.4	98.3	218.6	165.0	90.0	224.0	328.0	52.0	184.0	481.0
	+18.0%	+358.4%	--	+33.1%	+58.6%	--	-9.1%	+23.7%	+796.7%	-8.4%	+2.5%	+98.8%	-42.2%	-17.9%	+46.6%
ANNUAL SHARE, BY DIAMETER	42.1%	57.5%	.4%	35.8%	58.3%	5.9%	20.4%	45.5%	34.1%	14.0%	35.0%	51.0%	7.3%	25.8%	66.9%

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

TABLE 55
 FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE
 APPLICATIONS SUMMARY
 Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	133.9	69.1	372.8	52.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	50.0	25.8	301.9	42.1
PERSONAL COMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	4.9	2.6	.7	.1
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	4.8	2.5	41.6	5.8
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.1	.1	--	--
Total	193.6	100.1	717.0	100.0

TABLE 56
 FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
IMPRIMIS (CDC)	6.5	22.6	--	29.1	41.1	7.7	31.7	--	39.4	37.9
NEC	--	22.0	--	22.0	31.1	--	29.0	--	29.0	27.9
FUJITSU	5.5	7.5	--	13.0	18.4	9.7	17.1	--	26.8	25.8
Other U.S.	--	1.6	.9	2.5	3.5	--	2.5	1.0	3.5	3.4
Other Non-U.S.	--	4.2	--	4.2	5.9	--	5.2	--	5.2	5.0
TOTAL	12.0	57.9	.9	70.8	100.0	17.4	85.5	1.0	103.9	100.0

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

FIXED DISK DRIVES, OVER 1 GIGABYTE

FIXED DISK DRIVES, MORE THAN 1 GIGABYTECoverage

Examples of disk drives in this group include:

14" disk diameter

Comparex	8485
Hitachi	DKU-85I, DKU-98I
Ibis	1400, 2812
IBM	3380-AJ4, 3380-CJ2, 3380-BK4
Imprimis (Control Data)	9772-13G
Memorex Telex	3680, 3682
National Advanced Systems	7380-BD, 7380-BE
NEC	N7765
Storage Technology	8380-BE4, 8380-RXX
Unisys	9494-12, 9494-24

10.5" disk diameter

Amdahl	6380-BE4, 6380-BK4
Fujitsu	F6425M4, F6425H

9.5" disk diameter

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

9" disk diameter

Digital Equipment	RA90
Hitachi	DK815-10
NEC	D2367, D2377

8" disk diameter

Century Data	C21500
DDC Pertec	DX1246
Imprimis (Control Data)	9730-1230
Fujitsu	M2382K/P
Memorex Telex	3835, 3890-00K4
Northern Telecom	8514

IBM's 3380 series of high-end mainframe disk drives comprise the core of this product group. The original 3380 was first shipped in 4th quarter of 1981, after an extremely expensive (to IBM) delay of over a year from

the announced delivery schedule. The double density 3380E arrived in July, 1985, and the triple density 3380K in October, 1987, marking the first time that IBM has offered two mid-life enhancements in a disk drive model series.

The other 14", 10.5", and 9.5" drives in this group are intended for mainframe and supermini applications similar to IBM's, and most use technology similar to IBM's 3380 drives, relying on oxide coated disks and thin film heads. The exceptions are a few drives using ferrite heads, plus the Ibis drives, which use plated disks and offer 12 megabyte/second transfer rates for supercomputer and high-end imaging applications through parallel transfer electronics.

The 8" and 9" drives, both captive and OEM, also utilize advanced Winchester technology, and are used typically in small mainframe, supermini and imaging applications. Some are also finding their way into mainframe PCM applications, with Fujitsu 8" drives expected to be included in a plug compatible 3380E equivalent subsystem scheduled for early 1989 shipment.

Starting with this year's DISK/TREND Report, plug compatible drives sold by major PCM vendors such as Amdahl, National Advanced Systems, Comparex and Memorex Telex have been included in the product specification section and are mentioned in the list of examples shown above even though not manufactured by these companies, in the interest of clarity. Currently, Fujitsu makes the drives sold by Amdahl, while Hitachi makes the drives sold by National Advanced Systems and Comparex. Drives currently offered in the plug compatible market by Memorex Telex are made by Unisys, Fujitsu and Northern Telecom.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
U.S. manufacturers	4,005.8	4,673.6	6,829.7	8,495.3	10,586.2
All manufacturers	5,054.4	5,993.0	8,244.5	9,955.8	12,207.7

Total revenues for this product group increased by a half billion dollars in 1987, with most of the gain provided by expanding usage of double capacity 3380 equivalent drives with Japanese mainframe computers.

During 1987, IBM's estimated total spindle count declined slightly and revenues stayed at 1986's \$3.5 billion, while IBM's customers waited most of the year for the triple capacity 3380K. The 3380K arrived late in 1987, and is expected to provide more than 70% of IBM's unit shipments in this product group for 1988. The current forecast of IBM's captive 3380 shipments for 1988 is below last year's, but nevertheless is expected to top \$4 billion. 1988 revenues for plug compatible drives are expected to increase slightly to \$663.4 million, as PCM vendors prepare to transition to 3380K equivalent drives, with all except Storage Technology using drives with disks smaller than 14".

Not all of the important developments in high-end disk drives involve IBM and the PCM vendors. OEM drive manufacturers have introduced several new 8" drives during 1988 with capacities above 1 gigabyte, and the market for smaller drives is responding quickly. OEM shipments of 8" and 9" drives are expected to reach 32,500 units in 1988, and worldwide OEM drive revenues should grow by over 500%, to \$179.1 million. Outside of the IBM market, the news in other captive drives was the mid-1988 start of shipments for Digital Equipment's RA90 9" drive, which is expected to provide a major contribution to future captive revenues.

1988 DISK/TREND REPORT

Hitachi continued to lead in 1987 worldwide shipments of non-captive drives with a 34.1% share, followed by Fujitsu with 20.4% and Storage Technology with 16.2%. IBM's OEM sales of 3380s to Siemens and Honeywell are included in the "Other U.S." totals in Table 63, and the non-captive totals for Hitachi and Fujitsu include both PCM and OEM shipments.

Marketing trends

1991 worldwide revenues for this product group are forecasted at \$12.2 billion, double the 1988 level. IBM's captive revenues are expected to provide 70% of the 1991 total, constituting an increase of \$4.5 billion over 1988 which will be generated mostly by products not yet introduced.

Two key assumptions underlie the current projections: (1) That IBM will ship in the first half of 1989 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 to achieve improved cost per megabyte. The impact on IBM's current product mix will be improved functional performance and a cost-effective replacement for the triple capacity 3380K.

As usual, the PCM suppliers which survive these changes will be those which are able to react quickly to compete with IBM's new drives. Most plug compatible drive vendors are still scrambling to start production of their 3380K equivalent models. However, IBM's 10.25" drive is expected to be a tougher target, with new heads, motors and head positioning systems which the independents will probably take 18-24 months to match, and some may not choose to do so, considering the specialized nature of the market opportunity. The IBM 5.25" drive will be the future mainstream disk drive for mainframes, and all companies staying in the PCM market will need to have an equivalent product, the first of which is expected in 1991.

A new surge in captive shipments by other system manufacturers is expected to be underway by next year, led by Digital Equipment's 9" RA90. 8" and 9" drives will dominate non-IBM captive shipments by 1991, with 71,700 spindles forecasted. Shipments of OEM 8" and 9" drives will be growing during the same period to an even higher level, to 88,000 drives, but 5.25" drives with capacities over 1 gigabyte will be on a faster track. The first 5.25" OEM drives in this group are expected next year.

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 first half of 1989 and will ship a new high capacity 5.25" drive 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 57
FIXED DISK DRIVES, MORE THAN 1 GIGABYTE
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1987		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
	-----Forecast-----									
	Revenues									
U.S. Manufacturers	-----									
IBM Captive	2,148.9	3,538.1	2,548.4	4,044.8	3,492.4	5,416.5	4,379.7	6,703.4	5,560.4	8,560.8
Other U.S. Captive	31.7	52.4	127.1	184.2	555.6	954.2	738.7	1,218.8	764.4	1,293.6
TOTAL U.S. CAPTIVE	2,180.6	3,590.5	2,675.5	4,229.0	4,048.0	6,370.7	5,118.4	7,922.2	6,324.8	9,854.4
PCM	168.6	232.8	148.4	232.7	84.4	160.9	103.5	192.0	173.9	286.4
OEM	101.5	182.5	122.3	211.9	203.6	298.1	258.9	381.1	296.7	445.4
TOTAL U.S. NON-CAPTIVE	270.1	415.3	270.7	444.6	288.0	459.0	362.4	573.1	470.6	731.8
TOTAL U.S. REVENUES	2,450.7	4,005.8	2,946.2	4,673.6	4,336.0	6,829.7	5,480.8	8,495.3	6,795.4	10,586.2
Non-U.S. Manufacturers	-----									
Captive	--	485.6	5.4	596.4	39.0	505.0	45.6	488.6	52.7	511.7
PCM	176.7	412.7	194.5	430.7	323.3	639.8	374.0	701.7	502.5	831.8
OEM	18.9	150.3	127.1	292.3	124.0	270.0	128.4	270.2	153.7	278.0
TOTAL NON-U.S. REVENUES	195.6	1,048.6	327.0	1,319.4	486.3	1,414.8	548.0	1,460.5	708.9	1,621.5
Worldwide Recap	-----									
TOTAL WORLDWIDE REVENUES	2,646.3	5,054.4	3,273.2	5,993.0	4,822.3	8,244.5	6,028.8	9,955.8	7,504.3	12,207.7
OEM Average Price (\$000)	17.2	20.8	7.9	10.9	6.3	7.9	4.6	5.4	3.7	4.2

TABLE 58
FIXED DISK DRIVES, MORE THAN 1 GIGABYTE
UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1987		Forecast							
	Shipments		1988		1989		1990		1991	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	49.7	82.0	53.2	85.0	67.6	105.0	123.2	194.0	189.0	307.0
Other U.S. Captive	1.0	1.7	4.4	6.2	21.9	37.5	29.5	48.5	30.8	52.0
TOTAL U.S. CAPTIVE	50.7	83.7	57.6	91.2	89.5	142.5	152.7	242.5	219.8	359.0
PCM	6.5	9.4	5.9	9.5	3.0	5.7	3.7	6.8	8.6	14.0
OEM	3.9	7.0	7.9	11.4	26.8	35.8	51.1	70.6	73.3	104.4
TOTAL U.S. NON-CAPTIVE	10.4	16.4	13.8	20.9	29.8	41.5	54.8	77.4	81.9	118.4
TOTAL U.S. SHIPMENTS	61.1	100.1	71.4	112.1	119.3	184.0	207.5	319.9	301.7	477.4
Non-U.S. Manufacturers										
Captive	--	16.3	.3	19.3	2.0	20.0	2.4	23.4	2.7	25.7
PCM	7.5	18.3	8.4	18.9	10.2	20.0	11.3	21.2	20.9	35.0
OEM	3.1	9.0	23.5	34.7	24.8	36.0	33.0	48.5	46.0	67.0
TOTAL NON-U.S. SHIPMENTS	10.6	43.6	32.2	72.9	37.0	76.0	46.7	93.1	69.6	127.7
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	71.7	143.7	103.6	185.0	156.3	260.0	254.2	413.0	371.3	605.1
Cumulative Shipments										
IBM	244.0	418.9	297.2	503.9	364.8	608.9	488.0	802.9	677.0	1,109.9
Non-IBM	63.6	163.5	114.0	263.5	202.7	418.5	333.7	637.5	516.0	935.6
WORLDWIDE TOTAL	307.6	582.4	411.2	767.4	567.5	1,027.4	821.7	1,440.4	1,193.0	2,045.5

TABLE 59
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1987		Forecast										
	Revenues		1988		1989			1990			1991		
	14"	8"	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS													
IBM Captive	3,538.1	--	4,044.8	--	5,375.4	--	41.1	5,470.4	--	1,233.0	5,820.8	--	2,740.0
Other U.S. Captive	52.4	--	80.2	104.0	124.6	829.6	--	158.4	1,060.4	--	175.0	1,118.6	--
PCM	232.8	--	232.7	--	128.9	32.0	--	120.0	72.0	--	142.8	61.2	82.4
OEM	178.5	4.0	191.2	20.7	179.4	101.2	17.5	167.2	133.2	80.7	155.4	147.2	142.8
TOTAL U.S. REVENUES	4,001.8	4.0	4,548.9	124.7	5,808.3	962.8	58.6	5,916.0	1,265.6	1,313.7	6,294.0	1,327.0	2,965.2
NON-U.S. MANUFACTURERS													
Captive	483.4	2.2	535.0	61.4	310.0	195.0	--	120.0	368.6	--	30.0	481.7	--
PCM	412.7	--	353.7	77.0	51.6	588.2	--	--	701.7	--	259.0	408.0	164.8
OEM	124.6	25.7	133.9	158.4	115.0	155.0	--	99.0	152.0	19.2	63.0	151.2	63.8
TOTAL NON-U.S. REVENUES	1,020.7	27.9	1,022.6	296.8	476.6	938.2	--	219.0	1,222.3	19.2	352.0	1,040.9	228.6
WORLDWIDE RECAP													
Captive	4,073.9 +8.1%	2.2 --	4,660.0 +14.4%	165.4 --	5,810.0 +24.7%	1,024.6 +519.5%	41.1 --	5,748.8 -1.1%	1,429.0 +39.5%	1,233.0 --	6,025.8 +4.8%	1,600.3 +12.0%	2,740.0 +122.2%
PCM	645.5 +10.4%	-- --	586.4 -9.2%	77.0 --	180.5 -69.2%	620.2 +705.5%	-- --	120.0 -33.5%	773.7 +24.8%	-- --	401.8 +234.8%	469.2 -39.4%	247.2 --
OEM	303.1 +52.3%	29.7 --	325.1 +7.3%	179.1 +503.0%	294.4 -9.4%	256.2 +43.0%	17.5 --	266.2 -9.6%	285.2 +11.3%	99.9 +470.9%	218.4 -18.0%	298.4 +4.6%	206.6 +106.8%
Total Revenues	5,022.5 +10.3%	31.9 --	5,571.5 +10.9%	421.5 --	6,284.9 +12.8%	1,901.0 +351.0%	58.6 --	6,135.0 -2.4%	2,487.9 +30.9%	1,332.9 --	6,646.0 +8.3%	2,367.9 -4.8%	3,193.8 +139.6%
ANNUAL SHARE, BY DIAMETER	99.5%	.5%	93.1%	6.9%	76.3%	23.1%	.6%	61.7%	25.0%	13.3%	54.5%	19.4%	26.1%

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

TABLE 60
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1987		Forecast										
	Shipments		1988		1989			1990			1991		
	14"	8"	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS													
IBM Captive	82.0	--	85.0	--	102.0	--	3.0	104.0	--	90.0	107.0	--	200.0
Other U.S. Captive	1.7	--	2.0	4.2	3.5	34.0	--	4.5	44.0	--	5.0	47.0	--
PCM	9.4	--	9.5	--	4.9	.8	--	4.8	2.0	--	4.2	1.8	8.0
OEM	6.6	.4	8.1	3.3	7.8	23.0	5.0	7.6	37.0	26.0	7.4	46.0	51.0
TOTAL U.S. SHIPMENTS	99.7	.4	104.6	7.5	118.2	57.8	8.0	120.9	83.0	116.0	123.6	94.8	259.0
NON-U.S. MANUFACTURERS													
Captive	16.2	.1	16.2	3.1	10.0	10.0	--	4.0	19.4	--	1.0	24.7	--
PCM	18.3	--	15.6	3.3	3.0	17.0	--	--	21.2	--	7.0	12.0	16.0
OEM	4.8	4.2	5.5	29.2	5.0	31.0	--	4.5	38.0	6.0	3.0	42.0	22.0
TOTAL NON-U.S. SHIPMENTS	39.3	4.3	37.3	35.6	18.0	58.0	--	8.5	78.6	6.0	11.0	78.7	38.0
WORLDWIDE RECAP													
Captive	99.9	.1	103.2	7.3	115.5	44.0	3.0	112.5	63.4	90.0	113.0	71.7	200.0
	+7.8%	--	+3.3%	--	+11.9%	+502.7%	--	-2.6%	+44.1%	--	+4%	+13.1%	+122.2%
PCM	27.7	--	25.1	3.3	7.9	17.8	--	4.8	23.2	--	11.2	13.8	24.0
	+10.4%	--	-9.4%	--	-68.5%	+439.4%	--	-39.2%	+30.3%	--	+133.3%	-40.5%	--
OEM	11.4	4.6	13.6	32.5	12.8	54.0	5.0	12.1	75.0	32.0	10.4	88.0	73.0
	+58.3%	--	+19.3%	+606.5%	-5.9%	+66.2%	--	-5.5%	+38.9%	+540.0%	-14.0%	+17.3%	+128.1%
Total Shipments	139.0	4.7	141.9	43.1	136.2	115.8	8.0	129.4	161.6	122.0	134.6	173.5	297.0
	+11.2%	--	+2.1%	+817.0%	-4.0%	+168.7%	--	-5.0%	+39.6%	--	+4.0%	+7.4%	+143.4%
ANNUAL SHARE, BY DIAMETER	96.8%	3.2%	76.8%	23.2%	52.5%	44.5%	3.0%	31.4%	39.1%	29.5%	22.2%	28.8%	49.0%

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

TABLE 61
 WORLDWIDE SHIPMENTS OF IBM AND PCM FIXED DISK DRIVES FOR MAINFRAMES
 PRODUCT MIX ANALYSIS

	-----DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000 SPINDLES)-----									
	1987		-----FORECAST-----							
	---Shipments---		-----1988-----		-----1989-----		-----1990-----		-----1991-----	
	US	WW	US	WW	US	WW	US	WW	US	WW
<u>IBM 3370 (729 MB)</u>	2.8	7.0	2.0	5.0	--	--	--	--	--	--
<u>IBM 9335 (856 MB)</u>	17.6	32.0	25.0	48.0	28.0	55.0	28.0	58.0	16.0	35.0
<u>3380D/J Type (1260 MB)</u>										
IBM	15.6	26.0	11.8	20.0	7.0	12.0	5.1	9.0	3.9	7.0
PCM*	4.4	10.7	3.8	8.6	3.1	6.8	1.8	4.0	--	--
TOTAL	20.0	36.7	15.6	28.6	10.1	18.8	6.9	13.0	3.9	7.0
<u>3380E Type (2520 MB)</u>										
IBM	27.6	46.0	2.4	4.0	--	--	--	--	--	--
PCM*	9.6	17.0	10.1	18.9	2.2	4.2	--	--	--	--
TOTAL	37.2	63.0	12.5	22.9	2.2	4.2	--	--	--	--
<u>3380K Type (3780 MB)</u>										
IBM	6.5	10.0	39.0	61.0	37.8	60.0	18.6	30.0	6.1	10.0
PCM*	--	--	.4	.9	7.9	14.7	13.2	24.0	8.8	16.0
TOTAL	6.5	10.0	39.4	61.9	45.7	74.7	31.8	54.0	14.9	26.0
<u>Not yet announced</u>										
IBM 10.25 INCH (3000 MB)	--	--	--	--	21.0	30.0	45.5	65.0	63.0	90.0
PCM 10.25 INCH (3000 MB)	--	--	--	--	--	--	--	--	6.3	9.0
TOTAL 10.25 INCH	--	--	--	--	21.0	30.0	45.5	65.0	69.3	99.0
IBM 5.25 INCH (1200 MB)	--	--	--	--	1.8	3.0	54.0	90.0	116.0	200.0
PCM 5.25 INCH (1200 MB)	--	--	--	--	--	--	--	--	14.4	24.0
TOTAL 5.25 INCH	--	--	--	--	1.8	3.0	54.0	90.0	130.4	224.0
TOTAL SPINDLES	84.1	148.7	94.5	166.4	108.8	185.7	166.2	280.0	234.5	391.0
TOTAL CAPACITY (Terabytes)		275.3		372.4		457.3		573.1		702.9
		+20%		+35%		+23%		+25%		+23%

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

TABLE 62
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE
 APPLICATIONS SUMMARY
 Percentage of Worldwide Shipments

APPLICATION	1987 Estimate		1991 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	140.0	97.4	517.4	85.5
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	1.7	1.2	36.9	6.1
PERSONAL COMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	--	--	--	--
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	2.0	1.4	50.8	8.4
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	143.7	100.0	605.1	100.0

TABLE 63
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1987 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
	14"	8"	Total		14"	8"	Total	
HITACHI	3.1	.4	3.5	16.7	14.4	.5	14.9	34.1
FUJITSU	4.4	.2	4.6	21.9	8.7	.2	8.9	20.4
STORAGE TECHNOLOGY	5.5	--	5.5	26.2	7.1	--	7.1	16.2
Other U.S.	4.7	.2	4.9	23.3	8.9	.4	9.3	21.3
Other Non-U.S.	--	2.5	2.5	11.9	--	3.5	3.5	8.0
TOTAL	17.7	3.3	21.0	100.0	39.1	4.6	43.7	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

Coverage

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

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

Generic type

Where applicable, model numbers of IBM or other manufacturers are used to describe 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.

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 embedded controllers, 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.

1988 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, 30-60 MB |
| | 5. Fixed disk drives, 60-100 MB |
| | 6. Fixed disk drives, 100-300 MB |
| | 7. Fixed disk drives, 300-500 MB |
| | 8. Fixed disk drives, 500 MB-1 GB |
| | 9. Fixed disk drives, more than 1 GB |

MANUFACTURER	ALPHA DATA	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE					
	Atlas 520	DRM020A	DRM020E	DRP020A	DRP020D
DISK/TREND GROUP	8	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite*	Ferrite*
Interface	ESMD	ST412	SASI	Alps	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 520	U: 25.5	F: 21.4	U: 25.6	F: 21.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 10,416	F: 8,704	U: 20,813	F: 17,398
Data surfaces per spindle	7.6	4	4	2	2
Heads per data surface	10	1	1	1	1
Tracks per surface	2250	615	615	615	615
Track density (TPI)	1000	880	880	880	880
Maximum linear density (BPI)	11700	12720	12720	27022 BPI** 18015 FCI	27022 BPI** 18015 FCI
Rotational speed (RPM)	3600	3545	3545	2640	2640
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	18	75 (including settling)	75 (including settling)	75 (including settling)	75 (including settling)
Average rotational delay (msec)	8.3	8.46	8.46	11.4	11.4
Average access time (msec)	26.3	83.46	83.46	86.4	86.4
Data transfer rate (KBytes/sec)	1800	625	625	937.5	937.5
FIRST CUSTOMER SHIPMENT	2Q86	1986	1987	1987	1987
U.S. OEM PRICE FOR 100 UNITS	\$7,495	--	--	--	--
COMMENTS	8 Parallel channel version available	41 mm high Available in external package	41 mm high	25 mm high *Metal in Gap **2,7 RLL Code	30 mm high *Metal in Gap **2,7 RLL Code

1988 DISK/TREND REPORT

RSPEC-5

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	AMDAHL
DRIVE	DRP020E	DRP020L	DRQ040A	DRQ040D	6380-AA4 6380-M4 6380-B4
DISK/TREND GROUP	3	3	4	4	8
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	10.5" OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	4.0" ID Oxide Coated
DRIVE: Heads	Ferrite*	Ferrite*	Ferrite*	Ferrite*	Ferrite
Interface	SASI	Alps	Alps	SCSI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20	U: 25.6	U: 51.2	F: 40	F: 630.2
REMOVABLE	--				--
Capacity per track (Bytes)	F: 16,260	U: 20,813	U: 20,813	F: 16,260	F: 47,476
Data surfaces per spindle	2	2	4	4	8
Heads per data surface	1	1	1	1	2
Tracks per surface	615	615	615	615	1770
Track density (TPI)	880	880	880	880	905
Maximum linear density (BPI)	27022 BPI** 18015 FCI	27022 BPI** 18015 FCI	27022 BPI** 18015 FCI	27022 BPI** 18015 FCI	24420*
Rotational speed (RPM)	2640	2640	2640	2640	3620
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	60 (including settling)	75 (including settling)	45 (including settling)	45 (including settling)	15
Average rotational delay (msec)	11.4	11.4	11.4	11.4	8.3
Average access time (msec)	71.4	86.4	56.4	56.4	23.3
Data transfer rate (KBytes/sec)	937.5	937.5	937.5	937.5	3000
FIRST CUSTOMER SHIPMENT	1988	1988	1988	1988	3Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	30 mm high *Metal in Gap **2,7 RLL Code	25 mm high *Metal in Gap **2,7 RLL Code	25 mm high *Metal in Gap **2,7 RLL Code	30 mm high *Metal in Gap **2,7 RLL Code	PCM 3380 Drive has 4 spindles *2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	AMDAHL	AMDAHL	AMDAHL	AREAL TECHNOLOGY	AREAL TECHNOLOGY
DRIVE	6380-AJ4 6380-BJ4	6380-AE4 6380-BE4	6380-AK4 6380-BK4	BP 50	BP 100
DISK/TREND GROUP	8	9	9	4	6
MARKET	PCM	PCM	PCM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Sputtered	Oxide Sputtered	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	IBM	IBM	IBM	SCSI, PC AT	SCSI, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 630.2	F: 1,260	F: 1,890	F: 50	F: 100
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 30,720	F: 30,720
Data surfaces per spindle	8	12	16	1	2
Heads per data surface	2	2	2	1	1
Tracks per surface	1770	2360	2656	1720	1720
Track density (TPI)	*	1160	*	1720	1720
Maximum linear density (BPI)	*	24989*	*	57000 BPI* 38000 FCI	57000 BPI* 38000 FCI
Rotational speed (RPM)	3620	3620	3620	1600	1600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	12	17	16	29	29
Average rotational delay (msec)	8.3	8.3	8.3	18.75	18.75
Average access time (msec)	20.3	25.3	24.3	47.75	47.75
Data transfer rate (KBytes/sec)	3000	3000	3000	937.5	937.5
FIRST CUSTOMER SHIPMENT	1Q89	4Q86	1Q89	4Q88	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PCM 3380J Drive has 4 spindles *Not announced	PCM 3380E Drive has 4 spindles *2,7 RLL Code	PCM 3380K Drive has 4 spindles *Not announced	25 mm high Embedded Servo 1 watt operating	25 mm high Embedded Servo 1 watt operating

MANUFACTURER	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES
DRIVE	BT9053	BT8085	BT9075	BT9107S	BT8128
DISK/TREND GROUP	4	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	130 mm OD	95 mm OD	95 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	40 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 53.3	U: 85.3	U: 74.7	F: 91.9	U: 127.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	F: 17,920	U: 15,624
Data surfaces per spindle	5	8	7	5	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1024	1024
Track density (TPI)	1240	1053	1240	1240	1053
Maximum linear density (BPI)	13700	9290	13700	27450 BPI* 18300 FCI	13935 BPI* 9250 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, DC Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, DC Motor
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	1250	937.5
FIRST CUSTOMER SHIPMENT	1Q89	2Q87	1Q89	1Q89	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	\$525 (1000)	--	--	\$625 (1000)
COMMENTS	41 mm high		41 mm high	41 mm high *2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES
DRIVE	BT8170E	BT8170S	BT9107E	BT9149E	BT9149S
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 170.6	F: 150.9	U: 107	U: 149	F: 128
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	F: 18,432	U: 20,832	U: 20,832	F: 17,920
Data surfaces per spindle	8	8	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1024	1024
Track density (TPI)	1053	1053	1240	1240	1240
Maximum linear density (BPI)	18580 BPI* 12387 FCI	18580 BPI* 12387 FCI	27450 BPI* 18300 FCI	27450 BPI* 18300 FCI	27450 BPI* 18300 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, DC Motor	Rotary, DC Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	22	22	25	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	30.3	30.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	4Q87	3Q88	1Q89	1Q89	1Q89
U.S. OEM PRICE FOR 100 UNITS	\$955 (1000)	\$1,050 (1000)	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	41 mm high 2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code

MANUFACTURER	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CENTURY DATA	CENTURY DATA
DRIVE	F3057 Classic	F3096 Classic	F3127 Classic	7100S	7110
DISK/TREND GROUP	4	5	6	1	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	8" Cartridge	8" Cartridge
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	SCSI, PC AT	ESDI, SCSI, PC AT	ESDI, SCSI, PC AT	SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 48.88	U: 95.62	U: 127.5	--	U: 26.9
REMOVABLE	--	--	--	U: 103.8	U: 26.9
Capacity per track (Bytes)	F: 13,312	U: 15,624	U: 20,832	U: 31,392	U: 20,928
Data surfaces per spindle	3	5	5	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	1224	1653	644
Track density (TPI)	1389	1389	1389	1350	555
Maximum linear density (BPI)	22168 BPI* 14778 FCI	22168 BPI* 14778 FCI	29557 BPI* 19704 FCI	16950 BPI* 11300 FCI	10986 BPI* 7324 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)	20	20	20	29	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	28.3	28.3	37.3	33.3
Data transfer rate (KBytes/sec)	937.5	937.5	1250	2000	1229
FIRST CUSTOMER SHIPMENT	1Q89	1Q89	1Q89	1Q88	1Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$4,160	\$4,285
COMMENTS	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo

	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
MANUFACTURER					
DRIVE					
	7130	PhD	T306 Trident	14203	14404
DISK/TREND GROUP	1	1	2	6	6
MARKET	OEM	End User	OEM	OEM	OEM
MEDIA: Generic type	8" Cartridge	8" Cartridge	3336-11	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	14"	130 mm OD	130 mm OD
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	Oxide Coated	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SMD, SCSI	SCSI, PC	SMD	ESDI, SCSI	ESDI, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 80.9	U: 80.9	--	F: 85	F: 114
REMOVABLE	U: 26.9	U: 26.9	U: 315.2	--	--
Capacity per track (Bytes)	U: 20,928	U: 20,928	U: 20,160	F: 17,700	F: 17,700
Data surfaces per spindle	8	8	19	3	4
Heads per data surface	1	1	1	1	1
Tracks per surface	644	644	823	1600	1600
Track density (TPI)	555	555	384	1440	1440
Maximum linear density (BPI)	10986 BPI* 7324 FCI	10986 BPI* 7324 FCI	6060	19405 BPI* 12937 FCI	19405 BPI* 12937 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)	25	25	30	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	38.3	33.3	33.3
Data transfer rate (KBytes/sec)	1229	1229	1209	1250	1250
FIRST CUSTOMER SHIPMENT	1/86	1/86	8/76	2Q88	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$3,845	\$3,890	\$12,320	\$1,220	\$1,320
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo		41 mm high *2,7 RLL Code Embedded Servo	41 mm high *2,7 RLL Code Embedded Servo

1988 DISK/TREND REPORT

	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
MANUFACTURER					
DRIVE					
	14405	14406	AMS 315	C2400	C2476
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	High Dens Oxide
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Thin Film	Thin Film
Interface	ESDI, SCSI	ESDI, SCSI	SMD	SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 140	F: 170	U: 315.2	U: 344	U: 475.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,700	F: 17,700	U: 20,160	U: 20,160	U: 28,160
Data surfaces per spindle	5	6	9.5	24	10
Heads per data surface	1	1	2	1	2
Tracks per surface	1600	1600	1646	711	1690
Track density (TPI)	1440	1440	712	1143	1143
Maximum linear density (BPI)	19405 BPI* 12937 FCI	19405 BPI* 12937 FCI	6363	12783 BPI* 8522 FCI	17900 BPI* 11933 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3961
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	25	25	25	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.57
Average access time (msec)	33.3	33.3	33.3	23.3	22.57
Data transfer rate (KBytes/sec)	1250	1250	1209	1209	1859
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	11/82	3Q85	3/85
U.S. OEM PRICE FOR 100 UNITS	\$1,460	\$1,695	\$7,065	\$5,835	\$6,200
COMMENTS	41 mm high *2,7 RLL Code Embedded Servo	41 mm high *2,7 RLL Code Embedded Servo	T306 Trident compatibility	*2,7 RLL Code	*2,7 RLL Code Eagle I compatibility

MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
DRIVE	C2600	C2800	DS21200	DS21600	DS2600
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Modified SMD	Modified SMD	SDI (DEC)	SDI (DEC)	SDI (DEC)
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 613	U: 830	F: 900	F: 625	F: 451
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 40,960	F: 30,720	F: 22,240	F: 22,240
Data surfaces per spindle	12	16	16	16	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1690	1221	1831	1221	1690
Track density (TPI)	1143	1087	1087	1087	1143
Maximum linear density (BPI)	19200 BPI* 12800 FCI	19739 BPI* 13159 FCI	24846 BPI* 16564 FCI	19739 BPI* 13159 FCI	19200 BPI* 12800 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)	15	15	18	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	26.3	23.3	23.3
Data transfer rate (KBytes/sec)	1813	2400	2400	2400	1813
FIRST CUSTOMER SHIPMENT	3Q85	8/86	2Q88	3Q88	1Q88
U.S. OEM PRICE FOR 100 UNITS	\$6,905	\$8,005	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code RA82/90 compatible DEC market	*2,7 RLL Code RA90 compatible DEC market Drive has 2 spindles	*2,7 RLL Code RA81 compatible DEC market

1988 DISK/TREND REPORT

	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
MANUFACTURER					
DRIVE					
	DS2800	T2801	T2802	C21200	C21500
DISK/TREND GROUP	8	8	8	9	9
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SDI (DEC)	Modified SMD	DIMS-500X	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 625	U: 830	U: 830	U: 1,200	U: 1,500
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 31,990	U: 40,960	U: 40,960	U: 40,960	U: 40,960
Data surfaces per spindle	16	12	12	16	16
Heads per data surface	1	2	2	1	1
Tracks per surface	1221	845	845	1831	2277
Track density (TPI)	1087	1115	1115	1087	1362
Maximum linear density (BPI)	19739 BPI* 13159 FCI	24787 BPI* 16525 FCI	24787 BPI* 16525 FCI	24846 BPI* 16564 FCI	24846 BPI* 16564 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)	15	15	15	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	23.3	26.3	26.3
Data transfer rate (KBytes/sec)	2400	2458/9830/12288	11760	2400	2400
FIRST CUSTOMER SHIPMENT	1Q88	1Q88	2Q88	1Q88	3Q88
U.S. OEM PRICE FOR 100 UNITS	--	\$10,390	--	--	--
COMMENTS	*2,7 RLL Code RA82 compatible DEC market	*2,7 RLL Code Parallel data transfer, 1 or 5 channels 4 spare heads	*2,7 RLL Code 2 HDA'S parallel data transfer	*2,7 RLL Code	*2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	CENTURY DATA	CENTURY DATA	COMPAREX	COMPAREX	COMPAREX
DRIVE	DS21500	DS22400	6480AJ 6480BJ	6480D 6481D	6480AE 6480BE
DISK/TREND GROUP	9	9	8	8	9
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	9.5"	14"	9.5"
Recording medium	63.5 mm ID Thin Film	63.5 mm ID Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SDI (DEC)	SDI (DEC)	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,125	F: 900	F: 630	F: 630	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 30,880	F: 30,720	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	16	16	8	10	8
Heads per data surface	1	1	2	2	2
Tracks per surface	2277	1831	1327.5	1327.5	2655
Track density (TPI)	1362	1087	*	*	*
Maximum linear density (BPI)	24846 BPI*	24846 BPI*	*	*	*
Rotational speed (RPM)	16564 FCI 3600	16564 FCI 3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	18	18	11	15	13
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	19.3	23.3	21.3
Data transfer rate (KBytes/sec)	2400	2400	3000	3000	3000
FIRST CUSTOMER SHIPMENT	3Q88	3Q88	1988	1986	1988
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code RA90 compatible DEC market	*2,7 RLL Code RA90 compatible DEC market Drive has 2 spindles	PCM 3380J Drive has 4 spindles *Not announced	PCM 3380D Drive has 4 spindles *Not announced	PCM 3380E Drive has 4 spindles *Not announced

MANUFACTURER	COMPAREX	COMPAREX	COMPORT	COMPORT	COMPORT
DRIVE	6480AK 6480BK	6485 6486	2040	2041	2082
DISK/TREND GROUP	9	9	4	4	5
MARKET	PCM	PCM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	14"	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film
Recording medium	Oxide Coated	Oxide Coated			
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ST412	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,890	F: 1,260	U: 51.3	F: 43.7	F: 85.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	U: 15,624	F: 13,312	F: 17,408
Data surfaces per spindle	8	12	4	4	6
Heads per data surface	4	2	1	1	1
Tracks per surface	2655	2212.5	820	820	820
Track density (TPI)	*	*	1065	1065	1065
Maximum linear density (BPI)	*	*	20196 BPI* 13464 FCI	20196 BPI* 13464 FCI	26928 BPI* 17952 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Linear, Stepping Motor	Linear, Stepping Motor	Linear, Stepping Motor
Average positioning time (msec)	12.5	17	35	29	29
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	20.8	25.3	43.3	37.3	37.3
Data transfer rate (KBytes/sec)	3000	3000	937.5	937.5	1250
FIRST CUSTOMER SHIPMENT	1988	1986	3Q88	4Q88	1Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PCM 3380K Drive has 4 spindles *Not announced	PCM 3380E Drive has 4 spindles *Not announced	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP3022	CP340	CP344	CP3100	CP3104
DISK/TREND GROUP	3	4	4	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21	F: 40	F: 42	F: 100	F: 104
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 13,312	F: 13,312	F: 16,896	F: 16,896
Data surfaces per spindle	2	4	4	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	636	788	805	748	776
Track density (TPI)	1150	1000	1000	1150	1150
Maximum linear density (BPI)	21594 BPI* 14396 GCI	21379 BPI* 14253 FCI	21379 BPI* 14253 FCI	23280 BPI* 15520 FCI	23441 BPI* 15627 FCI
Rotational speed (RPM)	3575	3600	3600	3575	3575
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	29	29	25	25
Average rotational delay (msec)	8.4	8.3	8.3	8.4	8.4
Average access time (msec)	35.4	37.3	37.3	33.4	33.4
Data transfer rate (KBytes/sec)	1250	1000	1000	1250	1250
FIRST CUSTOMER SHIPMENT	2Q88	4Q86	4Q86	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	25 mm high *2,7 RLL Code Embedded Servo	38 mm high *2,7 RLL Code Embedded Servo	38 mm high *2,7 RLL Code Embedded Servo	41 mm high *2,7 RLL Code Embedded Servo	41 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	CONNER PERIPHERALS	DATA GENERAL	DATA GENERAL	DATA GENERAL	DATA GENERAL
DRIVE	CP3114	6060	6122	6236 6237	6239 6290 6240
DISK/TREND GROUP	6	2	2	7	8
MARKET	OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	3336-1	3336-11	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	14"	14"	14"	14"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	Data General	Data General	Data General	Data General
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 112	--	--	F: 354.1	F: 592.2
REMOVABLE	--	F: 95.957	F: 277.491	--	--
Capacity per track (Bytes)	F: 16,896	F: 12,288	F: 17,920	F: 28,672	F: 38,400
Data surfaces per spindle	8	19	19	8	8
Heads per data surface	1	1	1	2	2
Tracks per surface	833	411	815	1572	1956
Track density (TPI)	1150	192	370	714	800
Maximum linear density (BPI)	*	4040	6060	10438*	14154*
Rotational speed (RPM)	3575	3600	3600	3000	2940
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	25	35	35	20	21
Average rotational delay (msec)	8.4	8.3	8.3	10	10.2
Average access time (msec)	33.4	43.3	43.3	30	31.2
Data transfer rate (KBytes/sec)	1250	806	1209	1680	2200
FIRST CUSTOMER SHIPMENT	1988	1976	1Q80	9/83	2/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code Embedded Servo			*2,7 RLL Code 6237-3 Spindles	*2,7 RLL Code 6239-1 spindle 6290-2 spindles 6240-3 spindles

MANUFACTURER	DATA GENERAL	DATA GENERAL	DDC PERTEC	DDC PERTEC	DDC PERTEC
DRIVE	6357 6398 6399 6400	6581	DX199	DX265	DX332
DISK/TREND GROUP	8	8	6	6	7
MARKET	Captive	Captive	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	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Ferrite	Ferrite	Ferrite
Interface	Data General	Data General	SMD,SCSI,ESDI	SMD,SCSI,ESDI	SMD,SCSI,ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 862	F: 500	U: 199	U: 265	U: 332
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 35,840	F: 27,648	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	8	12	6	8	10
Heads per data surface	2	1	1	1	1
Tracks per surface	3058	1545	1649	1649	1649
Track density (TPI)	1250	1279	1083	1083	1083
Maximum linear density (BPI)	14614*	12223 BPI* 8149 FCI	12022*	12022*	12022*
Rotational speed (RPM)	3000	4630	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)	22	16	22	22	22
Average rotational delay (msec)	10	6.5	8.3	8.3	8.3
Average access time (msec)	30	22.5	30.3	30.3	30.3
Data transfer rate (KBytes/sec)	2310	2670	1208	1208	1208
FIRST CUSTOMER SHIPMENT	1/88	7/88	4/85	4/85	4/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$3,500
COMMENTS	*2,7 RLL Code 6357-1 spindle 6398-2 spindles 6399-3 spindles 6400-6 spindles	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	DDC PERTEC	DDC PERTEC	DDC PERTEC	DDC PERTEC	DDC PERTEC
DRIVE					
	DX368	DX375	DX914	DX548	DX731
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD	Modified SMD	Modified SMD	SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 368	U: 374.8	U: 914.2	U: 548.5	U: 731.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 40,320	U: 50,400	U: 30,240	U: 40,320
Data surfaces per spindle	10	11	11	11	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1217	845	1649	1649	1649
Track density (TPI)	1083	1083	1083	1083	1083
Maximum linear density (BPI)	15176*	17785*	30075*	18046*	24061*
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	14	16	20	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	22.3	24.3	28.3	26.3
Data transfer rate (KBytes/sec)	1815	2418	3020	1815	2418
FIRST CUSTOMER SHIPMENT	1Q86	4Q87	1988	2Q86	4Q87
U.S. OEM PRICE FOR 100 UNITS	\$3,500	\$4,830	\$6,230	\$4,830	\$6,050
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	DDC PERTEC	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE					
	DX1246	RC25	RA60	RA70	RA81
DISK/TREND GROUP	9	1	2	7	7
MARKET	OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Special Cartridge	Special Disk Pack	Fixed	Fixed
Nominal disk diameter	200 mm OD	8"	14"	130 mm OD	14"
Recording medium	63.5 mm ID Thin Film	Oxide Coated	Oxide Coated	40 mm ID Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	DEC	DEC	DEC	DEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,246	F: 26	--	U: 350 F: 280	F: 456
REMOVABLE	--	F: 26	F: 205.0	--	--
Capacity per track (Bytes)	U: 50,400	F: 15,872	F: 21,504	F: 17,408	F: 26,112
Data surfaces per spindle	15	4	6	11	7
Heads per data surface	1	1	1	1	2
Tracks per surface	1649	821	1600	1507	2496
Track density (TPI)	1083	1000	779	1355	960
Maximum linear density (BPI)	30075*	12350	9668*	22437*	11400*
Rotational speed (RPM)	3600	2850	3600	4000	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	35	41.7	19.5	28
Average rotational delay (msec)	8.3	10.5	8.3	7.5	8.3
Average access time (msec)	24.3	45.5	50.0	27.0	36.3
Data transfer rate (KBytes/sec)	3020	1250	1980	1450	2200
FIRST CUSTOMER SHIPMENT	1988	4Q83	3Q83	4/88	9/82
U.S. OEM PRICE FOR 100 UNITS	\$8,110	--	--	--	--
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

1988 DISK/TREND REPORT

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DMA TECHNOLOGIES	DMA TECHNOLOGIES
DRIVE	RA82	SA482	SA600 (RA90)	360	371
DISK/TREND GROUP	8	8	9	1	1
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed		
Nominal disk diameter	14"	14"	9"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	DEC	DEC	DEC	ST506	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 855 F: 622	U: 855 F: 622	U: 1,607 F: 1,216	--	--
REMOVABLE	--	--	--	U: 12.75	F: 20.0
Capacity per track (Bytes)	F: 29,184	F: 29,184	F: 35,328	U: 10,416	F: 8,704
Data surfaces per spindle	8	8	13	2	2
Heads per data surface	2	2	1	1	1
Tracks per surface	2846	2764	2649	612	1224
Track density (TPI)	1063	1063	1750	612	1222
Maximum linear density (BPI)	12545*	12545*	22839*	10894	10894
Rotational speed (RPM)	3600	3600	3600	3473	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	20	20	17.5	98 (including settling)	85
Average rotational delay (msec)	8.3	8.3	8.3	8.6	8.6
Average access time (msec)	28.3	28.3	27	106.6	93.6
Data transfer rate (KBytes/sec)	2400	2400	2800	625	625
FIRST CUSTOMER SHIPMENT	4Q87	1Q87	8/88	5/84	5/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo SA482 consists of 4 spindles Total 2,448 MB	*2,7 RLL Code SA600 consists of 4 or 8 spindles, up to 9,728 MB	41 mm high Embedded Servo	41 mm high Embedded Servo

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE					
	FK309-26	FK303-52	FK308S-39R	FK308S-58R	FK309-39R
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SCSI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.6	U: 51.2	F: 30.2	F: 45.3	U: 38.4*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 12,288	F: 12,288	U: 15,624*
Data surfaces per spindle	4	8	4	6	4
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	23300 BPI* 15500 FCI	23300 BPI* 15500 FCI	23400 BPI* 15600 FCI
Rotational speed (RPM)	3350	3350	3500	3500	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	8.57	8.57	8.96
Average access time (msec)	73.96	48.96	73.57	73.57	73.96
Data transfer rate (KBytes/sec)	625	625	937.5	937.5	937.5*
FIRST CUSTOMER SHIPMENT	4/87	8/87	12/86	5/87	4/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high	41 mm high	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *With RLL controller

1988 DISK/TREND REPORT

MANUFACTURER	FUJI ELECTRIC	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	FK309S-50R	M2225AD	M2225D2	M2230AS/B	M2230AT M2230BT
DISK/TREND GROUP	4	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	AS=ST412 B=SA4000	ST412, SA4000
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 41.5	U: 25.62	U: 25.6	U: 6.66	U: 6.66
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	4	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	320	320
Track density (TPI)	753	846	834	300	300
Maximum linear density (BPI)	29000 BPI* 19333 FCI	13330	14845	10200	10200
Rotational speed (RPM)	3150	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Encoder Motor	Rotary, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	47 (including settling)	85 (including settling)	35	83 (including settling)	95 (including settling)
Average rotational delay (msec)	9.5	8.3	8.3	8.3	8.3
Average access time (msec)	56.5	93.3	43.3	91.3	103.3
Data transfer rate (KBytes/sec)	937.5	625	625	625	625
FIRST CUSTOMER SHIPMENT		4Q86	2Q87	4/83	5/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	41 mm high	41 mm high		41 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2233AS/B	M2233AT M2233BT	M2234AS/B	M2235AS/B	M2226D2
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	Captive, OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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: Heads	Ferrite AS=ST412 B=SA4000	Ferrite ST412, SA4000	Ferrite AS=ST412 B=SA4000	Ferrite AS=ST412 B=SA4000	Ferrite ST412
Interface					
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 13.3	U: 13.33	U: 20	U: 26.66	U: 38.43
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	4	6	8	6
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	320	320	615
Track density (TPI)	300	300	300	300	834
Maximum linear density (BPI)	10200	10200	10200	10200	14845
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Encoder Motor
Average positioning time (msec)	83 (including settling)	95 (including settling)	83 (including settling)	83 (including settling)	35
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	91.3	103.3	91.3	91.3	43.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	4/83	5/84	4/83	10/83	1Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$585	\$525
COMMENTS		41 mm high			41 mm high

1988 DISK/TREND REPORT

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2227D2	M2241AS2 M2241B	M2242AS2 M2242B	M2311K/S	M2611S
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	Captive, OEM	Captive, 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	200 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412, SA4000	ST412, SA4000	SMD, SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.24	U: 31.4	U: 54.9	U: 48.25	F: 45.07
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 20,480	F: 16,896
Data surfaces per spindle	8	4	7	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	754	754	589	1334
Track density (TPI)	834	760	760	720	1681
Maximum linear density (BPI)	14845	10200	10200	9550	29571*
Rotational speed (RPM)	3600	3600	3600	3600	3490
PERFORMANCE					
Actuator type	Rotary, Encoder Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	35	30	30	20	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.6
Average access time (msec)	43.3	38.3	38.3	28.3	33.6
Data transfer rate (KBytes/sec)	625	625	625	1229	1250
FIRST CUSTOMER SHIPMENT	1Q87	5/84	5/84	4/81	4Q88
U.S. OEM PRICE FOR 100 UNITS	\$595	--	\$1,210	--	--
COMMENTS	41 mm high				25 mm high *1,7 RLL Code Embedded Servo

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2243AS2 M2243B	M2243T	M2244C/E	M2244S/SA/SB	M2312K/S
DISK/TREND GROUP	5	5	5	5	5
MARKET	Captive, OEM	OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	200 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412, SA4000	ST412	ESDI	SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 86.3	U: 86.4	U: 85.8	F: 63	U: 84.44
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 20,864	F: 16,640	U: 20,480
Data surfaces per spindle	11	7	5	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	754	1185	823	823	589
Track density (TPI)	760	1226	850	850	720
Maximum linear density (BPI)	10200	10200	20400*	20400*	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)	30	25	25	25	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	33.3	33.3	33.3	28.3
Data transfer rate (KBytes/sec)	625	625	1250	1500	1229
FIRST CUSTOMER SHIPMENT	5/84	3Q87	3Q85	2Q87	4/81
U.S. OEM PRICE FOR 100 UNITS	\$1,350	\$1,000	\$1,400	--	--
COMMENTS		41 mm high	*2,7 RLL Code	*2,7 RLL Code	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2321K/S	M2612S	M2243R	M2245C/E	M2245S/SA/SB
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD, SCSI	SCSI	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 84.2	F: 90.15	U: 129.6*	U: 120.2	F: 89.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	F: 16,896	U: 15,624*	U: 20,864	F: 16,640
Data surfaces per spindle	5	4	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	1334	1185	823	823
Track density (TPI)	683	1681	1226	850	850
Maximum linear density (BPI)	9867	29571*	15300 BPI* 10200 FCI	20400*	20400*
Rotational speed (RPM)	3600	3490	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	20	25	25	25
Average rotational delay (msec)	8.3	8.6	8.3	8.3	8.3
Average access time (msec)	28.3	28.6	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	1229	1250	937.5*	1250	1500
FIRST CUSTOMER SHIPMENT	11/83	4Q88	3Q87	3Q85	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	\$1,150	\$1,530	--
COMMENTS		25 mm high *1,7 RLL Code Embedded Servo	41 mm high *With RLL controller	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2246C/E	M2246S/SA/SB	M2247E	M2247S/SA/SB	M2248E
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive, OEM	Captive, OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 171.7	F: 130.3	U: 181.5	F: 137.9	U: 285.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	F: 16,640	U: 20,864	F: 16,640	U: 20,864
Data surfaces per spindle	10	10	7	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	1243	1243	1243
Track density (TPI)	850	850	1267	1267	1267
Maximum linear density (BPI)	20400*	20400*	19295*	19295*	19295*
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	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	1500	1250	1500	1250
FIRST CUSTOMER SHIPMENT	3Q85	2Q87	3Q87	1Q88	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$1,595	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2248S/SA/SB	M2284	M2322K/S	M2331K/KS/P	M2613S
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	14"	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SMD	SMD, SCSI	Mod. SMD, IPI-2	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 220.5	U: 168.6	U: 168.5	U: 168.5	F: 135.23
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,640	U: 20,480	U: 20,480	U: 40,960	F: 16,896
Data surfaces per spindle	11	5	10	5	6
Heads per data surface	1	2	1	1	1
Tracks per surface	1243	1646	823	823	1334
Track density (TPI)	1267	680	683	683	1681
Maximum linear density (BPI)	19295*	6580	9867	19734*	29571*
Rotational speed (RPM)	3600	2964	3600	3600	3490
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	27	20	20	20
Average rotational delay (msec)	8.3	10.12	8.3	8.3	8.6
Average access time (msec)	26.3	37.12	28.3	28.3	28.6
Data transfer rate (KBytes/sec)	1500	1012	1229	2458	1250
FIRST CUSTOMER SHIPMENT	1Q88	4Q79	11/83	11/84	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	\$3,450	--	--
COMMENTS	*1,7 RLL Code			*2,7 RLL Code	25 mm high *1,7 RLL Code Embedded Servo

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2614S	F6421	M2249E	M2249S/SA/SB	M2261E
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	10.5" OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	4.0" ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	Fujitsu	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY		1.607 or 1.144 MB Fixed Head Option			
Total capacity (Mbytes) FIXED	F: 180.31	F: 446/317.5	U: 389	F: 303.1	U: 415.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 26,793/ 19,069	U: 20,864	F: 16,640	U: 31,296
Data surfaces per spindle	8	10	15	15	8
Heads per data surface	1	2	1	1	1
Tracks per surface	1334	1680	1243	1243	1658
Track density (TPI)	1681	880	1267	1267	1712
Maximum linear density (BPI)	29571*	12790	19295*	19295*	28816*
Rotational speed (RPM)	3490	3961	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	18	18	18	16
Average rotational delay (msec)	8.6	7.5	8.3	8.3	8.3
Average access time (msec)	28.6	25.5	26.3	26.3	24.3
Data transfer rate (KBytes/sec)	1250	1859	1250	1500	1875
FIRST CUSTOMER SHIPMENT	4Q88	3Q81	3Q87	1Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	\$2,995	--	--
COMMENTS	25 mm high *1,7 RLL Code Embedded Servo	Drive has 4 spindles	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2261S	M2262S	M2294K/N	M2333K/KS/P	M2343K/KS
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	14"	210 mm OD	210 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	SMD	Mod. SMD, IPI-2	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 358.4	F: 492.7	U: 335.5	U: 337.1	U: 383.38
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	F: 27,136	U: 20,480	U: 40,960	U: 40,960
Data surfaces per spindle	8	11	8	10	7.5
Heads per data surface	1	1	2	1	2/1
Tracks per surface	1658	1658	2048	823	1248
Track density (TPI)	1712	1712	858	683	846
Maximum linear density (BPI)	28816*	28816*	6500	19734*	20767*
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)	16	16	27	20	16
Average rotational delay (msec)	8.3	8.3	10.12	8.3	8.3
Average access time (msec)	24.3	24.3	37.12	28.3	24.3
Data transfer rate (KBytes/sec)	1875	1875	1012	2458	2458
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	5/83	11/84	2/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$4,425	--
COMMENTS	*1,7 RLL Code	*1,7 RLL Code		*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2350A	M2351A	M2371K/KS	F6425G	F6425K4/L4
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD	10.5" OD	210 mm OD	10.5" OD	10.5" OD
Recording medium	4.0" ID Oxide Coated	4.0" ID Oxide Coated	100 mm ID Oxide Coated	4.0" ID Oxide Coated	4.0" ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	*	Ferrite
Interface	Modified SMD	Modified SMD	Modified SMD	Fujitsu	Fujitsu
CAPACITY/RECORDING DENSITY		1.69 MB Fixed Head Option			
Total capacity (Mbytes) FIXED	U: 474.2	U: 474.2	U: 457.7	F: 630.0	F: 630
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 28,160	U: 28,160	U: 40,960	F: 47,476	F: 47,476
Data surfaces per spindle	10	10	7.5	*	8
Heads per data surface	2	2	2/1	*	2
Tracks per surface	1684	1684	1490	*	1770
Track density (TPI)	880	880	1193	*	905
Maximum linear density (BPI)	12790	12790	20766*	*	24420*
Rotational speed (RPM)	3961	3961	3600	3620	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	16	12	15
Average rotational delay (msec)	7.5	7.5	8.3	8.3	8.3
Average access time (msec)	25.5	25.5	24.3	20.3	23.3
Data transfer rate (KBytes/sec)	1859/7436/9295	1859	2458	3000	3000
FIRST CUSTOMER SHIPMENT	2/84	3/82	9/87	12/88	3Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Parallel data transfer, 4 or 5 channels		*2,7 RLL Code	RLL Code Drive has 4 spindles *Not announced	*2,7 RLL Code Drive has 4 spindles

1988 DISK/TREND REPORT

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2262E	M2263E	M2263S	M2298K/N	M2344K/KS
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	SCSI	Modified SMD	Mod. SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 570.8	U: 778.3	F: 671.9	U: 671	U: 690.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,296	U: 31,296	F: 27,136	U: 40,960	U: 40,960
Data surfaces per spindle	11	15	15	8	13.5
Heads per data surface	1	1	1	2	2/1
Tracks per surface	1658	1658	1658	2048	1248
Track density (TPI)	1712	1712	1712	858	846
Maximum linear density (BPI)	28816*	28816*	28816*	13000 BPI* 8667 FCI	20767*
Rotational speed (RPM)	3600	3600	3600	2722	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	16	16	27	16
Average rotational delay (msec)	8.3	8.3	8.3	11	8.3
Average access time (msec)	24.3	24.3	24.3	38	24.3
Data transfer rate (KBytes/sec)	1875	1875	1875	1859	2458
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	4Q88	10/84	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	\$3,170	--	--	\$8,400
COMMENTS	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2360A	M2361A	M2372K/KS	M2381K/P	F6425H
DISK/TREND GROUP	8	8	8	8	9
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	10.5" OD 4.0" ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Sputtered
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	*
Interface	Modified SMD	Modified SMD	Modified SMD	Mod. SMD, IPI-2	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 689.8	U: 689.8	U: 823.9	U: 555.7	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 40,960	U: 49,728	F: 47,476
Data surfaces per spindle	10	10	13.5	7.5	*
Heads per data surface	2	2	2/1	2/1	2
Tracks per surface	1684	1684	1490	1490	*
Track density (TPI)	880	880	1193	1193	*
Maximum linear density (BPI)	18620*	18620*	20766*	25211*	*
Rotational speed (RPM)	3673	3600	3600	3620	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	16	16	16
Average rotational delay (msec)	8.17	8.3	8.3	8.3	8.3
Average access time (msec)	26.17	26.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	2507 - 12537	2458	2458	3000	3000
FIRST CUSTOMER SHIPMENT	3Q86	2Q85	9/87	1Q88	12/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Parallel Data Transfer, 4 or 5 channels	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code	RLL Code Drive has 4 spindles *Not announced

MANUFACTURER	FUJITSU	FUJITSU	GOLDSTAR TELE- COMMUNICATION	GOLDSTAR TELE- COMMUNICATION	HEWLETT- PACKARD
DRIVE	F6425M4/N4	M2382K/P	GSH-520	GSH-540	7907A
DISK/TREND GROUP	9	9	3	4	1
MARKET	Captive	OEM	OEM, Captive	OEM, Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	8" Cartridge
Nominal disk diameter	10.5" OD 4.0" ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Sputtered	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Fujitsu	Mod. SMD, IPI-2	SASI, SCSI	SASI, SCSI	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	U: 1,000.2	F: 20.7	F: 41.5	F: 20.5
REMOVABLE	--	--	--	--	F: 20.5
Capacity per track (Bytes)	F: 47,476	U: 49,728	F: 10,752	F: 10,752	F: 16,384
Data surfaces per spindle	12	13.5	2	4	4
Heads per data surface	2	2/1	1	1	1
Tracks per surface	2360	1490	966	966	644
Track density (TPI)	1160	1193	800	800	550
Maximum linear density (BPI)	24989*	25211*	13160	13160	10986 BPI* 7324 FCI
Rotational speed (RPM)	3620	3620	3600	3600	3523
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor	Linear, Voice Coil
Average positioning time (msec)	17	16	60 (including settling)	60 (including settling)	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.45
Average access time (msec)	25.3	24.3	68.3	68.3	38.45
Data transfer rate (KBytes/sec)	3000	3000	625	625	1229
FIRST CUSTOMER SHIPMENT	3Q86	1Q88	1988	1988	7/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Drive has 4 spindles	*1,7 RLL Code	41 mm high	41 mm high	*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	7957B	7957S	7958A
DISK/TREND GROUP	3	5	5	6	6
MARKET	Captive, OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	HP	HPIB	SCSI	SCSI	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20	F: 81.7	F: 81	F: 107	F: 130.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 7,168	F: 16,128	F: 16,128	F: 17,152	F: 16,128
Data surfaces per spindle	2	5	4	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1400	1013	1269	1572	1013
Track density (TPI)	1850	1000	1590	1590	1000
Maximum linear density (BPI)	12700	19794*	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	19794*
Rotational speed (RPM)	3000	3600	3350	3350	3600
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	17	17	29
Average rotational delay (msec)	10	8.3	8.95	8.95	8.3
Average access time (msec)	85	37.3	25.95	25.95	37.3
Data transfer rate (KBytes/sec)	500	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	12/85	4Q86	3Q88	2Q88	4Q86
U.S. OEM PRICE FOR 100 UNITS	\$950	--	--	--	--
COMMENTS	51 mm high Embedded Servo	*2,7 RLL Code Disk drive mfg. by Micropolis	*2,7 RLL Code HP 3000, 9000, 1000, 260	*2,7 RLL Code HP 9000	*2,7 RLL Code Disk drive mfg. by Micropolis

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	7958B 7962B	7958S	97532E	97532S	97533E
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 152	F: 161	U: 129.68	F: 101.71	U: 194.52
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,128	F: 17,152	U: 20,480	F: 16,384	U: 20,480
Data surfaces per spindle	6	6	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1552	1572	1583	1552	1583
Track density (TPI)	1590	1590	1590	1590	1590
Maximum linear density (BPI)	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI
Rotational speed (RPM)	3350	3350	3350	3350	3350
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	17	17	17	17	17
Average rotational delay (msec)	8.95	8.95	8.95	8.95	8.95
Average access time (msec)	25.95	25.95	25.95	25.95	25.95
Data transfer rate (KBytes/sec)	1250	1250	1250	**	1250
FIRST CUSTOMER SHIPMENT	4Q88	2Q88	3Q87	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	\$1,090	\$1,190	\$1,140
COMMENTS	*2,7 RLL Code HP 3000, 9000, 1000, 260	*2,7 RLL Code HP 9000	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo **Transfer rate max: S- 2000 KB/sec	*2,7 RLL Code Embedded Servo

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97533S	7936FL 7936H 7936XP	7959B 7963B	7959S	97536D 97536S 97536T
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Thin Film	Thin Film	Thin Film
Interface	SCSI	HPIB	HP	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 152.57	F: 307.6	F: 304	F: 323	F: 305.14
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 31,488	F: 16,128	F: 17,152	F: 16,384
Data surfaces per spindle	6	7	12	12	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1552	1396	1572	1572	1552
Track density (TPI)	1590	1121	1590	1590	1590
Maximum linear density (BPI)	20500 BPI* 13666 FCI	18800 BPI* 14101 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI
Rotational speed (RPM)	3350	3600	3350	3350	3350
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	17	20.5	17	17	17
Average rotational delay (msec)	8.95	8.3	8.95	8.95	8.95
Average access time (msec)	25.95	28.8	25.95	25.95	25.95
Data transfer rate (KBytes/sec)	**	2351	1250	1250	**
FIRST CUSTOMER SHIPMENT	3Q87	4Q86	2Q88	2Q88	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$1,250	--	--	--	\$1,680(S Model)
COMMENTS	*2,7 RLL Code Embedded Servo **Transfer rate max: S- 2000 KB/sec	*Variable Length Frequency Modulation Embedded Servo	*2,7 RLL Code HP 9000, 3000 1000	*2,7 RLL Code HP 9000	*2,7 RLL Code Embedded Servo **Transfer rate max: S- 2000 KB/sec. D- 4000 KB/sec.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI
DRIVE	97536E	7937FL 7937H 7937XP	7937S	DK302-2	DK505-2
DISK/TREND GROUP	7	8	8	3	3
MARKET	OEM	Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	HPIB	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 389.04	F: 571.4	F: 571.4	U: 25.5	U: 25.62
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	F: 31,488	F: 31,488	U: 10,416	U: 10,416
Data surfaces per spindle	12	13	13	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1583	1396	1396	615	615
Track density (TPI)	1590	1121	1121	822	650
Maximum linear density (BPI)	20500 BPI* 13666 FCI	18800 BPI* 14101 FCI	18800 BPI* 14101 FCI	13700	9490
Rotational speed (RPM)	3350	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)	17	20.5	20.5	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.95	8.3	8.3	8.45	8.45
Average access time (msec)	25.95	28.8	28.8	93.45	93.45
Data transfer rate (KBytes/sec)	1250	2351	2351	625	625
FIRST CUSTOMER SHIPMENT	3Q87	4Q86	4Q86	9/86	3/85
U.S. OEM PRICE FOR 100 UNITS	\$1,580	--	\$8,240	--	--
COMMENTS	*2,7 RLL Code Embedded Servo	*Variable Length Frequency Modulation Embedded Servo	*Variable Length Frequency Modulation Embedded Servo	41 mm high	41 mm high Mfg. by Tokico

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
	DK302-3	DK511-3	DK511-5	DK521-5	DK812S-5
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	130 mm OD	130 mm OD	130 mm OD	210 mm OD
Recording medium	25 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST506, 412	ST412, SCSI	ST412, SCSI	ST412	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.2	U: 36.4	U: 51.0	U: 51.4	U: 51
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 20,672
Data surfaces per spindle	6	5	7	6	3
Heads per data surface	1	1	1	1	1
Tracks per surface	615	699	699	823	823
Track density (TPI)	822	784	784	960	760
Maximum linear density (BPI)	13700	9340	9340	9300	9650 BPI* 6433 FCI
Rotational speed (RPM)	3550	3600	3600	3600	3510
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	85	30	30	25	25
Average rotational delay (msec)	8.45	8.3	8.3	8.3	8.5
Average access time (msec)	93.45	38.3	38.3	33.3	33.5
Data transfer rate (KBytes/sec)	625	625	625	625	1209
FIRST CUSTOMER SHIPMENT	9/86	1Q84	1Q84	12/86	7/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high			41 mm high	*2,7 RLL Code

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
	DK511-8	DK512-8	DK512C-8	DK812S-8	DK512-12
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	210 mm OD	130 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412, SCSI	ESDI, SMD	SCSI	SMD	ESDI, SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.7	U: 86.1	F: 73.3	U: 85	U: 120.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,944	F: 17,920	U: 20,672	U: 20,944
Data surfaces per spindle	10	5	5	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	819	823	823
Track density (TPI)	925	925	925	760	925
Maximum linear density (BPI)	9250	18500 BPI* 12333 FCI	18500 BPI* 12333 FCI	9650 BPI* 6433 FCI	18500 BPI* 12333 FCI
Rotational speed (RPM)	3600	3482	3482	3510	3482
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	23
Average rotational delay (msec)	8.3	8.6	8.6	8.5	8.6
Average access time (msec)	31.3	31.6	31.6	33.5	31.6
Data transfer rate (KBytes/sec)	625	1209	1500 Max.	1209	1209
FIRST CUSTOMER SHIPMENT	2Q84	3/85	1/87	7/83	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	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK512-17	DK512C-12	DK512C-17	DK512S-17	DK522-10
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	SCSI	SMD	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 172.3	F: 102.3	F: 146.7	U: 172.3	U: 103.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,944	F: 17,920	F: 17,920	U: 20,944	U: 20,944
Data surfaces per spindle	10	7	10	10	6
Heads per data surface	1	1	1	1	1
Tracks per surface	823	819	819	823	823
Track density (TPI)	925	925	925	925	960
Maximum linear density (BPI)	18500 BPI* 12333 FCI	18500 BPI* 12333 FCI	18500 BPI* 12333 FCI	18500 BPI* 12333 FCI	18500 BPI* 12333 FCI
Rotational speed (RPM)	3482	3482	3482	3482	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	25
Average rotational delay (msec)	8.6	8.6	8.6	8.6	8.3
Average access time (msec)	31.6	31.6	31.6	31.6	33.3
Data transfer rate (KBytes/sec)	1209	1500 Max.	1500 Max.	1215	1250
FIRST CUSTOMER SHIPMENT	3/85	1/87	1/87	3/85	12/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	41 mm high *2,7 RLL Code

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
	DK522C-10	DK812S-12	DK812S-17	DK814S-17	DK814S-24
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	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: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SMD	SMD	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 87.5	U: 119	U: 170.1	U: 170	U: 238
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	U: 20,672	U: 20,672	U: 32,768	U: 32,768
Data surfaces per spindle	6	7	10	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	819	823	823	823	823
Track density (TPI)	960	760	760	800	800
Maximum linear density (BPI)	18500 BPI* 12333 FCI	9650 BPI* 6433 FCI	9650 BPI* 6433 FCI	18500 BPI* 12333 FCI	18500 BPI* 12333 FCI
Rotational speed (RPM)	3600	3510	3510	2632	2632
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	20	20
Average rotational delay (msec)	8.3	8.5	8.5	11.4	11.4
Average access time (msec)	33.3	33.5	33.5	31.4	31.4
Data transfer rate (KBytes/sec)	1500 Max.	1209	1209	1815	1815
FIRST CUSTOMER SHIPMENT	1/87	6/83	6/83	12/84	12/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
	DK514-38	DK514C-38	DK514S-38	DK814S-34	DKU-80
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	Modified SMD	Modified SMD	IBM, SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 382.3	F: 321.8	U: 382.3	U: 340	U: 427.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	F: 25,600	U: 30,240	U: 32,768	U: 26,880
Data surfaces per spindle	14	14	14	10	13
Heads per data surface	1	1	1	1	2
Tracks per surface	903	898	903	823	1224
Track density (TPI)	1033	1033	1033	800	*
Maximum linear density (BPI)	26000 BPI* 17333 FCI	26000 BPI* 17333 FCI	26000 BPI* 17333 FCI	18500 BPI* 12333 FCI	*
Rotational speed (RPM)	3600	3600	3600	2632	3000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	16	16	20	18
Average rotational delay (msec)	8.3	8.3	8.3	11.4	10
Average access time (msec)	24.3	24.3	24.3	31.4	28
Data transfer rate (KBytes/sec)	1815	1500 max.	1815	1815	1344
FIRST CUSTOMER SHIPMENT	3Q87	1Q88	3Q87	12/84	11/83
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	*Not announced

1988 DISK/TREND REPORT

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK711S-60D DK711S-60S	DK815-5	DKU-85I-D14 DKU-85I-D24	DKU-971	DKU-97S
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM, Captive	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	224 mm OD 100 mm ID	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	IBM	IBM	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 600	U: 525.38	F: 630	F: 635	U: 697.059
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 30,240	F: 47,476	F: 19,069	U: 20,672
Data surfaces per spindle	22	14	*	20	20
Heads per data surface	1	1	2	2	2
Tracks per surface	903	1241	*	1666	1682
Track density (TPI)	1033	860	*	720	720
Maximum linear density (BPI)	26000 BPI* 17333 FCI	14585 BPI* 9723 FCI	*	6425	6425
Rotational speed (RPM)	4876	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)	12	18	15	20/18	20
Average rotational delay (msec)	6.15	8.3	8.3	8.3	8.3
Average access time (msec)	18.15	26.3	23.3	28.3/26.3	28.3
Data transfer rate (KBytes/sec)	2458	1815	3000	1198	1240
FIRST CUSTOMER SHIPMENT	4Q87	11/84	4/86	1/81	9/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Oversized packaging	*2,7 RLL Code	Drive has 4 spindles *Not announced	Drive has 2 spindles	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	H-6555	H-8576-12 H-8576-22	DKU-86I-K14 DKU-86I-K24 H-6586-K14 H-6586-K24	DK815-10	DKU-85I-E14 DKU-85I-E24 H-6585-14 H-6585-24
DISK/TREND GROUP	8	8	9	9	9
MARKET	Captive	Captive	PCM, Captive	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	224 mm OD 100 mm ID	14"	9.5"	224 mm OD 100 mm ID	14"
Recording medium	High Dens Oxide	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Ferrite
Interface	Hitachi	IBM	IBM	Mod SMD, IPI-II	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 500	F: 635	F: 1,890	U: 1,067	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 28,884	F: 19,069	F: 47,476	U: 40,960	F: 47,476
Data surfaces per spindle	14	20	15	15	*
Heads per data surface	1	2	2	1	2
Tracks per surface	1237	1666	2655	1737	*
Track density (TPI)	860	720	*	1160	*
Maximum linear density (BPI)	14585 BPI* 9723 FCI	6425	*	20000*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Dual, Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	20	12.5	15	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	28.3	20.8	23.3	25.3
Data transfer rate (KBytes/sec)	1815	1198	3000	2460	3000
FIRST CUSTOMER SHIPMENT	1Q85	4Q80	3Q88	1Q87	12/85
U.S. OEM PRICE FOR 100 UNITS	--	--		--	--
COMMENTS	*2,7 RLL Code Drive has 1 to 4 spindles	Drive has 2 spindles	Drive has 8 spindles *Not announced	*1,7 RLL Code	Drive has 4 spindles *Not announced

1988 DISK/TREND REPORT

MANUFACTURER	HITACHI	IBIS	IBIS	IBIS	IBM
DRIVE	DKU-98I H-8598-12 H-8598-22	1012	1400	2812	5525-021 5525-031
DISK/TREND GROUP	9	9	9	9	3
MARKET	Captive, OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	14"	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Ferrite
Interface	IBM	Custom, Mod.SMD	Custom, ISI, VME	Custom, ISI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	U: 1,010	U: 1,409.0	U: 2,830.0	F: 29.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	U: 199,680	U: 49,728	U: 99,840	F: 16,384
Data surfaces per spindle	20	5	16	16	5
Heads per data surface	2	2	2	2	1
Tracks per surface	1328 (Physical)	1012	1776	1776	359
Track density (TPI)	600	818	769	769	450
Maximum linear density (BPI)	15240 BPI* 10160 FCI	32000	15294	32000	8530
Rotational speed (RPM)	3600	3600	3600	3600	3125
PERFORMANCE					
Actuator type	Dual, Rotary, Voice Coil	Linear, Voice Coil	Dual, Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	18	16	16	27
Average rotational delay (msec)	8.3	8.3	8.3	8.3	9.6
Average access time (msec)	24.3	26.3	24.3	24.3	36.6
Data transfer rate (KBytes/sec)	3000	12000	12000	12000	1031
FIRST CUSTOMER SHIPMENT	4Q82	4/88	4Q83	4Q87	2/80
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Drive has 2 spindles 2 actuators per spindle	2 track parallel data transfer	Drive has 1 spindle with 2 actuators Up to 4 track parallel data transfer	Drive has 1 spindle with 2 actuators 2 track parallel data transfer	5520 Admin. System

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8525-001,004 8525-G01,G04 8525-L01,L04	8530-021	8550-021	WD-325	WDI-325
DISK/TREND GROUP	3	3	3	3	3
MARKET	Captive	Captive	Captive	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface		ST412	IBM	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20	F: 20.8	F: 20.8	U: 25.5	F: 21.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	F: 8,704	F: 8,704	U: 10,416	F: 8,704
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	610	598	598	612	612
Track density (TPI)	850	850	850	850	841
Maximum linear density (BPI)	13400	13400	13400	13400	13160
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Average positioning time (msec)	80 (including settling)	80 (including settling)	80 (including settling)	80 (including settling)	80 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	88.3	88.3	88.3	88.3	88.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	4Q88	4/87	4/87	5/86	6/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PS/2 Model 25 Optional drive with 38 ms avg. positioning time made by Seagate	41 mm high PS/2 Model 30	41 mm high PS/2 Model 50	41 mm high	41 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4956-G10(40 MB) 4956-H10(40 MB)	5170-319 5170-339 5170-839 5170-849	5363-P10	5364-001	6150-4735
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ESDI	IBM, ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 40	F: 31.9	F: 67.56	F: 41.92	F: 44.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	F: 8,704	F: 16,640	F: 8,192	F: 8,704
Data surfaces per spindle	7	5	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	733	733	580	733	733
Track density (TPI)	815	815	648	815	815
Maximum linear density (BPI)	9398	9398	18942*	9398	9398
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)	40	40	30	40	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	48.3	38.3	48.3	48.3
Data transfer rate (KBytes/sec)	625	625	1250	625	625
FIRST CUSTOMER SHIPMENT	9/86	10/85	10/87	6/85	3/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Series/1	System unit for PC AT	System unit for System/36 PC *2,7 RLL Code	System unit for System/36 PC	RT PC

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8550-031 5551-S09 5551-T09	8550-061 8570-E61 5551-T0A	8560-041 8580-041	4956-G10(72 MB) 4956-H10(72 MB) 4956-J00(72 MB)	4963-58A
DISK/TREND GROUP	4	4	4	5	5
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Microchannel	Microchannel	ST412	ESDI	IBM
CAPACITY/RECORDING DENSITY					0.131 MB Fixed Heads
Total capacity (Mbytes) FIXED	F: 31.3	F: 60.8	F: 44.6	F: 72	F: 58.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,800	F: 13,312	F: 8,704	F: 17,664	F: 16,384
Data surfaces per spindle	4	6	7	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	612	762	733	582	359
Track density (TPI)	841	1169	815	648	450
Maximum linear density (BPI)	19740	21700*	9398	18942*	8530
Rotational speed (RPM)	3600	3600	3600	3600	3125
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	39	27	40	30	27
Average rotational delay (msec)	8.3	8.3	8.3	8.3	9.6
Average access time (msec)	47.3	35.3	48.3	38.3	36.6
Data transfer rate (KBytes/sec)	937.5	1050	625	1250	1031
FIRST CUSTOMER SHIPMENT	5/88	5/88	2Q87	2/88	2/79
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PS/2 Model 50	PS/2 Model 50 and Model 70 *2,7 RLL Code	PS/2 Model 60 and Model 80	Series/1 *2,7 RLL Code	Series/1

1988 DISK/TREND REPORT

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4963-64A 4963-64B	4965-E00	5363-P20 5363-P22	5364-003 5364-004 5364-023 5364-024	5381- All Models
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	210 mm OD 100 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: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	ESDI	ESDI	ESDI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 64.5	F: 72	F: 106.2	F: 65.9	F: 64.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 17,664	F: 16,640	F: 16,640	F: 16,384
Data surfaces per spindle	11	7	7	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	359	582	912	580	359
Track density (TPI)	450	648	1000	648	450
Maximum linear density (BPI)	8530	18942*	19159*	18942*	8530
Rotational speed (RPM)	3125	3600	3600	3600	3125
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	30	31	30	27
Average rotational delay (msec)	9.6	8.3	8.3	8.3	9.6
Average access time (msec)	36.6	38.3	39.3	38.3	36.6
Data transfer rate (KBytes/sec)	1031	1250	1250	1250	1031
FIRST CUSTOMER SHIPMENT	2/79	2/88	10/87	2/87	8/79
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Series/1	Storage expansion unit for Series/1 *2,7 RLL Code	System unit for System/36 PC *2,7 RLL Code	System unit for System/36 PC *2,7 RLL Code	System/38 5381 Processor available with up to 6 disk spindles

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5525-032 5525-051	6150-115 6150-125 6150-B25 6151-115 6151-125 6151-B25	667-85	8101-A23	8130-A23 8130-B23 8140-A33 8140-A43, A53 8140-A63, A73
DISK/TREND GROUP	5	5	5	5	5
MARKET	Captive	Captive	OEM	Captive	Captive
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	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: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	ESDI	ESDI	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 64.5	F: 73.0	U: 85.0	F: 64.5	F: 64.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 17,920	U: 20,833	F: 16,384	F: 16,384
Data surfaces per spindle	11	7	7	11	11
Heads per data surface	1	1	1	1	1
Tracks per surface	359	582	582	359	359
Track density (TPI)	450	648	648	450	450
Maximum linear density (BPI)	8530	18942*	18942*	8530	8530
Rotational speed (RPM)	3125	3600	3600	3125	3125
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	30	30	27	27
Average rotational delay (msec)	9.6	8.3	8.3	9.6	9.6
Average access time (msec)	36.6	38.3	38.3	36.6	36.6
Data transfer rate (KBytes/sec)	1031	1250	1250	1031	1031
FIRST CUSTOMER SHIPMENT	11/80	9/86	9/86	8/79	3Q79
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	5520 Admin. System -051 model is dual spindle	RT PC *2,7 RLL code	*2,7 RLL Code	8100 System -A25 model is 2 spindles	8100 System

1988 DISK/TREND REPORT

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8560-071 8580-071 5571-TOA	669	671-284	678-200	4967-2CA 4967-2CB
DISK/TREND GROUP	5	6	6	6	6
MARKET	Captive	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	210 mm OD 100 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI, SCSI	IPI-3, SCSI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 70	U: 133	U: 284	U: 238.3 F: 200.3	F: 200.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 20,833	U: 21,080	U: 44,252 F: 37,376*	F: 25,088
Data surfaces per spindle	7	7	11	4	7
Heads per data surface	1	1	1	1	2
Tracks per surface	583	915	1225	1346	1140
Track density (TPI)	648	1000	1168	1096	485
Maximum linear density (BPI)	18942*	19159*	21384*	23110**	9751
Rotational speed (RPM)	3600	3600	3283	3119	2964
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	30	28	23	19.5	25
Average rotational delay (msec)	8.3	8.3	9.14	9.62	10.1
Average access time (msec)	38.3	36.3	32.14	29.12	35.1
Data transfer rate (KBytes/sec)	1250	1250	1250	2500	1500
FIRST CUSTOMER SHIPMENT	2Q87	4Q87	1Q88	6/86	7/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PS/2 Model 60 and Model 80 *2, 7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*Outer 893 Tr. **1,7 RLL Code Embedded Servo	Series/1 384 KB Cache

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5360-BXX	6150-13X 6150-B35 6150-4100 Opt. 6151-13X 6151-B35 6151-4100 Opt.	6156-001 6156-003	8102-A15	8570-121 8570-A21 5551-T0B
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	ESDI	ESDI	IBM	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 200.2	F: 114	F: 114	F: 129.7	F: 120.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	F: 17,920	F: 17,920	F: 16,384	F: 16,384
Data surfaces per spindle	7	7	7	11	8
Heads per data surface	2	1	1	1	1
Tracks per surface	1140	915	915	720	920
Track density (TPI)	485	1000	1000	850	1302
Maximum linear density (BPI)	9751	19159*	19159*	8770	26700*
Rotational speed (RPM)	2964	3600	3600	3125	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	28	28	27	23
Average rotational delay (msec)	10.1	8.3	8.3	9.6	8.3
Average access time (msec)	35.1	36.3	36.3	36.6	31.3
Data transfer rate (KBytes/sec)	1500	1250	1250	1031	1275
FIRST CUSTOMER SHIPMENT	7/83	4Q87	6/88	4/84	5/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	System/36 5360-BX4 uses 2 spindles, with total 400.4 MB	RT PC *2,7 RLL Code	Removable disk drive for RT PC 003 holds up to 3 disk modules. *2,7 RLL Code. 310 MB drive is optional	8100 System -A17 model is 2 spindles	PS/2 Model 70 *2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8580-111 5571-TOB	9332-240 9332-250	9332-A11	4967-3CA 4967-3CB	5360-BXA 5360-BXB 5360-C2X
DISK/TREND GROUP	6	6	6	7	7
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	IPI-3	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 115	F: 200.3	F: 200.3	F: 358	F: 359.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 37,376	F: 37,376	F: 25,088	F: 25,088
Data surfaces per spindle	7	4	4	7	7
Heads per data surface	1	1	1	1	2
Tracks per surface	915	1346	1346	2048	2048
Track density (TPI)	1000	1096	1096	869	869
Maximum linear density (BPI)	19159*	23100*	23100*	9751	9751
Rotational speed (RPM)	3600	3119	3119	2964	2964
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	28	19.5	19.5	25	25
Average rotational delay (msec)	8.3	9.62	9.62	10.1	10.1
Average access time (msec)	36.3	29.12	29.12	35.1	35.1
Data transfer rate (KBytes/sec)	1250	2500	2500	1500	1500
FIRST CUSTOMER SHIPMENT	4Q87	2Q87	8/86	9/86	2/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	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	Series/1	System/36 System uses multiple spindles

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	6150-4300 Opt. 6150-5300 Opt. 6151-4300 Opt. 6151-5300 Opt.	671-387	678-400	8580-311	9332-402
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	210 mm OD	130 mm OD	210 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	100 mm ID Oxide Coated	40 mm ID Thin Film	100 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI, SCSI	IPI-3, SCSI	ESDI	IPI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 310	U: 387	U: 476.5 F: 400.6	F: 314	F: 400.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	U: 21,080	U: 44,252 F: 37,376*	F: 17,408	F: 37,376
Data surfaces per spindle	15	15	8	15	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1225	1346	1225	1346
Track density (TPI)	1168	1168	1096	1168	1096
Maximum linear density (BPI)	21384*	21384*	23100**	21384*	23100*
Rotational speed (RPM)	3283	3283	3119	3283	3119
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	23	23	19.5	23	19.5
Average rotational delay (msec)	9.14	9.14	9.62	9.14	9.62
Average access time (msec)	32.14	32.14	29.12	32.14	29.12
Data transfer rate (KBytes/sec)	1250	1250	2500	1250	2500
FIRST CUSTOMER SHIPMENT	7/88	1Q88	6/86	1Q88	7/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	RT PC *2,7 RLL Code	*2,7 RLL Code	*Outer 893 Tr. **1,7 RLL Code Embedded Servo	PS/2 Model 80 *2,7 RLL Code	368 MB capacity when used with 9370 series *1,7 RLL Code Embedded Servo

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9332-440 9332-450	9332-A12	9404-B10 9404-B20	3370-A02	9332-600 9332-602
DISK/TREND GROUP	7	7	7	8	8
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	14"	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	SCSI	IPI-3	SCSI	IBM	IPI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 400.6	F: 400.6	F: 315.592	F: 729.8	F: 600
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 37,376	F: 37,376	F: 17,408	F: 31,744	F: 37,376
Data surfaces per spindle	8	8	15	12	8
Heads per data surface	1	1	1	2	1
Tracks per surface	1346	1346	1223	1916	2019
Track density (TPI)	1096	1096	1168	800	1644
Maximum linear density (BPI)	23100*	23100*	21384*	12134 BPI* 8128 FCI	23100*
Rotational speed (RPM)	3119	3119	3283	2964	3119
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	19.5	19.5	21.5	19	19.5
Average rotational delay (msec)	9.62	9.62	9.14	10.1	9.62
Average access time (msec)	29.12	29.12	30.64	29.1	29.12
Data transfer rate (KBytes/sec)	2500	2500	1250	1859	2500
FIRST CUSTOMER SHIPMENT	2Q87	8/86	3Q88	2Q84	9/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	RT PC *1,7 RLL Code Embedded Servo	System/36 System/38 *1,7 RLL Code Embedded Servo	AS/400 *2,7 RLL Code 2 or 3 drives per system	4341 4361 4381 *2,7 RLL Code	568 MB capacity when used with 9370 series *1,7 RLL Code Embedded Servo

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	685-B01	3380-AD4 3380-BD4	3380-AE4 3380-BE4	3380-AJ4 3380-BJ4 3380-CJ2	3380-AK4 3380-BK4
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	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: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,043.1 F: 855.9	F: 1,260.4	F: 2,520.9	F: 1,260.4	F: 3,781.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 44,280 F: 36,352	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	6	15	15	15	15
Heads per data surface	2	2	2	2	2
Tracks per surface	3926	1770	3540	1770	5310
Track density (TPI)	1600	*	1386	*	*
Maximum linear density (BPI)	16200*	*	16200	*	*
Rotational speed (RPM)	3623	3620	3620	3620	3620
PERFORMANCE					
Actuator type	Dual, Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	18	15	17	12	16
Average rotational delay (msec)	8.28	8.3	8.3	8.3	8.3
Average access time (msec)	26.28	23.3	25.3	24.3	24.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	6/86	2/85	7/85	10/87 (A,B)	10/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	685-A01 has IPI-3 interface *2,7 RLL Code	*Not announced Drive has 2 spindles	Drive has 2 spindles	*Not announced AJ4 & BJ4 have 2 spindles	*Not announced Drive has 2 spindles

MANUFACTURER	IBM	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	9335-B01	9710 RSD	9762 SMD	9766 SMD	94155-48 Wren II
DISK/TREND GROUP	9	2	2	2	4
MARKET	Captive	OEM	OEM, Captive	OEM, Captive	OEM
MEDIA: Generic type	Fixed	Removable Storage Drive	Storage Module Drive	3336-11	Fixed
Nominal disk diameter	14"	230 mm OD 100 mm ID	14"	14"	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	SMD	SMD	SMD	ST412, ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 855.9	--	--	--	U: 48.1
REMOVABLE	--	U: 82.9	U: 82.9	U: 315.2	--
Capacity per track (Bytes)	F: 36,352	U: 20,160	U: 20,160	U: 20,160	U: 10,416
Data surfaces per spindle	6	5	5	19	5
Heads per data surface	2	1	1	1	1
Tracks per surface	3924	823	823	823	925
Track density (TPI)	1600	550	384	384	960
Maximum linear density (BPI)	16200*	10000 BPI* 6666 FCI	6038	6038	9540
Rotational speed (RPM)	3623	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Dual, Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	30	30	30	30
Average rotational delay (msec)	8.28	8.3	8.3	8.3	8.3
Average access time (msec)	26.28	38.3	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	3000	1209	1209	1209	625
FIRST CUSTOMER SHIPMENT	8/86	1Q83	3/75	3/76	2Q84
U.S. OEM PRICE FOR 100 UNITS	--	\$4,915	\$6,715	\$12,355	\$735 (250)
COMMENTS	System/38 9335-A01 has IPI-3 interface *2,7 RLL Code Embedded Servo	*2,7 RLL Code			

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	94205-51 Wren II HH	94155-67 Wren II	94155-85 Wren II	94155-86 Wren II	94155-96 Wren II
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.5	U: 67.4	U: 85.3	U: 86.7	U: 96
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	9
Heads per data surface	1	1	1	1	1
Tracks per surface	989	925	1024	925	1024
Track density (TPI)	960	960	980	960	960
Maximum linear density (BPI)	9400	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)	28	30	28	30	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	38.3	36.3	38.3	36.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	1Q86	2Q84	1986	2Q84	1986
U.S. OEM PRICE FOR 100 UNITS	\$540 (250)	\$805 (250)	\$815 (250)	\$815 (250)	\$835 (250)
COMMENTS	41 mm high				

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	94156-67 Wren II	94156-86 Wren II	94204-65 Wren II HH	94204-71 Wren II HH	94205-77 Wren II HH
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	PC AT	PC AT	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 67.4	U: 86.7	F: 65	F: 71	U: 77*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 13,824	F: 13,824	U: 15,624*
Data surfaces per spindle	7	9	5	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	925	925	941	1032	989
Track density (TPI)	960	960	960	960	960
Maximum linear density (BPI)	9540	9540	14300 BPI* 9533 FCI	14300 BPI* 9533 FCI	14100 BPI* 9400 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	30	28	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	36.3	36.3	36.3
Data transfer rate (KBytes/sec)	625	625	937.5	937.5	937.5*
FIRST CUSTOMER SHIPMENT	2Q84	2Q84	7/88	7/88	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$1,455	\$1,640	\$865 (250)	\$895 (250)	\$580 (250)
COMMENTS			41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *With RLL controller

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	94211 Wren III HH	94155-135 Wren II	94166-101 Wren III	94166-141 Wren III	94166-182 Wren III
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	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	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ESDI, SCSI	ESDI, SCSI	ESDI, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 91	U: 135*	U: 101	U: 141	U: 182
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 15,624*	U: 20,880	U: 20,880	U: 20,880
Data surfaces per spindle	5	9	5	7	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	960	969	969	969
Track density (TPI)	960	960	960	960	960
Maximum linear density (BPI)	19058 BPI* 12705 FCI	14100 BPI* 9400 FCI	19058 BPI* 12705 FCI	19058 BPI* 12705 FCI	19058 BPI* 12705 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	28	16.4	16.4	16.4
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	36.3	24.7	24.7	24.7
Data transfer rate (KBytes/sec)	1250	937.5*	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2/87	3Q87	2Q86	2Q86	2Q86
U.S. OEM PRICE FOR 100 UNITS	\$965 (250)	\$885 (250)	\$1,240 (250)	\$1,355 (250)	\$1,345 (250)
COMMENTS	41 mm high *2,7 RLL Code	*With RLL controller	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	94126 Wren III HH	94221-190 Wren V HH	94351-134 Swift	94351-172 Swift	94354-134 Swift
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 106	F: 190	F: 134	F: 172	F: 134
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,880	**	F: 18,432	F: 18,432	F: 18,432
Data surfaces per spindle	5	5	7	9	7
Heads per data surface	1	1	1	1	1
Tracks per surface	969	1547	1072	1072	1072
Track density (TPI)	960	1280	1350	1350	1350
Maximum linear density (BPI)	19058 BPI* 12705 FCI	*	*	*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	15	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	1250	1125-1875	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2/87	2/88	2Q88	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	\$905 (250)	\$1,535 (250)	\$1,635 (250)	\$1,735 (250)	\$1,635 (250)
COMMENTS	41 mm high *2,7 RLL Code	41 mm high **Varies by zone *Not announced	41 mm high *Not announced	41 mm high *Not announced	41 mm high *Not announced

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	94354-172 Swift	94355-100 Swift	94355-150 Swift	94356-155 Swift	94356-200 Swift
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Thin Film	Thin Film
Interface	PC AT	ST412	ST412	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 172	U: 100	U: 150	U: 155	U: 200
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 14,416	U: 21,624	U: 20,880	U: 20,880
Data surfaces per spindle	9	9	9	7	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1072	1072	1072	1072	1072
Track density (TPI)	1350	1350	1350	1350	1350
Maximum linear density (BPI)	*	*	*	*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	15	15	15	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	1250	625	938	1250	1250
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	2Q88	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	\$1,735 (250)	\$1,075 (250)	\$1,145 (250)	\$1,535 (250)	\$1,635 (250)
COMMENTS	41 mm high *Not announced	41 mm high *Not announced	41 mm high *Not announced	41 mm high *Not announced	41 mm high *Not announced

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	9715-160 FSD	94171-307 Wren IV	94171-344 Wren IV	94186-383 Wren V	94186-383H Wren V
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
	100 mm ID	40 mm ID	40 mm ID	40 mm ID	40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film		
Interface	SMD	SCSI	SCSI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 165.9	F: 330	F: 344	U: 383	U: 383
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	**	**	U: 20,880	U: 20,880
Data surfaces per spindle	10	9	9	13	15
Heads per data surface	1	1	1	1	1
Tracks per surface	823	1365	1549	1412	1224
Track density (TPI)	550	1412	1280	1280	1280
Maximum linear density (BPI)	9500 BPI* 6333 FCI	19058 BPI* 12705 FCI	19500 BPI* 13000 FCI	*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	16.5	16.5	19.5	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	24.8	24.8	27.8	22.8
Data transfer rate (KBytes/sec)	1209	1250-1875	1125-1875	1250	1250
FIRST CUSTOMER SHIPMENT	4Q82	3/87	10/87	2/88	2/88
U.S. OEM PRICE FOR 100 UNITS	\$4,650	\$2,095 (250)	\$2,195 (250)	\$2,045 (250)	\$2,195 (250)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code **Varies by zone	*2,7 RLL Code **Varies by zone	*Not announced	*Not announced

	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
MANUFACTURER					
DRIVE	94186-442 Wren V	9715-300 FSD	9715-340 FSD	9720-368 Sabre	94181-638 Wren V
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SMD	SMD	SMD,SMD-E,SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 442	U: 315	U: 344.0	U: 368	F: 638
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,880	U: 20,160	U: 20,160	U: 30,240	**
Data surfaces per spindle	15	9.5	12	10	15
Heads per data surface	1	2/1	2	1	1
Tracks per surface	1412	1646	1422	1217	1546
Track density (TPI)	1280	1040	960	960	1280
Maximum linear density (BPI)	*	10040 BPI* 6693 FCI	10027 BPI* 6685 FCI	15185 BPI* 10123 FCI	*
Rotational speed (RPM)	3600	3600	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)	16	20	18	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	28.3	26.3	26.3	24.3
Data transfer rate (KBytes/sec)	1250	1209	1209	1815	1500-2000
FIRST CUSTOMER SHIPMENT	2/88	4Q85	4Q83	11/85	5/88
U.S. OEM PRICE FOR 100 UNITS	\$2,295 (250)	\$5,290	\$5,815	\$3,155	\$2,795 (250)
COMMENTS	*Not announced	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*Not announced **Varies by zone

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	9715-500 FSD	9720-500 Sabre	9720-736 Sabre	9771 XMD-I	9772 XMD-II
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD	210 mm OD	210 mm OD	14"	14"
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Mod.SMD, IPI-2	Mod.SMD, SCSI	Mod.SMD, SCSI	Modified SMD	SMD-E
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 516	U: 500	U: 741	U: 825	U: 858
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 41,088	U: 30,240	U: 50,400	U: 50,400
Data surfaces per spindle	12	10	15	8	8
Heads per data surface	2	1	1	2	2
Tracks per surface	1422	1217	1635	2128	2128
Track density (TPI)	960	960	1289	960	960
Maximum linear density (BPI)	15159 BPI* 10106 FCI	19816 BPI* 13210 FCI	14981 BPI* 9987 FCI	15400 BPI* 10266 FCI	15400 BPI* 10266 FCI
Rotational speed (RPM)	3600	3600	3600	2160	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	18	18	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	13.89	8.3
Average access time (msec)	26.3	26.3	24.3	29.89	24.3
Data transfer rate (KBytes/sec)	1825	2465	1815	1825	3000
FIRST CUSTOMER SHIPMENT	4Q83	2Q87	2Q87	3Q83	10/85
U.S. OEM PRICE FOR 100 UNITS	\$6,165	\$3,740	\$4,440	\$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	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)
DRIVE	9775 FMD	97704-700 Hydra	9720-850 Sabre	9720-1230 Sabre	97200-11G Sabre 1123
DISK/TREND GROUP	8	8	8	9	9
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	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD	ISI	Mod.SMD, IPI-2	SMD,SCSI,IPI-2	Mod. SMD
CAPACITY/RECORDING DENSITY	1.9 MB Fixed Head Option				
Total capacity (Mbytes) FIXED	U: 675	U: 703	U: 851	U: 1,236	U: 1123
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 49,728	U: 41,088	U: 50,400	U: 45,792
Data surfaces per spindle	20	8	15	15	15
Heads per data surface	2	2	1	1	1
Tracks per surface	1686	1776	1381	1635	1635
Track density (TPI)	660	800	1089	1289	1289
Maximum linear density (BPI)	6350	15200 BPI* 10266 FCI	19816 BPI* 13210 FCI	25264 BPI* 16842 FCI	22955 BPI* 15303 FCI
Rotational speed (RPM)	3600	3620	3600	3600	3600
PERFORMANCE	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Actuator type					
Average positioning time (msec)	25	16	16	16	16
Average rotational delay (msec)	8.3	8.29	8.3	8.3	8.3
Average access time (msec)	33.3	24.29	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1209	12000	2465	3000	2747
FIRST CUSTOMER SHIPMENT	4/80	2Q86	3Q87	2Q88	3Q88
U.S. OEM PRICE FOR 100 UNITS	\$15,155	\$27,500	\$4,615	\$6,105	--
COMMENTS		*2,7 RLL Code 4 track parallel data transfer	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code 22 Mhz version of Sabre 1230

MANUFACTURER	IMPRIMIS TECHNOLOGY (CONTROL DATA)	IMPRIMIS TECHNOLOGY (CONTROL DATA)	ISOT	ISOT	ISOT
DRIVE	97229-11G Sabre 2HP 1150	9772-13G XMD-III	CM 5400-00 CM 5400-01	CM 5410	ES 5066 ES 5067.01 ES 5067.02
DISK/TREND GROUP	9	9	1	1	2
MARKET	OEM	OEM	OEM	Captive OEM	OEM
MEDIA: Generic type	Fixed	Fixed	5440	5440	3336-1
Nominal disk diameter	210 mm OD 100 mm ID	14"	14"	14"	14"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	IPI-2	Mod.SMD, IPI-2	Various Options	Various Options	
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1154	U: 1,359	U: 3.125	U: 5.75	--
REMOVABLE	--	--	U: 3.125	U: 5.75	F: 100
Capacity per track (Bytes)	U: 50,400	U: 50,400	U: 7,812	U: 7,812	F: 13,030
Data surfaces per spindle	14	9.5	4	4	19
Heads per data surface	1	2	1	1	1
Tracks per surface	1635	2840	204	406	411
Track density (TPI)	1289	1280	100	200	192
Maximum linear density (BPI)	25264 BPI* 16842 FCI	15400 BPI* 10266 FCI	2200	2200	4040
Rotational speed (RPM)	3600	3600	2400/1500	2400/1500	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	16	16	50	50	30
Average rotational delay (msec)	8.3	8.3	12.5/20	12.5	8.3
Average access time (msec)	24.3	24.3	62.5/70	62.5	38.3
Data transfer rate (KBytes/sec)	6000	3000	312/195	312/195	806
FIRST CUSTOMER SHIPMENT	4Q88	12/86	1979	1982	1980
U.S. OEM PRICE FOR 100 UNITS	--	\$11,000	--	--	--
COMMENTS	*2,7 RLL Code 2 head parallel version of Sabre 1230	*2,7 RLL Code			

MANUFACTURER	ISOT	JOSEPHINE COUNTY TECHNOLOGY	JOSEPHINE COUNTY TECHNOLOGY	JVC	JVC
DRIVE	ES 5067	JCT-105	JCT-110	JD-3824L	JD-3824R
DISK/TREND GROUP	2	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	3336-11	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface		ST412	ST412	Proprietary	Proprietary
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 7.0	U: 14.0	F: 21.44	F: 21.44
REMOVABLE	F: 200	--	--	--	--
Capacity per track (Bytes)	F: 13,030	U: 11,504	U: 11,504	F: 17,408	F: 17,408
Data surfaces per spindle	19	2	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	815	306	306	615	615
Track density (TPI)	370	270	270	849	849
Maximum linear density (BPI)	4040	7690	7690	27410 BPI* 18273 FCI	27410 BPI* 18273 FCI
Rotational speed (RPM)	3600	3600	3600	2597	2597
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Band, Stepping Motor	Linear, Band, Stepping Motor	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor
Average positioning time (msec)	30	150 (including settling)	150 (including settling)	68 (including settling)	78 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	11.6	11.6
Average access time (msec)	38.3	158.3	158.3	79.6	89.6
Data transfer rate (KBytes/sec)	806	625	625	937.5	937.5
FIRST CUSTOMER SHIPMENT	1981	9/84	6/85	2Q88	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	\$265	\$295	--	--
COMMENTS		41 mm high	41 mm high	28.8 mm high *2,7 RLL Code Embedded Servo	28.9 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	JVC	JVC	KALOK	KALOK	KALOK
DRIVE					
	JD-3824T	JD-3848H	KL320 Octagon 20	KL330 Octagon 30	KL332 Octagon 30
DISK/TREND GROUP	3	4	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
	25 mm ID	25 mm ID	25 mm ID	25 mm ID	25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Proprietary	Proprietary	ST412	ST412	PS/2 (25/30)
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.44	F: 42.88	U: 25.62	U: 38.44*	F: 32.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 17,408	U: 10,416	U: 15,624*	F: 13,312
Data surfaces per spindle	2	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	615
Track density (TPI)	941	941	814	814	814
Maximum linear density (BPI)	25610 BPI*	25610 BPI*	13533	20300 BPI*	20300 BPI*
	17073 FCI	17073 FCI		13533 FCI	13533 FCI
Rotational speed (RPM)	2593	2593	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Average positioning time (msec)	65 (including settling)	45 (including settling)	40	40	40
Average rotational delay (msec)	11.6	11.6	8.3	8.3	8.3
Average access time (msec)	76.6	56.6	48.3	48.3	48.3
Data transfer rate (KBytes/sec)	937.5	937.5	625	937.5*	937.5
FIRST CUSTOMER SHIPMENT	3Q88	3Q88	2Q88	2Q88	12/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--		--
COMMENTS	25.4 mm high *2,7 RLL Code Embedded Servo	31.4 mm high *2,7 RLL Code Embedded Servo	41 mm high	41 mm high *With RLL controller	41 mm high *2,7 RLL Code

MANUFACTURER	KALOK	KALOK	KOVO (ARITMA)	KOVO (ARITMA)	KOVO (ZBROJOVKA BRNO)
DRIVE	KL341 Octagon 40	KL343 Octagon 40	Aritma 4080	Aritma 5080	KDP 724
DISK/TREND GROUP	4	4	2	2	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	3336-1	3336-11	2315
Nominal disk diameter	95 mm OD	95 mm OD	14"	14"	14"
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	IBM	IBM	
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 40.7	F: 40.7	--	--	U: 3.125
REMOVABLE	--	--	F: 100.0	F: 200.0	U: 3.125
Capacity per track (Bytes)	F: 15,360	F: 15,360	F: 13,030	F: 13,030	U: 7,812
Data surfaces per spindle	4	4	19	19	4
Heads per data surface	1	1	1	1	1
Tracks per surface	664	664	411	815	204
Track density (TPI)	814	814	192	370	100
Maximum linear density (BPI)	23610 BPI*	23610 BPI*	4040	4040	2200
Rotational speed (RPM)	15740 FCI 3600	15740 FCI 3600	3600	3600	2400
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	25	25	30	30	45
Average rotational delay (msec)	8.3	8.3	8.3	8.3	12.5
Average access time (msec)	33.3	33.3	38.3	38.3	57.5
Data transfer rate (KBytes/sec)	1062.5	1062.5	806	806	312.5
FIRST CUSTOMER SHIPMENT	10/88	1/89	1985	1986	1976
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code			

1988 DISK/TREND REPORT

MANUFACTURER	KYOCERA	KYOCERA	KYOCERA	KYOCERA	KYOCERA
DRIVE					
	KC 20A	KC 20B	KC 30A	KC 30B	KC 40C
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Oxide Coated	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	SCSI, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.5	U: 25.5	U: 38.4*	U: 38.4*	F: 43.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 15,624*	U: 15,624*	F: 13,824
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	616	615	616	615	788
Track density (TPI)	835	800	835	800	1100
Maximum linear density (BPI)	12268	13464	18402*	20196*	*
Rotational speed (RPM)	3600	3600	3600	3600	3528
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Linear, Encoder Motor
Average positioning time (msec)	65 (including settling)	62 (including settling)	65 (including settling)	62 (including settling)	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.5
Average access time (msec)	73.3	70.3	73.3	70.3	36.5
Data transfer rate (KBytes/sec)	625	625	937.5*	937.5*	1500 max.
FIRST CUSTOMER SHIPMENT	1987	1987	1987	1987	1Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS			*With RLL controller	*With RLL controller	41 mm high *2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	KYOCERA	MAGNUM TECHNOLOGY	MAGNUM TECHNOLOGY	MAGNUM TECHNOLOGY	MAGNUM TECHNOLOGY
DRIVE					
	KC 80C	MT2085	MT3085	MT2128	MT2170
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	95 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI, PC AT	SCSI	ST412	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 87.02	F: 74.02	U: 85.3	F: 115.15	F: 154.14
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 9,216	U: 10,416	F: 14,336	F: 14,336
Data surfaces per spindle	8	8	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	788	1004	1024	1004	1344
Track density (TPI)	1100	1029	1029	1029	1373
Maximum linear density (BPI)	*	9716	9716	14574 BPI* 9716 FCI	14574 BPI* 9716 FCI
Rotational speed (RPM)	3528	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Encoder Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	28	25	25	25	25
Average rotational delay (msec)	8.5	8.3	8.3	8.3	8.3
Average access time (msec)	36.5	33.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	1500 max.	625	625	937.5	937.5
FIRST CUSTOMER SHIPMENT	4Q88	3Q86	3Q85	3Q86	3Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code			*2,7 RLL Code	*2,7 RLL Code

RSPEC-75

MANUFACTURER	MAGNUM TECHNOLOGY	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	MT3000	JU-106	JU-114	JU-116	JU-126
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	200 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI, Mod. SMD	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 400	U: 20	U: 13.3	U: 25.6	U: 22.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 34,000	U: 20,877	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	5	2	2	4	3
Heads per data surface	2	1	1	1	1
Tracks per surface	2720	615	640	615	733
Track density (TPI)	1360	880	800	800	1019
Maximum linear density (BPI)	25500 BPI* 17000 FCI	26516	14423	14423	13171
Rotational speed (RPM)	3000	2640	3536	3536	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, DC Motor	Band, Stepping Motor	Band, Stepping Motor	Linear, DC Motor
Average positioning time (msec)	16	65	85 (including settling)	85 (including settling)	35
Average rotational delay (msec)	10	11.4	8.48	8.48	8.3
Average access time (msec)	26	76.4	93.48	93.48	43.3
Data transfer rate (KBytes/sec)	2000	937.5	625	625	625
FIRST CUSTOMER SHIPMENT	4Q88	1988	1986	1986	1987
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Sold only as 3.2 GB array with 8 spindles	25 mm high		3.5" drive in 5.25" form factor	41 mm high

	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
MANUFACTURER					
DRIVE					
	JU-614	JU-127	JU-128	JU-128A	JU-1381
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 ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 13.3	U: 38.17	U: 53.44	U: 53.44	F: 40.4
REMOVABLE	--	--	--		
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	F: 13,790
Data surfaces per spindle	4	5	7	7	4
Heads per data surface	1	1	1	1	1
Tracks per surface	320	733	733	733	733
Track density (TPI)	360	1019	1019	1019	1019
Maximum linear density (BPI)	9100	13171	13171	13171	22431
Rotational speed (RPM)	3600	3600	3600	3600	3367.6
PERFORMANCE					
Actuator type	Band, Stepping Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	85 (including settling)	35	35	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.9
Average access time (msec)	93.3	43.3	43.3	38.3	38.9
Data transfer rate (KBytes/sec)	625	625	625	625	150
FIRST CUSTOMER SHIPMENT	1984	1987	1987	1988	1988
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		41 mm high	41 mm high	41 mm high	41 mm high

1988 DISK/TREND REPORT

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	JU-1391	XT-1085	LXT-100S	LXT-200S	XT-1120R
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 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	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	SCSI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80.9	U: 85.32	F: 96	F: 202	U: 127.99*
REMOVABLE		--	--	--	--
Capacity per track (Bytes)	F: 13,790	U: 10,416	F: 16,384	F: 14,848- 25,088	U: 15,624*
Data surfaces per spindle	8	8	8	7	8
Heads per data surface	1	1	1	1	1
Tracks per surface	733	1024	733	1473	1024
Track density (TPI)	1019	1070	1019	1610	1070
Maximum linear density (BPI)	22431	9934	26229 BPI* 17486 FCI	24872*	14901 BPI* 9934 FCI
Rotational speed (RPM)	3367.6	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, DC Motor	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	27	29	15	27
Average rotational delay (msec)	8.9	8.3	8.3	8.3	8.3
Average access time (msec)	38.9	35.3	37.3	23.3	35.3
Data transfer rate (KBytes/sec)	150	625	1250	1008-1680	937.5*
FIRST CUSTOMER SHIPMENT	1988	2Q83	3Q88	4Q88	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high		41 mm high *2,7 RLL Code Embedded Servo	41 mm high *1,7 RLL Code 3 recording bands	*With RLL controller

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	XT-1140	XT-1240R	XT-2190	XT-4170E	XT-4170S
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ST412	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 143.42	U: 239.98*	U: 191.23	U: 179.45	F: 157.93
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624*	U: 10,416	U: 20,940	F: 18,432
Data surfaces per spindle	15	15	15	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	918	1024	1224	1224	1224
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI)	9280	14901 BPI* 9934 FCI	11155	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)	25.8	27	28.9	14	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	34.1	35.3	37.2	22.3	22.3
Data transfer rate (KBytes/sec)	625	937.5*	625	1250	1500
FIRST CUSTOMER SHIPMENT	2Q83	2Q87	3Q84	2Q87	2/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		*With RLL controller		*2,7 RLL Code	*2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	XT-4280S	XT-4380E	XT-4380S	XT-8380E	XT-8380S
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 248.17	U: 384.53	F: 338.41	U: 410.0	F: 360.97
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 20,940	F: 18,432	U: 31,410	F: 27,648
Data surfaces per spindle	11	15	15	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	1224	1632	1632
Track density (TPI)	1070	1070	1070	1376	1376
Maximum linear density (BPI)	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI	31596 BPI* 21064 FCI	31596 BPI* 21064 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	16	16	14.5	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	22.8	22.8
Data transfer rate (KBytes/sec)	1500	1250	1500	1875	1875
FIRST CUSTOMER SHIPMENT	2/86	2Q87	4Q87	1Q87	1Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	\$3,025	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MAXTOR	MAXTOR	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX
DRIVE					
	XT-8760E	XT-8760S	3890-00J4	3890-01J4	3680
DISK/TREND GROUP	8	8	8	8	9
MARKET	OEM	OEM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	14"
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Thin Film
Interface	ESDI	SCSI	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 768.9	F: 676.82	F: 630.24	F: 630.24	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,410	F: 27,648	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	15	15	13.5	13.5	15
Heads per data surface	1	1	2	2	2
Tracks per surface	1632	1632	990	990	1,768
Track density (TPI)	1376	1376	1193	1193	806
Maximum linear density (BPI)	31596 BPI* 21064 FCI	31596 BPI* 21064 FCI	25211*	25211*	15240*
Rotational speed (RPM)	3600	3600	3620	3620	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual Linear, Voice Coil
Average positioning time (msec)	16.5	16.5	12	12	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.8	24.8	20.3	20.3	24.3
Data transfer rate (KBytes/sec)	1875	1875	3000	3000	3000
FIRST CUSTOMER SHIPMENT	1Q87	1Q88	1st half 1989	1st half 1989	8/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	PCM 3380J Drive has 8 spindles *1,7 RLL Code	PCM 3380J Drive has 16 spindles *1,7 RLL Code	PCM 3380 Drive has 1 spindle *2,7 RLL Code

MANUFACTURER	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX
DRIVE					
	3680 HDP	3682	3835	3890-00K4	3890-01K4
DISK/TREND GROUP	9	9	9	9	9
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	200 mm OD 63.5 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	F: 2,520	F: 855.8	F: 945.36	F: 945.36
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 36,352	F: 47,476	F: 47,476
Data surfaces per spindle	15	15	14	13.5	13.5
Heads per data surface	2	2	2	2	2
Tracks per surface	1768	3540		1490	1490
Track density (TPI)	806	1386	1368	1193	1193
Maximum linear density (BPI)	15240*	16200*	23400 BPI* 15600 FCI	25211*	25211*
Rotational speed (RPM)	3600	3600	3656	3620	3620
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	17	17.5	16	16
Average rotational delay (msec)	8.3	8.3	8.2	8.3	8.3
Average access time (msec)	24.3	25.3	25.7	24.3	24.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	3Q85	12/86	3Q88	1st half 1989	1st half 1989
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PCM 3380 Drive has 8 spindles *2,7 RLL Code	PCM 3380E *2,7 RLL Code Drive has 2 spindles	PCM 9335 *2,7 RLL Code Embedded Servo	PCM 3380K Drive has 8 spindles *1,7 RLL Code	PCM 3380K Drive has 16 spindles *1,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1333A	1335	1353	1373	1373A
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 53.3	U: 85.3	U: 85.3	F: 77.0	F: 96.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 20,832	F: 19,456	F: 19,456
Data surfaces per spindle	5	8	4	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1016	1016
Track density (TPI)	1000	1000	1000	1000	1000
Maximum linear density (BPI)	9824	9824	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)	28	28	23	23	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	31.3	31.3	31.3
Data transfer rate (KBytes/sec)	625	625	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2Q84	2Q84	3Q85	1Q86	2/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS			*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
MANUFACTURER					
DRIVE					
	1353A	1354	1354A	1355	1374
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 106.7	U: 128	U: 149	U: 170.6	F: 109
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	U: 20,832	U: 20,832	F: 18,432
Data surfaces per spindle	5	6	7	8	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1024	1016
Track density (TPI)	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	3Q85	3Q85	3Q85	3Q85	3Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1374A	1375	1554	1556-11	1576-11
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film/Ferr.	Thin Film/Ferr.
Interface	SCSI	SCSI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 127	F: 154.0	U: 280	U: 280	F: 243
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 19,456	U: 20,832	U: 20,832	F: 18,432
Data surfaces per spindle	7	8	11	11	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1016	1016	1224	1224	1224
Track density (TPI)	1000	1000	1075	1075	1075
Maximum linear density (BPI)	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	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	31.3	31.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	4000 max.
FIRST CUSTOMER SHIPMENT	1Q86	1Q86	11/86	1Q87	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	SCSI version is Model 1574 *Not announced	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type
 Nominal disk diameter
 Recording medium

DRIVE: Heads
 Interface

CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED
 REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Rotational speed (RPM)

PERFORMANCE

Actuator type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

U.S. OEM PRICE FOR 100 UNITS

COMMENTS

MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
1653-4	1653-5	1654-6	1654-7	1673-4
6	6	6	6	6
OEM	OEM	OEM	OEM	OEM
Fixed 130 mm OD 40 mm ID Thin Film	Fixed 130 mm OD 40 mm ID Thin Film	Fixed 130 mm OD 40 mm ID Thin Film	Fixed 130 mm OD 40 mm ID Thin Film	Fixed 130 mm OD 40 mm ID Thin Film
Thin Film/Ferr. ESDI	Thin Film/Ferr. ESDI	Thin Film/Ferr. ESDI	Thin Film/Ferr. ESDI	Thin Film/Ferr. SCSI
U: 104 --	U: 130 --	U: 156 --	U: 182 --	F: 90 --
U: 20,832	U: 20,832	U: 20,832	U: 20,832	F: 18,432
4	5	6	7	4
1	1	1	1	1
1249	1249	1249	1249	1245
**	**	**	**	**
**	**	**	**	**
3600	3600	3600	3600	3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
16	16	16	16	16
8.3	8.3	8.3	8.3	8.3
24.3	24.3	24.3	24.3	24.3
1250	1250	1250	1250	1250
1Q88	1Q88	1Q88	1Q88	2Q88
--	--	--	--	--
41 mm high **Not announced	41 mm high **Not announced	41 mm high **Not announced	41 mm high **Not announced	41 mm high **Not announced

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1673-5	1674-6	1674-7	1557-12	1558-13
DISK/TREND GROUP	6	6	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.
Interface	SCSI	SCSI	SCSI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 112	F: 135	F: 158	U: 305	U: 331
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	F: 18,432	U: 20,832	U: 20,832
Data surfaces per spindle	5	6	7	12	13
Heads per data surface	1	1	1	1	1
Tracks per surface	1245	1245	1245	1224	1224
Track density (TPI)	**	**	**	1075	1075
Maximum linear density (BPI)	**	**	**	*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	16	16	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	2Q88	1Q87	1Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high **Not announced	41 mm high **Not announced	41 mm high **Not announced	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1558-14	1558-15	1577-12	1577-13	1578-14
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.
Interface	ESDI	ESDI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 356	U: 382	F: 266	F: 287	F: 310
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	F: 18,432	F: 18,432	F: 18,432
Data surfaces per spindle	14	15	12	13	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	1224	1224	1224
Track density (TPI)	1075	1075	1075	1075	1075
Maximum linear density (BPI)	*	*	*	*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	1Q87	1Q87	2Q87	2Q87	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1578-15	1566-11	1567-12	1567-13	1568-14
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Thin Film/Ferr.	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	ESDI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 332	U: 561	U: 612	U: 663	U: 714
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 31,250	U: 31,250	U: 31,250	U: 31,250
Data surfaces per spindle	15	11	12	13	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1632	1632	1632	1632
Track density (TPI)	1075	** **	**	**	**
Maximum linear density (BPI)	*	**	**	**	**
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	16	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	24.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	4000 max.	1875	1875	1875	1875
FIRST CUSTOMER SHIPMENT	2Q87	4Q88	4Q88	4Q88	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	**Not announced	**Not announced	**Not announced	**Not announced

	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
MANUFACTURER					
DRIVE					
	1568-15	1586-11	1587-12	1587-13	1588-14
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 765	F: 490	F: 535	F: 579	F: 624
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,250	F: 27,648	F: 27,648	F: 27,648	F: 27,648
Data surfaces per spindle	15	11	12	13	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	1628	1628	1628	1628
Track density (TPI)	**	**	**	**	**
Maximum linear density (BPI)	**	**	**	**	**
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1875	1875	1875	1875	1875
FIRST CUSTOMER SHIPMENT	4Q88	4Q88	4Q88	4Q88	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	**Not announced	**Not announced	**Not announced	**Not announced	**Not announced

MANUFACTURER	MICROPOLIS	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	1588-15	HH-325	HH-825	4050	7040
DISK/TREND GROUP	8	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	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated		
DRIVE: Heads		Ferrite	Ferrite		Ferrite
Interface	SCSI	ST412	ST412	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 668	U: 25.52	U: 25.5	U: 53.3	F: 47.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	U: 10,416	U: 10,416	U: 10,416	F: 18,432
Data surfaces per spindle	15	4	4	5	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1628	612	612	1024	855
Track density (TPI)	**	855	648	1250	1250
Maximum linear density (BPI)	**	13014	9680	14445	25406 BPI* 16937 FCI
Rotational speed (RPM)	3600	3550	3550	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	80 (including settling)	65 (including settling)	18	18
Average rotational delay (msec)	8.3	8.45	8.45	8.3	8.3
Average access time (msec)	24.3	88.45	73.45	26.3	26.3
Data transfer rate (KBytes/sec)	1875	625	625	625	1250
FIRST CUSTOMER SHIPMENT	4Q88	3/85	5/87	3Q88	3Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	**Not announced	41 mm high Embedded Servo	41 mm high Embedded Servo	41 mm high	41 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	HH-330	HH-738	HH-830	HH-1050	HH-1075
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	95 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm OD Thin Film	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Thin Film	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.28*	U: 38.28*	U: 38.28*	U: 51.04	U: 74.69
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 15,624*	U: 15,624*	U: 10,416	U: 10,416
Data surfaces per spindle	4	4	4	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	612	612	612	1024	1024
Track density (TPI)	855	648	648	960	1250
Maximum linear density (BPI)	13014*	14520*	14520*	10020	8464
Rotational speed (RPM)	3550	3550	3550	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	80 (including settling)	105 (including settling)	65 (including settling)	28	28
Average rotational delay (msec)	8.45	8.45	8.45	8.3	8.3
Average access time (msec)	88.45	113.45	73.45	36.3	36.3
Data transfer rate (KBytes/sec)	937.5*	937.5*	937.5*	625	625
FIRST CUSTOMER SHIPMENT	3/85	6/84	5/87	1/86	2/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	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	41 mm high

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE					
	HH-1060	HH-1090	5100	6100	7100
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ESDI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 79.99*	U: 95.81	U: 124.6	F: 110	F: 110
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 10,416	U: 20,832	F: 18,432	F: 18,435
Data surfaces per spindle	5	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1314	855	855	855
Track density (TPI)	960	1250	1250	1250	1250
Maximum linear density (BPI)	14935 BPI* 9957 FCI	9840	25406 BPI* 16937 FCI	25406 BPI* 16937 FCI	25406 BPI* 16937 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	28	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	937.5*	625	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2/86	9/87	4Q88	4Q88	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *With RLL controller	41 mm high	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	HH-1095	HH-1120	HH-2120	HH-2160	HH-3120
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 112.0*	U: 143.71*	U: 149.3	U: 186.08	F: 122.43
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 15,664*	U: 20,832	U: 20,833	F: 13,312
Data surfaces per spindle	7	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1314	1024	1276	1314
Track density (TPI)	1250	1250	1250	1250	1250
Maximum linear density (BPI)	12696 BPI* 8464 FCI	14760 BPI* 9840 FCI	16969 BPI* 11313 FCI	19247 BPI* 12832 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*	937.5*	1250	937.5	937.5
FIRST CUSTOMER SHIPMENT	2/88	10/87	4/88	7/88	11/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *With RLL controller	41 mm high *With RLL controller	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code

MANUFACTURER	MILTOPE	MILTOPE	MILTOPE	MILTOPE	MINISCRIBE
DRIVE					
	RDS-1500	RDS-3040	RDS-5000	RDS-1720	8225AT
DISK/TREND GROUP	3	4	4	6	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Special	Special	Special	Special	Fixed
Nominal disk diameter	130 mm OD	95 mm OD	130 mm OD	130 mm OD	95 mm OD
Recording medium	40 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412, SCSI	ST412	SCSI	ESDI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 18.5	F: 30.8	F: 47.0	F: 159.3	F: 21.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 9,216	F: 9,216	F: 9,216	F: 19,456	F: 13,312
Data surfaces per spindle	3	5	5	8	2
Heads per data surface	1	1	1	1	1
Tracks per surface	670	670	1024	1024	805
Track density (TPI)	680	1186	1000	960	898
Maximum linear density (BPI)	9890	11240	9824	20000*	*
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	46
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	54.3
Data transfer rate (KBytes/sec)	625	625	625	1250	937.5
FIRST CUSTOMER SHIPMENT	5/84	4Q86	4Q86	3Q86	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$310 (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 *Not announced

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE					
	8225XT	8425	8425F	8425S	3053
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC XT	ST412	ST412	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.4	U: 25.6	U: 25.6	F: 21.3	U: 53.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 10,416	U: 10,416	F: 8,704	U: 10,416
Data surfaces per spindle	2	4	4	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	805	615	615	612	1024
Track density (TPI)	898	804	804	804	1000
Maximum linear density (BPI)	*	13412	13412	13412	10200
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	Rotary, Voice Coil
Average positioning time (msec)	46	68 (including settling)	40 (including settling)	68 (including settling)	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	54.3	76.3	48.3	76.3	33.3
Data transfer rate (KBytes/sec)	937.5	625	625	625	625
FIRST CUSTOMER SHIPMENT	2Q88	3Q84	1Q87	3Q86	2Q87
U.S. OEM PRICE FOR 100 UNITS	\$295 (2500)	\$215 (2500)	\$250 (2500)	\$280 (2500)	\$440 (2500)
COMMENTS	41 mm high *Not announced	41 mm high	41 mm high	41 mm high	41 mm high

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE					
	3650	8051A	8051S	8438	8438F
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	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
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	IBM PC AT	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 50.5	F: 42.0	F: 45.1	U: 38.4*	U: 38.4*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 14,336	F: 14,336	U: 15,624*	U: 15,624*
Data surfaces per spindle	6	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	809	745	793	615	615
Track density (TPI)	763	1109	1109	804	804
Maximum linear density (BPI)	10124	23202	23202	19900 BPI* 13412 FCI	19900 BPI* 13412 FCI
Rotational speed (RPM)	3600	3484	3484	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	61 (including settling)	28	28	68 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.6	8.6	8.3	8.3
Average access time (msec)	69.3	36.6	36.6	76.3	48.3
Data transfer rate (KBytes/sec)	625	1000	1000	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	1Q87	2Q88	1Q88	4Q85	1Q87
U.S. OEM PRICE FOR 100 UNITS	\$265 (2500)	\$390 (2500)	\$390 (2500)	\$225 (2500)	\$270 (2500)
COMMENTS	41 mm high			41 mm high *With RLL controller	41 mm high *With RLL controller

	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
MANUFACTURER					
DRIVE					
	8450AT	8450XT	3085	3675	6079
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	130 mm OD	130 mm OD	130 mm OD
	25 mm ID	25 mm ID	40 mm ID	40 mm ID	40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	PC XT	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.6	F: 42.6	U: 85.3	U: 75.8*	U: 79.9*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 13,312	U: 10,416	U: 15,624*	U: 15,624*
Data surfaces per spindle	4	4	7	6	5
Heads per data surface	1	1	1	1	1
Tracks per surface	805	805	1170	809	1024
Track density (TPI)	898	898	1100	763	1000
Maximum linear density (BPI)	*	*	10297	15186*	14925*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Linear, Voice Coil
Average positioning time (msec)	46	46	22	61	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	54.3	54.3	30.3	69.3	36.3
Data transfer rate (KBytes/sec)	937.5	937.5	625	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	4Q88	2Q88	4Q87	1Q88	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$350 (2500)	\$350 (2500)	\$580 (2500)	\$285 (2500)	\$470 (2500)
COMMENTS	41 mm high *Not announced	41 mm high *Not announced	41 mm high	41 mm high *With RLL controller	*With RLL controller

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE					
	6085	3180E	3180S	6128	9380E
DISK/TREND GROUP	5	6	6	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ESDI	SCSI	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.3	U: 182	F: 160	U: 128.0*	U: 382.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,832	F: 18,432	U: 15,624*	U: 20,832
Data surfaces per spindle	8	7	7	8	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1250	1255	1024	1224
Track density (TPI)	1000	1135	1135	1000	1100
Maximum linear density (BPI)	9950	20100*	20100*	14925*	20388*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	17	17	28	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	25.3	25.3	36.3	24.3
Data transfer rate (KBytes/sec)	625	1250	4000 max.	937.5*	1250
FIRST CUSTOMER SHIPMENT	4Q84	3Q88	4Q88	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$540 (2500)	\$910	\$970	\$580 (2500)	\$1,500 (2500)
COMMENTS		41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	*With RLL controller	*2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	MINISCRIBE	MINISCRIBE	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE					
	9380S	9780 E/S	MR321	MR322	MR335
DISK/TREND GROUP	7	8	3	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI, SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 347.0	U: 781	U: 12.75	U: 25.5	U: 54.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 18,944	U: 31,906	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	15	15	2	4	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1661	615	615	743
Track density (TPI)	1100	1490	821	821	992
Maximum linear density (BPI)	20388*	31241*	13840	13840	13840
Rotational speed (RPM)	3600	3600	3536	3536	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	16	16	85 (including settling)	85 (including settling)	25
Average rotational delay (msec)	8.3	8.3	8.48	8.48	8.3
Average access time (msec)	24.3	24.3	93.48	93.48	33.3
Data transfer rate (KBytes/sec)	1250	1915	625	625	625
FIRST CUSTOMER SHIPMENT	3Q87	3Q88	2Q86	2Q86	4Q88
U.S. OEM PRICE FOR 100 UNITS	\$1,500 (2500)	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	41 mm high	41 mm high	41 mm high

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MR533	MR533S	MR535	MR535S	MR537S
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	ST412	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 30.3	U: 30.3	U: 50.85	U: 50.85	U: 76.27
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 15,624
Data surfaces per spindle	3	3	5	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	977	977	977	977	977
Track density (TPI)	1028	1028	1028	1028	1028
Maximum linear density (BPI)	9358	9358	9358	9358	14037 BPI* 9358 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	28	28	28	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)	625	625	625	625	937
FIRST CUSTOMER SHIPMENT	3Q86	3Q88	3Q86	3Q88	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high	41 mm high Embedded SCSI	41 mm high	41 mm high Embedded SCSI	41 mm high Embedded SCSI *2,7 RLL Code

RSPEC-101

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Heads

Interface

CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Rotational speed (RPM)

PERFORMANCE

Actuator type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

U.S. OEM PRICE FOR 100 UNITS

COMMENTS

	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUMI ELECTRIC
	M4870F	MR5310E	M4875	E1880B E1880C E1880D	HD 320
	6	6	7	8	3
	OEM	OEM	OEM	Captive	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	210 mm OD 100 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	224 mm OD 100 mm ID Oxide Coated	95 mm OD 25 mm ID Thin Film
	Ferrite	Ferrite	Thin Film	Thin Film	Ferrite
	SMD	ESDI	Modified SMD	Mitsubishi	ST412
	U: 251.4	U: 101.7	U: 408.5	F: 630	U: 25.5
	--	--	--	--	--
	U: 20,480	U: 20,340	U: 30,720	F: 47,476	U: 10,416
	12	5	13	15	4
	1	1	1	2	1
	1023	977	1023	885	612
	1000	1028	1000	1060	1200
	10000	18716 BPI* 12477 FCI	14100*	21500*	12000
	3544	3600	3544	3620	3600
	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor
	20	28	20	13	85
	8.47	8.3	8.47	8.3	8.3
	28.47	36.3	28.47	21.3	93.3
	1209	1250	1814	3000	625
	4/84	4Q86	3Q85	3Q88	3/88
	--	--	--	--	--
		41 mm high *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code E1880B: 1 spindle E1880C: 4 spindles E1880D: 8 spindles	41 mm high

MANUFACTURER	NATIONAL ADVANCED SYSTEMS	NATIONAL ADVANCED SYSTEMS	NATIONAL ADVANCED SYSTEMS	NATIONAL ADVANCED SYSTEMS	NATIONAL ADVANCED SYSTEMS
DRIVE	7380-AD 7380-BD	7380-AJ 7380-BJ	7380-AJX 7380-BJX	7380-AE 7380-BE	7380-AK 7380-BK
DISK/TREND GROUP	8	8	9	9	9
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	9.5"	9.5"	14"	9.5"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 630	F: 630	F: 1,260	F: 1,260	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	10	8	8	12	8
Heads per data surface	2	2	2	2	4
Tracks per surface	1327.5	1327.5	2655	2212.5	2655
Track density (TPI)	*	*	*	*	*
Maximum linear density (BPI)	*	*	*	*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	11	13	17	12.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	19.3	21.3	25.3	20.8
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	3/86	7/88	7/88	4/86	9/88
U.S. OEM PRICE FOR 100 UNITS					
COMMENTS	PCM 3380D Drive has 4 spindles *Not announced	PCM 3380J 8 spindles per frame = 2 equivalent IBM units. *Not announced	PCM 3380E 8 spindles per frame = 2 equivalent IBM units. *Not announced	PCM 3380E Drive has 4 spindles *Not announced	PCM 3380K 8 spindles per frame = 2 equivalent IBM units. *Not announced

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	N7745	D3122	D3126	D3126H	D3821
DISK/TREND GROUP	2	3	3	3	3
MARKET	Captive	Captive	Captive, OEM	Captive, OEM	Captive
MEDIA: Generic type	3336-11	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	NEC	ST412	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 26.7	U: 25.62	U: 25.62	F: 22.52
REMOVABLE	F: 200	--	--	--	--
Capacity per track (Bytes)	F: 13,030	U: 10,416	U: 10,416	U: 10,416	F: 12,800
Data surfaces per spindle	19	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	815	642	615	615	440
Track density (TPI)	370	850	750	850	850
Maximum linear density (BPI)	4040	14000	15000	14000	17000*
Rotational speed (RPM)	3600	3600	3564	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Torque Motor	Linear, Band, Stepping Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	30	28	85 (including settling)	35	28
Average rotational delay (msec)	8.3	8.3	8.4	8.3	8.3
Average access time (msec)	38.3	36.3	93.4	43.3	36.3
Data transfer rate (KBytes/sec)	806	625	625	625	937.5
FIRST CUSTOMER SHIPMENT	11/75	5/88	7/85	6/87	5/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		41 mm high	41 mm high	41 mm high	41 mm high *2,7 RLL Code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5128	D5126H	D3142	D3146H	D3841
DISK/TREND GROUP	3	3	4	4	4
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID	25 mm ID	25 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.62	U: 25.62	U: 53.4	U: 51.24	F: 45.05
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	F: 12,800
Data surfaces per spindle	4	4	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	642	615	440
Track density (TPI)	700	700	850	850	850
Maximum linear density (BPI)	9000	9000	14000	14000	17000*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Band, Stepping Motor	Linear, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	85 (including settling)	40	28	35	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	48.3	36.3	43.3	36.3
Data transfer rate (KBytes/sec)	625	625	625	625	937.5
FIRST CUSTOMER SHIPMENT	10/87	4/86	1Q88	5/87	12/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high	41 mm high	41 mm high	41 mm high	*2,7 RLL Code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5127	D5127H	D5146H	D5147H	D5452
DISK/TREND GROUP	4	4	4	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 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.43	U: 38.43	U: 51.24	U: 76.87	U: 85.72
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624	U: 15,624	U: 10,416	U: 15,624	U: 10,416
Data surfaces per spindle	4	4	8	8	10
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	823
Track density (TPI)	700	700	700	700	926
Maximum linear density (BPI)	13500*	13500*	9000	13500*	9307
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Band, Stepping Motor	Linear, Torque Motor	Linear, Torque Motor	Linear, Torque Motor	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	40	40	40	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	48.3	48.3	48.3	31.3
Data transfer rate (KBytes/sec)	937.5	937.5	625	937.5	625
FIRST CUSTOMER SHIPMENT	4/87	4/87	4/86	5/87	4/86
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	41 mm high *2,7 RLL Code	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	D2257	D3661	D5652	D5655	D5852
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	95 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	100 mm ID Oxide Coated	25 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	ESDI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 167.7	U: 134.5	U: 172.76	U: 179.86	F: 147.48
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	U: 20,992	U: 20,992	U: 20,992	F: 17,920
Data surfaces per spindle	8	7	10	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	915	823	1224	823
Track density (TPI)	720	1311	926	1240	925
Maximum linear density (BPI)	9420	25484*	18758*	19610*	18759*
Rotational speed (RPM)	3510	3600	3573	3573	3573
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	23	23	18	23
Average rotational delay (msec)	8.55	8.3	8.4	8.4	8.4
Average access time (msec)	28.55	31.3	31.4	26.4	31.4
Data transfer rate (KBytes/sec)	1198	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	5/83	3Q88	2/86	12/87	5/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		41 mm high *2,7 RLL Code	*2,7 RLL Code	41 mm high *2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	D5855	D2268H	D5662	D5862	D2352
DISK/TREND GROUP	6	7	7	7	8
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Captive, OEM
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	Modified SMD	ESDI	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 153.5	U: 337.1	U: 385.41	F: 328.20	U: 520
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	U: 40,960	U: 20,992	F: 17,920	U: 36,288
Data surfaces per spindle	7	10	15	15	9.5
Heads per data surface	1	1	1	1	2/1
Tracks per surface	1224	823	1224	1221	1520
Track density (TPI)	1240	780	1240	1240	1020
Maximum linear density (BPI)	19610*	18900*	19660*	19660*	18600*
Rotational speed (RPM)	3573	3600	3573	3573	3070
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	20	18	18	15
Average rotational delay (msec)	8.4	8.3	8.4	8.4	9.8
Average access time (msec)	26.4	28.3	26.4	26.4	24.8
Data transfer rate (KBytes/sec)	1250	2460	1250	1250	1859
FIRST CUSTOMER SHIPMENT	12/87	11/85	11/87	11/87	1/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

	NEC	NEC	NEC	NEC	NEC
MANUFACTURER					
DRIVE					
	D2352H	D2362	D2366	D2462	N7755
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	Captive, OEM	Captive, OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD	230 mm OD	230 mm OD	230 mm OD	14"
Recording medium	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Mod.SMD, IPI-2	Modified SMD	IPI-2	SCSI	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 520	U: 800	U: 800	F: 737	F: 635.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 36,288	U: 40,960	U: 40,960	F: 37,888	F: 19,069
Data surfaces per spindle	9.5	11.5	11.5	11.5	15
Heads per data surface	2/1	2/1	2/1	2/1	2
Tracks per surface	1520	1700	1700	1700	2220
Track density (TPI)	1020	1070	1070	1070	960
Maximum linear density (BPI)	18600*	21400*	21400*	21400*	6400
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	15	15	15	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	23.3	23.3	28.3
Data transfer rate (KBytes/sec)	2180	2460	2460	2460	1198
FIRST CUSTOMER SHIPMENT	11/85	2/86	1Q87	2Q87	1979
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	Drive has 2 spindles

1988 DISK/TREND REPORT

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	N7756	N7757	N7761	D2363	D2367
DISK/TREND GROUP	8	8	8	9	9
MARKET	Captive	Captive	Captive	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	230 mm OD 100 mm ID	14"	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	NEC	NEC	NEC	Modified SMD	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 486.2	F: 750.5	F: 672.2	U: 1,132	U: 1,132
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 34,036	F: 38,708	F: 47,476	U: 40,960	U: 40,960
Data surfaces per spindle	9.5	11.5	8	13.5	13.5
Heads per data surface	2/1	2	2	2/1	2/1
Tracks per surface	1506	1686	1770	2048	2048
Track density (TPI)	1000	1070	800	1290	1290
Maximum linear density (BPI)	18600*	21400*	15300*	21400*	21400*
Rotational speed (RPM)	3070	3600	3620	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	15	15	16	15	15
Average rotational delay (msec)	9.8	8.3	8.3	8.3	8.3
Average access time (msec)	24.8	23.3	24.3	23.3	23.3
Data transfer rate (KBytes/sec)	1860	2460	3000	2460	2460
FIRST CUSTOMER SHIPMENT	3Q84	1988	1983	1Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Drive has 2 spindles	*2,7 RLL Code Drive has 2 spindles	*2,7 RLL Code Drive has 4 spindles	*2,7 RLL code	*2,7 RLL code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	D2373	D2377	D2463	N7765	N7767
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD	230 mm OD	230 mm OD	14"	230 mm OD
Recording medium	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	Oxide Coated	100 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	SMD-E	IPI-2	SCSI	NEC	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,415	U: 1,415	F: 1,044	F: 1,344.9	F: 635.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 51,200	U: 51,200	F: 37,888	F: 47,476	F: 32,768
Data surfaces per spindle	13.5	13.5	13.5	9.5	11.5
Heads per data surface	2/1	2/1	2/1	2	2
Tracks per surface	2048	2048	2048	2982	1686
Track density (TPI)	1290	1290	1290	1200	1070
Maximum linear density (BPI)	26800*	26800*	21400*	16100*	21400*
Rotational speed (RPM)	3600	3600	3600	3620	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	15	15	15	17	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	23.3	25.3	23.3
Data transfer rate (KBytes/sec)	3070	3070	2460	3000	19600
FIRST CUSTOMER SHIPMENT	3Q87	4Q87	3Q87	9/86	1988
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*1,7 RLL Code	*1,7 RLL Code	*2,7 RLL code	*2,7 RLL Code Drive has 4 spindles	*2,7 RLL Code Drive has 8 spindles Parallel array

	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA
MANUFACTURER					
DRIVE					
	NDR 1085	NDR 4175E	NDR 4175S	NDR 1140	NDR 2190
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Ferrite	Ferrite
Interface	ST412	ESDI	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.33	U: 179.38	F: 149.15	U: 143.43	U: 191.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,937	F: 17,408	U: 10,416	U: 10,416
Data surfaces per spindle	8	7	7	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1224	1224	918	1224
Track density (TPI)	995	1020	1020	995	1022
Maximum linear density (BPI)	9934	21975 BPI* 14650 FCI	21975 BPI* 14650 FCI	9280	11155
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)	26	19.8	19.8	25	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	34.3	28.1	28.1	33.3	36.3
Data transfer rate (KBytes/sec)	625	1250	1500	625	625
FIRST CUSTOMER SHIPMENT	1Q86	2Q87	1Q88	4Q84	1Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Licensed from Maxtor	*2,7 RLL Code	*2,7 RLL Code	Licensed from Maxtor	Licensed from Maxtor

MANUFACTURER	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NORTHERN TELECOM
DRIVE	NDR 4380E	NDR 4380S	NDR 6380E	NDR 6380S	8208X
DISK/TREND GROUP	7	7	7	7	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	200 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	63.5 mm ID Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 384.4	F: 319.61	U: 384.4	F: 332.0	SCSI(F): 142.0 (U): 187.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,937	F: 17,408	U: 31,406	F: 27,644	U: 21,912
Data surfaces per spindle	15	15	15	15	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	816	816	1069
Track density (TPI)	1020	1020	1020	1020	1039
Maximum linear density (BPI)	21975 BPI* 14650 FCI	21975 BPI* 14650 FCI	24849 BPI* 16566 FCI	24849 BPI* 16566 FCI	10238
Rotational speed (RPM)	3600	3600	3600	3600	3313.5
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Torque Motor
Average positioning time (msec)	19.8	19.8	16.4	16.4	19.5 (256 byte sector)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	9
Average access time (msec)	28.1	28.1	24.7	24.7	28.5
Data transfer rate (KBytes/sec)	1250	1500	1875	5000 Max.	1209
FIRST CUSTOMER SHIPMENT	2Q87	4Q87	3Q88	4Q88	9/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$3,040
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	Embedded Servo

MANUFACTURER	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
DRIVE	8210X	8212X	8308	8312	8412
DISK/TREND GROUP	6	7	7	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	SMD, SCSI	SMD, SCSI	H/P-SMD, SCSI	H/P-SMD, SCSI	SMD, SCSI, IPI-2
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: 750
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	19800 BPI* 13200 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	17.5
Average rotational delay (msec)	9	9	9	9	8.2
Average access time (msec)	28.5	30	29	27	25.7
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	\$4,400	\$4,800
COMMENTS	Embedded Servo	Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo

MANUFACTURER	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY
DRIVE	8414	8512	8514	PT225	PT338
DISK/TREND GROUP	8	8	9	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	200 mm OD	95 mm OD	95 mm OD
Recording medium	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SMD, SCSI,IPI-2	SMD, SCSI,IPI-2	SMD, SCSI,IPI-2	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 925	U: 883	U: 1,090	U: 25.6	U: 38.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 41,778	U: 49,200	U: 49,200	U: 10,416	U: 10,416
Data surfaces per spindle	14	12	14	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1583	1496	1583	615	615
Track density (TPI)	1368	1312	1368	983	983
Maximum linear density (BPI)	19800 BPI* 13200 FCI	23400 BPI* 15600 FCI	23400 BPI* 15600 FCI	12218	12218
Rotational speed (RPM)	3656	3656	3656	3517	3517
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	17	17.5	16	35 (including settling)	35 (including settling)
Average rotational delay (msec)	8.2	8.2	8.2	8.5	8.5
Average access time (msec)	25.2	25.7	24.2	43.5	43.5
Data transfer rate (KBytes/sec)	2550	3000	3000	625	625
FIRST CUSTOMER SHIPMENT	11/87	3/87	11/87	3Q86	3Q86
U.S. OEM PRICE FOR 100 UNITS	\$5,400	\$5,400	\$6,300	--	--
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	41 mm high Embedded Servo	41 mm high Embedded Servo

MANUFACTURER	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY
DRIVE	PT351	PT357R	PT238A	PT238R	PT238S
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	PC AT	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.2	U: 57.6*	F: 32.7	U: 38.4*	F: 31.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624*	F: 13,312	U: 15,624*	F: 12,800
Data surfaces per spindle	6	6	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	820	615	615	615	615
Track density (TPI)	983	983	983	983	983
Maximum linear density (BPI)	14479	18327 BPI* 12218 FCI	18327 BPI* 12218 FCI	18327 BPI* 12218 FCI	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*	937.5	937.5*	937.5
FIRST CUSTOMER SHIPMENT	9/87	3Q86	1988	3Q86	1988
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high Embedded Servo	41 mm high *With RLL controller Embedded Servo	41 mm high *2,7 RLL Code	41 mm high *With RLL controller Embedded Servo	41 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY
DRIVE					
	PT251A	PT251R	PT251S	PT357A	PT357S
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	ST412	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43.7	U: 51.2*	F: 41.8	F: 49.1	F: 47.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 15,624*	F: 12,800	F: 13,312	F: 12,800
Data surfaces per spindle	4	4	4	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	820	615	615
Track density (TPI)	983	983	983	983	983
Maximum linear density (BPI)	21719 BPI*	21719 BPI*	21719 BPI*	18327 BPI*	18327 BPI*
Rotational speed (RPM)	14479 FCI 3517	14479 FCI 3517	14479 FCI 3517	12212 FCI 3517	12218 FCI 3517
PERFORMANCE					
Actuator type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)
Average rotational delay (msec)	8.5	8.5	8.5	8.5	8.5
Average access time (msec)	43.5	43.5	43.5	43.5	43.5
Data transfer rate (KBytes/sec)	937.5	937.5*	937.5	937.5	937.5
FIRST CUSTOMER SHIPMENT	1988	1988	1988	1988	1988
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	41 mm high *With RLL controller Embedded Servo	41 mm high *2,7 RLL Code Embedded Servo	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY
DRIVE	PT376A	PT376R	PT376S	PT4102A	PT4102S
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	ST412	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 65.5	U: 76.8*	F: 62.7	F: 85.6	F: 85.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 15,624*	F: 12,800	F: 13,312	F: 13,312
Data surfaces per spindle	6	6	6	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	820	820	820
Track density (TPI)	983	983	983	903	903
Maximum linear density (BPI)	21719 BPI*	21719 BPI*	21719 BPI*	18327*	18327*
Rotational speed (RPM)	14479 FCI 3517	14479 FCI 3517	14479 FCI 3517	3517	3517
PERFORMANCE					
Actuator type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)
Average rotational delay (msec)	8.5	8.5	8.5	8.5	8.5
Average access time (msec)	43.5	43.5	43.5	43.5	43.5
Data transfer rate (KBytes/sec)	937.5	937.5*	937.5	937.5	937.5
FIRST CUSTOMER SHIPMENT	1988	3Q87	1988	1988	1988
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	41 mm high *With RLL controller Embedded Servo	41 mm high *2,7 RLL Code Embedded Servo	41 mm high *2,7 RLL Code Embedded controller	41 mm high *2,7 RLL Code Embedded controller

MANUFACTURER	PERIPHERAL TECHNOLOGY	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT
DRIVE	PT4102R	Hardcard 20	Plus Passport	Hardcard 40	Plus Passport
DISK/TREND GROUP	6	3	3	4	4
MARKET	OEM	PCM, OEM	PCM, OEM	PCM, OEM	PCM, OEM
MEDIA: Generic type	Fixed	Drive On Card	Removable Drive	Drive On Card	Removable Drive
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID	25 mm ID	25 mm ID Thin Film	25 mm ID
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	IBM PC	IBM PC	IBM PC	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 102.4*	F: 21.2	--	F: 42.26	--
REMOVABLE	--	--	F: 21.4	--	F: 42.6
Capacity per track (Bytes)	U: 19,968*	F: 8,704	F: 14,336 and 17,408	F: 14,336 and 17,408	F: 14,336 and 17,408
Data surfaces per spindle	8	4	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	820	615	612	612	612
Track density (TPI)	983	812	812	812	812
Maximum linear density (BPI)	18327	13917 BPI* 9278 FCI	21524 and 22392*	21524 and 22392*	21524 and 22392*
Rotational speed (RPM)	3517	3600	3000	3000	3000
PERFORMANCE					
Actuator type	Linear, DC Motor	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	35 (including settling)	49 (including settling)	40**	40	40**
Average rotational delay (msec)	8.5	8.3	10	10	10
Average access time (msec)	43.5	57.3	50	50	50
Data transfer rate (KBytes/sec)	937.5	625	843.7/1031	843.7/1031	843.7/1031
FIRST CUSTOMER SHIPMENT	1988	6/86	6/88	5/87	6/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *With RLL controller	*2,7 RLL Code	*2,7 RLL Code Drive with adapter mounts in half high 5.25" slot **About 27 msec using cache	*2,7 RLL Code	*2,7 RLL Code Drive with adapter mounts in half high 5.25" slot **About 27 msec using cache

MANUFACTURER	PRAIRIETEK	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE					
	220	803	7050	V160	V185A
DISK/TREND GROUP	3	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	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	Thin Film	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI, PC AT	Priam, SMD	Priam, SMD	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20	U: 85.68	U: 70.49	U: 60.7	U: 85.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,192	U: 20,160	U: 13,400	U: 10,416	U: 10,416
Data surfaces per spindle	4	5	5	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	612	850	1049	1166	1166
Track density (TPI)	1150	960	960	1047	1047
Maximum linear density (BPI)	22500 BPI* 15000 FCI	9167	6597	10526	10526
Rotational speed (RPM)	3367	3600	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)	28	35	42	28	28
Average rotational delay (msec)	8.9	8.3	8.3	8.3	8.3
Average access time (msec)	36.9	43.3	50.3	36.3	36.3
Data transfer rate (KBytes/sec)	625	1209	806	625	625
FIRST CUSTOMER SHIPMENT	4Q88	9/83	4Q81	2Q87	3Q84
U.S. OEM PRICE FOR 100 UNITS	--	\$2,950	\$3,280	\$630	\$720
COMMENTS	25 mm high *2,7 RLL Code Embedded Servo Ramp loaded heads				

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE					
	519	617	628	717	728
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	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*	21848 BPI*	21848 BPI*	21848 BPI*
Rotational speed (RPM)	3600	14565 FCI 3600	14565 FCI 3600	14565 FCI 3600	14565 FCI 3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	22	18	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	30.3	26.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	625	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	1Q86	4Q86	4Q86	1Q87	4Q86
U.S. OEM PRICE FOR 100 UNITS	\$1,675	\$1,560	\$1,915	\$1,670	\$2,030
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE	806	15450	638	738	807
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	200 mm OD	14"	130 mm OD	130 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	Oxide Coated	40 mm ID Thin Film	40 mm ID Thin Film	63.5 mm ID Oxide Coated
DRIVE: 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	18	18	25
Average rotational delay (msec)	8.3	9.7	8.3	8.3	8.3
Average access time (msec)	28.3	55.7	26.3	26.3	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	\$4,480	\$2,270	\$2,390	\$4,105
COMMENTS			*2,7 RLL Code	*2,7 RLL Code	

MANUFACTURER	PRIAM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	776	40AT ProDrive	40S ProDrive	80AT ProDrive	80S ProDrive
DISK/TREND GROUP	8	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 762	F: 42	F: 42	F: 84	F: 84
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,250	**	**	**	**
Data surfaces per spindle	15	3	3	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	834	834	834	834
Track density (TPI)	1400	1000	1000	1000	1000
Maximum linear density (BPI)	32330 BPI* 21553 FCI	22050 BPI* 14700 FCI	22050 BPI* 14700 FCI	22050 BPI* 14700 FCI	22050 BPI* 14700 FCI
Rotational speed (RPM)	3600	3662	3662	3662	3662
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	14	19	19	19	19
Average rotational delay (msec)	8.3	8.2	8.2	8.2	8.2
Average access time (msec)	22.3	27.2	27.2	27.2	27.2
Data transfer rate (KBytes/sec)	4000 Max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	4Q88	5/88	1/88	5/88	1/88
U.S. OEM PRICE FOR 100 UNITS	\$2,895	\$520	\$520	\$845	\$845
COMMENTS	*2,7 RLL Code	*2,7 RLL Code **Varies by zone	*2,7 RLL Code **Varies by zone	*2,7 RLL Code **Varies by zone	*2,7 RLL Code **Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE					
	Q250	Q280	100E ProDrive	120AT ProDrive	120S ProDrive
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film		Thin Film
Interface	SCSI	SCSI	ESDI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 53.4	F: 80.1	U: 115	F: 120	F: 120
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	U: 20,554	**	**
Data surfaces per spindle	4	6	5	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	815	815	1119	1119	1119
Track density (TPI)	876	876	1400	1400	1414
Maximum linear density (BPI)	20000 BPI* 15000 FCI	20000 BPI* 15000 FCI	27740 BPI* 20810 FCI	27740 BPI* 20810 FCI	27740 BPI* 20810 FCI
Rotational speed (RPM)	3600	3600	3605	3605	3605
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	26	26	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	34.3	34.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1250	1250	1250	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	4/86	4/86	4Q88	4Q88	4Q88
U.S. OEM PRICE FOR 100 UNITS	\$750 (1000)	\$850 (1000)	\$900	\$1000	\$1000
COMMENTS	41 mm high *1,7 RLL Code Embedded Servo	41 mm high *1,7 RLL Code Embedded Servo	*1,7 RLL Code	*1,7 RLL Code **Varies by zone	*1,7 RLL Code **Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	RICOH	RICOH
DRIVE	145E ProDrive	170AT ProDrive	170S ProDrive	RH5130	RH5260 RH5261
DISK/TREND GROUP	6	6	6	1	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	5.25" Cartridge	5.25" Cartridge
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	ESDI	PC AT	SCSI	ST412	ST506, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 165	F: 168	F: 168	--	--
REMOVABLE	--	--	--	U: 12.75	U: 25.5
Capacity per track (Bytes)	U: 20,554	**	**	U: 10,416	U: 10,416
Data surfaces per spindle	7	7	7	2	1
Heads per data surface	1	1	1	1	2
Tracks per surface	1119	1119	1119	612	1224
Track density (TPI)	1414	1414	1414	612	1222
Maximum linear density (BPI)	27740 BPI* 20810 FCI	27740 BPI* 20810 FCI	27740 BPI* 20810 FCI	10894	10894
Rotational speed (RPM)	3605	3605	3605	3473	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	16	16	16	98 (including settling)	98 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.6	8.6
Average access time (msec)	24.3	24.3	24.3	106.6	106.6
Data transfer rate (KBytes/sec)	1250	4000 max.	4000 max.	625	625
FIRST CUSTOMER SHIPMENT	4Q88	4Q88	4Q88	3Q85	1987
U.S. OEM PRICE FOR 100 UNITS	\$1100	\$1,200	\$1,200	--	--
COMMENTS	*1,7 RLL Code	*1,7 RLL Code **Varies by zone	*1,7 RLL Code **Varies by zone	41 mm high Embedded Servo DMA License	41 mm high Embedded Servo RH5261 has SCSI interface

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE	20 Plus 200 RX	R0652B	R0651	R0652	R0751
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	96 mm OD	96 mm OD	96 mm OD	96 mm OD	96 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.3	F: 20.68	F: 10.65	F: 21.3	F: 10.65
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 17,408	F: 16,896	F: 16,896	F: 16,896
Data surfaces per spindle	4	4	2	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	305	306	306	306	306
Track density (TPI)	600	600	600	600	600
Maximum linear density (BPI)	22100 BPI*	22100 BPI*	22100 BPI*	22100 BPI*	22100 BPI*
Rotational speed (RPM)	14700 FCI 2750	14700 FCI 2700	14700 FCI 2700	14700 FCI 2700	14700 FCI 2700
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)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	10.9	10.9	10.9	10.9	10.9
Average access time (msec)	95.9	95.9	95.9	95.9	95.9
Data transfer rate (KBytes/sec)	937.5	937.5	937.5	937.5	937.5
FIRST CUSTOMER SHIPMENT	1986	4Q85	1985	1985	1985
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE	R0752	45 Plus 450 RX	R03045	R03055	R03055A
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	96 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI	ST412	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.3	F: 45.3	U: 45.42	U: 54.5	F: 46.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 13,312	U: 10,417	U: 10,417	F: 14,848
Data surfaces per spindle	4	5	5	6	3
Heads per data surface	1	1	1	1	1
Tracks per surface	306	680	872	872	1053
Track density (TPI)	600	1040	1040	1040	1380
Maximum linear density (BPI)	22100 BPI*	18750 BPI*	15072	15072	23775 BPI*
Rotational speed (RPM)	14700 FCI 2700	12500 FCI 3433	3600	3600	15850 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	28	28	28	24
Average rotational delay (msec)	10.9	8.7	8.3	8.3	8.3
Average access time (msec)	95.9	36.7	36.3	36.3	32.3
Data transfer rate (KBytes/sec)	937.5	937.5	625	625	1060
FIRST CUSTOMER SHIPMENT	1985	1987	1Q87	1Q87	9/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	41 mm high	41 mm high	41 mm high *2,7 RLL Code

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03057S	R03065	R03090A	60 Plus 600 RX	R03085A
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ST412	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 45.3	U: 63.6	F: 78	F: 61.8	F: 78.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 10,417	F: 14,848	F: 16,896	F: 14,848
Data surfaces per spindle	5	7	5	3	5
Heads per data surface	1	1	1	1	1
Tracks per surface	680	872	1053	1219	1053
Track density (TPI)	1040	1040	1380	1100	1380
Maximum linear density (BPI)	18750 BPI* 12500 FCI	15072	23775 BPI* 15850 FCI	20050 BPI* 13366 FCI	23775 BPI* 15850 FCI
Rotational speed (RPM)	3433	3600	3600	2700	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	24	28	24
Average rotational delay (msec)	8.73	8.3	8.3	11.1	8.3
Average access time (msec)	36.73	36.3	32.3	39.1	32.3
Data transfer rate (KBytes/sec)	937.5	625	1060	937.5	1060
FIRST CUSTOMER SHIPMENT	1Q87	4Q86	9/88	1987	9/88
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	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	41 mm high *2,7 RLL Code

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03085S	R05090	100 Plus 1000 RX	140 Plus 1400 RX	R03130S
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ST412, ESDI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 69.9	U: 89.2	F: 102.9	F: 144.1	F: 105
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 10,417	F: 16,896	F: 16,896	F: 14,848
Data surfaces per spindle	7	7	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	750	1224	1219	1219	1053
Track density (TPI)	1040	1100	1100	1100	1380
Maximum linear density (BPI)	19950 BPI* 13300 FCI	10024	20050 BPI* 13366 FCI	20050 BPI* 13366 FCI	23775 BPI* 15850 FCI
Rotational speed (RPM)	3433	3600	2700	2700	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	24
Average rotational delay (msec)	8.73	8.3	11.1	11.1	8.3
Average access time (msec)	36.73	36.3	39.1	39.1	32.3
Data transfer rate (KBytes/sec)	937.5	625	937.5	937.5	1060
FIRST CUSTOMER SHIPMENT	3Q87	2Q87	1987	1987	9/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	41 mm high	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	41 mm high *2,7 RLL Code

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03130A	R05125E	R05125S	R05130R	R05180E
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	ESDI	SCSI	ST412, ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 109.4	U: 127.4	F: 102.98	U: 133*	U: 178.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 14,848	U: 20,833	F: 16,896	U: 15,625*	U: 20,833
Data surfaces per spindle	7	5	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1053	1224	1219	1224	1224
Track density (TPI)	1380	1100	1100	1100	1100
Maximum linear density (BPI)	23775 BPI* 15850 FCI	20050 BPI* 13366 FCI	20050 BPI* 13366 FCI	15036 BPI* 10024 FCI	20050 BPI* 13366 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	24	22	24	28	22
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	32.3	30.3	32.3	36.3	30.3
Data transfer rate (KBytes/sec)	1060	1250	1250	937.5*	1250
FIRST CUSTOMER SHIPMENT	9/88	2/88	2Q87	2/88	2/88
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 *2,7 RLL Code	41 mm high *With RLL controller	41 mm high *2,7 RLL Code

MANUFACTURER	RODIME	RODIME	RODIME	SAGEM	SAGEM
DRIVE					
	R05180S	R08067	R08074	MSA 240-25	MSA 240-50
DISK/TREND GROUP	6	8	8	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	210 mm OD	210 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SCSI	Modified SMD	Modified SMD	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 144.17	U: 674	U: 741	F: 25	F: 50
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	U: 40,960	U: 40,960	F: 14,848	F: 14,848
Data surfaces per spindle	7	10	11	4	8
Heads per data surface	1	1	1	8	8
Tracks per surface	1219	1646	1646	464	464
Track density (TPI)	1100	1270	1270	620	620
Maximum linear density (BPI)	20050 BPI* 13366 FCI	20540 BPI* 13693 FCI	20540 BPI* 13693 FCI	13110	13110
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	24	18	18	17	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	32.3	26.3	26.3	25.3	25.3
Data transfer rate (KBytes/sec)	1250	2458	2458	1500	1500
FIRST CUSTOMER SHIPMENT	2Q87	1Q87	2/88	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	Militarized Subsystem	Militarized Subsystem

MANUFACTURER	SAGEM	SAGEM	SAGEM	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE					
	MSA 250-50	MSA 250-100	MSA 252-200	SHD2040M	SHD2040R
DISK/TREND GROUP	4	6	6	4	4
MARKET	OEM	OEM	OEM	OEM, Captive	OEM, Captive
MEDIA: Generic type	Special	Special	Special	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	U: 34.16	U: 51.24*
REMOVABLE	F: 50	F: 100	F: 200	--	--
Capacity per track (Bytes)	F: 14,848	F: 14,848	F: 23,040	U: 10,416	U: 15,624*
Data surfaces per spindle	8	16	16	4	4
Heads per data surface	8	8	8	1	1
Tracks per surface	464	464	720	820	820
Track density (TPI)	620	620	950	1065	1065
Maximum linear density (BPI)	13110	13110	19680	13464	20196 BPI* 13464 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3568
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	17	17	17	35	35
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	25.3	25.3	25.3	43.3	43.3
Data transfer rate (KBytes/sec)	1500	1500	1500	625	937.5*
FIRST CUSTOMER SHIPMENT	1Q87	1Q89	1Q89	--	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Militarized Subsystem Removable Head/Disk Module	Militarized Subsystem Removable Head/Disk Module	Militarized Subsystem Removable Head/Disk Module	41 mm high	41 mm high *With RLL controller

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE					
	ST125	ST213	ST225	ST225N	ST4026
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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.6	U: 12.8	U: 25.6	F: 21.4	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	F: 8,704	U: 10,416
Data surfaces per spindle	4	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	615
Track density (TPI)	824	588	588	588	625
Maximum linear density (BPI)	15500	9827	9827	9827	9617
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Linear, Voice Coil
Average positioning time (msec)	30 (including settling)	65 (including settling)	65 (including settling)	65 (including settling)	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	73.3	73.3	73.3	48.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q87	4Q85	10/84	4Q85	11/84
U.S. OEM PRICE FOR 100 UNITS	\$305 (500)	\$250 (500)	\$260 (500)	\$355 (500)	\$490 (500)
COMMENTS	41 mm high	41 mm high	41 mm high	41 mm high	

1988 DISK/TREND REPORT

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST138	ST138N	ST138R	ST157N	ST157R
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	ST412	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.4	F: 32.3	U: 38.4*	F: 48.6	U: 57.7*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 13,312	U: 15,624*	F: 13,312	U: 15,624*
Data surfaces per spindle	6	4	4	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	613	615	613	615
Track density (TPI)	824	824	824	824	824
Maximum linear density (BPI)	15500	23250 BPI* 15500 FCI	23250 BPI* 15500 FCI	23250 BPI* 15500 FCI	23250 BPI* 15500 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	30 (including settling)	30 (including settling)	30 (including settling)	30 (including settling)	30 (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	38.3
Data transfer rate (KBytes/sec)	625	937.5	937.5*	937.5	937.5*
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	3Q87	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$350 (500)	\$425 (500)	\$325 (500)	\$525 (500)	\$460 (500)
COMMENTS	41 mm high	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

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST238R	ST250R	ST251	ST251-1	ST251N
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	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.4*	U: 50.02*	U: 51.2	U: 51.2	F: 43.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 18,750*	U: 10,416	U: 10,416	F: 13,312
Data surfaces per spindle	4	4	6	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	667	820	820	818
Track density (TPI)	588	588	777	777	777
Maximum linear density (BPI)	14740 BPI* 9827 FCI	18897 BPI* 12598 FCI	9935	9935	14902 BPI* 9935 FCI
Rotational speed (RPM)	3600	3000	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)	65 (including settling)	70 (including settling)	40 (including settling)	30 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	10	8.3	8.3	8.3
Average access time (msec)	73.3	80	48.3	38.3	48.3
Data transfer rate (KBytes/sec)	937.5*	937.5*	625	625	937.5
FIRST CUSTOMER SHIPMENT	1Q86	3Q88	2Q86	3Q87	1/87
U.S. OEM PRICE FOR 100 UNITS	\$265 (500)	--	\$450 (500)	\$520 (500)	\$520 (500)
COMMENTS	41 mm high *With RLL controller	41 mm high *With RLL controller	41 mm high	41 mm high	41 mm high *2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST251R	ST4038	ST4051	ST4053	ST277N
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
	40 mm ID	40 mm ID	40 mm ID	40 mm ID	40 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.2*	U: 38.2	U: 50.9	U: 53.3	F: 64.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 10,416	U: 10,416	U: 10,416	F: 13,312
Data surfaces per spindle	4	5	5	5	6
Heads per data surface	1	1	1	1	1
Tracks per surface	820	733	977	1024	818
Track density (TPI)	777	750	960	1031	777
Maximum linear density (BPI)	14902 BPI*	9617	9720	9792	14902 BPI*
	9935 FCI				9935 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Band, Stepping Motor
Average positioning time (msec)	40 (including settling)	40	40	28	40 (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	36.3	48.3
Data transfer rate (KBytes/sec)	937.5*	625	625	625	937.5
FIRST CUSTOMER SHIPMENT	3Q87	1/85	1/85	1/87	1/87
U.S. OEM PRICE FOR 100 UNITS	\$425 (500)	\$560 (500)	\$605 (500)	--	\$565 (500)
COMMENTS	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	ST4096	ST4096N	ST4144N
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	ST412	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 76.9*	F: 85.0	U: 96	F: 83.9	F: 126.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	F: 17,408	U: 10,416	F: 18,432	F: 18,432
Data surfaces per spindle	6	6	9	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	820	818	1024	1147	1147
Track density (TPI)	777	777	1031	1047	1047
Maximum linear density (BPI)	14902 BPI* 9935 FCI	19869 BPI* 13246 FCI	9792	20078 BPI* 13385 FCI	20078 BPI* 13385 FCI
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)	28	17	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	38.3	36.3	25.3	25.3
Data transfer rate (KBytes/sec)	937.5*	1250	625	1250	1250
FIRST CUSTOMER SHIPMENT	3Q86	4Q87	1Q86	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$465 (500)	\$950	\$880 (500)	\$1,000 (500)	\$1,100 (500)
COMMENTS	41 mm high *With RLL controller	41 mm high *2,7 RLL Code		*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEIKO EPSON	SEIKO EPSON
DRIVE	ST4144R	ST4192E	ST4192N	HMD-720	HMD-726
DISK/TREND GROUP	6	6	6	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 Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ESDI	SCSI	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 144*	U: 191.1	F: 168.5	U: 25.5	F: 20.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 20,832	F: 18,432	U: 10,416	F: 8,448
Data surfaces per spindle	9	8	8	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1147	1147	615	615
Track density (TPI)	1031	1047	1047	910	910
Maximum linear density (BPI)	14688 BPI*	20078 BPI*	20078 BPI*	12900	13791
Rotational speed (RPM)	9792 FCI 3600	13385 FCI 3600	13385 FCI 3600	3528	3300
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor
Average positioning time (msec)	28	17	17	69 (including settling)	80 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.5	9.1
Average access time (msec)	36.3	25.3	25.3	77.5	89.1
Data transfer rate (KBytes/sec)	937.5*	1250	1250	625	625
FIRST CUSTOMER SHIPMENT	3Q87	--	3Q87	3Q86	4Q86
U.S. OEM PRICE FOR 100 UNITS	\$1,000 (500)	--	\$1,200 (500)	--	--
COMMENTS	*With RLL controller	*2,7 RLL Code	*2,7 RLL Code	41 mm high	41 mm high

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SHINWA DIGITAL INDUSTRY
DRIVE	HMD-755	HMD-756	HMD-946	HMD-976	D110
DISK/TREND GROUP	3	3	4	5	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM PC XT	SCSI	SCSI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20.8	F: 20.8	F: 42.5	F: 70.5	U: 12.75
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 17,408	F: 13,824	F: 13,824	U: 10,416
Data surfaces per spindle	2	2	3	5	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	1025	1025	612
Track density (TPI)	910	910	1275	1275	608
Maximum linear density (BPI)	24976 BPI*	24976 BPI*	22548*	22548*	10262
Rotational speed (RPM)	16651 FCI 2650	16651 FCI 2650	3662	3662	3333
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor
Average positioning time (msec)	80 (including settling)	80 (including settling)	29	29	85 (including settling)
Average rotational delay (msec)	11.3	11.3	8.2	8.2	9
Average access time (msec)	91.3	91.3	37.2	37.2	94
Data transfer rate (KBytes/sec)	937.5	937.5	1000	1000	625
FIRST CUSTOMER SHIPMENT	1Q88	2Q88	3Q87	3Q87	2/86
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 *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high

MANUFACTURER	SHINWA DIGITAL INDUSTRY	SHINWA DIGITAL INDUSTRY	SIEMENS	SIEMENS	SIEMENS
DRIVE	D220	D440	2300	1300	4410
DISK/TREND GROUP	3	4	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	ST412	ST412	SCSI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.5	U: 51	F: 261.4	U: 310	U: 383
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 17,920	U: 21,280	U: 31,720
Data surfaces per spindle	4	8	12	12	11
Heads per data surface	1	1	1	1	1
Tracks per surface	612	615	1216	1216	1100
Track density (TPI)	608	846	1207	1207	1207
Maximum linear density (BPI)	10262	15,600	19331 BPI* 12887 FCI	19331 BPI* 12887 FCI	26907 BPI* 17997 FCI
Rotational speed (RPM)	3333	3314	3524	3524	3558
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	40 (including settling)	25	25	18
Average rotational delay (msec)	9	9	8.5	8.5	8.43
Average access time (msec)	94	49	33.5	33.5	26.43
Data transfer rate (KBytes/sec)	625	625	1250	1250	1875
FIRST CUSTOMER SHIPMENT	2/86	2Q88	4/87	1Q86	1Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	\$1,680	\$1,680	\$1,900
COMMENTS	41 mm high	41 mm high	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	SIEMENS	SIEMENS	SIEMENS	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION
DRIVE					
	4420	5710	5720	8380-BF4	8380-B04
DISK/TREND GROUP	7	8	8	9	9
MARKET	OEM	OEM	OEM	PCM	PCM, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	14"
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 322.2	U: 777	F: 677	F: 3,780	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,624	U: 31,740	F: 27,648	F: 47,476	F: 47,476
Data surfaces per spindle	11	15	15	19	15
Heads per data surface	1	1	1	2	2
Tracks per surface	1100	1632	1632		1770
Track density (TPI)	1207	1476	1476	1650	800
Maximum linear density (BPI)	26996 BPI* 17997 FCI	30825 BPI* 20550 FCI	30825 BPI* 20550 FCI	15240 BPI* 10160 FCI	15240 BPI* 10160 FCI
Rotational speed (RPM)	3558	3558	3558	3620	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	18	16	16	17	16
Average rotational delay (msec)	8.43	8.43	8.43	8.3	8.3
Average access time (msec)	26.43	24.43	24.43	25.3	24.3
Data transfer rate (KBytes/sec)	1875	1875	1875	3000	3000
FIRST CUSTOMER SHIPMENT	2Q88	4Q88	4Q88	1Q89	1983
U.S. OEM PRICE FOR 100 UNITS	\$1,900	\$3,500	\$3,650	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	PCM 3380K *2,7 RLL Code Drive has 2 spindles	PCM 3380 *2,7 RLL Code Drive has 2 spindles

MANUFACTURER	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	8380-BE4	8380-RXX	8380-BP4	SQ306RD	SQ312RD
DISK/TREND GROUP	9	9	9	1	1
MARKET	PCM, OEM	PCM	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: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	IBM	IBM	IBM	ST412	ST412
CAPACITY/RECORDING DENSITY		Subsystem: 10,080 to 30,240 in 2.52 increments			
Total capacity (Mbytes) FIXED	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	15/15/19	15	2	2
Heads per data surface	2	2	2	1	1
Tracks per surface	3540	1770/3540	1770	306	615
Track density (TPI)	1400	800/1400/1650	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)	17	12/17/17	12	90 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.46	8.46
Average access time (msec)	25.3	20.3/25.3/25.3	20.3	98.46	93.46
Data transfer rate (KBytes/sec)	3000	3000	3000	625	625
FIRST CUSTOMER SHIPMENT	6/86	1988	12/87	9/82	7/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$575 (1000)	\$550 (1000)
COMMENTS	PCM 3380-BE4 *Not announced Drive has 2 spindles	PCM 3380J,E,K. *2,7 RLL Code. Subsystem has 8 spindles. 1X or 2X or 3X by pairs.	PCM 3380J *2,7 RLL Code Drive has 2 spindles	41 mm high 4.8" Wide Embedded Servo	41 mm high 4.8" wide Embedded Servo

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	TEAC	TEAC	TOKICO
DRIVE	SQ319	SQ555	SD-521	SD-540	DK502-3
DISK/TREND GROUP	1	1	3	4	3
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	3.9" Cartridge	Syquest Q-Pak	Fixed	Fixed	Fixed
Nominal disk diameter	100 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM PC	SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	U: 25.62	U: 51.25	U: 26.6
REMOVABLE	U: 19.1	F: 44.5	--	--	--
Capacity per track (Bytes)	U: 15,048	F: 17,408	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	2	2	4	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	615	1278	615	615	320
Track density (TPI)	741	1086	690	690	360
Maximum linear density (BPI)	18912	23316 BPI* 15544 FCI	8940	8940	9260
Rotational speed (RPM)	3545	3280	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Band, DC Motor	Band, DC Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	25	40 (including settling)	40 (including settling)	85 (including settling)
Average rotational delay (msec)	8.46	9.15	8.3	8.3	8.3
Average access time (msec)	93.46	34.15	48.3	48.3	93.3
Data transfer rate (KBytes/sec)	937.5	1250	625	625	625
FIRST CUSTOMER SHIPMENT	7/86	3Q87	1987	1986	10/83
U.S. OEM PRICE FOR 100 UNITS	\$770	\$610 (1000)	--	--	--
COMMENTS	Includes controller, software, and mounting hardware	41 mm high *2,7 RLL Code Embedded Servo	41 mm high	41 mm high	

MANUFACTURER	TOKICO	TOKICO	TOKICO	TOKICO	TOKICO
DRIVE					
	DK503-2 TD5013	DK505-2 TD5025	TD3041C	TD3042C	TD5046 TD5046H
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	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite*	Ferrite*	Ferrite
Interface	ST412	ST412	SCSI	SCSI	ST506/412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 13.33	U: 25.5	F: 40	F: 40	U: 51.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 17,920	F: 22,528	U: 10,416
Data surfaces per spindle	4	4	3	2	8
Heads per data surface	1	1	1	1	1
Tracks per surface	320	612	904	900	615
Track density (TPI)	360	670	1175	1175	650
Maximum linear density (BPI)	9260	9490	28000**	39000**	9500
Rotational speed (RPM)	3600	3600	3600	2600	3550
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Band, Torque Motor
Average positioning time (msec)	85 (including settling)	85 (including settling)	20	28	40
Average rotational delay (msec)	8.3	8.3	8.3	11.5	8.45
Average access time (msec)	93.3	93.3	28.3	39.5	48.45
Data transfer rate (KBytes/sec)	625	625	1250	1250	625
FIRST CUSTOMER SHIPMENT	10/83	3/85	10/88	12/88	4/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high	41 mm high	41 mm high *Metal in Gap **2,7 RLL Code	25.4 mm high *Metal in Gap **2,7 RLL Code	41 mm high H version has 28 ms average positioning time

MANUFACTURER	TOKICO	TOKICO	TOKICO	TOSHIBA	TOSHIBA
DRIVE					
	TD3081C	TD3081E	TD5087	MK-132FA	MK-53FB
DISK/TREND GROUP	5	5	5	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	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: Heads	Ferrite*	Ferrite*	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	ST506/412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80	U: 94.1	U: 96	U: 22.9	U: 43.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	U: 20,800	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	5	5	8	3	5
Heads per data surface	1	1	1	1	1
Tracks per surface	904	904	1152	733	830
Track density (TPI)	1175	1175	1000	930	900
Maximum linear density (BPI)	28000**	28000**	10676	14600	9383
Rotational speed (RPM)	3600	3600	3550	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Band, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	20	35	25	25
Average rotational delay (msec)	8.3	8.3	8.45	8.3	8.3
Average access time (msec)	28.3	28.3	43.45	33.3	33.3
Data transfer rate (KBytes/sec)	1250	1250	625	625	625
FIRST CUSTOMER SHIPMENT	10/88	12/88	10/87	3Q87	3/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$895
COMMENTS	41 mm high *Metal in Gap **2,7 RLL Code	41 mm high *Metal in Gap **2,7 RLL Code	41 mm high	41 mm high	

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE					
	MK-133FA	MK-134FA	MK-54FB	MK-56FB	MK-153FA
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.2	U: 53.4	U: 60.5	U: 86.5	U: 86.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 20,832
Data surfaces per spindle	5	7	7	10	5
Heads per data surface	1	1	1	1	1
Tracks per surface	733	733	830	830	830
Track density (TPI)	930	930	900	900	900
Maximum linear density (BPI)	14600	14600	9383	9383	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	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	1250
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	3/85	3/85	4/86
U.S. OEM PRICE FOR 100 UNITS	--	\$790	\$1,020	\$1,190	\$1,325
COMMENTS	41 mm high	41 mm high			*2,7 RLL Code

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE					
	MK-153FB	MK-182FB	MK-154FA	MK-154FB	MK-156FA
DISK/TREND GROUP	5	5	6	6	6
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 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	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SMD	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 74.8	U: 83	U: 121	F: 105.2	U: 172.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 20,160	U: 20,832	F: 18,432	U: 20,832
Data surfaces per spindle	5	5	7	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	830	823	830	830	830
Track density (TPI)	900	900	900	900	900
Maximum linear density (BPI)	18766 BPI* 12510 FCI	9000 BPI* 6000 FCI	18766 BPI* 12510 FCI	18766 BPI* 12510 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	18	25	25	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	26.3	33.3	33.3	31.3
Data transfer rate (KBytes/sec)	1250	1210	1250	1250	1250
FIRST CUSTOMER SHIPMENT	9/86	2Q83	4/86	9/86	4/86
U.S. OEM PRICE FOR 100 UNITS	\$1,435	\$2,275	\$1,430	\$1,535	\$1,535
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

1988 DISK/TREND REPORT

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE					
	MK-156FB	MK-284FC	MK-184FB	MK-186FB	MK-283FC
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	Modified SMD	SMD	SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 147.8	U: 238.2	U: 116.1	U: 165.9	U: 170.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 41,340	U: 20,160	U: 20,160	U: 41,340
Data surfaces per spindle	10	7	7	10	5
Heads per data surface	1	1	1	1	1
Tracks per surface	830	823	823	823	823
Track density (TPI)	900	765	900	900	765
Maximum linear density (BPI)	18766 BPI* 12510 FCI	19300 BPI* 12867 FCI	9000 BPI* 6000 FCI	9000 BPI* 6000 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)	23	18	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	26.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	2460	1210	1210	2480
FIRST CUSTOMER SHIPMENT	9/86	4/86	2Q83	4Q83	4/86
U.S. OEM PRICE FOR 100 UNITS	\$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	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE					
	MK-256FA	MK-256FB	MK-285FC	MK-286FC	MK-287FC
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	210 mm OD	210 mm OD	210 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	Modified SMD	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 382.5	F: 316.4	U: 340.2	U: 374.3	U: 442.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,248	F: 26,112	U: 41,340	U: 41,340	U: 41,340
Data surfaces per spindle	10	10	10	11	13
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1223	823	823	823
Track density (TPI)	1330	1330	765	765	765
Maximum linear density (BPI)	27872 BPI*	27800*	19300 BPI* 12867 FCI	19300 BPI* 12867 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)	1875	1875	2460	2460	2460
FIRST CUSTOMER SHIPMENT	2Q88	3Q88	9/86	4/86	4/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$3,235	--
COMMENTS	*1,7 RLL Code	*1,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	TOSHIBA	TOSHIBA	UNISYS	UNISYS	UNISYS
DRIVE					
	MK-288FC	MK-388FA	9484-13	9494-12	9494-24
DISK/TREND GROUP	8	8	2	9	9
MARKET	Captive, OEM	OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	3336-11	Fixed	Fixed
Nominal disk diameter	210 mm OD	210 mm OD	14"	14"	14"
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	Modified SMD	SMD	Burroughs	Burroughs	Burroughs
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 510.3	U: 720.6	--	F: 870	F: 1,740
REMOVABLE	--	--	F: 252	--	--
Capacity per track (Bytes)	U: 41,340	U: 41,240	F: 16,200	F: 32,781	F: 32,781
Data surfaces per spindle	15	15	19	15	15
Heads per data surface	1	1	1	2	2
Tracks per surface	823	1161	815	1768	3538
Track density (TPI)	765	1000	384	806	1386
Maximum linear density (BPI)	19300 BPI* 12867 FCI	19528 BPI* 13019 FCI	6060	15240 BPI* 10160 FCI	16200 BPI* 10800 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	18	18	28.5	16	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	36.8	24.3	25.3
Data transfer rate (KBytes/sec)	2460	2480	1209	3000	3000
FIRST CUSTOMER SHIPMENT	4/86	12/87	1Q83	1Q85	6/87
U.S. OEM PRICE FOR 100 UNITS	\$4,195	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	B2900 B7900 B7800 B4900 A3,A9,A15 V300	B7900 B4900 A9,A10, A15,V300. *2,7 RLL Code. Drive has 2 spindles	*2,7 RLL Code Drive has 2 spindles

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WD20ifc	WD93024-A	WD93028-A	WD93028-X	WD30ifc
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Drive On Card	Fixed	Fixed	Fixed	Drive On Card
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM PC	IBM AT	IBM AT	IBM PC	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.62	F: 21.62	F: 21.62	F: 21.62	F: 32.43
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 13,824	F: 13,824	F: 13,824	F: 13,824
Data surfaces per spindle	2	2	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	782	782	782	782	615
Track density (TPI)	1013	1013	1013	1013	804
Maximum linear density (BPI)	20608 BPI*	21406 BPI*	20672 BPI*	20672 BPI*	20715 BPI*
Rotational speed (RPM)	13739 FCI 3568	14270 FCI 3435	13781 FCI 3557	13781 FCI 3557	13810 FCI 3568
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	61.6	19.3	61.6	61.6	51.6
Average rotational delay (msec)	8.4	8.7	8.4	8.4	8.4
Average access time (msec)	70	28	70	70	60
Data transfer rate (KBytes/sec)	937.5	937.5	937.5	937.5	937.5
FIRST CUSTOMER SHIPMENT	2/86	8/88	4/88	1/88	4/86
U.S. OEM PRICE FOR 100 UNITS	\$355 (2500)	\$385 (2500)	\$301 (2500)	\$264 (2500)	\$375 (2500)
COMMENTS	*2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WD40ifc	WD93038-X	WD93044-A	WD93048-A	WD93048-X
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Drive On Card	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM PC	IBM PC	IBM AT	IBM AT	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43.24	F: 32.43	F: 43.24	F: 43.24	F: 43.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 13,824	F: 13,824	F: 13,824	F: 13,824
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	782	615	782	782	782
Track density (TPI)	1013	804	1013	1013	1013
Maximum linear density (BPI)	20608 BPI* 13739 FCI	20715 BPI* 13810 FCI	21406 BPI* 14270 FCI	20672 BPI* 13781 FCI	20672 BPI* 13781 FCI
Rotational speed (RPM)	3568	3557	3435	3557	3557
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	61.6	51.6	19.3	61.6	61.6
Average rotational delay (msec)	8.4	8.4	8.7	8.4	8.4
Average access time (msec)	70	60	28	70	70
Data transfer rate (KBytes/sec)	937.5	937.5	937.5	937.5	937.5
FIRST CUSTOMER SHIPMENT	7/88	6/88	8/88	6/88	6/88
U.S. OEM PRICE FOR 100 UNITS	\$395 (2500)	\$293 (2500)	\$422 (2500)	\$359 (2500)	\$322 (2500)
COMMENTS	*2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code	41 mm high *2,7 RLL Code

MANUFACTURER	XEBEC	XEBEC	XEBEC	Y-E DATA	Y-E DATA
DRIVE					
	Owl II	Owl 40AT	Owl 40XT	YD-3042	YD-3540
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SASI	SASI	SASI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.3	F: 40	F: 40	F: 43.52	U: 53.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	F: 11,264	F: 11,264	F: 14,336	U: 10,416
Data surfaces per spindle	4	4	4	4	7
Heads per data surface	1	1	1	1	1
Tracks per surface	612	888	888	788	731
Track density (TPI)	736	800	800	1104	1019
Maximum linear density (BPI)	8845	13120	13120	22391 BPI* 14927 FCI	13200
Rotational speed (RPM)	3600	3662	3662	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, DC Motor	Rotary, DC Motor
Average positioning time (msec)	65 (including settling)	40	65 (including settling)	28	29
Average rotational delay (msec)	8.3	8.2	8.2	8.3	8.3
Average access time (msec)	73.3	48.2	73.2	36.3	37.3
Data transfer rate (KBytes/sec)	625	625	625	1062	625
FIRST CUSTOMER SHIPMENT	4/86	8/87	8/87	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41 mm high	41 mm high	41 mm high	41 mm high *2,7 RLL Code Embedded Servo	41 mm high

MANUFACTURER	Y-E DATA			
DRIVE	YD-3082			
DISK/TREND GROUP	5			
MARKET	OEM			
MEDIA: Generic type	Fixed			
Nominal disk diameter	95 mm OD			
Recording medium	25 mm ID Thin Film			
DRIVE: Heads	Ferrite			
Interface	SCSI			
CAPACITY/RECORDING DENSITY				
Total capacity (Mbytes) FIXED	F: 87.04			
REMOVABLE	--			
Capacity per track (Bytes)	F: 14,336			
Data surfaces per spindle	8			
Heads per data surface	1			
Tracks per surface	788			
Track density (TPI)	1104			
Maximum linear density (BPI)	22391 BPI*			
Rotational speed (RPM)	14927 FCI 3600			
PERFORMANCE				
Actuator type	Rotary, DC Motor			
Average positioning time (msec)	28			
Average rotational delay (msec)	8.3			
Average access time (msec)	36.3			
Data transfer rate (KBytes/sec)	1062			
FIRST CUSTOMER SHIPMENT	2Q88			
U.S. OEM PRICE FOR 100 UNITS	--			
COMMENTS	41 mm high *2,7 RLL Code Embedded Servo			

MANUFACTURER PROFILES

All manufacturers now producing moving head rigid magnetic disk drives, or which have indicated specific plans to enter the market, are listed in this section. The heading "1987 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. "1987 total net sales" covers the fiscal year ending December 31, 1987, 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 1987 is used, as reported by the U.S. Federal Reserve Bulletin and rounded to three significant figures.

<u>Country</u>	<u>Currency</u>	<u>Currency units per U.S. dollar</u>
Canada	Dollar	1.33
France	Franc	6.01
Italy	Lira	1297.00
Japan	Yen	145.00
South Korea	Won	826.00
Taiwan	Dollar	31.8
United Kingdom	Pound	0.610
West Germany	Deutsch mark	1.80

U.S. Manufacturers

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

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

AMPEX CORPORATION
401 Broadway
Redwood City, CA 94063

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

AREAL TECHNOLOGY, INC.
3050 Scott Boulevard
Santa Clara, CA 95054

Areal Technology is a new startup company founded by Jack Swartz, an industry veteran and co-founder of Maxtor. The company is developing 3.5" high-end disk drives employing very high areal densities. The initial target is development of a single disk 100 megabyte drive for production start in first quarter of 1989, followed by a 200 megabyte drive later in the year. Very low power consumption is also planned, with laptop computers in mind.

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 establish 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. The Atasi products were sold to Western Digital along with Tandon's other disk drive manufacturing operations in 1987, and Western Digital subsequently licensed the Atasi products to Magnum Technology, a wholly owned subsidiary of Danbus Memory Systems.

BRAND TECHNOLOGIES, INC.
9559 Irondale Avenue
Chatsworth, CA 91311

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. Initial products included 85 and 128 megabyte full size drives. In mid-1987, Brand concluded an agreement with Hyosung Computer, a Korean firm, in which Hyosung obtained a 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. In 1988, Brand announced a line of 3.5" drives with capacities in the 50 to 150 megabyte range.

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 introduced in the fall of 1987 a family of high performance 3.5" drives with up to 127 megabytes capacity, but shipments are not expected to begin until early 1989. Cardiff has carried out extensive negotiations with potential financial partners, and recently has attracted an investment by Danbus Memory Systems.

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

1987 disk sales: \$42,100,000

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 manu-

facturing 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 1.5 gigabytes, plus product lines of the newly acquired firms and a new group of DEC compatible subsystems.

COMPORT CORPORATION
734 Sycamore Drive
Milpitas, CA 95035

Comport was founded in 1987 by several key former employees of ill-fated LaPine Technology. As a result of the current disinclination of U.S. venture capital firms to invest in the disk drive industry, Comport turned to Samsung Electronics for initial funding and a manufacturing agreement. As part of the agreement, production of at least the first two drive models will be the responsibility of Samsung. Initial products, 3.5" disk drives ranging from 51 to 85 megabyte capacities, were introduced at the Spring 1988 Comdex conference.

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

1987 disk sales: \$113,000,000	
1987 Total net sales: \$113,200,000	Net income: \$11,400,000

Conner Peripherals is pioneering the market for high performance 3.5" 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 attracted a minority investment by Compaq Computer and installed a high-volume production facility in San Jose, with first shipments in August, 1986, of a 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 acquired a second plant to manufacture 100 megabyte drives, has begun production in Singapore, and recently signed a lease for a new headquarters building. Conner has also entered into a joint venture with Olivetti, to establish an operation in Italy which will manufacture the Conner disk drive product line in Europe. The joint venture will provide captive drives to Olivetti and will have sales responsibility for OEM sales in Europe.

CONTROL DATA CORPORATION (See Imprimis Technology)

DATA GENERAL CORPORATION

4400 Computer Drive

Westboro, MA 01581

1987 disk sales: \$156,100,000

1987 total net sales: \$1,274,000,000
(FY ending 9/30/87)

Net income: (\$127,000,000)

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 and 888 megabytes in 1988. An 8" 500 megabyte drive was also introduced in 1988. Disk drive manufacturing is now located in a new facility at Durham, New Hampshire.

DIGITAL EQUIPMENT CORPORATION

146 Main Street

Maynard, MA 01754

1987 disk sales: \$724,900,000

1987 total net sales: \$9,389,444,000
(FY ending 6/30/87)

Net income: \$1,137,435,000

Until the 1980s, most revenues from DEC's internally manufactured disk drives were derived from disk cartridge drives, notably the high volume RL02 and its predecessors. However, in 1981 a new family of 14" Winchester drives appeared. The RA81, a 14" rack mounted Winchester drive with a formatted capacity of 456 megabytes was the big revenue producer for DEC until surpassed by follow-on products. The other early drive in the group is the RA60, a rack mounted disk pack drive with 205 megabytes formatted capacity. These were DEC's first internally designed and produced high-end disk drives, and the manufacturing 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 -- too late to maintain the company's disk cartridge drive market at its previous size. DEC became a major customer for 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. In mid-1988, DEC announced the 9" 1.2 gigabyte RA90, the first drive in which DEC has manufactured both the heads and media internally.

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 megabyte 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 restarted operations as DMA Technologies.

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

1987 disk sales:	\$328,100,000	
1987 total net sales:	\$8,090,000,000	Net income: \$644,000,000
	(FY ending 10/31/87)	

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

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

1987 disk sales: \$50,400,000

Ibis was one of the most ambitious of the industry's many startup 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 resour-

ces 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.

IMPRIMIS TECHNOLOGY INCORPORATED
 Subsidiary of Control Data Corporation
 8100 - 34th Avenue South
 Minneapolis, MN 55440

1987 disk sales: \$848,700,000
 1987 total net sales: \$3,366,500,000 Net income: \$19,300,000

In early 1988, Control Data indicated that it was preparing to establish its Data Storage Products Group as a separate subsidiary. The rationale given for this move was to permit a greater degree of flexibility in operations and in reacting to changing industry conditions. In September of 1988, the new subsidiary was launched as Imprimis Technology. Imprimis is now the second largest producer of OEM rigid disk drives. As CDC, 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. CDC's share of worldwide OEM revenues fell to 15.3% in 1986 from 1980's peak of 55%. But after seven years of watching its role as the leader in OEM disk drives gradually evaporate, Control Data was able to stabilize its position through installation of new management. During the last three years, CDC has maintained a flow of major new 9", 8", 5.25" and 3.5" drives, to replace declining shipments of older models.

Until this year, many of the disk drives sold by Control Data were designed and manufactured by Magnetic Peripherals, Inc., a joint venture with Honeywell, Unisys and Bull. In 1987, CDC bought out its minority partners. 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. 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 (now Laser Magnetic Storage International), an optical disk joint venture with Philips. However, majority control is now in Philips' hands.

Imprimis currently has responsibility for all of the magnetic disk drive activity of Control Data, including the high capacity 3.5" drives produced by the Rigidyne subsidiary. The minority ownership in Laser Magnetic Storage has remained with Control Data, but Imprimis will be responsible for the day-to-day interactions with LMSI.

1988 DISK/TREND REPORT

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1987 disk sales: \$6,844,400,000
1987 total net sales: \$54,217,000,000 Net income: \$5,258,000,000

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. 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. A 600 megabyte version of the 9332 became available in 1988. A 314 megabyte 5.25" model was first shipped in early 1988 for use with high-end personal computers, and later with office systems and technical workstations.

IBM's first significant OEM sales of disk drives were made in 1984, and involved the 3380 -- both Siemens and Honeywell are still buying the drive. For disk drives broadly sold on an OEM basis, it will be more difficult for IBM to establish a significant OEM disk drive business, due to tough competition and a rapidly changing market. IBM has begun to use industry standard interfaces for products that have some OEM potential, but while making IBM products more saleable, they improve the ability of other vendors to sell drives for attachment to IBM systems. IBM is still a significant, but occasional, buyer of OEM disk drives, primarily small diameter drives for personal computer systems, but the totals are down from the peak of a few years ago. Internal IBM manufacturing for small diameter disk drives has gone into high gear: 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, except for add-on 3.5" drives for the PS/2 model 25.

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 remain on a small scale, as operations are limited by a lack of financing.

KALOK CORPORATION
1287 Anvilwood Avenue
Sunnyvale, CA 94089

Kalok was founded in 1987 by Wayne Lockhart and Steve Kaczeus, a well known designer of low-end disk drives. The firm has announced 20 and 40

megabyte 3.5" drives, designed for very low manufacturing cost. Unable to obtain adequate funding from U.S. venture capital sources, the firm negotiated a manufacturing and inventory financing arrangement with Oriental Precision Company of South Korea. OPC is now manufacturing Kalok drives, with shipments of 20 megabyte drives starting in mid-1988.

LAPINE TECHNOLOGY CORPORATION
182 Topaz Avenue
Milpitas, CA 95035

1987 disk sales: \$26,400,000

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 most activities as a result of disputes between the owners, and the firm ceased all operations by the end of 1987. Kyocera has continued to produce the drives under its own name.

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

Magnum has been in existence since 1983, functioning primarily as a development company working to perfect a manufacturing process for thin film disks suitable for very high areal densities. In 1986, the firm bought a small disk production plant from National Micronetics, since supplemented with sputtering equipment purchased from Lanx when that firm failed and a disk substrate facility purchased from Seagate Technology. Extensive corporate merger activity ensued in 1988, when Magnum was merged into Danbus, a Canadian company which is publicly traded on the Vancouver stock exchange. Among other things, Magnum, Danbus and related companies now have a license from Western Digital to make the old Atasi 5.25" disk drives, a manufacturing contract with CAST to make these drives in Singapore, ownership purchased from Swan Instruments of a high capacity 8" disk drive, 49% interest in Cardiff Peripherals, and various agreements covering future disk drive operations in China.

MAXTOR CORPORATION
 150 River Oaks Parkway
 San Jose, CA 95134

1987 disk sales:	\$228,600,000	
1987 total net sales:	\$271,190,000	Net income: \$18,768,000
	(FY ending 3/27/88)	

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

Maxtor maintained its place in the spotlight by announcing a 765 megabyte 5.25" drive, with first shipments in 1987, and a 170 megabyte 3.5" drive, subsequently dropped. In 1987, the firm received wide attention in the industry for shipment delays in newer models of its 380 and 765 megabyte drives, blamed on a shortfall in promised deliveries of thin film heads. Maxtor added additional thin film head suppliers, and was able to resume normal shipments in early 1988. The delay, plus the large number of competitors in the 380 megabyte market, prevented Maxtor from obtaining the share of market it had anticipated. Another 3.5" drive, this time with 200 megabyte capacity, was announced in 1988, along with a magneto-optical 5.25" drive, maintaining the Maxtor role as a leading edge supplier of OEM disk drives. The departure of several key employees has also had some impact, but the long-term effects, if any, are yet to be determined. In order to round out its product lines, Maxtor has made sourcing arrangements with Japanese manufacturers for two optical disk drives, to supplement internally produced drives.

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

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. Telex was acquired by Memorex in early 1988 and the firm adopted its new name at that time. Memorex, now headquartered in London, includes PCM marketing operations, the Memorex Communications Division, and the flexible media operations.

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

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

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1987 disk sales: \$287,800,000
1987 total net sales: \$288,256,000 Net income: \$27,240,000

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 became a market leader in high capacity 5.25" drives -- the first firm to establish volume deliveries of 85 megabyte models. Micropolis has been the 5.25" industry leader at 85 megabytes and 170 megabytes, and is also in contention for leadership at 380 megabytes and 760 megabytes. A half high 180 megabyte drive was announced in late 1987 but suffered production delays during most of 1988. 760 megabyte 5.25" drives are promised by early 1989.

MICROSCIENCE INTERNATIONAL CORPORATION
305 North Mathilda Avenue
Sunnyvale, CA 94086

1987 disk sales: \$151,600,000

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 its own production in Taiwan for voice coil drives. Microscience appears to have weathered a management change in 1987, and as of mid-1988, the Taiwan facility was in full production.

MILTOPE CORPORATION
 1770 Walt Whitman Road
 Melville, NY 11747

Miltope manufactures both flexible and rigid disk drives for use in its line of militarized peripherals, which includes disk, tape and bubble memory subsystems. Miltope's internally manufactured Winchester drives include 5.25" and 3.5" models incorporating heads and media in removable cartridges. In 1988, Miltope announced an agreement to acquire the disk drive product line of Vermont Research.

MINISCRIBE CORPORATION
 1871 Lefthand Circle
 Longmont, CO 80501

1987 disk sales: \$361,100,000
 1987 total net sales: \$362,467,000 Net income: \$31,147,000

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" deliveries for the personal computer program. Other major OEM customers were subsequently added, but it's not been an easy life, with drastic changes in IBM's procurements in 1984, coupled with the adverse fortunes of some of Miniscribe's customers which lost market share in the personal computer wars to IBM. 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.

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 Miniscribe has returned to profitability. Miniscribe has successfully introduced a high degree of manufacturing automation into its production processes, so much so that in 1987 it formed a subsidiary, Technistar, to market its manufacturing technology in non-competing industries. As of mid-1988, the 5.25" product line extended to 780 megabytes and the 3.5" product line to 40 megabytes. Production facilities are in Singapore and Colorado.

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

1987 disk sales: \$49,700,000
 1987 total net sales: \$4,853,500,000 Net income: \$347,200,000

Northern Telecom's Memory Systems Division in Ann Arbor, Michigan, is shipping a family of high performance 8" Winchester drives, with capaci-

ties now up to 1,090 megabytes. These drives are used for captive applications with Northern Telecom and are supported with an active OEM sales program, which has been in a growth mode in 1988.

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

Pertec, a pioneer manufacturer of OEM 14" disk cartridge drives, was acquired by Triumph-Adler in early 1980. After struggling to bring its disk drive line up to date, the initial 8" Winchester drives announced a few years ago were dropped in favor of a new series of 8" high capacity drives which now extends to 1,246 megabytes capacity. Olivetti purchased Triumph-Adler in 1986 and sold Pertec to Digital Development Corporation, which integrated all operations under a single management, with the disk drive operations now under the DDC Pertec name.

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

1987 disk sales: \$72,800,000

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

PRAIRIETEK CORPORATION
2120 Miller Drive
Longmont, CO 80501

Another new startup, PrairieTek announced the first of a new breed, the 2.5" rigid disk drive, in late 1988. The capacity of the drive is 20

megabytes, and it has a 28 millisecond seek time. Laptop computers are the initial target market for PrairieTek, as the drive is not only physically small, but uses little power. The firm was established in 1986 by Terry Johnson, founder of Miniscribe.

PRIAM CORPORATION
20 West Montague Expressway
San Jose, CA 95134

1987 disk sales:	\$116,600,000	
1987 total net sales:	\$129,603,000	Net income: (\$41,334,000)
	(FY ending 6/30/87)	

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 has seen several management changes. The 5.25" product line now extends to 760 megabytes. In 1987, Priam began manufacturing drives in Taiwan, the largest U.S. disk drive manufacturer yet to do so.

QUANTUM CORPORATION
1804 McCarthy Boulevard
Milpitas, CA 95035

1987 disk sales:	\$105,100,000	
1987 total net sales:	\$188,529,000	Net income: (\$3,226,000)
	(FY ending 3/31/88)	

Quantum's original strategy was to manufacture a low-cost upgrade to the Shugart Associates 8" Winchester drives. The Quantum plan worked well, and 5.25" drives with capacities up to 40 megabytes were added in 1983, becoming the company's major product. As the Quantum full size 40 megabyte 5.25" drives peaked, the firm announced half high OEM 5.25" drives with up to 80 megabytes capacity, for delivery before the end of 1985. First shipment of these drives was late, however, and Quantum's sales growth flattened out 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. Growth resumed in 1987 and 1988 due to the success of Plus Development and new 3.5" drives. Quantum's OEM products now include 3.5" drives up to 168 megabytes (formatted) capacity.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1987 disk sales: \$1,065,700,000
1987 total net sales: \$1,257,000,000 (FY ending 6/30/88) Net income: \$77,300,000

The term "Seagate compatible" has become part of the industry's language. In 1981, Seagate shipped two thirds of the 5.25" drives produced worldwide, with 35,000 units -- and another de facto standard was created. Seagate took the lead in moving production for its high volume drives offshore to secure lower manufacturing costs. But the world changed for Seagate in mid-1984, with a sharp reduction in sales to its largest customer, IBM -- and an up-and-down buying pattern which continued in 1985. Through tough management, Seagate stayed profitable, rebuilt its revenues, and in 1986 and 1987 became the worldwide leader in OEM disk drive revenues.

Seagate is attempting to diversify into 3.5" and higher capacity 5.25" drives, but during the last three years a major part of the firm's growth has come from the personal computer aftermarket. After IBM cut back purchases of Seagate drives in favor of internal captive production, Seagate launched a successful campaign to take the business away from IBM at the dealer level, with phenomenal success. But the company remains vulnerable to the changes IBM has made in the PC attachment opportunity for disk drives, by "bundling" hard disk drives with systems at the factory instead of giving dealers an easy opportunity to upgrade with independent disk drives. The effect of this bundling, plus Seagate's late arrival in the 3.5" marketplace, has begun to cut into Seagate's shipment rate. The firm overestimated the market in early 1988, causing excess inventory accumulation and disappointing financial results. However, Seagate has already demonstrated the resiliency likely to be necessary for future survival.

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

1987 disk sales: \$179,400,000
1987 total net sales: \$750,028,000 Net income: \$26,008,000

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

ability of the STC double capacity 3380 equivalent drive in mid-1986. After a series of complex negotiations with creditors, the firm emerged from bankruptcy in mid-1987. Orders for STC's innovative 1/2" tape cartridge library system have been strong, and if this program is executed well, it will go a long way to restoring STC's position in the storage products industry. A triple capacity IBM 3380 equivalent drive has been announced for delivery in early 1989.

SYQUEST TECHNOLOGY
47923 Warm Springs Boulevard
Fremont, CA 94538

1987 disk sales: \$22,900,000

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, and is achieving some success in the Apple add-on market.

TANDON CORPORATION
20320 Prairie Street
Chatsworth, CA 91311

1987 disk sales: \$220,000,000
1987 total net sales: \$289,086,000 Net income: \$23,455,000

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 manufactured 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 rigid disk drives 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. In late 1987, Tandon ceased the manufacture of rigid disk drives and sold its disk drive operations to Western Digital.

TULIN CORPORATION
2393 Qume Drive
San Jose, CA 95131

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 under the Oki Electric contract prohibitively expensive. Tulin retreated into Chapter 11, and the Oki Electric contracts were abrogated in the bankruptcy proceedings. Tulin continued to manufacture disk drives with a skeleton crew at the original San Jose facility during 1987, but discontinued production in the last half of the year.

UNISYS CORPORATION
Burroughs Place
Detroit, MI 48232

1987 disk sales: \$54,800,000
1987 total net sales: \$9,712,900,000 Net income: \$578,000,000

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

VERMONT RESEARCH CORPORATION
Precision Park
North Springfield, VT 05156

VRC has been primarily a manufacturer of head-per-track disk drives and magnetic drum memories, with manufacturing both in Vermont and England.

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 stopped production and announced a high performance 625 megabyte 8" drive for late 1987 availability. This effort was unsuccessful, and the firm sold its disk drive business and production equipment to Miltope in mid-1988.

WESTERN DIGITAL CORPORATION
2445 McCabe Way
Irvine, CA 92714

1987 total net sales: \$462,462,000 Net income: \$48,184,000
(FY ending 6/30/87)

Western Digital, a major supplier of controllers and specialized semiconductor components, entered the rigid disk drive market by purchasing the rigid disk drive operations of Tandon at the end of 1987. The product line consists of 3.5" drives in the 20 to 40 megabyte range, with emphasis on models utilizing embedded controllers. The 5.25" Atasi product line also acquired from Tandon was licensed to Magnum Technology shortly after acquisition.

XEBEC
3579 Highway 50 East
Carson City, NV 89701

1987 total net sales: \$69,319,000 Net income: (\$41,552,000)
(FY ending 10/2/87)

Xebec's management looked for an entry point into the disk drive manufacturing business for years, as an extension of the firm's success in producing high-volume controllers. In 1984, several programs were launched, including purchase of the Datapoint Sunnyvale operations, the Epelo start-up for high performance 5.25" disk drives, and the Owl, an internally manufactured half high 5.25" drive with an embedded SASI interface. However, Xebec ran short on the cash required to fund all of its expansion programs, and only the Owl series, ranging from 20 to 40 megabytes, remained in production as of mid-1988. Reeling from loss of its controller contracts with IBM and unsettled by several lawsuits, the firm faces a substantial rebuilding job.

Asian Manufacturers

(All fiscal years end in March, 1987 unless otherwise noted. Firms are in Japan unless otherwise noted.)

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

1987 total net sales: \$2,549,283,000 Net income: \$29,110,000

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 IBM, 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 30 mm high 3.5" drive. A 25.4 mm high, 20 megabyte drive was announced in 1987 and a 50 megabyte version in 1988. A variant of these products is 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 were low-end half high 5.25" Winchester drives. Production started in mid-1983, but shipments remained small, with all operations eventually in Taiwan. Manufacturing ended in 1988.

EPSON (See Seiko Epson)

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

1987 disk sales: \$35,000,000
1987 total net sales: \$2,710,269,000 Net income: \$18,262,000

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

provided contract manufacturing services to Fujitsu and Nippon Peripherals for 5.25" and 3.5" drives. The firm began selling 3.5" drives under its own name in 1985, but has cut back on export sales in 1988, squeezed by exchange rates and low priced competition.

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

1987 disk sales: \$1,482,700,000
1987 total net sales: \$12,340,807,000 Net income: \$149,028,000

Fujitsu derives about 70% of its sales from the computer industry and is known as the leading manufacturer of computers for the Japanese domestic market. Fujitsu is also a major exporter to the worldwide computer market. Since 1982, the company has been among the leaders in worldwide disk drive revenues, and skillfully managed a transition from older removable disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters.

Fujitsu 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" 48/84/168/337/690/824/1000 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 is manufacturing some of its high performance drives at a new facility near Portland, Oregon, which is now in full operation.

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

Goldstar Telecommunications is a joint venture between the Lucky Goldstar Group, Siemens, Fuji Electric and DEG, a German firm. The firm's main activities are in telecommunications equipment (67%), computers and peripherals (10%), and other electronic equipment (23%). Already in volume floppy drive production, Goldstar plans to manufacture a broad rigid disk drive product line of 3.5" drives and half high 5.25" drives, with the first models going into production in 1988.

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

1987 disk sales: \$639,800,000
1987 total net sales: \$33,439,007,000 Net income: \$680,524,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. The firm currently makes a wide range of Winchester technology fixed disk drives which are sold as captive drives with Hitachi computer systems and, in several cases, as OEM drives. In addition to significant OEM sales of smaller capacity fixed disk drives, Hitachi also sells IBM compatible 3380 equivalent drives 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 Comporex, the joint venture PCM vendor owned by BASF and Siemens. Hitachi was the first independent disk drive supplier to ship a double capacity drive equivalent to the IBM 3380E. 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 high 5.25" drives. Hitachi introduced an unusual 600 megabyte 5.25" drive in 1987 that rotates the disks at nearly 4900 RPM -- a harbinger of things to come in the high end drive market.

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

Hyosung was formed in 1979 to help its parent diversify into the computer industry. The firm produces a variety of small systems and specialized terminals. The computers are sold in the U.S. under the Maxar brand. In 1987, Hyosung made a minority investment in Brand Technologies and now holds a 25% interest in Brand. Hyosung is manufacturing drives for Brand Technologies, and has marketing rights for the Far East.

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

1987 disk sales: \$80,500,000
1987 total net sales: \$4,872,869,000 Net income \$45,083,000

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

1987 total net sales: \$1,904,772,000 Net income: \$120,448,000

Kyocera is the world's largest manufacturer of ceramic packages for integrated circuits, and also makes a variety of electronic and optical components. As the result of an investment and manufacturing agreement with LaPine Technology, Kyocera started production in 1986 of LaPine's 3.5" drives and shipped significant quantities until mid-1987. In late 1986, Kyocera and Prudential Bache, both of which had been minority shareholders in LaPine, purchased the remainder of the firm, with Kyocera obtaining one third ownership and Prudential Bache two thirds. Due to the shifting exchange rate, Kyocera was not able to meet LaPine's quantity requirements profitably, and a shortfall in shipments occurred. Inability of the partners to agree on a mutually satisfactory course of action resulted in a suit against Kyocera by LaPine. LaPine's operations were subsequently halted, but the corporate shell remains, under Prudential Bache control, to prosecute the Kyocera suit. Kyocera, undeterred by the legal maneuvering, has been producing the drives under its own name and has added 40 and 80 megabyte models in 1988.

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

1986 total net sales: \$2,187,724,000 Net income: \$55,724,000
(FY ending 11/30/86)

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. 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. As of mid-1988, the 3.5" rigid disk product line extends to 81 megabytes.

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

1987 disk sales: \$61,800,000
 1987 total net sales: \$14,534,517,000 Net income: \$73,090,000

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 mid-range drives, and 8" and 9" drives to 630 megabytes are in production as of mid-1988.

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

1987 total net sales: \$804,710,000 Net income: (\$4,359,000)

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

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

1987 disk sales: \$1,271,800,000
 1987 total net sales: \$16,894,724,000 Net income: \$103,683,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 44% of the firm's total revenues. Current disk drive production involves fixed disk drives, from large to small configurations, for both captive and OEM markets. Fixed disk drives include 14", 9", 8", 5.25" and 3.5" disk diameters, with large scale production for several small diameter drives. Sales of the smaller drives have been very strong as a result of success in the OEM market and the strong position of NEC in the Japanese personal computer market. NEC, Fujitsu, and NTT have jointly developed a 2.2 gigabyte drive using thin film technology. The drives will be packaged to provide capacities as large as 8.8 gigabytes using multiple spindles.

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

1987 total net sales: \$178,566,000 Net income: \$1,434,000

Nippon Electric Industry (NEC owns 34.5% of the firm) is known in Japan by its trade name, Densai. The company produces power supplies for communications and computer equipment, automatic control systems and other electronic equipment. Densai entered the OEM disk drive market with 5.25" Winchester of its own design, and introduced half high models. However, since December, 1986, production has been dedicated to NEC.

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 ended in 1987.

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

1986 total net sales: \$119,633,000 Net income: \$1,854,000

OPC, founded in 1953, is one of Korea's pioneering firms in the electronics industry. It is a major supplier of telecommunications equipment, video systems, and a volume producer of CRT terminals. About 22.1% of the firm's 1986 shipments was computer equipment. In the past, OPC produced a 3.9" cartridge disk drive on a contract manufacturing basis for SyQuest, as well as 3.5" drives for Peripheral Technology. Most recently, OPC invested in the U.S. startup firm Kalok, and will be manufacturing drives for this firm as well.

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

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 is now in a Korean facility, after initial production runs contracted to Oriental Precision. Additional production is done in the U.S. in existing facilities. As of mid-1988, the product line extended to 85 megabyte capacities.

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

1987 total net sales: \$4,085,338,000 Net income: \$75,510,000

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 produced a write-once optical drive marketed in the U.S. by Maxtor.

SAMSUNG ELECTRONICS CO., LTD.
Affiliate of Samsung Group
7, Soonwha-dong
Chung-du
Seoul, South Korea

1986 total net sales: \$16,900,000,000 Net income: \$186,516,000

Samsung Electronics, founded in 1969, is Korea's largest electronics company, producing a variety of consumer, industrial and computer products. Samsung has made an investment in Comport, a new U.S. startup, and will manufacture Comport's 3.5" line of disk drives. Distribution rights in Korea have been retained by Samsung. The Samsung group plans to merge Samsung Electronics and Samsung Semiconductor & Telecommunication into a single organization in the fall of 1988.

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

1987 disk sales: \$48,600,000

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also control Japan's Seiko companies, known for watches and electronics. Epson is best known for its dot-matrix printers, but also manufactures a portable computer, displays, line prin-

ters, paper tape equipment and floppy disk drives. In 1985, Epson introduced a line of half high 5.25" rigid disks with capacities to 20 megabytes. Epson has since broadened its product line to include 3.5" drives up to 72 megabytes, but the firm dropped its plans to produce 40 and 80 megabyte 5.25" drives.

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

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

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

1987 total net sales: \$9,283,331,000 Net income: \$288,883,000

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 in 1987, with half high 5.25" SCSI drives offering up to 40 megabytes formatted, but Sony decided to withdraw the product due to late market entry.

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

1987 total net sales: \$632,986,000 Net income: \$3,483,000
(FY ending 9/30/87)

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 previous years, the firm operated at a loss, but returned to profitability in 1987.

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

1987 disk sales: \$69,400,000
1987 total net sales: \$693,455,000 Net income: \$12,455,000

Tokico, a member of the Hitachi group, is a manufacturer of automotive equipment, including shock absorbers, brakes and air compressors. Factory automation is a newly developed product area. The company began disk drive manufacturing with a 5.25" fixed disk drive design derived from the discontinued Nippon Peripherals Ltd. joint venture with Fujitsu, with versions of the Tokico drive sold separately by Hitachi and by the Hitachi group trading company, Nissei Sangyo. A half high version went into production in late 1983. More recently, the 5.25" product line has extended to 96 megabytes capacity and the 3.5" line to 94 megabytes capacity. Tokico began to market its disk drive products under its own name in 1987 and has steadily been expanding its product line.

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

1987 disk sales: \$163,200,000
1986 total net sales: \$22,810,986,000 Net income: \$235,710,000

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. The product line currently extends to 383 megabytes for 5.25" drives and to 721 megabytes for 8" drives. 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 expand its U.S. operations.

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

1987 total net sales: \$1,530,000,000 Net income: \$18,379,000

Tosoh was founded in 1935 under the name Toyo Soda. The firm was renamed in 1987. Tosoh is a major chemical products manufacturer and produces materials for use in the electronics industry, including sputtered thin film media for 3.5" and 5.25" rigid disk drives. The firm initially intended to begin manufacturing in mid-1987 a drive based upon the designs of now defunct Applied Information Memories, but deferred production until a more competitive design could be accomplished.

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

1987 total net sales: \$269,566,000 Net income: \$5,738,000

Yaskawa Electric produces primarily heavy electrical machinery and automation equipment. Y-E Data is best known for its line of floppy disk drives, with the firm's biggest success coming in 1984 when it was selected by IBM as supplier for the 1.6 megabyte 5.25" drive used in the PC AT. At the 1986 NCC show, Y-E Data's 3.5" 50 megabyte drive was introduced by C. Itoh Electronics, a major importer of Japanese electronic industry products for the U.S. market. Floppy drives remain the largest part of Y-E Data's business, but the line of rigid 3.5" drives now ranges from 44 to 87 megabytes in capacity.

European Manufacturers

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

Comparex became operational at the beginning of January, 1987, as a new joint venture operation comprising the former BASF and Siemens PCM businesses. The joint venture markets systems and peripherals made by Fujitsu and Hitachi. Current disk drive activities involve only PCM 3380 equivalent drives produced by Hitachi, plus an optical drive produced by LMSI and integrated with a Cygnet jukebox. Semiconductor and cartridge tape systems, both made by third parties, are also offered.

ISOT
51, Chapaev St.
Sofia, Bulgaria

1987 disk sales: \$155,000,000

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

LEXIKON 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

1987 disk sales: \$136,700,000

1987 total net sales: \$5,705,474,000

Net income: \$309,946,000

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

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

1987 disk sales: \$29,300,000

Newbury Data is the current name for the organization once known as Data Recording Equipment, or DRE. Disk drives were manufactured for several years by a joint venture company owned by DRI, its parent firm, and Magnetic Peripherals, Inc., the U.S. disk drive development and manufacturing firm managed by Control Data. When the joint venture was dissolved in 1983, DRI regained ownership. Newbury Data then placed emphasis on newer disk drives, some produced under manufacturing licenses with U.S. firms, including a license from Maxtor for high capacity 5.25" drives. For its disk drive program Newbury eventually concentrated entirely on high capacity 5.25" drives, including 380 megabyte models. In 1988, a decision was made by the parent company, DRI, to sell the Newbury disk drive operations and concentrate on printers.

SAGEM

(Societe d'Applications Generales d'Electricite et de Mecanique)
 6 Avenue d'lana
 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. The firm's more recent products have focused upon a line of removable disk drives ranging in capacity from 50 to 200 megabytes. These, also, are militarized products.

SIEMENS AG

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

1987 disk sales:	\$65,100,000	
1987 total net sales:	\$28,572,800,000	Net income: \$708,300,000
	(FY ending 9/30/87)	

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. A 777 megabyte 5.25" drive is scheduled to begin shipping in late 1988. Siemens is selling the drives 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.

DISK/TREND ON DISK

DISK/TREND ON DISK

Introduction

DISK/TREND ON DISK is a set of floppy disks containing the statistical tables and specification tables from the annual DISK/TREND reports. The disk files have been prepared in a format usable by Lotus 1-2-3 on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. All files contain data only -- manipulation of the data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended. While the files supplied can be used with Lotus 1-2-3 versions 1A and up, we recommend the use of versions 2.0 and up in order to be able to take advantage of Lotus advanced features to manipulate data.

Two or three disks are used for each DISK/TREND disk drive report. The first disk contains the statistical tables. File names are keyed to the table numbers in the report for easy identification. The second and third disks contain the specification section in a data base format. Two disks are provided for specifications when the specification data base is too large to fit on a single 360 KB floppy disk. Both types of data are directly loadable by Lotus 1-2-3. The color used on the label of each floppy disk is similar to the color used on the cover of the corresponding report for ease in identification.

Because the statistical tables are provided in ASCII format, they can be used with any spreadsheet program that can import ASCII text files. However, the specification tables have been prepared specifically in Lotus 1-2-3 format to allow them to be searchable using Lotus 1-2-3 data base commands. If you are using a spreadsheet program other than Lotus 1-2-3 that can translate Lotus WK1 formatted files to its own format, it may be able to import the specification tables.

The authors of this manual assume that you are familiar with personal computers, Lotus 1-2-3, and MS-DOS, and do not cover their operation in this manual. This manual deals specifically with how to load and use the files supplied on the floppy disks.

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

DISK/TREND ON DISK Information License

DISK/TREND supplies diskettes containing selected information from the 1988 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1988 DISK/TREND Report volume.

YOU MAY:

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

YOU MAY NOT:

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

Trademarks

IBM is a trademark of International Business Machines Corporation.

Lotus and Lotus 1-2-3 are trademarks of Lotus Development Corporation.

MS-DOS is a trademark of Microsoft Corporation.

Getting Started

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

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

STATISTICAL TABLESLoading

1. Place the floppy disk marked 'Tables' in a floppy disk drive able to read 5.25", 360 KB disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the Lotus 1-2-3 system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the 'Tables' disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

```
TYPE A:READ.ME (Use the appropriate drive letter if not A)
```

If you wish to print the instructions, turn on your printer and type:

```
TYPE A:READ.ME>PRN
```

2. Do this step if you have a hard disk. Log into the hard disk directory in which Lotus 1-2-3 normally stores worksheet files. Using the DOS 'COPY' command, copy all the statistical table files to the hard disk. This can be done in one step using the copy command as follows:

```
COPY A:?\T*.*
```

Several utility files should also be copied. The command is:

```
COPY A:*.PRN
```

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

```
/FIT<filename>
```

The file names are in the format XYY.ZZX, where:

```
X= Type of data
  F (Flexible disk drive data)
  R (Rigid disk drive data)
  O (Optical disk drive data)
```

```
YY= Table number, as shown in the appropriate report volume
```

```
ZZ= Year of Report.
```

Examples:

File RT10.88R is 1988 Rigid Disk Drive Report Table 10
 File FT2.87F is 1987 Flexible Disk Drive Report Table 2
 File OT1.880 is 1988 Optical Disk Drive Report Table 1

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

Data Parsing made easy

Most Lotus 1-2-3 users are not familiar with the Data Parse commands. They allow the user to convert a table which has been imported in the form of a block of text to a form in which the individual numbers and labels can be manipulated as spreadsheet elements or used to prepare graphics.

Before proceeding, it would be useful to read the Lotus reference manual on this subject if you are not a regular user of the Data Parse commands.

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

- o FORMLINA.PRN Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of the reports.
- o FORMLINB.PRN Used with Table 2.
- o FORMLINC.PRN Used with Tables 3 through 6.
- o FORMLIND.PRN Used with Application tables.

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

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

The Parsing Process

The basic process of parsing the data table goes like this:

1. Enter Lotus 1-2-3 and obtain the blank spreadsheet screen.
2. Import the file to be parsed using the /FIT<filename>command.
3. Move the cursor in the A column to the blank row just above the first line of numbers.
4. Import the Formline file.

Example: /FIT FORMLINA.PRN

A sample format line will appear in the row. See the figure below.

Portion of sample file with sample format line imported

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

ALL EXISTING MOVING HEAD DISK DRIVE GROUPS

REVENUE SUMMARY

	1986		1987		1988	
	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.
Other U.S. Captive	1,123.8	1,902.8	1,355.0	2,059.3	1,808.9	2,649.
TOTAL U.S. CAPTIVE	4,934.1	8,314.8	6,146.9	9,766.3	6,796.8	10,688.

5. Move the cursor down one row to the first row of numbers. In the example above, this will place it on the 'IBM Captive' label.
6. Use the Data Parse format command /DPFCFE. This creates the actual format line and puts it into EDIT mode. You will now see two format lines: the sample format line (above) and the actual format line (below).
7. Now edit the actual format line until it is identical to the sample format line.

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

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

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

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

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

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

SPECIFICATION TABLES

The 1988 rigid disk drive specifications are supplied on two diskettes. Diskette 1 contains the specifications for DISK/TREND groups one through five. The second diskette contains groups six through nine. If your computer has enough available memory (it may require expanded memory in some cases) you can load the two data bases sequentially into one large data base for ease of data manipulation. See comments below.

Loading

1. Place the floppy disk marked 'Specifications' in a floppy disk drive able to read 5.25", 360 KB disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the Lotus 1-2-3 system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the 'Tables' disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

```
TYPE A:READ.ME (Use the appropriate drive letter if not A)
```

If you wish to print the instructions, turn on your printer and type:

```
TYPE A:READ.ME>PRN
```

2. Do this step if you have a hard disk. Log into the hard disk directory in which Lotus 1-2-3 normally stores worksheet files. Using the DOS 'COPY' command, copy all the specification table files to the hard disk. This can be done in one step using the copy command as follows:

```
COPY A:?S*.*
```

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

```
/FR<filename>
```

The file names are in the format XSYZZ.WK1 or XSYZZ.WKS, depending upon which version of Lotus 1-2-3 you are using. X,Y, and Z are:

```
X= F (Flexible disk drive data)
   O (Optical disk drive data)
   R (Rigid disk drive data)
```

Y= Table number. Usually, there is only one table, but if the specification file is so large as to need multiple disks to hold it, there may be several.

ZZ= Year of report.

Examples: FS188 Flexible disk specification table
 RS188A Rigid disk spec table: Groups 1-5
 RS188B Rigid disk spec table: Groups 6-9

Note that the specification tables load directly as a data base. You can use the data base functions of Lotus 1-2-3 to sort, count or otherwise manipulate the data for purposes of special analysis.

Using the specification data base

Introduction: If you have not used the Lotus 1-2-3 /DATA QUERY commands, it will be helpful for you to review the sections of the Lotus 1-2-3 reference manual that pertain to their use before proceeding further.

The specification data base fits into a worksheet format of 25 to 30 columns, depending upon whether rigid, optical or floppy drives are involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a column in the Specifications section of the DISK/TREND report. Each column represents a specific specification parameter, and is equivalent to one row of the DISK/TREND report.

The database has been set up for data extraction using Lotus 1-2-3 commands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the database is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specs.

Operating tips

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

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

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

Combining specification data bases: Lotus 1-2-3 allows you to combine worksheets into a larger worksheet. If you think your computer has enough memory, you can combine the specification data bases by doing the following:

1. Load the worksheet RS188A from specification diskette 1 into a new worksheet. Move the cursor to column A and the row immediately below the last manufacturer's name.
2. Load the worksheet RS188B from specification diskette 2 using the Lotus 1-2-3 command /FCC.
3. Edit the worksheet to remove the header and criterion range areas that were loaded with the second worksheet.
4. Using the data query (/DQ) command, select the new input range so that it covers the entire worksheet area in which there is data. Remember, the column header row must be included in the input range. Quit the DQ menu.
5. Copy the column header row to a row 5 to 10 lines below the input range. Using the /DQ command, select the output range. It should include the header row you just established plus as many rows as you would like, and should extend to the comments column.
6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it in a new file name first so that you can easily reload it if you inadvertently make an unrecoverable alteration.

Saving time

The rigid disk specification data bases are large and take significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups you are interested in into a new worksheet and use that for the analysis. Use Lotus 1-2-3 file extract and file combine commands for this purpose.

Another way to save time is to use the SORT capabilities of Lotus 1-2-3 to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, etc.

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

Technical Support

Just about all of your questions regarding the use of DISK/TREND ON DISK should be answered in this manual or in the Lotus 1-2-3 reference manual. However, if you need to contact us to resolve any points of confusion, report errors, or otherwise receive comfort:

Call us at: 415-961-6209

Ask for Technical Support

In order to make this process efficient, when you call--

1. Tell us what is on the diskette label.
2. Have your computer up and displaying the data or operation that is the subject of your call.
3. Have this manual and the Lotus 1-2-3 reference manual handy.