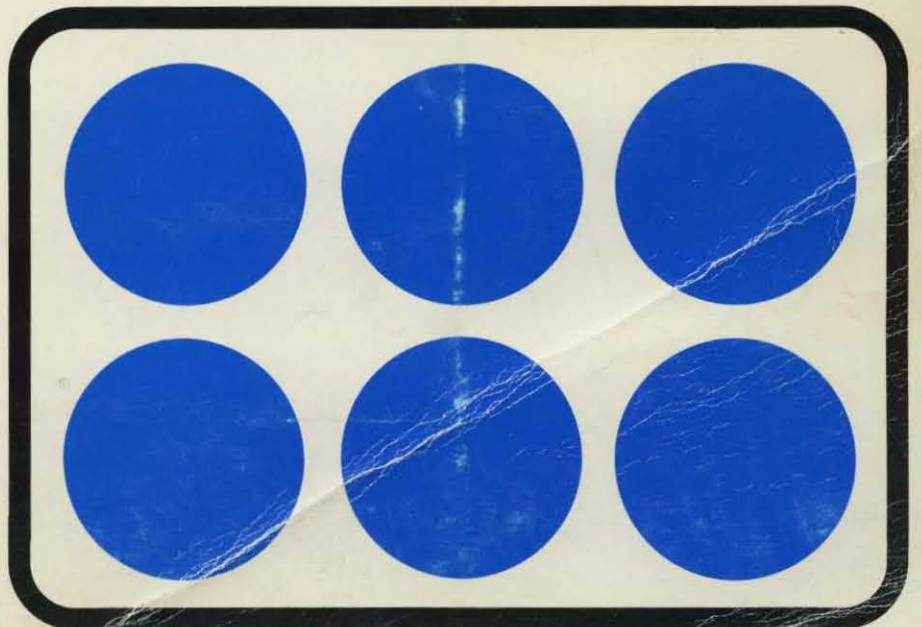


1985 DISK/TREND[®] REPORT

RIGID
DISK
DRIVES



1985 DISK/TREND® REPORT

RIGID DISK DRIVES

October, 1985

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FOREWORD

No one ever promised it would be easy to make money manufacturing disk drives (except possibly in some of the business plans submitted to venture capitalists). The industry is growing this year, but not as much as in recent years. Producers of OEM drives have been squeezed the most, as they scramble for business by cutting prices -- and profit margins. For the first time in living memory, the worldwide number of rigid disk drive manufacturers is down slightly.

But the industry has a continuing pattern of renewing itself with new products. In addition to many new small rigid disk drives, a number of serious optical disk drive programs have appeared on the scene. Coverage in this year's rigid disk drive section of the DISK/TREND Report has been expanded to include full statistical coverage of optical disk drives, and we will go farther when the time is right. Eventually, we expect to give optical disk drives their own separate volume in the DISK/TREND series, when the business is large enough to warrant it.

As many of you already know, Robert H. Katzive has joined our organization and has been actively involved in preparation of this year's reports. Bob and I 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 report are always welcome.

James N. Porter

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INTRODUCTION

New information in this year's DISK/TREND Report

Although we have added extensive information on optical disk drives in this year's DISK/TREND Report, we continue to maintain consistency in the report's organization and in the formats used to present statistical information. This is what's new:

- * In recognition of the fact that optical disk drives are finally becoming commercial products, detailed information and statistical projections in the usual DISK/TREND formats have been included in this report. Although coverage is combined in one section of the report, analysis and tables are grouped in three subgroups:
 10. Read-only optical disk drives
 11. Read/write optical disk drives, less than 1 gigabyte
 12. Read/write optical disk drives, more than 1 gigabyte
- * Specifications for optical disk drives now announced or in production have been split off from the section covering rigid disk drives and are now covered in a separate section.
- * In view of the fact that most of the disk drives in the fixed disk drive groups labeled <5.25" are really 3.5" drives, we have now changed the column headings to read 3.5". The <5.25" headings used in the disk cartridge drive groups are still the same, since most of the applicable drives actually use 3.9" disks.

This information will help you use the report

- * All unit totals are given in spindles. A disk drive containing two spindles is counted in DISK/TREND statistics as two spindles.
- * Prices for most OEM drives sold in the United States are shown, usually at the 100 unit level. When prices for higher quantities have been used, the applicable quantity is shown in parentheses. Please remember that prices may be changed without notice by the manufacturers.
- * The value of all leased disk drives is given on an "if sold" basis in all DISK/TREND estimates.

SUMMARY: RIGID MAGNETIC DISK DRIVESIndustry size

1985 finds disk drive manufacturers under pressure, as growth in computer system shipments has slowed during the past year. Having invested in new capacity, many disk drive manufacturers are now facing desperate price competition and lower demand than they expected.

But the industry is still growing in 1985, despite the difficulties many manufacturers are having in generating profits. The growth rate is lower: Worldwide revenues for 1985 are expected to be \$13,728,900,000, an increase of only 15.7%, compared to 1984's 30.2% increase.

After 1985, the industry's growth is projected to return to a more typical rate. Average annual growth in worldwide revenues for the period 1986-1988 is forecasted at 17.9%. Unit shipments for OEM drives will rise at an even higher rate, but declining average unit prices tend to mask the increases. Declining shipments of older removable disk drives will also hold down the overall rate of revenue growth.

IBM's disk drive revenues will be 40.9% of the worldwide total for all disk drives in 1985, and will stay above that level through 1988, when they will reach \$9,754,600,000. Worldwide PCM revenues were lower than expected for 1984, at \$611,800,000. The shortfall was due to poor performance by U.S. producers, who have now given over leadership to non-U.S. manufacturers, apparently permanently.

Other captive revenues are expected to continue growing in the 16% to 20% range during 1986-1988, after a 1985 dip to 5.3%, caused by slowed system growth and discontinuance of several captive manufacturing programs.

TABLE 1
 CONSOLIDATED WORLDWIDE REVENUES
 ALL EXISTING RIGID MAGNETIC DISK DRIVE GROUPS
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		-----Forecast-----							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										

IBM Captive	2,931.9	4,657.6	3,622.4	5,618.7	4,728.2	7,431.9	5,494.8	8,619.4	6,210.6	9,754.6
Other U.S. Captive	1,527.5	2,299.4	1,301.2	2,097.0	1,444.3	2,378.1	1,785.6	2,890.4	2,213.5	3,558.7
TOTAL U.S. CAPTIVE	4,459.4	6,957.0	4,923.6	7,715.7	6,172.5	9,810.0	7,280.4	11,509.8	8,424.1	13,313.3
PCM	115.5	163.8	133.6	218.2	163.0	255.0	337.6	526.9	382.1	634.6
OEM	1,501.1	1,952.6	1,614.2	2,051.2	1,721.2	2,187.0	1,860.6	2,356.6	1,981.2	2,514.9
TOTAL U.S. NON-CAPTIVE	1,616.6	2,116.4	1,747.8	2,269.4	1,884.2	2,442.0	2,198.2	2,883.5	2,363.3	3,149.5
TOTAL U.S. REVENUES	6,076.0	9,073.4	6,671.4	9,985.1	8,056.7	12,252.0	9,478.6	14,393.3	10,787.4	16,462.8
Non-U.S. Manufacturers										

Captive	21.7	1,686.0	128.6	2,100.0	220.7	2,510.1	314.3	2,998.8	359.5	3,283.9
PCM	162.4	448.0	216.6	647.7	266.0	664.8	361.6	800.0	405.0	929.9
OEM	269.5	658.8	418.8	996.1	639.8	1,329.8	794.2	1,562.9	952.7	1,761.3
TOTAL NON-U.S. REVENUES	453.6	2,792.8	764.0	3,743.8	1,126.5	4,504.7	1,470.1	5,361.7	1,717.2	5,975.1
Worldwide Recap										

TOTAL WORLDWIDE REVENUES	6,529.6	11,866.2	7,435.4	13,728.9	9,183.2	16,756.7	10,948.7	19,755.0	12,504.6	22,437.9

Marketing channels

In a reversal of the long term trend, the 1985 DISK/TREND Report shows a decrease of three rigid disk drive manufacturers since last year, down to a total of 72. This year only 43 U.S. manufacturers are listed, the result of 12 deletions and only three additions. Although 12 deletions sounds like a large number, the majority of the companies involved had produced negligible quantities of disk drives, or none at all. The five additional Japanese firms have announced plans to produce drives with 5.25" diameter or smaller.

Users of the DISK/TREND Report should bear in mind that revenues are given in this report at the level of each drive's first public sale. In other words, 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.

It is expected that the surge in OEM disk drive revenues generated by rapid growth of small diameter drives in recent years, which has pushed the worldwide share of revenues to over 20% of the total, will level off, dropping below 20% again by 1988.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES

MARKET CLASS REVIEW
REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	-----1984-----		-----Forecast-----							
	---Revenues---		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
U.S. Manufacturers										
IBM Captive	4,657.6	39.2	5,618.7	40.9	7,431.9	44.3	8,619.4	43.6	9,754.6	43.4
Other U.S. Captive	2,299.4	19.3	2,097.0	15.2	2,378.1	14.1	2,890.4	14.6	3,558.7	15.8
PCM	163.8	1.3	218.2	1.5	255.0	1.5	526.9	2.6	634.6	2.8
OEM	1,952.6	16.4	2,051.2	14.9	2,187.0	13.0	2,356.6	11.9	2,514.9	11.2
Total U.S. Mfgr's.	9,073.4	76.2	9,985.1	72.5	12,252.0	72.9	14,393.3	72.7	16,462.8	73.2
Non-U.S. Manufacturers										
Captive	1,686.0	14.2	2,100.0	15.2	2,510.1	14.9	2,998.8	15.1	3,283.9	14.6
PCM	448.0	3.7	647.7	4.7	664.8	3.9	800.0	4.0	929.9	4.1
OEM	658.8	5.9	996.1	7.6	1,329.8	8.3	1,562.9	8.2	1,761.3	8.1
Total Non-U.S. Mfgr's.	2,792.8	23.8	3,743.8	27.5	4,504.7	27.1	5,361.7	27.3	5,975.1	26.8
Worldwide Total	11,866.2	100.0	13,728.9	100.0	16,756.7	100.0	19,755.0	100.0	22,437.9	100.0

Product mix

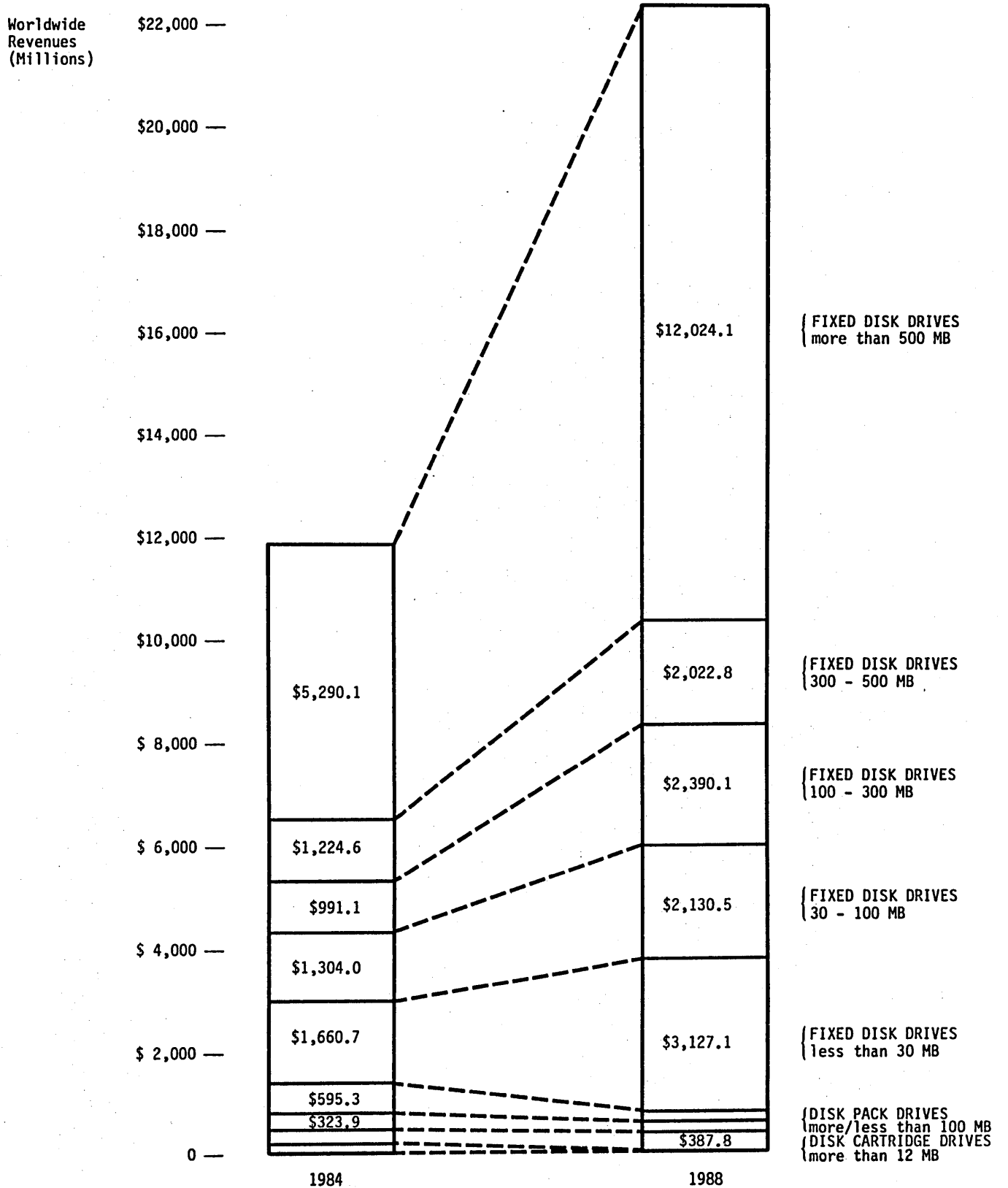
Despite the public impression produced by problems in the personal computer industry and poor financial performance by several major producers of 5.25" fixed disk drives, shipments of low-end rigid disk drives are still growing, although at a slower rate. 1984's total worldwide shipments of 5.25" and 3.5" drives with less than 30 megabytes capacity were 2,463,300 units, an increase of 113.0% over the previous year. In 1985, the estimated total is 3,358,300 drives, up only 36.3%, and the average annual increase in 1986-88 is expected to be about 30%.

The four DISK/TREND product groups for fixed disk drives above 30 megabytes also have seen excellent growth, with no slow-down in sight. Drives over 500 megabytes topped \$5 billion in worldwide revenues in 1984, and are forecasted at over \$12 billion in 1988, boosted by IBM's high-end drives for use with mainframes.

But even though not as large, the other fixed disk drive groups are also enjoying sustained long term growth, with broad participation by numerous producers of captive and OEM disk drives. The only significant slow-down in growth rate is expected for 30-100 megabyte drives, as momentum passes to higher capacity models after 1986.

Total revenues for removable disk drives continue to decline. 1984 total revenue for all removable disk drives was \$1,395,700,000 worldwide, but the 1988 DISK/TREND forecast is only \$743,300,000. Although disk pack drives enjoyed an interruption in their downward trend in 1984, the respite will be temporary, with further declines predicted for 1985, and continuing. The only removable disk group expected to see growth is disk cartridge drives over 12 megabytes, driven by small diameter drives.

Figure 1
 CHANGING PRODUCT MIX
 CONSOLIDATED WORLDWIDE RIGID DISK DRIVE REVENUES



OEM market

The volatility of the OEM disk drive market is well known. OEM disk drives are characterized by short product life cycles, sudden prominence for successful new product configurations, and the need for equally sudden readjustments when major customers turn to internal manufacturing programs.

During 1984 and 1985, the OEM segment of the disk drive industry is changing as rapidly as ever. Worldwide unit shipments for all types of OEM rigid disk drives increased 97.7% in 1984, but revenues grew only 35.6%, an indication of intense competitive pressures and changes in product mix. The 1985 increase in worldwide unit shipments is estimated at only 30.2%, with the revenue increase limited to 16.6%.

The dominance of U.S. manufacturers in worldwide OEM disk drive markets is eroding. U.S. producers held 79.2% of 1984's worldwide unit shipments, but will drop to an estimated 70.4% in 1985, then to 58.2% in 1988. In certain mid-range fixed disk drive groups, U.S. firms hold a minority of 8" drive shipments, due to an earlier production start by Japanese firms. Several Japanese companies, new to rigid disk drive manufacturing, are now entering the market for 3.5" and 5.25" drives, and other newcomers are expected.

But the largest changes will come from IBM's actions. Since starting its personal computer programs, IBM has purchased huge quantities of 5.25" fixed disk drives. However, IBM began making 5.25" drives in three factories during the past year, and has already cut outside purchases sharply. With a 3.5" program start-up in 1986 expected, IBM's role as the world's biggest customer for OEM disk drives is probably at an end.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	-----1984-----		-----Forecast-----							
	----Revenues----		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
DISK CARTRIDGE DRIVES less than 12 MB	206.0	1.7	131.2	1.0	102.2	.6	59.1	.3	40.2	.2
DISK CARTRIDGE DRIVES more than 12 MB	270.5	2.3	180.9	1.3	239.1	1.4	316.0	1.6	387.8	1.7
DISK PACK DRIVES less than 100 MB	323.9	2.7	224.8	1.6	182.0	1.1	152.9	.8	140.9	.6
DISK PACK DRIVES more than 100 MB	595.3	5.0	419.4	3.1	335.0	2.0	246.6	1.2	174.4	.8
FIXED DISK DRIVES less than 30 MB	1,660.7	14.0	2,028.4	14.8	2,430.3	14.5	2,925.7	14.8	3,127.1	13.9
FIXED DISK DRIVES 30 - 100 MB	1,304.0	11.0	1,541.1	11.2	1,929.7	11.5	2,026.2	10.3	2,130.5	9.5
FIXED DISK DRIVES 100 - 300 MB	991.1	8.4	1,107.8	8.1	1,445.4	8.6	1,895.1	9.6	2,390.1	10.7
FIXED DISK DRIVES 300 - 500 MB	1,224.6	10.3	1,524.4	11.1	1,714.1	10.2	1,799.6	9.1	2,022.8	9.0
FIXED DISK DRIVES more than 500 MB	5,290.1	44.6	6,570.9	47.8	8,378.9	50.0	10,333.8	52.3	12,024.1	53.6
Total Worldwide Revenue	11,866.2	100.0	13,728.9	100.0	16,756.7	100.0	19,755.0	100.0	22,437.9	100.0
% U.S. Mfg.	76.4	--	72.7	--	73.1	--	72.8	--	73.3	--
Annual Growth Rate	+30.2%	--	+15.6%		+22.0%		+17.8%		+13.5%	

TABLE 4

OEM WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

	-----1984-----		-----Forecast-----							
	-----Revenues-----		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
WORLDWIDE REVENUES ALL MANUFACTURERS	----	----	----	----	----	----	----	----	----	----
DISK CARTRIDGE DRIVES less than 12 MB	84.8	3.2	60.9	2.0	47.3	1.3	36.4	.9	24.4	.6
DISK CARTRIDGE DRIVES more than 12 MB	111.8	4.3	73.8	2.4	93.6	2.7	128.7	3.3	151.6	3.5
DISK PACK DRIVES less than 100 MB	151.7	5.8	129.2	4.3	125.6	3.6	127.5	3.3	132.9	3.1
DISK PACK DRIVES more than 100 MB	279.4	10.7	167.1	5.4	142.6	4.0	114.0	2.9	88.0	2.1
FIXED DISK DRIVES less than 30 MB	958.2	36.8	1,009.5	33.3	992.2	28.3	1,083.3	27.7	1,239.2	29.1
FIXED DISK DRIVES 30 - 100 MB	482.7	18.5	757.7	24.8	924.0	26.3	963.4	24.6	1,000.3	23.4
FIXED DISK DRIVES 100 - 300 MB	225.0	8.6	311.5	10.3	458.7	13.1	575.1	14.7	678.0	15.8
FIXED DISK DRIVES 300 - 500 MB	183.9	7.1	263.2	8.6	325.9	9.2	372.5	9.5	393.6	9.2
FIXED DISK DRIVES more than 500 MB	133.9	5.0	274.4	8.9	406.9	11.5	518.6	13.1	568.2	13.2
Total Worldwide Revenues	2,611.4	100.0	3,047.3	100.0	3,516.8	100.0	3,919.5	100.0	4,276.2	100.0
% U.S. Mfg.	74.7	--	67.3	--	62.1	--	60.1	--	58.8	--
Annual Growth Rate	+35.6%	--	+16.6%		+15.4%		+11.4%		+9.1%	

TABLE 5

OEM WORLDWIDE SHIPMENTS
RIGID MAGNETIC DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

WORLDWIDE UNIT SHIPMENTS ALL MANUFACTURERS	-----1984-----		-----FORECAST (000 UNITS)-----							
	---Shipments---		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	Units	%	Units	%	Units	%	Units	%	Units	%
DISK CARTRIDGE DRIVES less than 12 MB	61.9	2.1	54.6	1.4	41.5	.9	30.0	.5	16.0	.2
DISK CARTRIDGE DRIVES more than 12 MB	35.9	1.2	60.1	1.6	102.0	2.1	158.4	2.7	206.4	2.8
DISK PACK DRIVES less than 100 MB	32.7	1.1	28.2	.7	27.5	.5	26.5	.4	27.0	.4
DISK PACK DRIVES more than 100 MB	31.8	1.1	19.4	.5	16.7	.4	13.2	.2	10.0	.1
FIXED DISK DRIVES less than 30 MB	2,267.5	77.4	2,717.0	71.2	3,394.6	70.0	4,233.5	71.1	5,454.0	73.5
FIXED DISK DRIVES 30 - 100 MB	391.0	13.3	742.7	19.5	939.1	19.3	1,027.7	17.2	1,086.5	14.7
FIXED DISK DRIVES 100 - 300 MB	72.6	2.5	120.5	3.1	204.8	4.2	304.0	5.1	418.2	5.6
FIXED DISK DRIVES 300 - 500 MB	31.5	1.1	53.7	1.4	82.3	1.7	107.6	1.8	130.5	1.8
FIXED DISK DRIVES more than 500 MB	10.1	.2	26.4	.6	47.1	.9	64.4	1.0	76.7	.9
Total Worldwide Shipments	2,935.0	100.0	3,822.6	100.0	4,855.6	100.0	5,965.3	100.0	7,425.3	100.0
% U.S. Mfg.	79.2	--	70.4	--	63.3	--	59.8	--	58.2	--
Annual Growth Rate	+97.7%	--	+30.2%		+27.0%		+22.8%		+24.4%	

TABLE 6

1984 ESTIMATED MARKET SHARES
 WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
 (Value of non-U.S. currencies estimated at July, 1985, rates)

	CAPTIVE		PCM		OEM		TOTAL INDUSTRY	
	\$M	%	\$M	%	\$M	%	\$M	%
U.S. MANUFACTURERS								
Ampex	--	--	--	--	45.2	1.7	45.2	.4
Atasi	--	--	--	--	48.0	1.8	48.0	.4
Burroughs	249.6	2.9	--	--	--	--	249.6	2.1
Century Data Systems	12.5	.1	--	--	53.9	2.1	66.4	.6
Computer Memories	--	--	--	--	74.4	2.9	74.4	.6
Control Data/MPI	674.9	7.8	20.0	3.3	619.9	23.7	1,314.8	11.1
Data General	145.9	1.7	--	--	--	--	145.9	1.2
Digital Equipment	633.0	7.3	--	--	--	--	633.0	5.3
Hewlett-Packard	315.5	3.7	--	--	--	--	315.5	2.7
IBM	4,657.6	53.9	--	--	33.7	1.3	4,691.3	39.5
International Memories	74.5	.9	--	--	99.3	3.8	173.8	1.5
Maxtor	--	--	--	--	32.8	1.3	32.8	.3
Micropolis	--	--	--	--	56.3	2.2	56.3	.5
Microscience International	--	--	--	--	25.5	1.0	25.5	.2
Miniscribe	--	--	--	--	122.8	4.7	122.8	1.0
Priam	--	--	--	--	81.2	3.1	81.2	.7
Quantum	--	--	--	--	107.5	4.1	107.5	.9
Seagate	--	--	--	--	302.5	11.6	302.5	2.5
Shugart	77.9	.9	--	--	35.3	1.4	113.2	1.0
Storage Technology	--	--	127.5	20.8	2.6	.1	130.1	1.1
Tandon	--	--	--	--	58.7	2.2	58.7	.5
Texas Instruments	48.0	.5	--	--	--	--	48.0	.4
Vertex	--	--	--	--	30.0	1.1	30.0	.3
Other U.S.	67.6	.8	16.3	2.7	123.0	4.7	206.9	1.7
U.S. Total	6,957.0	80.5	163.8	26.8	1,952.6	74.8	9,073.4	76.5
NON-U.S. MANUFACTURERS								
BASF	--	--	--	--	29.7	1.1	29.7	.3
Bull	69.7	.8	--	--	11.1	.4	80.8	.7
Fujitsu	487.2	5.6	161.6	26.4	230.2	8.8	879.0	7.4
Hitachi	234.6	2.7	231.2	37.8	35.7	1.4	501.5	4.2
ISOT	31.0	.4	--	--	110.1	4.2	141.1	1.2
Mitsubishi	38.3	.5	--	--	8.7	.3	47.0	.4
NEC	573.2	6.6	--	--	67.1	2.6	640.3	5.4
Nippon Peripherals	--	--	55.2	9.0	27.9	1.1	83.1	.7
Nixdorf	80.0	.9	--	--	--	--	80.0	.7
Olivetti	86.3	1.0	--	--	1.0	--	87.3	.7
Rodime	--	--	--	--	74.8	2.9	74.8	.6
Siemens	36.5	.4	--	--	--	--	36.5	.3
Other Non-U.S.	49.2	.6	--	--	62.5	2.4	111.7	.9
Non-U.S. Total	1,686.0	19.5	448.0	73.2	658.8	25.2	2,792.8	23.5
Worldwide Total	8,643.0	100.0	611.8	100.0	2,611.4	100.0	11,866.2	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 PCM market values.

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

TABLE 7
 CURRENT PRODUCT LINES
 MANUFACTURERS OF MOVING HEAD MAGNETIC DISK DRIVES

DISK/TREND PRODUCT GROUP:		1	2	3	4	5	6	7	8	9
Type		Disk Cartridge Drives <12 MB	Disk Cartridge Drives >12 MB	Disk Pack Drives <100 MB	Disk Pack Drives >100 MB	Fixed Disk Drives <30 MB	Fixed Disk Drives 30-100 MB	Fixed Disk Drives 100-300 MB	Fixed Disk Drives 300-500 MB	Fixed Disk Drives >500 MB
U.S. Manufacturers										
Advanced Storage Technology	0						5	5		
Alpha Data	0						14			
Amcodyne	0		8							
Ampex	0				14	5		14	14	14
Atasi	0						5			
Burroughs	C				14			14		14
Century Data Systems	0		8		14			14	8,14	14
Cogito	0					5				
Computer Memories	0					5	5			
Control Data	0,C,P		8,14	8,14	14	5	5	8,14	8	8,14
Data General	C				14	8,14	14		14	14
Digital Equipment	C	14	8					14	14	
Disc Tech One	0					5	8,14	14	14	
Disctron	0	8					8			
Hewlett-Packard	C,0		14	14	14	3,14	14	14	14	
Ibis	0									14
IBM	C,0					5,8	5,8	14		14
Josephine County Technology	0					5				
Kennedy	0					8	8,14	8,14		
LaPine Technology	0					3				
Maxtor	0						5	5	5	
Megavault	0						8	8	8	8
Memorex	C,P									14
Microcomputer Memories	0					3				
Micropolis	0						5	5		
Microscience International	0					3,5				
Micro Storage	0		5							
Miltope	0		3,5							
Miniscribe	0					3,5	5			
Northern Telecom	0						8	8	8	
Peripheral Technology	0					3	3			
PerSci	0	14	14							
Priam	0						5,8,14	5,8,14	8	8
Quantum	0					3,5,8	5,8			
Seagate Technology	0					5	5			
Storage Technology	0,P									14
SyQuest Technology	0	3	3			3	3			
Tandon	0					3,5	5			
Tecstor	0								14	
Tulin	0					5	5			
Vermont Research	0		14							
Western Dynex	0	5,14	14							
Xebec	0					5				
Japanese Manufacturers										
Alps Electric	0					3,5				
Epson	C,0					5				
Fujitsu	C,0,P		14			3,5,8	5,8	8,14	8,10,14	10,14
Hitachi	C,0,P					3,5,8	5,8	5,8	8	8,14
Matsushita Com. Ind.	0					3,5				
Mitsubishi	C,0					3,5,8	5,8	5,8	8	
NEC	C,0				14	3,5	5,8,14	8,14	8	8,14
Nippon Electric Industry	0					5	5			
Nippon Peripherals	C,0,P					3,5	5		14	14
Nippon Systemhouse	0	3				3	3			
Okii Electric	C,0					5	5			
Ricoh	C,0		5							
Utari	0					5				
Sord	C					5				
TEAC	0					5				
Tokico	0					5				
Tokyo Electric	0					5				
Toshiba	C,0		14			5,8	5,8	8		
Victor Company of Japan	0					3				
European Manufacturers										
BASF	0					5	5			
Bull	C,0	10	5,10			5	5,10	10		
ISOT	C,0	14		14	14					
Kovo	C,0	14			14					
Newbury	0	5				3	3,5	5		
Nixdorf	C			14						
Olivetti	C,0					5				
Pertec	0							8	8	
Rodime	0					3,5	5			
Stiemens	0							5	5	

TECHNICAL REVIEW

Competing technologies

The large size and the high growth rate of the market for magnetic disk drives has inspired many attempts to apply other technologies in an attempt to capture a significant share of market. Of these competitive technologies, only a few remain as likely contenders.

Two perennial candidates for serious consideration as data storage technologies continue to show promise: Magnetic bubbles and optical disks. Bubbles are now used in many harsh environment applications and are being designed into selected data processing systems, such as portable computers. Some types of optical disks have now achieved the status of actual commercial products, with a few manufacturers making limited shipments. Both technologies will be discussed in more detail later in this section, and an expanded DISK/TREND section on optical disk drives this year covers the current market situation.

Sponsors of other would-be alternates to magnetic rigid disk recording, such as semiconductor memory, have found the competition tougher than expected. Magnetic disk technology is frequently described as a "moving target." As the target moves, it becomes continually more cost effective. The history of magnetic disk recording is one of continually improving recording densities, and this advancement translates directly into lower cost for data storage. Higher density means fewer heads and disks for a given capacity, thus reduced physical size, smaller motors, less heat, lower power, etc. And as densities have been improved, development in head positioning techniques has provided faster access to data.

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

- * Read only optical disks: This technology borrows heavily from the designs of the 4.72" CD audio players now in volume production. Its acceptance will benefit from industry agreement on the CD standards developed jointly by Sony and Philips. Storage capacities of 550 to 600 megabytes are typical of these products, known popularly as CD-ROMs. The success of read-only optical disks in general depends upon the existence and timely development of a data base publishing industry willing to make use of the CD-ROM format to support its clients. Most read-only optical drives will be used with small systems.

In addition to the 4.72" CD-ROM, which is limited in performance, high performance read-only drives are also being shipped by Reference Technology.

- * 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 beginning to be introduced as shippable products.

Write-once drives are capable of higher areal densities than magnetic recording techniques now in use. Some planned systems provide several gigabytes on a single removable disk. Other

products are being used in mass storage systems which access large numbers of optical disks under system control. 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.

In broad terms, two kinds of systems will be offered: Document storage and data storage systems. Systems intended to store images of documents are already on the market in Japan, offered by Toshiba and Matsushita Electric. Document storage systems do not require the extremely low error rates demanded for data storage, and can live with the relatively poor raw error rates common to all optical recording systems. 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 numerous specialized applications. The early emphasis on optical document storage systems in the Japanese market is explained by the extremely complicated character of the Japanese alphabet. Since most business communication and records are in handwritten characters, the emphasis first on copying machines, then facsimile transmission, and now optical document storage systems is understandable.

Optical data storage systems and disk drives from a variety of firms, including Storage Technology, Control Data, Xerox, Alcatel Thomson, Hitachi, Toshiba, NEC and Sony are now starting to appear. STC's 7640, with first shipments delayed until 1986, is probably the most ambitious of these projects, involving a program intended to rapidly build a major market among users of large IBM mainframes. The disk subsystem carries a list purchase price of \$130,000, uses the STC 8880 controller, and has a transfer rate of 3 megabytes/second, the same as the 3380 magnetic disk drive. Each disk cartridge contains a single 14" disk, is priced from \$140 to \$225, depending on quantity, and has a capacity of four gigabytes. STC has identified a large number of target applications involving databases which are infrequently or never updated, and for which a write once system would not be at a disadvantage -- such as stock market history, legal files, seismic data and banking transaction logs. Replacement of magnetic tape for archival storage is also high on the target list.

The other write-once systems now entering the market use comparable, but different technologies, with capacities per disk in the range of one tenth to three gigabytes. These systems will be marketed initially as OEM drives, and some will probably be used also in captive systems. Obviously, the market for this generation of optical disk systems will be limited to the niches which can tolerate nonreversability. These niches do exist and the low cost per byte stored will start to open selected markets to

optical disk systems. But the markets will be specialized, with system manufacturers slow to act. Little displacement of magnetic disk drives will result in the foreseeable future.

- * Erasable optical disks: The possibility for real inroads into the market for magnetic disk drives exists with reversible optical disk systems, when either of the principal proposed technologies reaches the status of a reliable production product. Magneto-optical recording has seen development activity for twenty years, and "phase change" optical recording has attracted considerable attention during the past few years.

Most current magneto-optical development programs involve using a low power laser to change the magnetic state of an amorphous coating on a disk. The laser raises surface temperatures into the range of the coating's Curie point while a magnetic field is present, causing the stored magnetic field on the disk to align with the direction of the external field. These changes 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.

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

Advocates of both technologies claim the ability to reverse the state at individual disk locations more times than would ever be necessary, and believe that their disks will be adequately stable for archival storage. Individual firms are also working on other proposed reversible optical recording technologies, but none of these are known to 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 and phase change technologies have been developed to the point where they both appear to have some hope of becoming reliable, producible products. However, it is believed that the first volume shipments of major erasable optical disk drive systems will take another two to three years. Most of the technical problems may have been overcome by some of the U.S., Japanese or European companies working in the area, but none of these firms are yet known to have committed to the heavy investment required to establish volume production capability. Lack of standardization between optical technologies is causing potential manufacturers to proceed with caution, lest they make inappropriate investments in large scale production tooling. No shippable product is anticipated before 1987, but technology announcements have been made by Verbatim and several Japanese firms.

* 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 has developed was clearly not acceptable for the drop-outs, which had plans for much more immediate returns on their investments.

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

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

The successful bubble program of Intel Magnetics has been instrumental in developing a wide variety of applications. Intel led the market with 1 Mbit chips, the introduction of support circuits and a guaranteed future price reduction policy. The company has attracted a variety of customers in specialized and harsh environment applications -- at least sufficient to establish quantity production and start down the learning curve. The hottest new market area for bubbles is potentially the largest one: Portable computers. Several of the new portable computer manufacturers have incorporated bubble memories as basic auxiliary memory devices, because of bubbles' advantages of physical size and durability while being transported.

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

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

- * High capacity flexible disk drives: Ironically, the most likely type of product to displace certain rigid disk drives is the high capacity flexible disk drive. Some new floppy drives, and others to be announced, have the potential to do just that. The market for personal computers has grown at a rapid rate, and shipments of small Winchester disk drives are keeping pace, creating a market segment large enough to attract new product types.

The 3.3 megabyte 5.25" floppies now being shipped by Eastman Kodak are developing markets with specialized systems and in the personal computer add-on market, with a promise to double capacities to 6.6 megabytes. But capacities in this range are only the beginning of the potential expansion of floppy drive capabilities. Two other more significant rival technologies are waiting in the wings to boost floppy capacity.

Perpendicular recording for flexible disks has received considerable attention in recent years, and has the potential to increase capacity for a 5.25" drive to 5-10 MB without significant increases in track density. By using a sputtered thin film on a Mylar substrate, disks for perpendicular recording could achieve linear densities of at least 50,000 BPI.

It is likely that the largest limitation to the development of markets for such a drive will be media availability. Success would require that media be produced by the millions of units, which would be difficult with today's batch sputtering processes. Toshiba, Sony and Matsushita Electric have revealed programs to develop 3.5" drives and media using perpendicular recording.

The other technology with real promise for improving floppy capacities involves use of very small magnetic particles, not much longer than they are wide. Use of such particles in coatings with conventional binder systems could result in "isotropic" magnetic recording, in which many more flux changes per inch could be obtained than with conventional recording. The big advantage for this technique may be producibility of the media, with little to change in existing floppies but the magnetic particles. Presumably, existing coating lines operated by the several major floppy media suppliers could be used.

The Spin Physics subsidiary of Eastman Kodak is the principal advocate for this technology, and has provided media samples to manufacturers for evaluation. The principal difficulty with isotropic media to date has been oversensitivity to thermal change, with the potential under some circumstances to lose recorded data. However, several firms are working in this area, and there is a high probability that magnetic particles for coated flexible disks will be produced with the ability to extend linear densities into ranges approaching 50,000 BPI.

- * 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 magnetically coated plastic film 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 that bulges slightly in the region 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 can 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. Several firms are currently working with 3M on various versions of products using SSR. If adequately supported and promoted by 3M, SSR has the potential to be a major commercial technology by 1990.

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

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

- * Recording disks: As IBM progressed through succeeding generations of disk drives, the disk media employed underwent only a refinement of the basic process of applying an oxide coating, to achieve a continually thinner application of a uniform coating, plus improvements in surface lubricants. The disks used in a majority of Winchester drives today are derived from IBM's process improvements.

There is now a stampede by numerous established and new firms to establish production capability for thin film disks. Most are aiming 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. Some of this activity has been generated because of the higher density potential of thin film disks (few of the above drives need more density than oxide disks offer), but most of the early choices were made because of plated disks' better physical durability.

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. However, several other companies also installed production capacity for plated disk production. Plated disks have been difficult to produce in adequate quantities because the plating process is difficult to control to the degree required for high yields. 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 metal films has begun to ship disks in significant quantities. These firms are finding that the sputtering process is easier to control than the plating process, 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 inability of producers of 8" disk drives to obtain assured sources of sputtered 8" media. Sputtered disk producers are concentrating on 5.25" or 3.5" media because the bulk of the near term demand is in those sizes.

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

- * Head positioning methods: The industry is not moving forward rapidly with TPI improvements. Several of the highest performance drives operate at about 960 TPI, but such precision is too costly for most drives. The industry still has plenty of room for innovation in this area -- the majority of disk drives still operate below 500 TPI. IBM introduced a double density version of the 3380 in the first half of 1985 that uses higher track density. This drive uses an estimated 1,450 TPI, and will be influential in moving the rest of the industry to higher track densities.
- * Perpendicular recording: Today's disk drives all use longitudinal recording, making use of long, thin magnetic particles oriented parallel to the surface of the recording medium. As many as 100,000 BPI could theoretically be resolved by recording heads if magnetization were oriented in a plane perpendicular to the recording surface.

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 established manufacturers have development programs, but it appears that the earliest products may come from small firms. Lanx has supplied sputtered small diameter disks to manufacturers of existing high performance small drives, with the objective of making significant increases in capacity possible for existing drive mechanisms at modest cost increases. The firm sold a license to Control Data for this technology, and both companies have cooperated in development of hardware. Although the CDC program will probably take a few years to result in actual products, it is expected that some other firms may find the potential competitive advantages they are looking for in perpendicular recording.

As of yet, no major system manufacturer appears close to shipping a drive or system using perpendicular recording in any form other than a demonstration model. The resources required to provide appropriate system channels and drive controllers are more than most firms have chosen to expend. The high bit densities implicit in perpendicular recording result in very high data transfer rates that currently available controllers can't handle. Most system suppliers will wait for someone else to pay the development costs.

DEFINITIONS

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

MARKET CLASSIFICATION

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

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

Examples:

- * Drives sold by DEC, Hewlett-Packard or Burroughs are considered captive, if internally manufactured.
- * In the case of a joint venture disk drive manufacturer such as Magnetic Peripherals, Inc., a joint venture of Control Data, Sperry, and Honeywell, MPI drives sold by Honeywell are included in captive, and MPI drives sold by CDC are included in captive, PCM or OEM groups, as appropriate. Sperry became a co-owner of MPI in 1983, and starting in 1983 Sperry shipments have been combined with those of Control Data, MPI's managing partner.

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

Examples:

- * Shipments by Toshiba are non-captive, except for drives sold with systems by the parent company or other subsidiaries.
- * CDC disk drive sales to NCR are non-captive, in that NCR does not share in ownership of MPI, and are 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 pack drives sold by CDC to end users of IBM Series/1 systems.
- * On an arbitrary basis, drives manufactured by Fujitsu, Hitachi, or Nippon Peripherals and resold in the PCM market by other companies are included in PCM totals, in order to avoid distortion of total industry PCM activity.

OEM: Disk drives sold through any non-captive distribution channel except PCM. (See also the definition of "Distribution channel"). Drives are normally sold to OEMs to be included in complete systems or subsystems; such drives are included in OEM totals whether or not the OEM actually manufactures the remainder of the system or subsystem, or merely assembles components and adds software. Sales by a disk drive manufacturer to a second drive manufacturer for resale are included only in shipment totals for the originating drive manufacturer, except when drives are produced on a contract manufacturing basis with a design supplied by the disk drive manufacturer which finally sells the drive to a third party. Distributors and dealers are arbitrarily defined to be included in OEM totals.

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:

- * IBM, Seagate and Hewlett-Packard are considered U.S. manufacturers, even though each firm manufactures some of its disk drives in non-U.S. locations.
- * Pertec and Northern Telecom are considered non-U.S. manufacturers, since they are subsidiaries of non-U.S. firms.

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, even though some drive configurations include more than one spindle. In order to avoid distortion of shipment information for certain large fixed disk drives used with mainframe systems, certain models have been arbitrarily counted on the basis that two spindles are equivalent to one IBM 3380 spindle (noted in the statistical tables as needed).

Revenue: Based on sales of disk drives alone, as normally sold by individual manufacturers. Controllers sold as separate units are not included, nor are spare parts or service. When individual disk drive models include integral control functions, such as may be required for the first drive on a string of drives, the actual value of the complete unit is used. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM or OEM levels. Prices used for leased drives are on an "if sold" basis, at captive or PCM levels, as appropriate. All prices are in 1985 constant dollars.

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 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.

DISTRIBUTION CHANNEL CLASSIFICATION

Shipments of non-captive drives (OEM and PCM market classes) are analyzed by each of the following distribution channels:

Mainframe computer manufacturers: The major computer manufacturers, sometimes popularly known as "mainframers". In the U.S. this group consists of IBM, Sperry, Honeywell, Burroughs, Control Data, and NCR.

Mini/micro computer manufacturers: Computer manufacturers primarily oriented to the minicomputer class, such as DEC, Hewlett-Packard, and Data General, and the manufacturers of microprocessor-based systems, such as Intel and National Semiconductor.

System OEMs/systems houses: (1) OEMs which manufacture a system requiring disk drives, such as Foxboro, Wang or Compaq. (2) System houses, of any size, which combine finished components and software to offer users complete systems.

Independent peripherals suppliers: Specialized manufacturers which add controllers, interfaces and other equipment or software, and offer plug compatible subsystems to end users, system OEMs and systems houses. Examples are Tallgrass, Tecmar, Xylogics and Emulex.

Distributors, dealers, end users: (1) Sales of plug compatible (PCM) disk drives with any other necessary hardware directly to end users by disk drive manufacturers, whether or not title to the equipment is to be held by end users themselves or by lessors. (2) Distribution through wholesalers, such as Hamilton Avnet or Arrow.

DISK CARTRIDGE DRIVES, LESS THAN 12 MB

DISK CARTRIDGE DRIVES, LESS THAN 12 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Digital Equipment	RL02
ISOT	CM 5400, CM 5410
PerSci	VF-2221, VT-2222
Western Dynex	DD-6221

10.5" disk diameter

Bull	D120
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8" disk diameter

Disctron	DP-100
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5.25" disk diameter

Newbury Data	505
Western Dynex	WD-505

3.9" disk diameter

SyQuest Technology	SQ-306RD
Nippon Systemhouse	SQ-306RD

This product group includes all removable-only or fixed/removable disk drives with a total capacity per spindle of less than 12 MB. Each fixed/removable combination drive is counted as one spindle.

The number of disk drives offered in this group is reduced again this year, as older models are discontinued. Control Data's 9427H "Hawk", for many years the group's leading product, is no longer in production.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	150.8	61.5	34.7	11.5	9.4
All manufacturers	206.0	131.2	102.2	59.1	40.2

Total worldwide revenues for this product group continue to decline, as 14" disk cartridge drive shipments are impacted by newer drive configurations and as most would-be producers of smaller diameter disk cartridge drives have failed either to gain substantial customers or, in several cases, to achieve production in the first place.

SyQuest Technology has provided a notable exception to the general slowdown in this product group, with 1984 shipments of 27,200 drives, 68.6% of the worldwide unit shipment total for the group. The rapid growth of 1984 shipments for SyQuest 3.9" removable disk drives was driven in large part by excellent response from personal computer users who were not offered removable media drives adequate to copy large files by the manufacturers of most PCs.

While worldwide shipments for 3.9" drives are expected to increase again in 1985, the entire increase will come from SyQuest's Japanese licensee -- U.S. shipments for drives with less than 12 megabytes capacity are falling off, as higher capacity models take over the growth. Shipments of 5.25" drives have currently dropped to insignificant levels, since DMA Systems, the pioneer manufacturer of 5.25" removable disk drives, was forced to close in August, 1985, by its impatient bank.

14" disk drives in this group have been displaced in small business systems, their largest market, by the flood of 8" and 5.25" fixed disk drives which have become available in recent years. Shipments of drives

using removable disks in these diameters were very small before 1983, due to limited availability.

Captive drive shipments are mostly Digital Equipment Corporation's RLO2 14" drives. Shipments of these drives remained high during 1983 and 1984, primarily because of DEC's delays in introducing the planned replacement product, the 8" "Aztec" drive, with 52 megabytes per spindle. The Aztec, however, has been shipping since late 1983 as the RC25, even though the early shipment rate was low, due to technical problems. But DEC now has plenty of RC25s to sell, and the expected result is that shipments of DEC's 14" disk cartridge drives will fall off rapidly.

The character of OEM drive shipments has been transformed in the last few years, as the once-large shipments of 14" drives by U.S. manufacturers have dropped to negligible levels. ISOT, the Bulgarian organization which manufactures disk cartridge drives for minicomputers produced in Eastern Bloc countries, increased its production to 13,500 drives in 1984, representing 21.8% of worldwide OEM unit shipments for 1984.

Marketing trends

1986 is expected to be the last year of captive 14" disk cartridge drive shipments in this product group by U.S. producers, with the last U.S. 14" OEM shipments occurring in 1985. In the U.S. and Western European markets, 14" disk cartridge drives have been largely replaced by small diameter fixed disk drives in most new system designs. OEM and captive shipments of 14" drives by non-U.S. manufacturers are expected to continue indefinitely, principally for Eastern Bloc consumption.

The outlook for 8" and 10.5" drives in this group also is poor, for both captive and OEM drives. Only a few manufacturers produce such

drives, and their marketing efforts have been frustrated by lack of industry standards -- plus prices which are high when compared to 5.25" drives, using either fixed or removable disks.

The projections for 3.9" disk cartridge drive shipments in this group show continued decline, in view of the fact that drive manufacturers are now emphasizing drives with over 12 megabytes, which are covered in another product group. 5.25" drive forecasts have been held to modest levels, due to the reduced number of manufacturers offering them.

The combined worldwide forecast for 5.25" drives and those with smaller diameters is 35,900 units in 1986, going down to 17,500 in 1988. These will be mostly 6 megabyte drives, with much smaller market potential than higher capacity models. Most system OEMs have already switched from 6 to 12 megabyte drives for their fixed disk drive requirements, and the majority of those OEMs which need removability are expected to prefer more capacity than the 6 megabytes offered by drives in this group.

It is expected that much of the market available to 6 megabyte 5.25" disk cartridge drives will be through subsystem builders active in the personal computer add-on market. The rapid growth of 1984 shipments for SyQuest 3.9" removable disk drives was driven in large part by excellent response from PC users who were not offered any removable media recording device with equal capacity by IBM or most other PC system manufacturers.

Technical trends

Technology used in the new small disk cartridge drives is adapted from older designs. Heads use variations from 3330 and 3350 designs, in

some cases combined with smaller sliders. Disks used in current drives include conventional Winchester oxide coated, plus newer plated and sputtered disks.

3M's stretched surface recording technology may be a potential contender in this product group, depending on actual availability and the results of the extensive testing expected before drive manufacturers use it in production drives. SSR disks have the potential to cut media costs sharply and probably would be much more durable than conventional disks in difficult shock and vibration environments or when exposed to contamination, as removable disk cartridges frequently are.

Forecasting assumptions

1. 14" disk cartridge drives will continue to decline, due to competitive pressure from higher capacity disk cartridge drives and small diameter disk drives, both fixed and disk cartridge types.
2. Shipments of 8" disk cartridge drives in this group will disappear after 1986, due to competition from smaller drives.
3. Both 5.25" and less than 5.25" drives in this group will be available in quantities adequate to meet demand.
4. OEM price levels will increase after 1986, as the percentage of 14" drives shipped primarily within the Eastern Bloc countries increases.

TABLE 8
DISK CARTRIDGE DRIVES, LESS THAN 12 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		-----Forecast-----							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	63.0	105.0	25.2	42.0	17.1	25.5	7.8	7.8	9.4	9.4
TOTAL U.S. CAPTIVE	63.0	105.0	25.2	42.0	17.1	25.5	7.8	7.8	9.4	9.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	35.6	45.8	16.8	19.5	8.2	9.2	3.1	3.7	--	--
TOTAL U.S. NON-CAPTIVE	35.6	45.8	16.8	19.5	8.2	9.2	3.1	3.7	--	--
TOTAL U.S. REVENUES	98.6	150.8	42.0	61.5	25.3	34.7	10.9	11.5	9.4	9.4
Non-U.S. Manufacturers										
Captive	--	16.2	--	28.3	--	29.4	--	14.9	--	6.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	3.9	39.0	1.3	41.4	--	38.1	--	32.7	--	24.4
TOTAL NON-U.S. REVENUES	3.9	55.2	1.3	69.7	--	67.5	--	47.6	--	30.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	102.5	206.0	43.3	131.2	25.3	102.2	10.9	59.1	9.4	40.2
OEM Average Price (\$000)	.9	1.3	.6	1.1	.5	1.1	.4	1.2	1.2	1.5

TABLE 9
DISK CARTRIDGE DRIVES, LESS THAN 12 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		-----Forecast-----							
	---Shipments---		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers -----										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	15.0	25.0	6.0	10.0	4.5	6.5	2.8	2.8	3.6	3.6
TOTAL U.S. CAPTIVE	15.0	25.0	6.0	10.0	4.5	6.5	2.8	2.8	3.6	3.6
PCM	--	--	--	--	--	--	--	--	--	--
OEM	38.8	46.8	26.4	30.7	14.3	16.5	6.8	8.0	--	--
TOTAL U.S. NON-CAPTIVE	38.8	46.8	26.4	30.7	14.3	16.5	6.8	8.0	--	--
TOTAL U.S. SHIPMENTS	53.8	71.8	32.4	40.7	18.8	23.0	9.6	10.8	3.6	3.6
Non-U.S. Manufacturers -----										
Captive	--	2.3	--	6.5	--	8.3	--	3.5	--	.8
PCM	--	--	--	--	--	--	--	--	--	--
OEM	.8	15.1	.3	23.9	--	25.0	--	22.0	--	16.0
TOTAL NON-U.S. SHIPMENTS	.8	17.4	.3	30.4	--	33.3	--	25.5	--	16.8
Worldwide Recap -----										
TOTAL WORLDWIDE SHIPMENTS	54.6	89.2	32.7	71.1	18.8	56.3	9.6	36.3	3.6	20.4
Cumulative Shipments -----										
IBM Captive	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0
Non-IBM	577.7	1,044.7	610.4	1,115.8	629.2	1,172.1	638.8	1,208.4	642.4	1,228.8
WORLDWIDE TOTAL	631.0	1,123.7	663.7	1,194.8	682.5	1,251.1	692.1	1,287.4	695.7	1,307.8

TABLE 10
DISK CARTRIDGE DRIVES, LESS THAN 12 MEGABYTES
WORLDWIDE SHIPMENTS (000)
BREAKDOWN BY DISK DIAMETER

	1984				1985				1986				1987			1988		
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	5.25"	<5.25"	14"	5.25"	<5.25"
U.S. MANUFACTURERS																		
IBM Captive	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	25.0	--	--	--	10.0	--	--	--	5.0	--	1.5	--	--	2.8	--	--	3.6	--
OEM	5.0	7.9	1.9	32.0	.7	2.0	1.0	27.0	--	1.0	.5	15.0	--	--	8.0	--	--	--
TOTAL U.S. SHIPMENTS	30.0	7.9	1.9	32.0	10.7	2.0	1.0	27.0	5.0	1.0	2.0	15.0	--	2.8	8.0	--	3.6	--
NON-U.S. MANUFACTURERS																		
Captive	1.6	.7	--	--	1.6	.5	.4	4.0	1.4	.3	.6	6.0	1.2	.3	2.0	.8	--	--
OEM	14.4	.6	--	.1	14.7	.2	1.0	8.0	12.5	--	3.5	9.0	10.0	5.0	7.0	6.5	6.5	3.0
TOTAL NON-U.S. SHIPMENTS	16.0	1.3	--	.1	16.3	.7	1.4	12.0	13.9	.3	4.1	15.0	11.2	5.3	9.0	7.3	6.5	3.0
WORLDWIDE RECAP																		
Total Shipments	46.0	9.2	1.9	32.1	27.0	2.7	2.4	39.0	18.9	1.3	6.1	30.0	11.2	8.1	17.0	7.3	10.1	3.0
ANNUAL SHARE, BY DIAMETER	51.7%	10.3%	2.1%	35.9%	38.1%	3.8%	3.4%	54.7%	33.7%	2.3%	10.8%	53.2%	31.0%	22.3%	46.7%	35.9%	49.5%	14.6%

NOTE: 8 inch totals include 10.5 inch drives

TABLE 11
 DISK CARTRIDGE DRIVES, LESS THAN 12 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984				1985				1986				Forecast					
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	5.25"	<5.25"	14"	5.25"	<5.25"
U.S. MANUFACTURERS																		
IBM Captive	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	105.0	--	--	--	42.0	--	--	--	21.0	--	4.5	--	--	7.8	--	--	9.4	--
OEM	16.4	11.2	2.2	16.0	2.1	2.8	1.5	13.1	--	1.4	.8	7.0	--	--	3.7	--	--	--
TOTAL U.S. REVENUES	121.4	11.2	2.2	16.0	44.1	2.8	1.5	13.1	21.0	1.4	5.3	7.0	--	7.8	3.7	--	9.4	--
NON-U.S. MANUFACTURERS																		
Captive	12.8	3.4	--	--	12.8	2.3	1.2	12.0	11.2	1.4	1.8	15.0	9.6	.9	4.4	6.4	--	--
OEM	38.0	1.0	--	--	37.3	.3	1.1	2.7	31.3	--	3.9	2.9	25.0	5.5	2.2	16.3	7.2	.9
TOTAL NON-U.S. REVENUES	50.8	4.4	--	--	50.1	2.6	2.3	14.7	42.5	1.4	5.7	17.9	34.6	6.4	6.6	22.7	7.2	.9
WORLDWIDE RECAP																		
Total Revenues	172.2	15.6	2.2	16.0	94.2	5.4	3.8	27.8	63.5	2.8	11.0	24.9	34.6	14.2	10.3	22.7	16.6	.9
ANNUAL SHARE, BY DIAMETER	83.7%	7.6%	1.1%	7.6%	71.9%	4.1%	2.9%	21.1%	62.2%	2.7%	10.8%	24.3%	58.6%	24.0%	17.4%	56.6%	41.3%	2.1%

NOTE: 8 inch totals include 10.5 inch drives

TABLE 12

DISK CARTRIDGE DRIVES, LESS THAN 12 MEGABYTES
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution channel	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	5.0	12.6	8.0	4.3	--	--
Mini/micro computer manufacturers	12.9	32.6	25.9	19.2	12.6	--
System OEMs/systems houses	3.0	7.6	20.5	33.4	46.3	--
Independent peripherals suppliers	10.5	26.5	27.5	28.5	29.6	--
Distributors, dealers, end users	<u>8.2</u>	20.7	18.1	14.6	11.5	--
TOTAL	39.6					

TABLE 13

DISK CARTRIDGE DRIVES, LESS THAN 12 MEGABYTES
MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1984 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	--	--	--	27.2	27.2	68.6	--	--	--	32.0	32.0	51.7
Isot	--	--	--	--	--	--	13.5	--	--	--	13.5	21.8
Disctron	--	7.6	--	--	7.6	19.2	--	7.8	--	--	7.8	12.6
Control Data	2.0	--	--	--	2.0	5.1	3.2	--	--	--	3.2	5.2
Other U.S.	1.0	.1	.9	--	2.0	5.1	1.8	.1	1.9	--	3.8	6.1
Other Non-U.S.	.8	--	--	--	.8	2.0	.9	.6	--	.1	1.6	2.6
TOTAL	3.8	7.7	.9	27.2	39.6	100.0	19.4	8.5	1.9	32.1	61.9	100.0

NOTE: 8 inch totals include 10.5 inch drives

DISK CARTRIDGE DRIVES, MORE THAN 12 MB

DISK CARTRIDGE DRIVES, MORE THAN 12 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Ampex	DFR-932, DFR-964, DFR-996
Control Data	9448-32, 9448-64, 9448-96
Fujitsu	F6417
Hewlett-Packard	7906
PerSci	VT-2422
Toshiba	MK-900R-32/64/96
Vermont Research	5017-4

10.5" disk diameter

Bull	D140, D145
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8" disk diameter

Arcodyne	Arapahoe 7110
Century Data Systems	C2075, C2120
Control Data	9457
Vermont Research	8520
Digital Equipment	RC25

5.25" disk diameter

Bull	D520
Micro Storage	MS 212
Miltope	RDS-15, RDS-86
Ricoh	RH5130

3.9" disk diameter

SyQuest Technology	SQ312RD
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3.5 disk diameter

Miltope	RDS-10
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This is a diverse group of drives, all of which use a removable disk cartridge, which is usually, but not always combined with one or more fixed disks in a single drive. Several unique configurations are also included, such as Fujitsu's F6417 (67 MB removable), Miltope's drives

incorporating heads and media in a removable cartridge, and Vermont Research's pioneer embedded servo drive, the 5017-4 (14" 26 MB fixed/26 MB removable).

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	235.4	154.2	185.9	228.9	277.6
All manufacturers	270.5	180.9	239.1	316.0	387.8

The product mix in this group is changing rapidly, as older 14" drives and some unsuccessful 8" drives near the end of their production lives, while smaller diameter drives are starting to achieve significant shipment levels. While overall worldwide revenues are expected to drop from 1984's \$270,500,000 to \$180,900,000 in 1985, unit shipments will be up from 54,600 to 74,200 for the same years -- reflecting a combination of the movement to smaller drives and reduced captive shipments.

The most striking example of changes underway in the OEM disk drive market is provided by the Control Data 9448 "Phoenix", a 14" disk cartridge drive with capacities up to 96 megabytes, first shipped in 1978. OEM shipments of the Phoenix peaked at 28,500 drives in 1982, dropping to 23,900 in 1983, then to 9,800 in 1984. 1985 is expected to be the last production year for the Phoenix, mortally wounded by competition from fixed disk drives offering lower cost, better reliability and smaller size -- and to a more limited extent from smaller disk cartridge drives.

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

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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 who previously used 14" disk cartridge drives in small office and engineering systems, and would have liked to continue with removable disk drives in smaller sizes, tired of waiting and switched to fixed disk drives.

In 8" drives, Amcodyne currently appears to have won most of the significant remaining OEM customers, while Control Data's early lead has dwindled. In 1984, 5.25" drive shipments were only 7,300 units worldwide, and DMA Systems, the early leader, is now out of business -- but new 5.25" drives from Ricoh, Bull and Micro Systems are expected to bring the 1985 total up to 20,400.

1985's leading company in unit shipments, however, will be SyQuest Technology, the 1984 leader in OEM shipments of disk cartridge drives below 12 megabytes. SyQuest has been shipping a 12.75 megabyte version of its 3.9" drive since the second half of 1984, with good response from both system manufacturers and the personal computer add-on market. SyQuest was not a factor in the 1984 OEM market for disk cartridge drives with over 12 megabytes capacity. Control Data held 19.9% of worldwide shipments, with DMA Systems at 18.9%.

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Marketing trends

DISK/TREND forecasts through 1988 for this product group have been increased, reflecting an expected modest recovery in unit shipments for 8" drives, plus stronger growth for smaller diameter drives, especially those with disk diameters less than 5.25". It is expected that total worldwide shipment growth for all drives in the group will average 52% through 1988, reaching 258,400 units in that year.

We continue to expect the last production of 14" drives in 1986. All remaining production of 8" drives is expected to be from U.S. companies, for both captive and OEM markets. 8" drives are expected to find use mainly with minicomputer systems, replacing older 14" drives now being phased out.

5.25" drives will provide the lion's share of future growth for this product group, with 1988 worldwide unit shipments forecasted at 98,900 for 5.25" drives and 121,000 for less than 5.25" drives.

5.25" fixed/removable drives are expected to find acceptance mostly with general purpose and specialized microcomputer systems, which themselves are now in a rapid growth phase, penetrating the markets previously served by small minicomputers. Removable-only 5.25" and smaller drives will probably find their major market opportunity in add-on subsystems aimed at the high end of the personal computer market. This market, of course, is a volatile one -- with the continuing possibility that the emergence of high capacity flexible disk drives could impact the projected shipment growth for rigid disk cartridge 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 used variations to the older 3330 technology.

The 8" 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, and all use embedded servo techniques in order to maximize the disk surface area available for recording.

The major difference in high density recording between disk cartridge drives and fixed disk drives is higher probability of particulate contamination in removable disk drives. At existing linear recording densities, removability appears to be completely practical. But at densities well above 10,000 BPI, already in use with high capacity fixed disk drives, heads must fly at lower altitudes, increasing the need for lower contamination levels. It may be possible to increase density in removable disk drives, but the degree of engineering difficulty will be high. Changes in heads, filtration systems and seals may be necessary, and plated or sputtered disks may be used because their surfaces seem to be more durable than oxide coated disks.

Forecasting assumptions

1. 8" disk cartridge drives will find adequate markets in mini-computer applications, due to integral backup capability, small physical size and competitive pricing.
2. Production for 5.25" disk cartridge drives will be available in large production quantities from multiple sources starting in 1986, with good acceptance.

TABLE 14
DISK CARTRIDGE DRIVES, MORE THAN 12 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		Forecast							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	106.6	137.7	56.5	93.3	65.3	107.9	76.5	127.5	96.6	161.0
TOTAL U.S. CAPTIVE	106.6	137.7	56.5	93.3	65.3	107.9	76.5	127.5	96.6	161.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	71.4	97.7	49.5	60.9	68.6	78.0	88.1	101.4	101.1	116.6
TOTAL U.S. NON-CAPTIVE	71.4	97.7	49.5	60.9	68.6	78.0	88.1	101.4	101.1	116.6
TOTAL U.S. REVENUES	178.0	235.4	106.0	154.2	133.9	185.9	164.6	228.9	197.7	277.6
Non-U.S. Manufacturers										
Captive	--	21.0	--	13.8	--	37.6	--	59.8	--	75.2
PCM	--	--	--	--	--	--	--	--	--	--
OEM	.3	14.1	4.7	12.9	6.2	15.6	10.7	27.3	14.4	35.0
TOTAL NON-U.S. REVENUES	.3	35.1	4.7	26.7	6.2	53.2	10.7	87.1	14.4	110.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	178.3	270.5	110.7	180.9	140.1	239.1	175.3	316.0	212.1	387.8
OEM Average Price (\$000)	3.2	3.1	1.2	1.2	.9	.9	.8	.8	.7	.7

TABLE 15
 DISK CARTRIDGE DRIVES, MORE THAN 12 MEGABYTES
 UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	12.2	15.7	6.4	10.6	7.9	13.1	10.2	17.0	13.8	23.0
TOTAL U.S. CAPTIVE	12.2	15.7	6.4	10.6	7.9	13.1	10.2	17.0	13.8	23.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	22.1	32.1	39.1	50.2	68.5	79.6	94.3	110.8	117.0	137.4
TOTAL U.S. NON-CAPTIVE	22.1	32.1	39.1	50.2	68.5	79.6	94.3	110.8	117.0	137.4
TOTAL U.S. SHIPMENTS	34.3	47.8	45.5	60.8	76.4	92.7	104.5	127.8	130.8	160.4
Non-U.S. Manufacturers	-----									
Captive	--	3.0	--	3.5	--	11.5	--	21.0	--	29.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	.1	3.8	5.8	9.9	11.2	22.4	20.3	47.6	28.7	69.0
TOTAL NON-U.S. SHIPMENTS	.1	6.8	5.8	13.4	11.2	33.9	20.3	68.6	28.7	98.0
Worldwide Recap	-----									
TOTAL WORLDWIDE SHIPMENTS	34.4	54.6	51.3	74.2	87.6	126.6	124.8	196.4	159.5	258.4
Cumulative Shipments	-----									
IBM Captive	--	--	--	--	--	--	--	--	--	--
Non-IBM	191.2	339.5	242.5	413.7	330.1	540.3	454.9	736.7	614.4	995.1
WORLDWIDE TOTAL	191.2	339.5	242.5	413.7	330.1	540.3	454.9	736.7	614.4	995.1

TABLE 16
DISK CARTRIDGE DRIVES, MORE THAN 12 MEGABYTES
WORLDWIDE SHIPMENTS (000)
BREAKDOWN BY DISK DIAMETER

	1984				1985				1986				1987			1988		
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	8"	5.25"	<5.25"	8"	5.25"	<5.25"
U.S. MANUFACTURERS																		
Other U.S. Captive	2.0	13.7	--	--	1.3	9.3	--	--	.6	12.5	--	--	17.0	--	--	23.0	--	--
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	9.9	13.4	6.8	2.0	2.0	6.4	9.8	32.0	--	9.0	14.6	56.0	12.5	27.3	71.0	15.5	38.9	83.0
TOTAL U.S. SHIPMENTS	11.9	27.1	6.8	2.0	3.3	15.7	9.8	32.0	.6	21.5	14.6	56.0	29.5	27.3	71.0	38.5	38.9	83.0
NON-U.S. MANUFACTURERS																		
Captive	--	3.0	--	--	--	1.5	2.0	--	--	.5	8.0	3.0	--	13.0	8.0	--	17.0	12.0
OEM	2.4	.9	.5	--	1.0	.3	8.6	--	--	--	18.4	4.0	--	31.6	16.0	--	43.0	26.0
TOTAL NON-U.S. SHIPMENTS	2.4	3.9	.5	--	1.0	1.8	10.6	--	--	.5	26.4	7.0	--	44.6	24.0	--	60.0	38.0
WORLDWIDE RECAP																		
Total Shipments	14.3	31.0	7.3	2.0	4.3	17.5	20.4	32.0	.6	22.0	41.0	63.0	29.5	71.9	95.0	38.5	98.9	121.0
ANNUAL SHARE, BY DIAMETER	26.3%	56.8%	13.4%	3.5%	5.8%	23.6%	27.6%	43.0%	.5%	17.4%	32.5%	49.6%	15.0%	36.7%	48.3%	14.9%	38.3%	46.8%

NOTE: 8 inch totals include 10.5 inch drives

TABLE 17
 DISK CARTRIDGE DRIVES, MORE THAN 12 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984 Revenues				1985				1986				Forecast					
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	8"	5.25"	<5.25"	8"	5.25"	<5.25"
U.S. MANUFACTURERS																		
Other U.S. Captive	24.2	113.5	--	--	16.2	77.1	--	--	7.9	100.0	--	--	127.5	--	--	161.0	--	--
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	46.4	41.6	8.1	1.6	8.7	18.8	12.6	20.8	--	25.2	19.2	33.6	35.0	27.4	39.0	43.4	31.7	41.5
TOTAL U.S. REVENUES	70.6	155.1	8.1	1.6	24.9	95.9	12.6	20.8	7.9	125.2	19.2	33.6	162.5	27.4	39.0	204.4	31.7	41.5
NON-U.S. MANUFACTURERS																		
Captive	--	21.0	--	--	--	9.8	4.0	--	--	3.3	25.6	8.7	--	39.0	20.8	--	47.6	27.6
OEM	10.4	2.6	1.1	--	4.4	.9	7.6	--	--	--	13.8	1.8	--	20.5	6.8	--	24.6	10.4
TOTAL NON-U.S. REVENUES	10.4	23.6	1.1	--	4.4	10.7	11.6	--	--	3.3	39.4	10.5	--	59.5	27.6	--	72.2	38.0
WORLDWIDE RECAP																		
Total Revenues	81.0	178.7	9.2	1.6	29.3	106.6	24.2	20.8	7.9	128.5	58.6	44.1	162.5	86.9	66.6	204.4	103.9	79.5
ANNUAL SHARE, BY DIAMETER	30.0%	66.1%	3.4%	.5%	16.2%	59.0%	13.4%	11.4%	3.3%	53.8%	24.5%	18.4%	51.5%	27.5%	21.0%	52.7%	26.8%	20.5%

NOTE: 8 inch totals include 10.5 inch drives

TABLE 18

DISK CARTRIDGE DRIVES, MORE THAN 12 MEGABYTES
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution channel	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	4.8	21.5	19.8	15.8	11.0	7.8
Mini/micro computer manufacturers	6.7	30.3	21.5	18.7	17.9	17.7
System OEMs/systems houses	8.7	39.1	27.9	24.1	23.2	22.9
Independent peripherals suppliers	.9	3.9	22.5	29.3	32.2	34.4
Distributors, dealers, end users	1.1	5.2	8.3	12.1	15.7	17.2
TOTAL	22.2					

TABLE 19

DISK CARTRIDGE DRIVES, MORE THAN 12 MEGABYTES
MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1984 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	
Control Data	8.1	7.1	--	--	15.2	68.5	9.8	10.1	--	--	19.9	55.4
DMA Systems	--	--	2.7	--	2.7	12.2	--	--	6.8	--	6.8	18.9
Amcodyne	--	2.2	--	--	2.2	9.9	--	3.0	--	--	3.0	8.4
Other U.S.	--	.3	--	1.7	2.0	9.0	.1	.3	--	2.0	2.4	6.7
Other Non-U.S.	.1	--	--	--	.1	.4	2.4	.9	.5	--	3.8	10.6
TOTAL	8.2	9.6	2.7	1.7	22.2	100.0	12.3	14.3	7.3	2.0	35.9	100.0

NOTE: 8 inch totals include 10.5 inch drives

DISK PACK DRIVES, LESS THAN 100 MB

DISK PACK DRIVES, LESS THAN 100 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Control Data	9762, 271-10
Hewlett-Packard	7920
ISOT	CM 5412

9" disk diameter

Control Data	9710
--------------	------

The Control Data 9760 series, the original "storage module drives", have exerted broad influence in the industry since their 1974 introduction. "SMD" became the generally used term for drives using 3330 technology in packs with five data surfaces, as well as for the larger 19 data surface disk pack drives using similar interfaces. The SMD interface also became the dominant industry standard for high performance OEM disk drives. The term SMD is used throughout the DISK/TREND Report as a generic description for these 14" Control Data drives and competitive equivalents. Starting with this year's DISK/TREND report, the continuing Eastern Bloc production of drives equivalent to the older IBM 2314 is also included in this product group.

Control Data's 9" "RSD", or 9710, is functionally similar to the 80 MB SMD in every way except for smaller size and lower price. Its physical size is matched to the 160 MB "FSD" 9" fixed disk drive, which was also introduced at the 1982 NCC.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	180.6	103.3	90.0	70.9	62.9
All manufacturers	323.9	224.8	182.0	152.9	140.9

The long term decline in shipments for this product group was interrupted in 1984 by a short term surge in Control Data's shipments of 14" drives and the inclusion of continuing Bulgarian production of drives using 2314 technology for Eastern Bloc consumption. The downward slope has resumed in 1985, with the worldwide unit shipment total expected to be 34,500 drives, down from 44,300 in 1984.

In 1984, Control Data continued to lead all other manufacturers of OEM drives by a wide margin, holding 66.8% of worldwide shipments, consisting of 17,900 14" and 4,000 8" drives. ISOT held 26.8% of total shipments.

During 1985, U.S. shipments of OEM 14" drives are expected to drop to less than half of the 1984 total, but 8" drives will almost double in unit shipments. Non-U.S. OEM shipments of 14" drives are expected to increase to 12,000 units, all for Eastern Bloc usage. Captive production will continue its decline this year, throughout the world.

Marketing trends

By 1988, all U.S. production of 14" drives in this group is expected to stop, as will all production in Japan and Western Europe. Continued growth is forecasted for Control Data's 9" RSD drives, reaching 17,000 units in 1988. The only remaining production of 14" drives in 1988 is expected in Eastern Bloc countries.

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

Technical trends

Control Data has used a conservative approach in designing the RSD. Recording density is higher than the SMD, but well below the most advanced drives of today -- leaving adequate design margins for the double density version the firm originally planned to add. Today's RSD is well designed to take advantage of the existing SMD customer base, providing exactly the same capacity, performance, file organization and interface, but in half the space, at a significant price reduction. However, nothing has been heard from Century Data Systems or Ampex, CDC's traditional rivals in the SMD market, about additional 9" disk pack drives. These firms appear to be using all their energies on fixed disk drives of various sizes.

Forecasting assumptions

1. Captive and OEM shipments of 14" drives in this group by Western nations will continue to decline through 1987, displaced by smaller disk pack drives and a variety of fixed disk drives.
2. RSD drives will dominate shipments after 1985.
3. CDC will remain the only manufacturer for 9" disk pack drives.

TABLE 20
DISK PACK DRIVES, LESS THAN 100 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		1985		1986		1987		1988	
	Revenues						Forecast			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	53.0	71.6	26.4	30.7	23.0	24.4	9.4	9.4	--	--
TOTAL U.S. CAPTIVE	53.0	71.6	26.4	30.7	23.0	24.4	9.4	9.4	--	--
PCM	.9	.9	.9	.9	--	--	--	--	--	--
OEM	52.2	108.1	40.5	71.7	48.8	65.6	51.1	61.5	54.8	62.9
TOTAL U.S. NON-CAPTIVE	53.1	109.0	41.4	72.6	48.8	65.6	51.1	61.5	54.8	62.9
TOTAL U.S. REVENUES	106.1	180.6	67.8	103.3	71.8	90.0	60.5	70.9	54.8	62.9
Non-U.S. Manufacturers										
Captive	--	99.7	--	64.0	--	32.0	--	16.0	--	8.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	43.6	--	57.5	--	60.0	--	66.0	--	70.0
TOTAL NON-U.S. REVENUES	--	143.3	--	121.5	--	92.0	--	82.0	--	78.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	106.1	323.9	67.8	224.8	71.8	182.0	60.5	152.9	54.8	140.9
OEM Average Price (\$000)	4.5	4.6	4.3	4.5	4.1	4.5	3.9	4.8	3.7	4.9

TABLE 21
DISK PACK DRIVES, LESS THAN 100 MEGABYTES
UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1984		Forecast							
	Shipments		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	3.9	5.3	1.9	2.2	1.7	1.8	.7	.7	--	--
TOTAL U.S. CAPTIVE	3.9	5.3	1.9	2.2	1.7	1.8	.7	.7	--	--
PCM	.1	.1	.1	.1	--	--	--	--	--	--
OEM	11.5	23.7	9.3	16.2	11.7	15.5	13.0	15.5	14.8	17.0
TOTAL U.S. NON-CAPTIVE	11.6	23.8	9.4	16.3	11.7	15.5	13.0	15.5	14.8	17.0
TOTAL U.S. SHIPMENTS	15.5	29.1	11.3	18.5	13.4	17.3	13.7	16.2	14.8	17.0
Non-U.S. Manufacturers										
Captive	--	6.2	--	4.0	--	2.0	--	1.0	--	.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	9.0	--	12.0	--	12.0	--	11.0	--	10.0
TOTAL NON-U.S. SHIPMENTS	--	15.2	--	16.0	--	14.0	--	12.0	--	10.5
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	15.5	44.3	11.3	34.5	13.4	31.3	13.7	28.2	14.8	27.5
Cumulative Shipments										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Non-IBM	202.4	342.6	213.7	377.1	227.1	408.4	240.8	436.6	255.6	464.1
WORLDWIDE TOTAL	202.4	342.6	213.7	377.1	227.1	408.4	240.8	436.6	255.6	464.1

TABLE 22
 DISK PACK DRIVES, LESS THAN 100 MEGABYTES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1984		Forecast							
	14"	8"	1985		1986		1987		1988	
	Shipments		14"	8"	14"	8"	14"	8"	14"	8"
U.S. MANUFACTURERS										
Other U.S. Captive	5.3	--	1.8	.4	1.3	.5	.5	.2	--	--
PCM	.1	--	.1	--	--	--	--	--	--	--
OEM	19.7	4.0	8.6	7.6	5.0	10.5	1.5	14.0	--	17.0
TOTAL U.S. SHIPMENTS	25.1	4.0	10.5	8.0	6.3	11.0	2.0	14.2	--	17.0
NON-U.S. MANUFACTURERS										
Captive	6.2	--	4.0	--	2.0	--	1.0	--	.5	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	9.0	--	12.0	--	12.0	--	11.0	--	10.0	--
TOTAL NON-U.S. SHIPMENTS	15.2	--	16.0	--	14.0	--	12.0	--	10.5	--
WORLDWIDE RECAP										
Total Shipments	40.3	4.0	26.5	8.0	20.3	11.0	14.0	14.2	10.5	17.0
ANNUAL SHARE, BY DIAMETER	91.1%	8.9%	76.9%	23.1%	65.0%	35.0%	49.7%	50.3%	38.3%	61.7%

NOTE: 8 inch totals include 9 inch drives

TABLE 23
 DISK PACK DRIVES, LESS THAN 100 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984		Forecast							
	14"	8"	14"	8"	14"	8"	14"	8"	14"	8"
U.S. MANUFACTURERS										
Other U.S. Captive	71.6	--	25.9	4.8	18.4	6.0	7.0	2.4	--	--
PCM	.9	--	.9	--	--	--	--	--	--	--
OEM	90.1	18.0	39.0	32.7	22.5	43.1	6.8	54.7	--	62.9
TOTAL U.S. REVENUES	162.6	18.0	65.8	37.5	40.9	49.1	13.8	57.1	--	62.9
NON-U.S. MANUFACTURERS										
Captive	99.7	--	64.0	--	32.0	--	16.0	--	8.0	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	43.6	--	57.5	--	60.0	--	66.0	--	70.0	--
TOTAL NON-U.S. REVENUES	143.3	--	121.5	--	92.0	--	82.0	--	78.0	--
WORLDWIDE RECAP										
Total Revenues	305.9	18.0	187.3	37.5	132.9	49.1	95.8	57.1	78.0	62.9
ANNUAL SHARE, BY DIAMETER	94.5%	5.5%	83.4%	16.6%	73.1%	26.9%	62.8%	37.2%	55.5%	44.5%

NOTE: 8 inch totals include 9 inch drives

TABLE 24

DISK PACK DRIVES, LESS THAN 100 MEGABYTES
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

<u>Distribution channel</u>	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	1.9	16.3	15.8	15.3	14.9	14.5
Mini/micro computer manufacturers	8.1	69.8	68.7	67.6	66.6	65.5
System OEMs/systems houses	1.1	9.4	12.1	14.6	16.6	18.6
Independent peripherals suppliers	--	--	--	--	--	--
Distributors, dealers, end users	.5	4.5	3.4	2.5	1.9	1.4
TOTAL	11.6					

TABLE 25

DISK PACK DRIVES, LESS THAN 100 MEGABYTES
MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

<u>Drive Manufacturers</u>	1984 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)		%	Total	Units (000)		%	Total
14"	8"		14"		8"			
Control Data	6.9	3.6	10.5	90.5	17.9	4.0	21.9	66.8
ISOT	--	--	--	--	8.8	--	8.8	26.8
Other U.S.	1.1	--	1.1	9.5	1.9	--	1.9	5.8
Other Non-U.S.	--	--	--	--	.2	--	.2	.6
TOTAL	8.0	3.6	11.6	100.0	28.8	4.0	32.8	100.0

DISK PACK DRIVES, MORE THAN 100 MB

DISK PACK DRIVES, MORE THAN 100 MEGABYTESCoverage

Examples of disk drives in this group include:

Ampex	DM-9300
Burroughs	9484-13
Century Data Systems	T306
Control Data	9766, 270-30
Data General	6060, 6061, 6122
Digital Equipment	RA60
Hewlett-Packard	7935H
ISOT	ES 5066, ES 5067.02
NEC	N7745

IBM's introduction of the 3330, with 19 data surfaces, in 1971 set the model for the physical configuration now in predominant use, even though the initial IBM drive had only 100 MB capacity. The major product still in new production today is the Control Data 300 MB SMD. Products introduced in more recent years include the Digital Equipment RA60 (14" 205 MB using 6 data surfaces) and the Hewlett-Packard 7935H (14" 404 MB using 13 data surfaces).

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	532.0	356.7	284.0	204.6	134.4
All manufacturers	595.3	419.4	335.0	246.6	174.4

As expected, 1984 saw a temporary reversal in the long term decline in worldwide shipments for this product group, as unit shipments increased 16.7%, to 51,100 spindles. The growth was not shared by most producers, however, with Digital Equipment's captive drives and Control Data's OEM

drives accounting for most of the increase.

The outlook for 1985 is not nearly as promising. 1985 total worldwide shipments are expected to drop to 35,500 spindles, with both captive and OEM drives declining. The improved cost-per-megabyte offered by large fixed disk drives has finally caught up with this product group.

Control Data led in 1984 shipments of non-captive drives, as usual, with 24,600 spindles, for 77.1 of the worldwide total. Other U.S. OEM drives totaled only 3,900 spindles in 1984. The only significant remaining production of large disk pack drives outside the U.S. is in Eastern Bloc countries.

Marketing trends

U.S. manufacturers of OEM drives in this group saw their last good year in 1984. Although the decline is expected to be on a fairly gentle slope -- from 14,900 spindles this year to 6,000 in 1988 -- nothing on the horizon is likely to reverse the basic trend. Competition from fixed disk drives, including 8", 10.5" and 14" versions, is simply too effective, considering the improved reliability and lower cost they offer. The fixed disk drives are obviously being designed into most new systems requiring capacities in this range. The increase in shipments of non-U.S. drives is caused by ISOT's production of large disk pack drives for use with Eastern Bloc mainframes and minicomputers.

Technical trends

It remains unclear whether any significant new disk pack drives will be introduced. Higher effective areal densities have been achieved by DEC's RA60 and H-P's 7935H, partially through use of run length limited

encoding. However, there are no known plans by any drive manufacturer to develop a new drive in this group using today's technology -- with the possible exception of Control Data, which has previously indicated to customers that the firm might produce a 160 megabyte version of its RSD 9" disk pack drive.

Forecasting assumptions

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

TABLE 26
DISK PACK DRIVES, MORE THAN 100 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	157.1	284.8	133.9	232.8	109.2	184.6	78.8	132.6	52.8	86.4
TOTAL U.S. CAPTIVE	157.1	284.8	133.9	232.8	109.2	184.6	78.8	132.6	52.8	86.4
PCM	1.8	1.8	1.8	1.8	1.8	1.8	--	--	--	--
OEM	168.4	245.4	75.3	122.1	58.4	97.6	43.2	72.0	28.8	48.0
TOTAL U.S. NON-CAPTIVE	170.2	247.2	77.1	123.9	60.2	99.4	43.2	72.0	28.8	48.0
TOTAL U.S. REVENUES	327.3	532.0	211.0	356.7	169.4	284.0	122.0	204.6	81.6	134.4
Non-U.S. Manufacturers	-----									
Captive	--	29.3	--	17.7	--	6.0	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	34.0	--	45.0	--	45.0	--	42.0	--	40.0
TOTAL NON-U.S. REVENUES	--	63.3	--	62.7	--	51.0	--	42.0	--	40.0
Worldwide Recap	-----									
TOTAL WORLDWIDE REVENUES	327.3	595.3	211.0	419.4	169.4	335.0	122.0	246.6	81.6	174.4
OEM Average Price (\$000)	8.6	8.7	8.2	8.6	8.0	8.5	8.0	8.6	8.0	8.8

TABLE 27
DISK PACK DRIVES, MORE THAN 100 MEGABYTES
UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1984		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----										
-----Forecast-----										
-----Shipments-----										
U.S. Manufacturers										

IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	10.3	18.2	9.0	15.4	8.4	14.2	6.3	10.6	4.4	7.2
TOTAL U.S. CAPTIVE	10.3	18.2	9.0	15.4	8.4	14.2	6.3	10.6	4.4	7.2
PCM	.1	.1	.1	.1	.1	.1	--	--	--	--
OEM	19.4	28.4	9.1	14.9	7.3	12.2	5.4	9.0	3.6	6.0
TOTAL U.S. NON-CAPTIVE	19.5	28.5	9.2	15.0	7.4	12.3	5.4	9.0	3.6	6.0
TOTAL U.S. SHIPMENTS	29.8	46.7	18.2	30.4	15.8	26.5	11.7	19.6	8.0	13.2
Non-U.S. Manufacturers										

Captive	--	1.0	--	.6	--	.2	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	3.4	--	4.5	--	4.5	--	4.2	--	4.0
TOTAL NON-U.S. SHIPMENTS	--	4.4	--	5.1	--	4.7	--	4.2	--	4.0
Worldwide Recap										

TOTAL WORLDWIDE SHIPMENTS	29.8	51.1	18.2	35.5	15.8	31.2	11.7	23.8	8.0	17.2
Cumulative Shipments										

IBM Captive	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6
Non-IBM	246.5	429.1	264.7	464.6	280.5	495.8	292.2	519.6	300.2	536.8
WORLDWIDE TOTAL	287.8	501.7	306.0	537.2	321.8	568.4	333.5	592.2	341.5	609.4

TABLE 28

DISK PACK DRIVES, MORE THAN 100 MEGABYTES
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

<u>Distribution channel</u>	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	.8	4.1	1.9	--	--	--
Mini/micro computer manufacturers	15.6	79.9	82.7	85.1	85.3	85.5
System OEMs/systems houses	2.1	10.9	11.2	11.5	11.8	12.1
Independent peripherals suppliers	.8	4.1	3.3	2.6	2.1	1.7
Distributors, dealers, end users	<u>.2</u>	1.0	.9	.8	.8	.7
TOTAL	19.5					

TABLE 29

DISK PACK DRIVES, MORE THAN 100 MEGABYTES
MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

<u>Drive Manufacturers</u>	1984 Net Shipments			
	<u>To United States Destinations</u>		<u>Worldwide</u>	
	Units (000)	%	Units (000)	%
Control Data	16.1	82.6	24.6	77.1
Other U.S.	3.4	17.4	3.9	12.2
Other Non-U.S.	<u>--</u>	<u>--</u>	<u>3.4</u>	<u>10.7</u>
TOTAL	19.5	100.0	31.9	100.0

FIXED DISK DRIVES, LESS THAN 30 MB

FIXED DISK DRIVES, LESS THAN 30 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Control Data	230-10, 240-15
Data General	6100
Hewlett-Packard	7911

8 disk diameter

Data General	6220, 6227
Fujitsu	M2301, M2302
Hitachi	DK811-2
IBM	4956-30D, 5247-011
Mitsubishi	M2860-1
Quantum	Q2010, Q2020
Toshiba	MK-80F-10/20

5.25" disk diameter

Alps Electric	DRA010A*, DRA020A*
Ampex	Pyxis 13, 27
BASF	6185, 6188*
Bull	D506, D510
Cogito Systems	PT912*, PT925*
Computer Memories	CM3426*, CM6426
Control Data	9415-321, 518
Disc Tech One	5014, 5019, 5026
Epson	HD-830*, HD860*
Fujitsu	M2232, M2230, M2233*
Hitachi	DK502-1/2/3, DK503-2*
IBM	5160-087, 5170-089
Josephine County Technology	JCT-100, JCT-110
Matsushita Communication Ind.	JU-614, JU-616, JU-664*
Microscience International	HH612*, HH-725*
Miniscribe	3212*, 3425*
Mitsubishi	MR521*, MR522*
NEC	D5244, D5124*
Nippon Electric Industry	RD-4127, RD-2127*, RD-2255*
Nippon Peripherals	NP02-13*, NP04-26
Olivetti	562/12, HD563/13, HD661/12*
Otari	C-514, C-526, C-226*
Quantum	Q520
Rodime	R0201, R0204
Seagate Technology	ST212*, ST225*, ST4026
Sord	HD-503, HD-513

5.25" disk diameter (continued)

Tandon	TM503, TM252*
TEAC	SD-412, SD-510*
Tokico	DK502-3, DK503-2*
Tokyo Electric	TD-5512*, TD-5526*
Toshiba	MK-50F
Tulin	TL226*
Xebec	4000 Owl

3.9" disk diameter

Nippon Systemhouse	SQ325F*
SyQuest Technology	SQ325F*

3.5" disk diameter

Alps Electric	DRLO10A*, DRM020A*
Fujitsu	M2223A*, M2224A*
Hewlett-Packard	97501A
Hitachi	DK301-1*, DK301-2*
LaPine Technology	3512*, 3525*
Matsushita Com. Ind.	JU-104*
Microcomputer Memories	M-112*, M-125*
Microscience International	HH-312*, HH-325*
Miniscribe	8425*
Mitsubishi Electric	MR321*, MR322*
NEC	D3116*, D3126*
Newbury Data	320*
Nippon Peripherals	NP03-13*, NP03-20*
Peripheral Technology	PT-325*
Plus Development	Hardcard
Rodime	RO 351*, R0352*
Tandon	TM362*
Victor Company of Japan	JD-3806M*, JD3812M*

*Indicates drives 1.625 inches high
(one half the standard height for
drives using 5.25" disks), or less.

All drives in this group use variations of the technology loosely described as "Winchester". Most use 3340/3350 type ferrite heads, and some use the newer "mini-Winchester" heads which employ ferrite cores in 3370-type sliders. The majority of drives in this group use conventional oxide disks, but a growing number of manufacturers have started to use plated or sputtered disks.

Most of the 5.25" drives and some of the 8" and 14" drives use head positioning systems driven by stepping motors, with relatively slow average access times, but low costs. The other drives use voice coil or torque motor actuators, rotary or linear, to produce access times suitable for multiple workstation systems.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	1,126.5	1,301.8	1,470.7	1,784.6	1,923.4
All manufacturers	1,660.7	2,028.4	2,430.3	2,925.7	3,127.1

1984 total worldwide revenue of \$1,660,700,000 for fixed disk drives less than 30 megabytes has made this the second largest DISK/TREND product group. Worldwide shipments of all drives were 2,530,200 units in 1984, up 102.7% from the previous year, with 1985's shipments expected to reach 3,385,900 drives.

With shipments of 14" and 8" drives now down to less than 1% of this product group, the low-end 5.25" drives currently composing most of the group have become the industry's dominant leader in shipment volume -- expected to attain over 3 million drives in 1985. But 1985 is also seeing the beginning of significant production for 3.5" drives, which are probably destined to pass up the current leader.

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

1985 DISK/TREND REPORT

IBM's actions, both as a customer and as a captive producer, have thoroughly shaken the stability of the leading manufacturers of 5.25" drives in this group. With the introduction of the PC XT, IBM became the largest OEM customer for 10 megabyte 5.25" drives from Seagate, Miniscribe and International Memories. And with the advent of the PC AT in 1984, IBM's purchases of 20 megabyte drives overwhelmed Computer Memories, eventually becoming over 80% of the firm's sales. Ironically, the managements of each of these companies were delighted with their huge sales to IBM, right up to the point of abrupt termination.

IBM's erratic buying patterns had created chaos among vendors of low-end 5.25" drives starting in early 1984, but the more severe stroke was establishment of major internal production programs by IBM for stepping motor 5.25" drives at Fujisawa and voice coil 5.25" drives at Rochester, Minnesota, and Havant, in England. IBM now appears to be relying entirely on Fujisawa for drives used in the PC XT and, starting at the end of this year, on Rochester/Havant for drives used in the PC AT, with possibly a portion of the PC AT requirements to be given to Seagate.

IBM's estimated 390,000 5.25" drives this year will overshadow captive drive production by other firms. Other U.S. captive production of 5.25" drives has ceased, as programs by Apple, Texas Instruments, International Memories and Datapoint closed down. Hewlett-Packard's 3.5" drive is the only U.S. captive program in this product group likely to survive after 1985. Major non-U.S. captive production for 5.25" drives remains, however, led by substantial Olivetti and NEC shipments. Captive 3.5" programs by NEC and Mitsubishi Electric are also expected to be underway this year.

After another painful year, most manufacturers of OEM 5.25" drives again shipped more units in 1984 than in the previous year (even though profitability was another story). When 5.25" and 3.5" OEM drives in this group are combined, 1984's 2,230,000 units represented a 106.0% increase over the previous year, and 1985's estimated 2,703,500 drives will provide an increase of 21.2%. Seagate remained the leading company in 1984, with 776,000 drives, 34.2% of the worldwide total for OEM drives of all disk diameters in this product group. Miniscribe held 14.1%, and International Memories, which discontinued production at the end of 1984, had 9.2%.

Most of the U.S. drive manufacturers are expecting tough competition for half high 5.25" and 3.5" markets. To prepare for the extremely competitive pricing the industry is undergoing, most U.S. firms have established their own Asian manufacturing facilities, to obtain benefits in labor rates, material costs and labor productivity. But while the cost savings are attractive, the disruption to organizations has been severe during the transition to off-shore manufacturing.

It has also been difficult for many manufacturers to keep up with the short product life cycles of specific configurations. New products -- 10 megabyte half high 5.25", 20 megabyte half high 5.25", plus 3.5" in the same capacities -- are essential to holding market share, but some firms have not been able to translate plans into producible products.

Marketing trends

Further expansion of the IBM internal production programs discussed above is expected. At Fujisawa, it is assumed that 3.5" 10/20 megabyte drives will go into production in mid-1986, for use with mid-life enhancements to the PC XT single user personal computer and related products.

1985 DISK/TREND REPORT

1986 shipments of these drives are estimated at 170,000 units, going up to 1,150,000 in 1988. At Rochester and Havant, it is assumed that production will be increased sharply for 5.25" voice coil drives in 1986, but that greater emphasis will be placed on higher capacity models, such as the 40 megabyte version first shipped in mid-1985 with the System/36 PC. 30-40 megabyte models, when offered on the PC AT, are likely to displace much of the demand for the 20 megabyte model, with shipments declining to an estimated 32,000 in 1988.

During this period, the forces of competition and the tastes of system designers will continue to change the product mix for small drives:

<u>Worldwide captive & OEM Unit shipments (000)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
5.25" full size	1,701.9 69.1%	1,375.4 40.9%	849.8 18.7%	408.8 6.9%	68.0 .9%
5.25" half high	695.1 28.2%	1,678.6 50.0%	2,595.2 57.3%	2,832.0 48.1%	2,289.0 31.1%
3.5" (including 3.9")	66.3 2.7%	304.3 9.1%	1,088.0 24.0%	2,652.0 45.0%	5,010.0 68.0%

Half high 5.25" drives are now the leading configuration but will probably top out in 1986, as 3.5" drives grow rapidly. 3.5" fixed drives got off to a slower start in 1985 than expected, due to shortages of suitable media and delays in IBM's programs. But the only thing holding 3.5" shipments down has been availability, outside of IBM's internal considerations. By 1986, however, drives should be widely available, and IBM will probably be ready to enhance the PC XT with more disk storage.

Average annual growth in unit shipments of 5.25" and 3.5" drives from 1986 to 1988 is expected to be 30%, reaching 7,367,000 units, with 68% using 3.5" disks. During that period, however, the OEM share of total

1985 DISK/TREND REPORT

5.25"/3.5" unit shipments is expected to decline to the low 70% range, compared to over 90% in 1985. Even more striking is the expected drop in share of OEM 5.25"/3.5" drives held by U.S. manufacturers, from 80% in 1984 to 57% in 1988.

Technical trends

Large production volume and low cost are the key factors addressed in the engineering effort devoted to disk drives in this group. The problem is to achieve the high production volumes despite use of continually higher recording densities, as disk diameters go down and users' appetite for more capacity go up.

Although several initially available 3.5" drives used disks with 40 mm inner diameters, 25 mm has been more widely used, to increase the recording area per disk. The result is linear densities in the 13,000 to 15,000 bits per inch range. Plated, sputtered and high density oxide disks suitable at this density range are available, but have never been used in disk drives produced by the hundreds of thousands per year. The bugs are being worked out, but it is a difficult time for those charged with manufacturing the drives in high quantity at low cost.

Forecasting assumptions

1. IBM will initiate production of a 3.5" drive in 1986 and will continue production of 5.25" stepping motor and voice coil drives in this product group.
2. Half high 5.25" and 3.5" drives will lead shipments in this group through 1987, to be passed by 3.5" in 1988.
3. Continued growth in the overall desktop and portable computer market will maintain growth for 5.25" and smaller drives.

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

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		Forecast							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	122.2	158.5	364.8	485.9	556.6	793.8	684.8	1,053.5	640.2	1,067.0
Other U.S. Captive	198.6	208.8	71.0	77.0	27.3	49.5	50.6	92.0	79.7	144.9
TOTAL U.S. CAPTIVE	320.8	367.3	435.8	562.9	583.9	843.3	735.4	1,145.5	719.9	1,211.9
PCM	.9	1.4	.9	1.0	.4	.5	--	--	--	--
OEM	643.8	757.8	608.8	737.9	515.1	626.9	528.5	639.1	591.1	711.5
TOTAL U.S. NON-CAPTIVE	644.7	759.2	609.7	738.9	515.5	627.4	528.5	639.1	591.1	711.5
TOTAL U.S. REVENUES	965.5	1,126.5	1,045.5	1,301.8	1,099.4	1,470.7	1,263.9	1,784.6	1,311.0	1,923.4
Non-U.S. Manufacturers										
Captive	13.2	333.8	110.3	455.0	149.6	594.3	188.7	696.9	202.8	676.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	62.1	200.4	97.5	271.6	167.6	365.3	240.3	444.2	331.0	527.7
TOTAL NON-U.S. REVENUES	75.3	534.2	207.8	726.6	317.2	959.6	429.0	1,141.1	533.8	1,203.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,040.8	1,660.7	1,253.3	2,028.4	1,416.6	2,430.3	1,692.9	2,925.7	1,844.8	3,127.1
				22%		17.5		20-3%		6.9%
OEM Average Price (\$000)	.415	.423	.375	.372	.291	.292	.255	.256	.226	.227

TABLE 31
FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		-----Forecast-----							
	---Shipments---		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	67.4	85.0	298.3	397.1	503.5	719.1	682.5	1,050.0	709.2	1,182.0
Other U.S. Captive	52.3	54.9	23.3	28.4	24.8	45.0	50.6	92.0	88.6	161.0
TOTAL U.S. CAPTIVE	119.7	139.9	321.6	425.5	528.3	764.1	733.1	1,142.0	797.8	1,343.0
PCM	.6	.9	.7	.8	.3	.4	--	--	--	--
OEM	1,555.8	1,825.4	1,587.1	1,929.9	1,745.8	2,126.2	2,045.6	2,473.8	2,581.2	3,104.5
TOTAL U.S. NON-CAPTIVE	1,556.4	1,826.3	1,587.8	1,930.7	1,746.1	2,126.6	2,045.6	2,473.8	2,581.2	3,104.5
TOTAL U.S. SHIPMENTS	1,676.1	1,966.2	1,909.4	2,356.2	2,274.4	2,890.7	2,778.7	3,615.8	3,379.0	4,447.5
Non-U.S. Manufacturers										
Captive	5.8	121.9	61.3	242.6	95.8	383.0	136.2	522.0	173.1	577.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	146.5	442.1	296.9	787.1	599.5	1,268.4	974.5	1,759.7	1,506.6	2,349.5
TOTAL NON-U.S. SHIPMENTS	152.3	564.0	358.2	1,029.7	695.3	1,651.4	1,110.7	2,281.7	1,679.7	2,926.5
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,828.4	2,530.2	2,267.6	3,385.9	2,969.7	4,542.1	3,889.4	5,897.5	5,058.7	7,374.0
				<i>25.3%</i>		<i>24.0</i>		<i>22.5</i>		<i>25.0%</i>
Cumulative Shipments										
IBM Captive	176.6	233.9	474.9	631.0	978.4	1,350.1	1,660.9	2,400.1	2,370.1	3,582.1
Non-IBM	3,188.2	4,338.3	5,157.5	7,327.1	7,623.7	11,150.1	10,830.6	15,997.6	15,180.1	22,189.6
WORLDWIDE TOTAL	3,364.8	4,572.2	5,632.4	7,958.1	8,602.1	12,500.2	12,491.5	18,397.7	17,550.2	25,771.7

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

	1984				1985				Forecast			1987			1988		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	--	10.0	75.0	--	--	7.1	390.0	--	4.1	545.0	170.0	--	290.0	760.0	--	32.0	1,150.0
Other U.S. Captive	4.1	13.3	37.5	--	1.7	4.7	12.0	10.0	--	--	45.0	--	--	92.0	--	--	161.0
PCN	--	--	.9	--	--	--	.8	--	--	.4	--	--	--	--	--	--	--
OEM	1.2	27.7	1,790.2	6.3	.5	10.7	1,780.3	138.4	3.0	1,683.2	440.0	--	1,579.8	894.0	--	1,176.5	1,928.0
TOTAL U.S. SHIPMENTS	5.3	51.0	1,903.6	6.3	2.2	22.5	2,183.1	148.4	7.1	2,228.6	655.0	--	1,869.8	1,746.0	--	1,208.5	3,239.0
NON-U.S. MANUFACTURERS																	
Captive	--	2.0	119.9	--	--	.6	236.0	6.0	--	310.0	73.0	--	318.0	204.0	--	261.0	316.0
OEM	--	8.6	373.5	60.0	--	2.3	634.9	149.9	2.0	906.4	360.0	4.5	1,053.2	702.0	7.0	887.5	1,455.0
TOTAL NON-U.S. SHIPMENTS	--	10.6	493.4	60.0	--	2.9	870.9	155.9	2.0	1,216.4	433.0	4.5	1,371.2	906.0	7.0	1,148.5	1,771.0
WORLDWIDE RECAP																	
Total Shipments	5.3	61.6	2,397.0	66.3	2.2	25.4	3,054.0	304.3	9.1	3,445.0	1,088.0	4.5	3,241.0	2,652.0	7.0	2,357.0	5,010.0
ANNUAL SHARE, BY DIAMETER	.2%	2.4%	94.8%	2.6%	.1%	.8%	90.3%	8.8%	.2%	75.9%	23.9%	.1%	55.1%	44.8%	.1%	32.1%	67.8%

NOTE: 3.5 inch totals include 3.9 inch drives

TABLE 33
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984				Forecast												
	Revenues				1985				1986			1987			1988		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	--	76.0	82.5	--	--	51.8	434.1	--	29.1	577.7	187.0	--	293.5	760.0	--	32.0	1,035.0
Other U.S. Captive	27.2	68.1	113.5	--	11.1	23.5	31.4	11.0	--	--	49.5	--	--	92.0	--	--	144.9
PCM	--	--	1.4	--	--	--	1.0	--	--	.5	--	--	--	--	--	--	--
OEM	1.8	31.8	721.8	2.4	1.0	11.9	678.0	47.0	3.3	496.9	126.7	--	415.5	223.6	--	283.5	428.0
TOTAL U.S. REVENUES	29.0	175.9	919.2	2.4	12.1	87.2	1,144.5	58.0	32.4	1,075.1	363.2	--	709.0	1,075.6	--	315.5	1,607.9
NON-U.S. MANUFACTURERS																	
Captive	--	11.0	322.8	--	--	3.4	444.6	7.0	--	514.0	80.3	--	492.9	204.0	--	391.6	284.4
OEM	--	10.7	168.7	21.0	--	3.0	222.3	46.3	2.6	266.9	95.8	5.9	274.8	163.5	9.1	213.0	305.6
TOTAL NON-U.S. REVENUES	--	21.7	491.5	21.0	--	6.4	666.9	53.3	2.6	780.9	176.1	5.9	767.7	367.5	9.1	604.6	590.0
WORLDWIDE RECAP																	
Total Revenues	29.0	197.6	1,410.7	23.4	12.1	93.6	1,811.4	111.3	35.0	1,856.0	539.3	5.9	1,476.7	1,443.1	9.1	920.1	2,197.9
ANNUAL SHARE, BY DIAMETER	1.7%	11.9%	85.0%	1.4%	.6%	4.6%	89.4%	5.4%	1.4%	76.5%	22.1%	.2%	50.6%	49.2%	.3%	29.5%	70.2%

NOTE: 3.5 inch totals include 3.9 inch drives

TABLE 34
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
 DISTRIBUTION CHANNEL SUMMARY
 U.S. Non-Captive Disk Drives

Distribution channel	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	832.6	48.9	34.5	16.7	12.1	9.8
Mini/micro computer manufacturers	158.5	9.3	12.1	14.5	16.6	18.3
System OEMs/systems houses	462.6	27.2	34.3	51.5	54.3	55.3
Independent peripherals suppliers	119.3	7.0	7.9	8.2	8.5	8.7
Distributors, dealers, end users	129.9	7.6	11.2	9.1	8.5	7.9
TOTAL	1,702.9					

TABLE 35
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1984 Net Shipments											
	To United States Destinations					Worldwide						
	Units (000)					%						
	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	%
Seagate Technology	--	--	660.0	--	660.0	38.7	--	--	776.0	--	776.0	34.2
Miniscribe	--	--	287.8	.3	288.1	16.9	--	--	319.4	.3	319.7	14.1
International Memories	--	5.4	185.0	--	190.4	11.2	--	6.0	202.0	--	208.0	9.2
Tandon	--	--	124.1	--	124.1	7.3	--	--	152.3	--	152.3	6.7
Computer Memories	--	--	106.8	--	106.8	6.3	--	--	125.3	--	125.3	5.5
Rodime	--	--	33.0	54.0	87.0	5.1	--	--	60.0	60.0	120.0	5.3
Shugart	.8	5.1	55.6	--	61.5	3.6	1.2	5.9	89.3	--	96.4	4.2
Microscience Int'l	--	--	66.5	--	66.5	3.9	--	--	70.0	--	70.0	3.1
Other U.S.	--	8.0	45.1	5.9	59.0	3.5	--	15.8	56.8	6.0	78.6	3.5
Other Non-U.S.	--	.6	58.9	--	59.5	3.5	--	8.6	313.5	--	322.1	14.2
TOTAL	.8	19.1	1622.8	60.2	1702.9	100.0	1.2	36.3	2164.6	66.3	2268.4	100.0

NOTE: 3.5 inch totals include 3.9 inch drives

FIXED DISK DRIVES, 30-100 MB

FIXED DISK DRIVES, 30-100 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Alpha Data	Atlas
Data General	6234
Disc Tech One	3306
Hewlett-Packard	7912
NEC	D-1245, N7723
Priam	6650

10.5" disk diameter

Bull	D160/4, D160/6
------	----------------

8" disk diameter

Disc Tech One	8533
Disctron	DP-400
Fujitsu	M2303, M2312K, M2321K
Hitachi	DK 811-4, DK812S-8
IBM	3310, 4963-64, 676, 680
Megavault	MV83
Mitsubishi	M2860-2
NEC	D2246, D2247
Northern Telecom	8204X
Priam	3450, 7050, 803
Quantum	Q2030, Q2040, Q2080
Toshiba	MK-80F-30, MK-182F

5.25" disk diameter

Advanced Storage Technology	AST 28060*, AST 38095*
Atasi	3046, 3075, 3085
BASF	6190-94
Bull	D550, D570, D585
Computer Memories	CM6640, CM7885
Control Data	94155-36, 94155-586
Fujitsu	M2241, M2242, M2243
Hitachi	DK511-5, DK512-8
IBM	5364
Maxtor	XT-1085, XT-2085
Micropolis	1323A, 1325
Miniscribe	6053, 6085
Mitsubishi Electric	MR533*, MR535*
NEC	D5146*

5.25" disk diameter (continued)

Newbury Data	1065
Nippon Electric Industry	RD-4510
Nippon Peripherals	NP04-36, NP04-50
Priam	V150, V185
Quantum	Q540, Q250*, Q280*
Rodime	RO 203E, RO 204E
Seagate	ST4038, ST4051
Tandon	TM703, TM755*
Toshiba	MK-56FAB
Tulin	TL 240*

3.9" disk diameter

Newbury Data	340*
Nippon Systemhouse	SQ328F
Peripheral Technology	PT-338*
SyQuest Technology	SQ328F

*Indicates drives 1.625 inches high (one half the standard height for drives using 5.25" disks), or less.

These are all nominally "Winchester" drives, but many variations to that technology are used, including plated disks, sputtered 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.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	976.7	1,136.1	1,454.4	1,529.4	1,619.8
All manufacturers	1,304.0	1,541.1	1,929.7	2,026.2	2,130.5

An excellent growth rate has made 5.25" drives the dominant leader in this product group, passing 8" drives in 1984 unit shipments, and rising to a forecasted 80% of the 1985 worldwide total for all disk diameters. 8" drives reached their worldwide shipment peak at 174,900 units in 1984,

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while 5.25" drive shipments were 306,600 units in 1984, going up to an expected 699,000 in 1985.

95.3% of 1984's 5.25" shipments were OEM drives, enjoying the rising demand for multiple user microcomputers and other small specialized systems. Production shipments of 85 megabyte 5.25" drives got underway in mid-1984, but most of the 1984 shipments were in the 40-50 megabyte range. OEM shipments accounted for only 50.7% of the 1984 8" total, due to established captive drive manufacturing programs by IBM and several Japanese system manufacturers.

Quantum was the run-away leader in non-captive drive shipments for 1984 with 20.1% of the worldwide unit total, consisting of 56,500 5.25" and 22,300 8" drives. Control Data and Micropolis followed with 15.0% and 11.9%. However, it should be noted that Vertex was merged into Priam in early 1985, and the 1984 total for the two firms, when combined, would have put them in third place with 13.6%.

Captive production by U.S. manufacturers remains small, except for IBM. 8" drive production in this product group by IBM is probably peaking in 1985, but shipments of 5.25" drives started this summer, and are expected to become very large programs at Rochester and Havant, the same IBM facilities making 8" drives. In the PCM area, Control Data supplies a version of its Wren 5.25" drive to the personal computer aftermarket.

Marketing trends

Even though IBM has not been a major buyer of OEM disk drives in this product group, its expected large scale production of 5.25" drives will tend to dampen the growth rate for manufacturers of OEM drives. IBM's shipments of 5.25" drives are expected to reach 484,000 units in 1988,

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with wide use anticipated for multiple user personal computers and other office and specialized systems.

The existence of this program means, of course, that IBM will not buy most of its drive requirements for these applications, thus restricting the OEM market opportunity to other system manufacturers. And, if IBM's personal computers continue to secure major market positions, the lower success level for IBM's system competitors will further limit the size of the OEM drive market.

Another factor affecting the future growth in OEM shipments within this product group is the movement by several manufacturers of 85 megabyte drives to provide 170 megabyte versions by doubling linear density, thus responding to demand but moving a significant part of the shipment gains out of this product group. This is the reason, combined with rapid growth in IBM's internal production, that the 121.8% growth in worldwide OEM shipments for 1985 is expected to decline to 32.7% in 1986, dropping to 4.5% in 1988.

Price competition in the OEM marketplace is not expected to be as sharp with products in this group as it has become with low end stepping motor 5.25" drives, but it will be severe. In view of the forecasted growth in worldwide shipments of 5.25" drives from 306,600 units in 1984 to 1,592,000 in 1988, a difficult competitive environment is understandable. Those manufacturers which have managed to become low cost producers will be the survivors. The DISK/TREND estimates of OEM average price indicate a drop from \$1,200 in 1984 to \$900 after 1985. However, this is an overall average of all disk diameters and all capacities within this product group, and tends to mask the effect on prices of declining 8" shipments and increasing average capacity for 5.25" drives.

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Until recently, almost all 5.25" drives shipped in this group have been in the standard form factor for full size 5.25" drives -- with a height of 3.25". However, half high drives have been introduced by several manufacturers and are expected to be widely used, along with new drives with disk diameters less than 5.25":

<u>Worldwide captive & OEM Unit shipments (000)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
5.25" full size	304.1 98.9%	617.0 86.7%	938.2 79.2%	997.6 68.2%	1,013.5 59.2%
5.25" half high	2.5 .8%	82.0 11.5%	215.8 18.2%	395.4 27.0%	578.5 33.8%
3.5" (including 3.9")	1.0 .3%	12.6 1.8%	30.0 2.6	70.0 4.8	120.0 7.0%

While full size drives will lose their monopoly status among 5.25" drives, they are nevertheless expected to constitute more than half of 1988 total shipments of drives with disk diameters 5.25" and less. It is estimated that IBM's full size voice coil 5.25" drives will lead all other manufacturers' drives in shipments starting in 1986. This program is the largest factor in retaining overall leadership for full size drives; without it half high drives would have a slight lead over full size models in 1988.

3.5" drives (with which we have combined 3.9" drives on an arbitrary basis) are starting to provide competition for 5.25" drives in the lower capacity range of this product group, and it is expected that additional drive manufacturers will join in this competition. 120,000 units are forecasted for 1988, 6.8% of that year's total for all drives.

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The last shipments of 14" drives in this group are expected in 1986, and the 8" share of worldwide unit shipments is forecasted to drop to only 1.1% of the total for all disk diameters in 1988.

Technical trends

It has been difficult to combine high recording densities and small box sizes with the high production volume and low cost required for the 5.25" drives in this group. There have been severe sourcing problems with media, as manufacturers transition to plated, sputtered and high density oxide disks. The many new disk manufacturers have had trouble maintaining consistent quality and several have shut down operations from time to time to solve problems with production processes. Although media quality has improved greatly, drive manufacturers must still devote excessive resources to media test and inspection.

Although the technology used in recording heads is also changing, both thin film and advanced ferrite heads are usable with the densities now required, and both are in production. Drive manufacturers have been able to obtain "mini-sliders", heads using ferrite cores mounted in sliders with contours similar to IBM's 3370/3380 thin film heads. Limited quantities of thin film heads are also being used in production disk drives, with more expected as head vendors establish volume production.

Although not settled, the political battles over interface standards are calming down. Most 5.25" drives in this group are still being shipped with 5 megabit transfer rates, using Seagate type interfaces. But a growing number of system manufacturers are planning to use SCSI interfaces and it is expected that the next several years will see many drives being offered with SCSI built in. As the disk and head sourcing problems ease,

10 megabit per second drives are expected to grow in importance, many of which will use ESDI as the drive level interface.

Forecasting assumptions

1. IBM will produce high volumes of 5.25" drives, relying primarily on internal manufacturing for drives in this group.
2. Continued growth for OEM 5.25" drives will be created by strong increases in shipments of multiple user desktop computers and file servers used in local area networks, but will be limited by IBM's competitive inroads at the system level and by movement to higher capacities.
3. 3.5" drives will be available from several manufacturers in 1986.

TABLE 36
FIXED DISK DRIVES, 30 - 100 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		-----Forecast-----							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	269.6	396.0	322.9	477.4	488.9	718.1	488.8	752.4	493.2	816.0
Other U.S. Captive	171.5	206.5	85.3	104.0	48.7	59.0	67.3	81.2	85.2	108.1
TOTAL U.S. CAPTIVE	441.1	602.5	408.2	581.4	537.6	777.1	556.1	833.6	578.4	924.1
PCM	1.2	1.8	3.9	6.5	6.2	10.4	10.9	18.2	14.8	24.7
OEM	306.9	372.4	464.3	548.2	549.8	666.9	570.9	677.6	556.9	671.0
TOTAL U.S. NON-CAPTIVE	308.1	374.2	468.2	554.7	556.0	677.3	581.8	695.8	571.7	695.7
TOTAL U.S. REVENUES	749.2	976.7	876.4	1,136.1	1,093.6	1,454.4	1,137.9	1,529.4	1,150.1	1,619.8
Non-U.S. Manufacturers										
Captive	8.5	217.0	15.5	195.5	24.0	218.2	27.9	211.0	29.3	181.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	54.6	110.3	87.5	209.5	113.0	257.1	130.0	285.8	159.4	329.3
TOTAL NON-U.S. REVENUES	63.1	327.3	103.0	405.0	137.0	475.3	157.9	496.8	188.7	510.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	812.3	1,304.0	979.4	1,541.1	1,230.6	1,929.7	1,295.8	2,026.2	1,338.8	2,130.5
OEM Average Price (\$000)	1.2	1.2	.9	1.0	.9	.9	.9	.9	.9	.9

TABLE 37
FIXED DISK DRIVES, 30 - 100 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		Forecast							
	Shipments		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	33.7	49.5	54.3	78.4	196.1	282.7	250.3	385.1	298.4	496.5
Other U.S. Captive	25.0	28.5	13.2	15.1	10.1	11.7	21.9	26.8	35.6	45.5
TOTAL U.S. CAPTIVE	58.7	78.0	67.5	93.5	206.2	294.4	272.2	411.9	334.0	542.0
PCM	.8	1.2	3.0	5.0	4.8	8.0	8.4	14.0	11.4	19.0
OEM	260.5	308.4	470.1	545.1	552.8	656.9	589.2	696.8	590.7	711.0
TOTAL U.S. NON-CAPTIVE	261.3	309.6	473.1	550.1	557.6	664.9	597.6	710.8	602.1	730.0
TOTAL U.S. SHIPMENTS	320.0	387.6	540.6	643.6	763.8	959.3	869.8	1,122.7	936.1	1,272.0
Non-U.S. Manufacturers										
Captive	1.5	28.0	3.5	33.5	6.1	52.0	9.7	69.0	13.6	83.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	39.8	82.6	82.0	197.6	126.3	282.2	154.3	330.9	184.7	375.5
TOTAL NON-U.S. SHIPMENTS	41.3	110.6	85.5	231.1	132.4	334.2	164.0	399.9	198.3	458.5
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	361.3	498.2	626.1	874.7	896.2	1,293.5	1,033.8	1,522.6	1,134.4	1,730.5
Cumulative Shipments										
IBM Captive	214.6	327.0	268.9	405.4	465.0	688.1	715.3	1,073.2	1,013.7	1,569.7
Non-IBM	536.8	813.9	1,108.6	1,610.2	1,808.7	2,621.0	2,592.2	3,758.5	3,428.2	4,992.5
WORLDWIDE TOTAL	751.4	1,140.9	1,377.5	2,015.6	2,273.7	3,309.1	3,307.5	4,831.7	4,441.9	6,562.2

TABLE 38
 FIXED DISK DRIVES, 30 - 100 MEGABYTES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1984				1985				1986				Forecast			1987			1988		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																					
IBM Captive	--	49.5	--	--	--	56.4	22.0	--	--	44.3	238.4	--	29.6	355.5	--	12.5	484.0	--			
Other U.S. Captive	6.1	9.7	12.7	--	2.9	3.6	8.6	--	1.2	--	10.5	--	--	19.8	7.0	--	29.5	16.0			
PCM	--	--	1.2	--	--	--	5.0	--	--	--	8.0	--	--	14.0	--	--	19.0	--			
OEM	9.0	61.4	237.0	1.0	5.9	56.5	475.7	7.0	2.5	36.5	602.4	15.5	17.0	647.8	32.0	3.0	655.0	53.0			
TOTAL U.S. SHIPMENTS	15.1	120.6	250.9	1.0	8.8	116.5	511.3	7.0	3.7	80.8	859.3	15.5	46.6	1,037.1	39.0	15.5	1,187.5	69.0			
NON-U.S. MANUFACTURERS																					
Captive	.6	27.0	.4	--	.2	18.3	15.0	--	--	12.5	36.5	3.0	7.0	54.0	8.0	2.0	67.0	14.0			
OEM	--	27.3	55.3	--	--	19.3	172.7	5.6	--	12.5	258.2	11.5	6.0	301.9	23.0	1.0	337.5	37.0			
TOTAL NON-U.S. SHIPMENTS	.6	54.3	55.7	--	.2	37.6	187.7	5.6	--	25.0	294.7	14.5	13.0	355.9	31.0	3.0	404.5	51.0			
WORLDWIDE RECAP																					
Total Shipments	15.7	174.9	306.6	1.0	9.0	154.1	699.0	12.6	3.7	105.8	1,154.0	30.0	59.6	1,393.0	70.0	18.5	1,592.0	120.0			
ANNUAL SHARE, BY DIAMETER	3.2%	35.2%	61.5%	.1%	1.0%	17.6%	80.0%	1.4%	.3%	8.2%	89.3%	2.2%	3.9%	91.6%	4.5%	1.1%	92.1%	6.8%			

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

TABLE 39
 FIXED DISK DRIVES, 30 - 100 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984				1985				1986				Forecast			1987			1988		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS																					
IBM Captive	--	396.0	--	--	--	439.9	37.5	--	--	336.7	381.4	--	219.1	533.3	--	90.0	726.0	--			
Other U.S. Captive	65.4	77.6	63.5	--	32.2	28.8	43.0	--	13.2	--	45.8	--	--	67.2	14.0	--	79.3	28.8			
PCM	--	--	1.8	--	--	--	6.5	--	--	--	10.4	--	--	18.2	--	--	24.7	--			
OEM	22.1	103.4	246.1	.8	14.6	95.8	433.7	4.1	6.3	60.2	591.1	9.3	28.0	627.2	22.4	5.0	623.6	42.4			
TOTAL U.S. REVENUES	87.5	577.0	311.4	.8	46.8	564.5	520.7	4.1	19.5	396.9	1,028.7	9.3	247.1	1,245.9	36.4	95.0	1,453.6	71.2			
NON-U.S. MANUFACTURERS																					
Captive	7.7	207.1	2.2	--	2.2	144.9	48.4	--	--	98.8	112.8	6.6	55.3	138.8	16.9	15.8	137.6	28.0			
OEM	--	57.1	53.2	--	--	39.6	166.7	3.2	--	25.0	225.2	6.9	11.7	258.0	16.1	2.0	297.7	29.6			
TOTAL NON-U.S. REVENUES	7.7	264.2	55.4	--	2.2	184.5	215.1	3.2	--	123.8	338.0	13.5	67.0	396.8	33.0	17.8	435.3	57.6			
WORLDWIDE RECAP																					
Total Revenues	95.2	841.2	366.8	.8	49.0	749.0	735.8	7.3	19.5	520.7	1,366.7	22.8	314.1	1,642.7	69.4	112.8	1,888.9	128.8			
ANNUAL SHARE, BY DIAMETER	7.3%	64.6%	28.1%	--	3.2%	48.7%	47.7%	.4%	1.0%	27.1%	70.8%	1.1%	15.5%	81.2%	3.3%	5.3%	88.8%	5.9%			

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

TABLE 40

FIXED DISK DRIVES, 30-100 MEGABYTES
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution channel	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	43.2	14.4	10.8	9.2	7.8	6.6
Mini/micro computer manufacturers	107.3	35.6	37.7	40.0	42.4	44.9
System OEMs/systems houses	112.0	37.2	38.7	37.9	36.9	35.5
Independent peripherals suppliers	20.3	6.7	7.2	7.7	8.2	8.6
Distributors, dealers, end users	<u>18.3</u>	6.1	5.6	5.2	4.7	4.4
TOTAL	301.1					

TABLE 41

FIXED DISK DRIVES, 30-100 MEGABYTES
MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1984 Net Shipments											
	To United States Destinations					Worldwide						
	Units (000)					%						
	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	
Quantum	--	8.3	55.7	--	64.0	21.3	--	22.3	56.5	--	78.8	20.1
Control Data	1.5	1.4	50.5	--	53.4	17.7	1.7	1.5	55.5	--	58.7	15.0
Micropolis	--	4.2	28.9	--	33.1	11.0	--	8.4	38.5	--	46.9	11.9
Atasi	--	--	36.0	--	36.0	11.9	--	--	40.0	--	40.0	10.2
Rodime	--	--	9.0	--	9.0	3.0	--	--	30.0	--	30.0	7.6
Vertex	--	--	24.6	--	24.6	8.2	--	--	27.3	--	27.3	7.0
Fujitsu	--	8.2	3.5	--	11.7	3.9	--	14.7	11.8	--	26.5	6.7
Priam	8.4	16.2	--	--	21.6	7.2	6.0	20.2	--	--	26.2	6.7
Hitachi	--	2.0	12.0	--	14.0	4.6	--	6.0	12.0	--	18.0	4.6
Other U.S.	1.3	8.8	17.6	.9	28.6	9.5	1.3	9.0	20.4	1.0	31.7	8.1
Other Non-U.S.	--	<u>4.9</u>	<u>.2</u>	--	<u>5.1</u>	<u>1.7</u>	--	<u>6.6</u>	<u>1.5</u>	--	<u>8.1</u>	<u>2.1</u>
TOTAL	8.2	54.0	238.0	.9	301.1	100.0	9.0	88.7	293.5	1.0	392.2	100.0

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

FIXED DISK DRIVES, 100-300 MB

FIXED DISK DRIVES, 100-300 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Ampex	Capricorn 165, 165E
Century Data Systems	M160
Control Data	9730-160, 241
Digital Equipment	RA80, RM80
Disc Tech One	4160, 4230
Fujitsu	M2284
Hewlett-Packard	7914
IBM	4967-2CX, 5360-BXX
NEC	D1280
Priam	15450

10.5" disk diameter

Bull	D160/8
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9" disk diameter

Control Data	9715-160
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8" disk diameter

Fujitsu	M2322K, M2331K
Hitachi	DK812S-12, DK814S-17
Megavault	MV212
Mitsubishi Electric	M4870F
NEC	D2257, D2247E
Northern Telecom	MFD/8208X, MFD/8210X
Pertec	DX199, DX265
Priam	806
Toshiba	MK184FB, MK186FB

5.25" disk diameter

Advanced Storage Technology	AST 28100, AST 38158
Hitachi	DK512-17
Maxtor	XT-1140, XT-2190, EXT-4280
Micropolis	1354, 1355
Mitsubishi Electric	MR5310
Newbury Data	1105, 1140
Priam	514, 519
Siemens	1100, 1200

IBM's 3344, a 280 MB version of the classic 3350, was in production from 1976 through 1981, and preceded all other drives in this group. Currently, IBM's only drive in the group is a 200 MB 14" drive used with Series/1 minicomputers and the System/36 business system.

The last two years have seen many new 8" drive introductions, with the start of an expected wave of 5.25" drives. These, as well as the older 14" drives, all use variations of Winchester technology. Disks are mostly oxide coated, but plated and sputtered disks are used on the 5.25" drives. Heads are mostly ferrite types, and several are "mini" types patterned after the 3370 slider. There is limited use of thin film heads, so far exclusively on 5.25" drives.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	700.5	702.6	846.1	1,148.0	1,614.7
All manufacturers	991.1	1,107.8	1,445.4	1,895.1	2,390.1

Rapid changes in product mix have characterized this product group during 1984 and 1985. 14" drives provided 49.6% of worldwide unit shipments in 1984, but their share is dropping rapidly as 8" and 5.25" drives grow sharply in production levels.

In 1984, U.S. companies shipped 56,000 14" drives, with only 5,500 from non-U.S. firms. Several older OEM 14" drives have had a relatively stable market with minicomputer manufacturers, and a number of captive drives have been used for the same applications. All of IBM's shipments are attributable to the "Star" 14" drive. With 200 megabyte capacity and conservative use of recording technology, the Star is clearly intended to

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be easily producible in large quantities. It's used as a capacity upgrade to the 64 megabyte Piccolo 8" drives produced since 1979 and the Spartan 8" drives originally introduced in 1982 and shipped in 15, 30 and 60 megabyte versions.

The major product type in this group, however, has been the 8" 160 megabyte drive, pioneered originally by Fujitsu in an 84 megabyte model. Fujitsu has been joined by several other Japanese manufacturers who collectively shipped most of 1984's 27,500 8" unit shipments by non-U.S. manufacturers -- a total projected at 51,200 for 1985. OEM shipments of 8" drives by U.S. manufacturers have been hovering at about 10,000 per year. U.S. companies are expected to ship 35,000 5.25" drives in 1985, but these shipments are mostly from a single company, with others initiating production of drives in this group during late 1985 and 1986.

In 1984, Fujitsu became the leader in overall unit shipments, with 27.6% of the worldwide total, consisting of 4,800 14" drives and 15,300 8" drives. Combinations of 14" and 8" drives gave Control Data 23.8% and Priam 23.8%. Maxtor was fourth with 13.7%, and was the only company to ship 5.25" drives in this product group in 1984.

Marketing trends

In 1986, shipments of 5.25" drives in this group will enjoy explosive growth, taking 48% of the worldwide shipments for drives of all disk diameter. Several aggressive U.S. and non-U.S. drive manufacturers are expected to be in production with 170 megabyte models, joining the Maxtor 140 and 190 megabyte drives now dominating 5.25" shipments. The forecasted 1988 total of 5.25" 491,700 drives will be 81.3% of all drives for

that year. 8" drives are expected to reach their shipment peak in 1987, while 14" drives continue in a permanent decline.

DISK/TREND forecasts for IBM drives in this group are based on the assumption that 1986 will be the last year of significant shipments for the 14" Star 200 megabyte drive currently used with System/36 office computers and Series/1 minicomputers. It is expected that a new 8" drive to be introduced in 1986 will replace the Star. A new 5.25" drive is expected for first shipment in 1987, an upgraded version of the 5.25" drive with 40 megabyte capacity now produced at Rochester, Minnesota, and Havant, in England.

Other captive programs are expected to remain at modest levels in the U.S., providing an attractive and large market for manufacturers of 5.25" drives with manufacturers of office and specialized systems, plus heavy use with file servers for local area network requirements. The 1988 forecast of 383,000 OEM 5.25" drives worldwide is 77.9% of the 5.25" total for that year.

Technical trends

This product group continues to be a likely proving ground for new recording technologies with the potential to provide drastic increases in linear recording density. All of the 5.25" drives with capacities over 100 MB offered to date use either plated or sputtered disks, to facilitate the high recording densities used. With thin film heads now starting to be available at prices competitive to high density ferrite heads, some new drives offered in this product group will probably use them. And if perpendicular recording finds a home with any rigid disk drives in the next few years, this group is probably the most likely place.

Marketability of drives with higher transfer rates will be directly affected by whether the industry reaches an early consensus on interface standards suitable for higher transfer rates, paving the way for availability of appropriate controllers. The marketplace is in the process of settling the issues, and in the meantime, most new drives will use existing interface standards in order to make immediate sales possible.

Several drive manufacturers are offering ESDI interfaces with new 5.25" drives operating at 10 megabit/second transfer rates, and some will offer the option of IPI-2 drive level interfaces. On-board SCSI interfaces will also be available from some manufacturers, with a growing number offering this option as time goes on.

Forecasting assumptions

1. IBM's 14" drive shipments will end in 1985, impacted by introduction of 8" drives in 1986 and 5.25" drives in 1987.
2. Several additional vendors will successfully start production of 5.25" drives for the OEM market by 1986.
3. Non-U.S. manufacturers will continue to dominate OEM shipments of 8" drives.

TABLE 42
FIXED DISK DRIVES, 100 - 300 MEGABYTES
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	232.2	340.2	239.4	363.6	280.4	430.2	352.2	523.7	503.6	770.6
Other U.S. Captive	142.8	221.3	104.1	167.5	119.0	182.4	221.8	311.0	333.2	458.8
TOTAL U.S. CAPTIVE	375.0	561.5	343.5	531.1	399.4	612.6	574.0	834.7	836.8	1,229.4
PCM	5.2	5.2	3.8	3.8	2.4	2.4	1.2	1.2	--	--
OEM	112.9	133.8	141.9	167.7	194.6	231.1	255.8	312.1	309.1	385.3
TOTAL U.S. NON-CAPTIVE	118.1	139.0	145.7	171.5	197.0	233.5	257.0	313.3	309.1	385.3
TOTAL U.S. REVENUES	493.1	700.5	489.2	702.6	596.4	846.1	831.0	1,148.0	1,145.9	1,614.7
Non-U.S. Manufacturers	-----									
Captive	--	199.4	1.1	261.4	42.0	371.7	91.0	484.1	119.2	482.7
PCM	--	--	--	--	--	--	--	--	--	--
OEM	61.1	91.2	96.5	143.8	159.1	227.6	178.9	263.0	201.5	292.7
TOTAL NON-U.S. REVENUES	61.1	290.6	97.6	405.2	201.1	599.3	269.9	747.1	320.7	775.4
Worldwide Recap	-----									
TOTAL WORLDWIDE REVENUES	554.2	991.1	586.8	1,107.8	797.5	1,445.4	1,100.9	1,895.1	1,466.6	2,390.1
OEM Average Price (\$000)	3.0	3.0	2.5	2.5	2.2	2.2	1.8	1.8	1.6	1.6

TABLE 43
FIXED DISK DRIVES, 100 - 300 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		-----Forecast-----							
	Shipments		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	12.9	18.9	13.3	20.2	17.2	26.3	29.3	43.3	44.3	67.3
Other U.S. Captive	10.6	16.7	7.4	12.0	10.4	15.5	23.7	32.2	39.7	53.3
TOTAL U.S. CAPTIVE	23.5	35.6	20.7	32.2	27.6	41.8	53.0	75.5	84.0	120.6
PCM	.4	.4	.3	.3	.2	.2	.1	.1	--	--
OEM	34.3	40.3	53.3	62.8	88.7	105.4	137.6	168.1	194.3	242.5
TOTAL U.S. NON-CAPTIVE	34.7	40.7	53.6	63.1	88.9	105.6	137.7	168.2	194.3	242.5
TOTAL U.S. SHIPMENTS	58.2	76.3	74.3	95.3	116.5	147.4	190.7	243.7	278.3	363.1
Non-U.S. Manufacturers										
Captive	--	15.7	.1	26.1	5.0	39.9	12.8	59.5	18.7	66.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	21.9	32.3	38.8	57.7	69.2	99.4	91.5	135.9	120.2	175.7
TOTAL NON-U.S. SHIPMENTS	21.9	48.0	38.9	83.8	74.2	139.3	104.3	195.4	138.9	241.7
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	80.1	124.3	113.2	179.1	190.7	286.7	295.0	439.1	417.2	604.8
Cumulative Shipments										
IBM Captive	21.8	32.3	35.1	52.5	52.3	78.8	81.6	122.1	125.9	189.4
Non-IBM	144.7	236.8	244.6	395.7	418.1	656.1	683.8	1,051.9	1,056.7	1,589.4
WORLDWIDE TOTAL	166.5	269.1	279.7	448.2	470.4	734.9	765.4	1,174.0	1,182.6	1,778.8

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

	1984			Forecast											
	Shipments			1985			1986			1987			1988		
	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	18.9	--	--	20.2	--	--	15.5	10.8	--	--	26.8	16.5	--	36.1	31.2
Other U.S. Captive	16.2	.5	--	10.4	1.6	--	6.2	3.8	5.5	2.8	8.4	21.0	--	14.8	38.5
PCM	.4	--	--	.3	--	--	.2	--	--	.1	--	--	--	--	--
OEM	20.5	9.8	10.0	17.5	10.3	35.0	12.4	8.5	84.5	8.1	4.0	156.0	3.5	1.0	238.0
TOTAL U.S. SHIPMENTS	56.0	10.3	10.0	48.4	11.9	35.0	34.3	23.1	90.0	11.0	39.2	193.5	3.5	51.9	307.7
NON-U.S. MANUFACTURERS															
Captive	.7	15.0	--	.3	25.4	.4	.1	33.0	6.8	--	34.5	25.0	--	27.0	39.0
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	4.8	27.5	--	1.3	51.2	5.2	.6	57.8	41.0	--	43.9	92.0	--	30.7	145.0
TOTAL NON-U.S. SHIPMENTS	5.5	42.5	--	1.6	76.6	5.6	.7	90.8	47.8	--	78.4	117.0	--	57.7	184.0
WORLDWIDE RECAP															
Total Shipments	61.5	52.8	10.0	50.0	88.5	40.6	35.0	113.9	137.8	11.0	117.6	310.5	3.5	109.6	491.7
ANNUAL SHARE, BY DIAMETER	49.6%	42.5%	7.9%	28.0%	49.4%	22.6%	12.2%	39.8%	48.0%	2.5%	26.9%	70.6%	.6%	18.1%	81.3%

NOTE: 8 inch totals include 9 and 10.5 inch drives

TABLE 45
 FIXED DISK DRIVES, 100 - 300 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984			Forecast											
	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	340.2	--	--	363.6	--	--	279.0	151.2	--	--	375.2	148.5	--	505.4	265.2
Other U.S. Captive	214.8	6.5	--	146.7	20.8	--	86.8	47.6	48.0	39.2	100.8	171.0	--	170.3	288.5
PCM	5.2	--	--	3.8	--	--	2.4	--	--	1.2	--	--	--	--	--
OEM	73.1	38.7	22.0	57.7	33.5	76.5	39.7	23.8	167.6	25.1	10.4	276.6	10.5	2.4	372.4
TOTAL U.S. REVENUES	633.3	45.2	22.0	571.8	54.3	76.5	407.9	222.6	215.6	65.5	486.4	596.1	10.5	678.1	926.1
NON-U.S. MANUFACTURERS															
Captive	11.9	187.5	--	5.1	253.7	2.6	1.7	330.0	40.0	--	338.1	146.0	--	259.2	223.5
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	15.3	75.9	--	4.2	129.0	10.6	1.9	144.5	81.2	--	101.0	162.0	--	67.5	225.2
TOTAL NON-U.S. REVENUES	27.2	263.4	--	9.3	382.7	13.2	3.6	474.5	121.2	--	439.1	308.0	--	326.7	448.7
WORLDWIDE RECAP															
Total Revenues	660.5	308.6	22.0	581.1	437.0	89.7	411.5	697.1	336.8	65.5	925.5	904.1	10.5	1,004.8	1,374.8
ANNUAL SHARE, BY DIAMETER	66.7%	31.1%	2.2%	52.6%	39.4%	8.0%	28.6%	48.2%	23.2%	3.5%	48.9%	47.6%	.4%	42.1%	57.5%

NOTE: 8 inch totals include 9 and 10.5 inch drives

TABLE 46

FIXED DISK DRIVES, 100-300 MEGABYTES
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution channel	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	10.3	18.2	15.5	13.3	11.4	8.7
Mini/micro computer manufacturers	14.9	26.3	28.9	31.8	35.0	38.5
System OEMs/systems houses	24.8	43.8	43.0	41.8	40.3	39.3
Independent peripherals suppliers	3.0	5.3	7.4	8.3	9.1	9.7
Distributors, dealers, end users	3.6	6.4	5.2	4.8	4.2	3.8
TOTAL	56.3					

TABLE 47

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

Drive Manufacturers	1984 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)		%			Units (000)		%		
	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
Fujitsu	2.1	9.2	--	11.3	20.0	4.8	15.3	--	20.1	27.6
Control Data	7.2	6.8	--	14.0	24.7	8.9	8.5	--	17.4	23.8
Priam	8.6	.6	--	9.2	16.3	9.5	1.0	--	10.5	14.4
Maxtor	--	--	8.7	8.7	15.4	--	--	10.0	10.0	13.7
NEC	--	6.0	--	6.0	10.6	--	7.5	--	7.5	10.3
Other U.S.	2.5	.3	--	2.8	4.9	2.5	.3	--	2.8	3.8
Other Non-U.S.	--	4.6	--	4.6	8.1	--	4.7	--	4.7	6.4
TOTAL	20.4	27.5	8.7	56.6	100.0	25.7	37.3	10.0	73.0	100.0

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

FIXED DISK DRIVES, 300-500 MB

FIXED DISK DRIVES, 300-500 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Ampex	Capricorn 330
Century Data Systems	AMS 315
Data General	6236, 6237
Digital Equipment	RA81
Disc Tech One	4300
Fujitsu	M2294, F493
Hewlett-Packard	7933H
Nippon Peripherals	NP25
Tecstor	3/315, 3/332

10.5" disk diameter

Fujitsu	M2350A, F6421
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9" disk diameter

Control Data	9715-340
NEC	D2332

8" disk diameter

Century Data Systems	C2400, C2476
Control Data	9720 EMD
Fujitsu	M2333K
Hitachi	DKU-80
Megavault	MV330
Mitsubishi Electric	MR4875
NEC	JS4380N
Northern Telecom	8308, 8310
Pertec	DX300
Priam	807

5.25" disk diameter

Maxtor	EXT-4380
Siemens	1300

Many of the older disk drives in this group are patterned after IBM's 3350, and all are 317.5 MB floor-standing drives intended for use with mainframes, including both plug compatible applications and captive systems.

During recent years, however, newer rack-mounted 14" drives have been introduced for both captive (DEC, Data General, Hewlett-Packard) and OEM (Tecstor, Century, Fujitsu) markets. Led by the successful Fujitsu 10.5" Eagle, other small drives have included the Control Data 9" FSD with 344 MB, the Hitachi 8" DKU-80 with 427 MB, and the Maxtor 5.25" EXT-4380 with 382 MB.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	602.0	772.3	1,002.9	1,153.9	1,349.5
All manufacturers	1,224.6	1,524.4	1,714.1	1,799.6	2,022.8

In contrast, all other DISK/TREND product groups covering fixed disk drives, IBM's actions currently have no direct influence in this capacity range. The last of IBM's newly produced 3350's was shipped in early 1983, having been highly influential in broadening the usage of Winchester technology. U.S. PCM drive producers produced their last single density (317 megabytes) 3350 equivalent in 1983.

The last remaining evidence of the once-thriving business in making 317 megabyte drives for IBM and compatible mainframes is the plug compatible version of Fujitsu's Eagle I, sold in North America and Europe by Amdahl. For PCM markets this drive is formatted to 317 megabytes, with multiple spindles per box to compete with IBM's original 3380 in capacity, performance and price. It is believed that shipments in this program will peak in 1985, at just over 15,000 spindles worldwide in that year.

Despite IBM's lack of activity, other manufacturers of captive disk drives have major production programs in this product group. U.S. captive drive manufacturers, composed mostly of the traditional minicomputer manufacturers Digital Equipment, Hewlett-Packard and Data General, shipped 33,100 drives in 1983, going up to an estimated 41,100 units in 1985. Non-U.S. captive production, which is also expected to increase from 14,800 in 1984 to 19,900 in 1985, originates primarily from several major Japanese computer manufacturers. Siemens' long-standing program was discontinued in 1984, replaced by outside purchases.

Shipments of OEM drives by U.S. manufacturers is more than doubling in 1985, compared with 1984, but the gains are coming entirely from 8" and 9" drives. 3,100 8"/9" drives were shipped by U.S. firms in 1984, with 1985's total estimated at 16,500 units. The same trend is occurring with non-U.S. companies. Fujitsu's 10.5" Eagle I remains the leader in OEM shipments, but most of the growth this year is from 8"/9" drives, with last year's 1,600 units increasing to an estimated 11,200 in 1985.

1984's overall leader in worldwide shipments of non-captive drives (including both OEM and PCM) was Fujitsu, with 71.4% of worldwide unit shipments, totaling 32,000 drives. Century Data Systems held 8.9% and Control Data had 5.8%.

Marketing trends

Considering the gap in IBM's disk drive product offerings -- from the 200 megabyte Star to the 729 megabyte 3370 -- the company is long overdue for a new drive in this product group. The firm's competitive need for such a drive with Series/1 minicomputers and System/36 office computers is obvious. IBM's management probably hasn't agreed on the details yet, but

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we continue to assume that IBM will start shipments of an 8" drive in the 300-500 megabyte capacity range in 1986. It is expected that this will be a major program, with shipments reaching 40,000 spindles in 1988.

We expect that the last residue of the PCM business in this group will end in 1986, as Amdahl upgrades its plug compatible program to more emphasis on the 630 megabyte Eagle II. In the same way, other U.S. captive drive manufacturers are expected to produce fewer drives in this group each year starting in 1986, as they upgrade their 14" drives to capacities above 500 megabytes. Non-U.S. captive manufacturers are forecasted to increase 1986-1988 shipments, however, as they place greater emphasis on 8" and 5.25" drives.

Non-U.S. manufacturers are currently running slightly ahead of U.S. manufacturers in OEM shipments, and this balance is expected to remain through 1988, while total OEM shipments more than double during the same period. The product mix will change drastically during this period, however, as the 14" drives which led in 1984 shipments fade out. 8"/9" drives assumed the leadership in shipments during 1985, but 5.25" drives are expected to be on top in 1988.

Technical trends

Development activities in this product group will be concentrated on squeezing more capacity into smaller boxes during the next few years. Control Data's 340 megabyte version of the 9" FSD was designed to a fairly conservative linear density specification, by today's standards, of 9,492 BPI. The FSD's 230 mm disk provides more recording area than the 195-210 mm disks used with 8" drives, allowing use of less ambitious specifications and making it easier to produce the drive in large quantities.

Other development programs now underway for OEM drives target similar capacities for 8" and 5.25" drives, in order to conform to standard form factors established by flexible disk drives. These constraints, combined with transfer rate limitations imposed by de facto interface standards and availability of controllers, have forced manufacturers to seek innovative design solutions, such as Maxtor's placement of the drive motor inside the inner diameter of the stack 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.

Forecasting assumptions

1. IBM will introduce no new 14" drives in this group, but will add 8" drives in 1986.
2. Sustained growth for superminicomputers, large workstation clusters and specialized systems will create significant growth for both captive and OEM drives in this group with initial emphasis on 8"/9" drives.
3. Additional producers of OEM drives will successfully initiate volume production of 5.25" drives.

TABLE 48
 FIXED DISK DRIVES, 300 - 500 MEGABYTES
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		Forecast							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	161.5	237.5	313.5	475.0	460.8	720.0
Other U.S. Captive	348.9	537.7	424.0	656.1	397.7	622.6	324.1	516.8	280.5	461.0
TOTAL U.S. CAPTIVE	348.9	537.7	424.0	656.1	559.2	860.1	637.6	991.8	741.3	1,181.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	55.5	64.3	102.0	116.2	121.3	142.8	132.5	162.1	134.8	168.5
TOTAL U.S. NON-CAPTIVE	55.5	64.3	102.0	116.2	121.3	142.8	132.5	162.1	134.8	168.5
TOTAL U.S. REVENUES	404.4	602.0	526.0	772.3	680.5	1,002.9	770.1	1,153.9	876.1	1,349.5
Non-U.S. Manufacturers										
Captive	--	370.0	1.7	461.6	5.1	436.1	6.7	435.3	8.2	448.2
PCM	57.0	133.0	35.2	143.5	23.0	92.0	--	--	--	--
OEM	82.6	119.6	100.8	147.0	119.9	183.1	130.2	210.4	122.8	225.1
TOTAL NON-U.S. REVENUES	139.6	622.6	137.7	752.1	148.0	711.2	136.9	645.7	131.0	673.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	544.0	1,224.6	663.7	1,524.4	828.5	1,714.1	907.0	1,799.6	1,007.1	2,022.8
OEM Average Price (\$000)	5.8	5.8	4.7	4.9	3.9	3.9	3.3	3.4	2.8	3.0

TABLE 49
FIXED DISK DRIVES, 300 - 500 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		-----Forecast-----							
	---Shipments---		---1985---		---1986---		---1987---		---1988---	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	8.5	12.5	16.5	25.0	25.6	40.0
Other U.S. Captive	21.5	33.1	26.6	41.1	25.1	39.3	20.6	32.9	18.6	30.5
TOTAL U.S. CAPTIVE	21.5	33.1	26.6	41.1	33.6	51.8	37.1	57.9	44.2	70.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	10.3	11.8	22.7	25.9	31.6	37.2	41.3	50.5	49.2	61.5
TOTAL U.S. NON-CAPTIVE	10.3	11.8	22.7	25.9	31.6	37.2	41.3	50.5	49.2	61.5
TOTAL U.S. SHIPMENTS	31.8	44.9	49.3	67.0	65.2	89.0	78.4	108.4	93.4	132.0
Non-U.S. Manufacturers										
Captive	--	14.8	.1	19.9	.3	20.9	.4	23.7	.5	28.0
PCM	5.7	13.3	3.7	15.1	2.5	10.0	--	--	--	--
OEM	13.4	19.7	20.0	27.8	29.9	45.1	36.2	57.1	40.4	69.0
TOTAL NON-U.S. SHIPMENTS	19.1	47.8	23.8	62.8	32.7	76.0	36.6	80.8	40.9	97.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	50.9	92.7	73.1	129.8	97.9	165.0	115.0	189.2	134.3	229.0
Cumulative Shipments										
IBM Captive	116.3	198.3	116.3	198.3	124.8	210.8	141.3	235.8	166.9	275.8
Non-IBM	137.4	256.1	210.5	385.9	299.9	538.4	398.4	702.6	507.1	891.6
WORLDWIDE TOTAL	253.7	454.4	326.8	584.2	424.7	749.2	539.7	938.4	674.0	1,167.4

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

	1984		Forecast											
	Shipments		1985			1986			1987			1988		
	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS														
IBM Captive	--	--	--	--	--	--	12.5	--	--	25.0	--	--	40.0	--
Other U.S. Captive	32.9	.2	40.3	.8	--	36.8	2.5	--	27.1	5.8	--	18.5	9.5	2.5
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	8.7	3.1	8.4	16.5	1.0	6.7	22.0	8.5	3.5	26.0	21.0	--	29.5	32.0
TOTAL U.S. SHIPMENTS	41.6	3.3	48.7	17.3	1.0	43.5	37.0	8.5	30.6	56.8	21.0	18.5	79.0	34.5
NON-U.S. MANUFACTURERS														
Captive	13.5	1.3	13.5	6.4	--	10.1	10.8	--	6.5	15.2	2.0	3.0	18.0	7.0
PCM	13.3	--	15.1	--	--	10.0	--	--	--	--	--	--	--	--
OEM	18.1	1.6	15.0	11.2	1.6	13.2	19.4	12.5	8.5	25.6	23.0	5.0	30.0	34.0
TOTAL NON-U.S. SHIPMENTS	44.9	2.9	43.6	17.6	1.6	33.3	30.2	12.5	15.0	40.8	25.0	8.0	48.0	41.0
WORLDWIDE RECAP														
Total Shipments	86.5	6.2	92.3	34.9	2.6	76.8	67.2	21.0	45.6	97.6	46.0	26.5	127.0	75.5
ANNUAL SHARE, BY DIAMETER	93.4%	6.6%	71.2%	26.9%	1.9%	46.6%	40.7%	12.7%	24.1%	51.7%	24.2%	11.6%	55.6%	32.8%

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

TABLE 51
 FIXED DISK DRIVES, 300 - 500 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984		1985			1986			1987			1988		
	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS														
IBM Captive	--	--	--	--	--	--	237.5	--	--	475.0	--	--	720.0	--
Other U.S. Captive	534.7	3.0	644.1	12.0	--	585.1	37.5	--	430.9	85.9	--	292.3	138.7	30.0
PCM	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	47.2	17.1	44.3	68.3	3.6	34.2	81.4	27.2	17.5	85.8	58.8	--	88.5	80.0
TOTAL U.S. REVENUES	581.9	20.1	688.4	80.3	3.6	619.3	356.4	27.2	448.4	646.7	58.8	292.3	947.2	110.0
NON-U.S. MANUFACTURERS														
Captive	347.1	22.9	351.3	110.3	--	252.5	183.6	--	156.0	255.3	24.0	69.0	295.2	84.0
PCM	133.0	--	143.5	--	--	92.0	--	--	--	--	--	--	--	--
OEM	110.2	9.4	91.6	50.4	5.0	66.0	79.6	37.5	51.0	97.3	62.1	35.0	105.1	85.0
TOTAL NON-U.S. REVENUES	590.3	32.3	586.4	160.7	5.0	410.5	263.2	37.5	207.0	352.6	86.1	104.0	400.3	169.0
WORLDWIDE RECAP														
Total Revenues	1,172.2	52.4	1,274.8	241.0	8.6	1,029.8	619.6	64.7	655.4	999.3	144.9	396.3	1,347.5	279.0
ANNUAL SHARE, BY DIAMETER	95.8%	4.2%	83.7%	15.8%	.5%	60.2%	36.1%	3.7%	36.5%	55.5%	8.0%	19.6%	66.7%	13.7%

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

TABLE 52

FIXED DISK DRIVES, 300-500 MEGABYTES
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution channel	1984 U.S. Net Shipments		FORECAST			
	Units (000)	%	1985 %	1986 %	1987 %	1988 %
Mainframe computer manufacturers	.6	2.0	3.2	2.9	2.4	1.9
Mini/micro computer manufacturers	9.0	30.6	34.0	35.8	36.2	36.4
System OEMs/systems houses	11.3	38.4	42.7	45.0	45.6	45.6
Independent peripherals suppliers	2.4	8.2	11.9	12.2	14.0	15.2
Distributors, dealers, end users	<u>6.1</u>	20.8	8.2	4.1	1.8	.9
TOTAL	29.4					

(cc 5/2 - 4)

TABLE 53

FIXED DISK DRIVES, 300-500 MEGABYTES
MARKET SHARE SUMMARY - (cc 5/2 - 10)
Worldwide Shipments of Non-Captive Disk Drives (cc 5/2 - 23)

Drive Manufacturers	1984 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
	14"	8"	Total		14"	8"	Total	
Fujitsu	18.8	.3	19.1	65.0	30.9	1.1	32.0	71.4
Century Data Systems	4.0	--	4.0	13.6	4.0	--	4.0	8.9
Control Data	--	2.2	2.2	7.5	--	2.6	2.6	5.8
Other U.S.	3.7	.4	4.1	13.9	4.7	.5	5.2	11.6
Other Non-U.S.	--	--	--	--	.5	.5	1.0	2.3
TOTAL	26.5	2.9	29.4	100.0	40.1	4.7	44.8	100.0

NOTE: 14 inch totals include 10.5 inch drives

FIXED DISK DRIVES, MORE THAN 500 MB

FIXED DISK DRIVES, MORE THAN 500 MEGABYTESCoverage

Examples of disk drives in this group include:

14" disk diameter

Ampex	A-660, A-825
Burroughs	9494-12
Century Data Systems	AMS 513, AMS 571
Control Data	9771, 9772, 9775
Data General	6239, 6290
Fujitsu	M2298
Hitachi	DKU-97S, H-8598
Ibis	1400
IBM	3370, 3375, 3380D/E
Memorex	3680
NEC	N7761, N7765
Nippon Peripherals	NP-37, NP-38
Storage Technology	8650, 8380-B4, 8380-BE4

10.5" disk diameter

Fujitsu	F6425, F6425L4
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8-9" disk diameter

Control Data	9715-500
Hitachi	DK815-5
Megavault	MV660
NEC	D2352, N7756
Priam	808

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.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
U.S. manufacturers	4,568.9	5,396.6	6,883.3	8,261.5	9,471.1
All manufacturers	5,290.1	6,570.9	8,378.9	10,333.8	12,024.1

As expected, IBM rolled out a double capacity version of the 3380 this year. After announcing in February that first shipments of the 2.5 gigabyte/spindle "E" models would be in fourth quarter of 1985, first deliveries actually started in July, apparently as an assist to IBM management's attempts to meet the firm's 1985 business plan.

DISK/TREND estimates indicate worldwide IBM shipments of 74,000 3380 spindles (37,000 drives) in 1984. The 1985 estimate is 81,000 spindles (40,500 drives) of all 3380 models, of which 25,000 spindles are expected to be double capacity.

When combined with 3370 and 3375 shipments, these totals indicate IBM worldwide captive shipments in 1984 of 106,500 spindles, going up to 112,000 in 1985. With a value on an "if sold" basis at \$4.2 billion, IBM's revenues in this product group will equal 31% of the entire disk drive industry's 1985 revenues for all types of drives.

Plug compatible disk drive vendors continue to find IBM's act hard to follow, especially the U.S. PCM drive manufacturers. In late 1984, Control Data withdrew from the high end PCM disk drive market, and has been selling off its inventory during 1985. Storage Technology declared bankruptcy in October, 1984, the victim of bankers' nervousness regarding overdue loans and its own overexpansion into non-data storage businesses. STC has found it difficult to keep customers and to finance new products while operating under Chapter 11.

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Worldwide PCM shipments were 20,300 spindles in 1984, increasing to an estimated 32,500 in 1985. 28,700 of the 1985 total will be 3380 equivalent spindles, all single density. Japanese disk drive manufacturers are expected to ship 70% of 1985's total PCM shipments.

Other U.S. captive drive manufacturers are expected to ship 22,100 spindles in 1985, up from 16,500 the previous year, dominated by the parent companies of Magnetic Peripherals, Inc., and Burroughs usage of Memorex drives. Non-U.S. captive shipments, confined to Fujitsu, Hitachi and NEC, are estimated at 17,100 for 1985, up 6,000 spindles over 1984.

Worldwide shipments of OEM drives are now increasing sharply, from 1984's 10,100 spindles to an estimated 26,400 in 1985. U.S. companies will ship 63.6% of this total, and 43.9% will be 8" and 9" drives. IBM became a significant vendor of OEM disk drives for the first time in 1984, with shipments of 3380s to both Honeywell and Siemens. Both firms are using IBM's drives with their own mainframe systems, and Siemens has sold some on a PCM basis to IBM's own system customers in Europe.

In 1984, worldwide shipments of non-captive drives (including both OEM and PCM models) were 30,400 spindles. Hitachi led with 34.2% of the worldwide total, for 10,400 units. Control Data had 20.1%, and STC, 17.4%.

Marketing trends

DISK/TREND forecasts assume the "E" series double capacity 3380 will remain IBM's main answer for mainframe disk drive requirements through at least 1988, but it may be joined by a new companion or two. It is well known that not all of IBM's mainframe customers are happy with the combination of performance and capacity offered by the 3380.

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The difficulty is that the access times offered are not adequate for some high-throughput requirements, and adding more capacity per actuator only compounds the problem. Another fact worth noting is that the 3370/3375 drive family is now quite old by IBM standards, the original drives first having been shipped in 1979. With today's technology, a smaller, more cost effective drive is clearly possible.

This year's DISK/TREND forecasts assume that a new IBM drive addressing some of the above requirements will first be shipped in 1987, with a rapid growth in 1988. Undoubtedly, IBM's management still has some decisions to make in this area, but we expect that the drive will be smaller in physical size (shown in our tables as 8", but could be in 10" range), probably about 800 megabytes capacity, and with a version designed to provide sharply improved access time, perhaps through use of multiple-head sliders.

PCM shipments are projected to be flat for 1986, as IBM's competitors struggle during the next year with delayed availability of double capacity 3380 equivalent drives, then achieve modest growth again in 1987-88.

Other captive shipments will more than triple through 1988, spurred by availability of higher capacity rack mounted 14" drives, wide use of 8"/9" drives, and by an expected higher capacity version of Digital Equipment's RA81. OEM drives will also experience excellent growth, with more than half of 1988's shipments expected to be 8"/9" drives (and perhaps even a few 5.25" drives by that time).

Technical trends

IBM has taken the track density of the "E" series up to about 1,450 TPI. Despite the fact that the new models have been shipping since July,

they coyly refuse to release the exact number, waiting for competitors to buy drives and perform autopsies on the head-disk assemblies. However, since the track density of the older 3380 model was not doubled to 1,600 TPI, it is a clear indication that the range around 1,450 was considered today's safe limit for a production drive.

So what happens next with technology used in high-end disk drives? As always, IBM will have several options, but it is likely that system functional requirements and customers' sarcasm will steer development efforts in the directions suggested earlier in this section: Toward smaller physical size and specialized drives with improved performance. It is probable that a majority of IBM's mainframe customers still merely want improved cost per megabyte in their next drive, but others are already finding troublesome performance limitations with today's drives.

An obvious answer will be to develop drives using disks less than 14" diameter, using the higher areal densities now attainable. These drives will be smaller, quieter, cheaper and require less power -- and the basic models would be very appropriate replacements, at about 800 megabytes, for the aging 3370/3375 family. A variation of the same drive could readily contain the performance features needed with high-throughput applications, notably multiple head sliders, providing access to many additional tracks by electronic switching, without the delay of actuator movement.

Forecasting assumptions

1. IBM will manufacture adequate double capacity 3380 drives to meet 1985 demand, and ship a new 8"/10" drive in 1987.
2. First PCM shipments of double capacity 3380s in mid-1986.
3. Other captive and OEM products will both experience strong growth, driven by mainframe and supermini markets.

TABLE 54
 FIXED DISK DRIVES, MORE THAN 500 MEGABYTES
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		-----Forecast-----							
	-----Revenues-----		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	2,307.9	3,762.9	2,695.3	4,291.8	3,240.8	5,252.3	3,655.5	5,814.8	4,112.8	6,381.0
Other U.S. Captive	286.0	526.0	374.8	693.6	637.0	1,122.2	949.3	1,612.1	1,276.1	2,129.1
TOTAL U.S. CAPTIVE	2,593.9	4,288.9	3,070.1	4,985.4	3,877.8	6,374.5	4,604.8	7,426.9	5,388.9	8,510.1
PCM	105.5	152.7	122.3	204.2	152.2	239.9	325.5	507.5	367.3	609.9
OEM	54.4	127.3	115.1	207.0	156.4	268.9	187.4	327.1	204.6	351.1
TOTAL U.S. NON-CAPTIVE	159.9	280.0	237.4	411.2	308.6	508.8	512.9	834.6	571.9	961.0
TOTAL U.S. REVENUES	2,753.8	4,568.9	3,307.5	5,396.6	4,186.4	6,883.3	5,117.7	8,261.5	5,960.8	9,471.1
Non-U.S. Manufacturers										
Captive	--	399.6	--	602.7	--	784.8	--	1,080.8	--	1,406.0
PCM	105.4	315.0	181.4	504.2	243.0	572.8	361.6	800.0	405.0	929.9
OEM	4.9	6.6	30.5	67.4	74.0	138.0	104.1	191.5	123.6	217.1
TOTAL NON-U.S. REVENUES	110.3	721.2	211.9	1,174.3	317.0	1,495.6	465.7	2,072.3	528.6	2,553.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,864.1	5,290.1	3,519.4	6,570.9	4,503.4	8,378.9	5,583.4	10,333.8	6,489.4	12,024.1
OEM Average Price (\$000)	11.4	13.2	8.8	10.3	7.8	8.6	7.6	8.0	7.1	7.4

TABLE 55
FIXED DISK DRIVES, MORE THAN 500 MEGABYTES
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		1985		1986		1987		1988	
	Shipments						Forecast			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	64.2	106.5	68.1	112.0	72.5	117.5	79.7	127.0	92.2	144.0
Other U.S. Captive	9.0	16.5	12.0	22.1	22.1	38.8	35.4	59.8	50.7	84.1
TOTAL U.S. CAPTIVE	73.2	123.0	80.1	134.1	94.6	156.3	115.1	186.8	142.9	228.1
PCM	4.3	6.3	5.7	9.6	5.9	9.3	9.3	14.5	10.9	18.1
OEM	4.3	8.9	10.7	16.8	17.9	27.3	21.9	35.4	25.4	41.7
TOTAL U.S. NON-CAPTIVE	8.6	15.2	16.4	26.4	23.8	36.6	31.2	49.9	36.3	59.8
TOTAL U.S. SHIPMENTS	81.8	138.2	96.5	160.5	118.4	192.9	146.3	236.7	179.2	287.9
Non-U.S. Manufacturers										
Captive	--	11.1	--	17.1	--	23.2	--	33.8	--	45.8
PCM	4.6	14.0	8.2	22.9	9.8	23.1	11.3	25.0	12.5	28.7
OEM	.9	1.2	5.7	9.6	11.3	19.8	16.3	29.0	20.3	35.0
TOTAL NON-U.S. SHIPMENTS	5.5	26.3	13.9	49.6	21.1	66.1	27.6	87.8	32.8	109.5
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	87.3	164.5	110.4	210.1	139.5	259.0	173.9	324.5	212.0	397.4
Cumulative Shipments										
IBM Captive	143.5	255.5	211.6	367.5	284.1	485.0	363.8	612.0	456.0	756.0
Non-IBM	92.4	188.1	134.7	286.2	201.7	427.7	295.9	625.2	415.7	878.6
WORLDWIDE TOTAL	235.9	443.6	346.3	653.7	485.8	912.7	659.7	1,237.2	871.7	1,634.6

TABLE 56
 FIXED DISK DRIVES, MORE THAN 500 MEGABYTES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1984		Forecast							
	14"	8"	14"	8"	14"	8"	14"	8"	14"	8"
U.S. MANUFACTURERS										
IBM Captive	106.5	--	112.0	--	117.5	--	118.0	9.0	119.0	25.0
Other U.S. Captive	16.3	.2	20.9	1.2	35.8	3.0	48.8	11.0	62.1	22.0
PCM	6.3	--	9.6	--	9.3	--	14.5	--	18.1	--
OEM	7.7	1.2	10.7	6.1	12.5	14.8	15.8	19.6	17.2	24.5
TOTAL U.S. SHIPMENTS	136.8	1.4	153.2	7.3	175.1	17.8	197.1	39.6	216.4	71.5
NON-U.S. MANUFACTURERS										
Captive	11.1	--	15.1	2.0	19.6	3.6	26.5	7.3	35.0	10.8
PCM	14.0	--	22.9	--	23.1	--	25.0	--	28.7	--
OEM	.9	.3	4.1	5.5	7.8	12.0	11.5	17.5	14.0	21.0
TOTAL NON-U.S. SHIPMENTS	26.0	.3	42.1	7.5	50.5	15.6	63.0	24.8	77.7	31.8
WORLDWIDE RECAP										
Total Shipments	162.8	1.7	195.3	14.8	225.6	33.4	260.1	64.4	294.1	103.3
ANNUAL SHARE, BY DIAMETER	99.1%	.9%	93.1%	6.9%	87.2%	12.8%	80.3%	19.7%	74.1%	25.9%

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

TABLE 57
 FIXED DISK DRIVES, MORE THAN 500 MEGABYTES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984		-----Forecast-----							
	14"	8"	1985		1986		1987		1988	
Revenues	14"	8"	14"	8"	14"	8"	14"	8"	14"	8"
U.S. MANUFACTURERS										
IBM Captive	3,762.9	--	4,291.8	--	5,252.3	--	5,616.8	198.0	5,831.0	550.0
Other U.S. Captive	521.6	4.4	667.2	26.4	1,056.2	66.0	1,381.1	231.0	1,689.1	440.0
PCM	152.7	--	204.2	--	239.9	--	507.5	--	609.9	--
OEM	119.0	8.3	171.8	35.2	187.5	81.4	229.1	98.0	240.8	110.3
TOTAL U.S. REVENUES	4,556.2	12.7	5,335.0	61.6	6,735.9	147.4	7,734.5	527.0	8,370.8	1,100.3
NON-U.S. MANUFACTURERS										
Captive	399.6	--	558.7	44.0	705.6	79.2	927.5	153.3	1,190.0	216.0
PCM	315.0	--	504.2	--	572.8	--	800.0	--	929.9	--
OEM	4.6	2.0	38.2	29.2	78.0	60.0	112.7	78.8	133.1	84.0
TOTAL NON-U.S. REVENUES	719.2	2.0	1,101.1	73.2	1,356.4	139.2	1,840.2	232.1	2,253.0	300.0
WORLDWIDE RECAP										
Total Revenues	5,275.4	14.7	6,436.1	134.8	8,092.3	286.6	9,574.7	759.1	10,623.8	1,400.3
ANNUAL SHARE, BY DIAMETER	99.8%	.2%	98.0%	2.0%	96.7%	3.3%	92.8%	7.2%	88.5%	11.5%

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

TABLE 58
WORLDWIDE SHIPMENTS OF IBM AND PCM FIXED DISK DRIVES FOR MAINFRAMES
PRODUCT MIX ANALYSIS

	-----DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		-----FORECAST-----							
	---Shipments---		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	US	WW	US	WW	US	WW	US	WW	US	WW
<u>3350 Type</u>										
PCM 317 MB*	5.7	13.3	3.7	15.1	2.5	10.0	--	--	--	--
PCM 635 MB	.7	2.7	.1	.6	--	--	--	--	--	--
TOTAL	6.4	16.0	3.8	15.7	2.5	10.0	--	--	--	--
<u>3370 Type (729 MB)</u>										
IBM	7.0	17.5	6.3	15.8	5.6	14.0	4.0	10.0	1.6	4.0
PCM	--	.8	.5	2.0	.4	1.6	.2	1.0	.1	.5
TOTAL	7.0	18.3	6.8	17.8	6.0	15.6	4.2	11.0	1.7	4.5
<u>3375 Type (819 MB)</u>										
IBM	6.9	15.0	6.8	15.2	6.4	14.5	4.7	11.0	2.1	5.0
PCM	.3	1.5	.5	1.2	.3	.8	.2	.5	.1	.3
TOTAL	7.2	16.5	7.3	16.4	6.7	15.3	4.9	11.5	2.2	5.3
<u>3380 Type (1260 MB)</u>										
IBM	50.3	74.0	37.5	56.0	20.5	31.0	8.5	13.0	3.8	6.0
PCM**	7.9	15.3	12.8	28.7	8.5	19.0	4.5	10.0	1.8	4.0
TOTAL	58.2	89.3	50.3	84.7	29.0	50.0	13.0	23.0	5.6	10.0
<u>2 x 3380 Type (2520 MB)</u>										
IBM	--	--	17.5	25.0	40.0	58.0	57.1	84.0	69.7	104.0
PCM	--	--	--	--	6.5	11.0	15.7	28.0	21.4	42.0
TOTAL	--	--	17.5	25.0	46.5	69.0	72.8	112.0	91.1	146.0
<u>NOT YET ANNOUNCED (800 MB)</u>										
IBM	--	--	--	--	--	--	5.4	9.0	15.0	25.0
TOTAL SPINDLES	78.8	140.1	85.7	159.6	90.7	159.9	100.3	166.5	115.6	190.8
TOTAL CAPACITY (Terabytes)		145.3 +52%		201.3 +39%		264.0 +31%		335.8 +27%		408.1 +22%

*Includes 10.5" drives in 317 MB 3350 format.

**Includes 10.5" drives, counted as equivalent to IBM 3380 (two 10.5" spindles = one IBM 3380 spindle)

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TABLE 59
 FIXED DISK DRIVES, MORE THAN 500 MEGABYTES
 DISTRIBUTION CHANNEL SUMMARY
 U.S. Non-Captive Disk Drives

<u>Distribution channel</u>	1984 U.S. Net Shipments		FORECAST			
	<u>Units (000)</u>	<u>%</u>	<u>1985 %</u>	<u>1986 %</u>	<u>1987 %</u>	<u>1988 %</u>
Mainframe computer manufacturers	1.1	7.8	7.0	6.3	5.4	4.7
Mini/micro computer manufacturers	3.0	21.3	31.9	38.2	36.7	35.8
System OEMs/systems houses	1.1	7.8	13.7	18.8	20.7	23.0
Independent peripherals suppliers	--	--	1.5	1.8	2.2	2.6
Distributors, dealers, end users	<u>8.9</u>	63.1	45.9	34.9	35.0	33.9
TOTAL	14.1					

TABLE 60
 FIXED DISK DRIVES, MORE THAN 500 MEGABYTES
 MARKET SHARE SUMMARY
 Worldwide Shipments of Non-Captive Disk Drives

<u>Drive Manufacturers</u>	1984 Net Shipments							
	To United States Destinations				Worldwide			
	<u>Units (000)</u>		<u>%</u>	<u>Total</u>	<u>Units (000)</u>		<u>%</u>	<u>Total</u>
	<u>14"</u>	<u>8"</u>			<u>14"</u>	<u>8"</u>		
Hitachi	3.6	--	3.6	25.5	10.4	--	10.4	34.2
Control Data	1.8	.8	2.6	18.5	4.9	1.2	6.1	20.1
Storage Technology	3.6	--	3.6	25.5	5.3	--	5.3	17.4
Other U.S.	2.4	--	2.4	17.0	3.8	--	3.8	12.5
Other Non-U.S.	<u>1.7</u>	<u>.2</u>	<u>1.9</u>	<u>13.5</u>	<u>4.5</u>	<u>.3</u>	<u>4.8</u>	<u>15.8</u>
TOTAL	13.1	1.0	14.1	100.0	28.9	1.5	30.4	100.0

NOTE: 14 inch totals include 10.5 inch drives

OPTICAL DISK DRIVES

Coverage

DISK/TREND covers only those optical disk drives that are sold for use with a computer. This excludes optical disks used primarily for audio or video signal storage, and also excludes optical products in non-disk form, such as optical tape and card devices. The DISK/TREND report divides optical disk drives into three types:

Group 10: Read-only optical disk drives. This includes products normally designated as optical read-only memory including CD-ROM.

Group 11: Read/write optical disk drives with capacity less than 1 gigabyte of formatted data.

Group 12: Read/Write optical disk drives with capacity greater than 1 gigabyte of storage.

Because of the undeveloped state of the optical drive market, all three types are discussed in one section. Typical products covered in this section include:

Group 10: Read-only optical drives

4.72" disk diameter (CD-ROM)

Nippon Columbia (Denon)	DRD-550
Hitachi	CDR-1502
Philips	CM-100
Sony	CDU-1

12" disk diameter

Reference Technology	2000
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Group 11: Read/write drives under 1 gigabyte3.5" disk diameter

Verbatim	Mod-1 (E)
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5.25" disk diameter

Information Storage Inc.	525WC
Optotech	5984

8" disk diameter

Matsushita Electric	LD-10*
Sony	WD-2000*

Group 12: Read/write drives over 1 gigabyte12" disk diameter

Alcatel-Thomson Gigadisc	GD1001
Fujitsu	F6441B1*
Hitachi	OD301-1
NEC	N7911/N6329-21*
Optical Storage International	Laserdrive 1200
Optimem	1000
Sony	WD3000
Toshiba	DF-0450*
Van Der Heem	DOR-RI

14" disk diameter

Storage Technology	7640
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Products designated "*" have been used almost entirely in Japan in document filing systems, and most use has been captive. Products designated (E) are erasable.

SUMMARY

Industry size

1984 was a year in which the emergence of an optical disk drive industry finally became a believable proposition. A small, but significant, number of units was shipped on both a captive and an OEM basis. 1984 worldwide revenues of optical disk drive producers were only \$29 million, but 1985 revenues should exceed \$71 million for a growth of 147%. Growth will remain high through 1988.

Most of 1984 revenue was the result of captive production by Japanese producers of high capacity drives. This pattern will be repeated in 1985. In future years, lower capacity drives will take a larger share of revenue and OEM shipments will become more significant. However, because high capacity drives have very high prices compared to the prices of the low capacity units, revenues from the high capacity units will dominate the worldwide market for the next several years.

While U.S. manufacturers captured only 7% of worldwide revenues in 1984, this percentage will be much larger in future years, rising to 37% by 1988. The OEM output of the U.S. producers will match that of the non-U.S. producers by that same period.

As yet, IBM is not a player in this industry segment. If the market for optical disk drives expands as expected, an eventual IBM entry is likely, but such an event is not expected in the immediate future. Even if IBM offers an optical disk drive product in the next three years, it will almost surely be remarketing another vendor's product rather than one of its own manufacture.

There are a number of factors that will influence the rate at which this segment of the industry grows. Use of optical storage technology by IBM would have an accelerating effect. This effect will occur even if the IBM product marketed is not manufactured by IBM per se. Adoption of any optical drive product by IBM would also have a profound influence upon the standards for optical disk drives and media.

The rate of acceptance of standards is another limiting influence on market growth. Because IBM is not expected to move soon in the optical storage area, the rate at which the rest of the industry comes to agreement upon standards for drives and media will have a strong influence upon the growth rate of the market.

A third factor is the availability of media. There is still a shortage of production capacity for all types of optical media. Several U.S. and foreign firms have indicated plans to begin quantity production in late 1985 or 1986, but sustained production capability has yet to be demonstrated. Furthermore, the lack of media standards means that most media products available in 1986 will not be interchangeable among drives.

Finally, there is much to be done in the preparation of software that will allow the optical disk to be efficiently used in a system. Integration of an optical drive requires additions or modifications to both system and application programs, to accommodate the specific characteristics of the write-once optical drive.

Unless it is easy and relatively risk-free to adopt optical storage technology, system manufacturers will remain skeptical and cautious. Most of them have been burned before by hasty adoption of the new and different, so initial progress for optical drives will be measured, not explosive.

TABLE 61
 CONSOLIDATED WORLDWIDE REVENUES
 ALL EXISTING OPTICAL DISK DRIVE GROUPS
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		-----Forecast-----							
	-----Revenues-----		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers -----										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	1.5	1.5	15.0	16.5	22.5	30.0
TOTAL U.S. CAPTIVE	--	--	--	--	1.5	1.5	15.0	16.5	22.5	30.0
PCM	--	--	--	--	--	--	52.0	52.0	104.0	104.0
OEM	1.2	1.9	14.3	17.0	40.1	50.6	167.2	202.4	248.4	300.8
TOTAL U.S. NON-CAPTIVE	1.2	1.9	14.3	17.0	40.1	50.6	219.2	254.4	352.4	404.8
TOTAL U.S. REVENUES	1.2	1.9	14.3	17.0	41.6	52.1	234.2	270.9	374.9	434.8
Non-U.S. Manufacturers -----										
Captive	--	24.1	--	39.1	2.1	109.9	32.4	294.4	65.4	399.6
PCM	--	--	--	--	--	--	--	--	--	--
OEM	1.4	3.0	5.0	15.5	25.8	86.2	70.7	176.0	141.5	317.5
TOTAL NON-U.S. REVENUES	1.4	27.1	5.0	54.6	27.9	196.1	103.1	470.4	206.9	717.1
Worldwide Recap -----										
TOTAL WORLDWIDE REVENUES	2.6	29.0	19.3	71.6	69.5	248.2	337.3	741.3	581.8	1,151.9

Marketing channels

Last year, DISK/TREND listed seven manufacturers of optical disk drives. For 1985, the number has expanded to seventeen with several more expected to enter the market shortly. Particularly notable this year is the emergence of the Colorado branch of the industry. Two firms in this group will begin shipments in 1985; other Colorado firms will be joining in during 1986. Most of this activity represents spinoffs from Optical Storage International and Storage Technology.

The revenues reported in this section of the report are defined in the same manner used for rigid disk drives. The channels of distribution are also consistent with the channel definitions used in the rigid disk sections.

By 1988, OEM sales will account for about 54% of optical disk drive revenues and captive sales will account for about 37%. The balance, 9%, is accounted for by PCM sales. No IBM sales are anticipated until after 1988. The 1988 situation is quite different from the 1984 situation, which is dominated by the captive sales of Japanese manufacturers. It is worthwhile to note that sales of most categories of data storage products first were made in significant volumes by U.S. suppliers. This is not the case with the optical disk drives; the Japanese and Europeans were there first in their own markets and to some degree in the U.S. market. Their initial lead in experience will make them more difficult to displace as a result.

TABLE 62
 CONSOLIDATED WORLDWIDE REVENUES
 OPTICAL DISK DRIVES
 REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	-----1984-----		-----Forecast-----							
	---Revenues---		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
U.S. Manufacturers -----										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	1.5	.6	16.5	2.2	30.0	2.6
PCM	--	--	--	--	--	--	52.0	7.0	104.0	9.0
OEM	1.9	6.5	17.0	23.7	50.6	20.3	202.4	27.3	300.8	26.1
Total U.S. Mfgr's.	1.9	6.5	17.0	23.7	52.1	20.9	270.9	36.5	434.8	37.7
Non-U.S. Manufacturers -----										
Captive	24.1	83.1	39.1	54.6	109.9	44.2	294.4	39.7	399.6	34.6
PCM	--	--	--	--	--	--	--	--	--	--
OEM	3.0	10.4	15.5	21.7	86.2	34.9	176.0	23.8	317.5	27.7
Total Non-U.S. Mfgr's.	27.1	93.5	54.6	76.3	196.1	79.1	470.4	63.5	717.1	62.3
Worldwide Total -----	29.0	100.0	71.6	100.0	248.2	100.0	741.3	100.0	1,151.9	100.0

Product mix

The original optical disk drive products have been high capacity, 12" units. In terms of unit shipments, the balance is swinging very rapidly towards the 4.72" CD-ROM and the 5.25" write-once optical drive. These smaller units will be used in increasingly large numbers as auxiliary mass storage for personal computers and other small systems. The larger drives will retain the largest share of revenue, however, because of price differentials ranging from 20:1 to 200:1 when compared to the smaller drives.

OEM market

As noted earlier, the 1985 OEM market is virtually non-existent. By 1988, it will account for over half of the revenues from optical disk drives. The U.S. OEMs will compete evenly with non-U.S. firms for the next few years, but after 1988 the superior experience and mass of major Japanese producers will begin to have a telling effect and the share of the worldwide OEM market held by non-U.S. firms will increasingly exceed that of the U.S. manufacturers. In the read-only disk drive segment, the Japanese firms will be especially powerful as a result of the leverage from their experience with the production of CD players and media they employ.

TABLE 63

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

	-----1984-----		-----Forecast-----							
	----Revenues----		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
WORLDWIDE REVENUES ALL MANUFACTURERS	----	----	----	----	----	----	----	----	----	----
READ-ONLY	--	--	6.9	9.7	35.1	14.2	83.3	11.2	108.9	9.5
READ/WRITE less than 1 Gb	--	--	3.7	5.2	61.1	24.6	188.9	25.5	287.3	24.9
READ/WRITE more than 1 Gb	29.0	100.0	61.0	85.1	152.0	61.2	469.1	63.3	755.7	65.6
Total Worldwide Revenue	29.0	100.0	71.6	100.0	248.2	100.0	741.3	100.0	1,151.9	100.0
% U.S. Mfg.	6.5	--	23.7	--	20.9	--	36.5	--	37.7	--
Annual Growth Rate	--	--	+146.8%		+246.6%		+198.6%		+55.3%	

TABLE 64

OEM WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

	-----1984-----		-----Forecast-----							
	-----Revenues-----		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
WORLDWIDE REVENUES ALL MANUFACTURERS	----	----	----	----	----	----	----	----	----	----
READ-ONLY	--	--	6.9	21.2	27.9	20.4	54.5	14.4	80.1	13.0
READ/WRITE less than 1 Gb	--	--	1.9	5.9	43.1	31.5	134.9	35.8	215.3	34.9
READ/WRITE more than 1 Gb	4.9	100.0	23.7	72.9	65.8	48.1	189.0	49.8	322.9	52.1
Total Worldwide Revenues	4.9	100.0	32.5	100.0	136.8	100.0	378.4	100.0	618.3	100.0
% U.S. Mfg.	38.7	--	52.3	--	36.9	--	53.4	--	48.6	--
Annual Growth Rate	--	--	+563.2%		+320.9%		+176.6%		+63.3%	

TABLE 65

OEM WORLDWIDE SHIPMENTS
OPTICAL DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

WORLDWIDE UNIT SHIPMENTS ALL MANUFACTURERS	-----1984-----		-----FORECAST (000 UNITS)-----							
	---Shipments---		-----1985-----		-----1986-----		-----1987-----		-----1988-----	
	Units	%	Units	%	Units	%	Units	%	Units	%
READ-ONLY	--	--	3.9	50.1	36.5	57.3	160.4	61.1	330.4	58.4
READ/WRITE less than 1 Gb	--	--	1.5	19.2	18.5	29.0	76.2	29.0	186.0	32.8
READ/WRITE more than 1 Gb	.4	100.0	2.4	30.7	8.8	13.7	26.2	9.9	50.2	8.8
Total Worldwide Shipments	.4	100.0	7.8	100.0	63.8	100.0	262.8	100.0	566.6	100.0
% U.S. Mfg.	50.0	--	42.3	--	27.4	--	29.8	--	31.0	--
Annual Growth Rate	--	--	+1850.0%		+717.9%		+311.9%		+115.6%	

READ ONLY OPTICAL DISK DRIVES

Optical read-only memories are expected to be the first category of optical disk drives to be used in high volume. The 4.72" CD-ROM benefits from the design, manufacturing and standards infrastructure that was developed for consumer products. CD-ROM product prices will decline rapidly, with early average OEM prices in the \$700 to \$800 range, declining to \$300-\$400 by 1987.

Applications for read-only memory drives relate primarily to distribution of information and represent a form of electronic publishing. Data bases such as Department of Commerce statistics, drug side effects, legal research materials, construction materials catalogs, and selected professional publications are typical possible contents.

Market status

In 1985, approximately 5,500 drives will be shipped. By the 4th quarter, CD-ROM units will be in production at Hitachi, Philips, and Sony. Several other Japanese firms, such as Nippon Columbia and Toshiba, may also begin production in 1985 or 1986. Reference Technology, a U.S. firm, is shipping a read-only memory in a 12" format that offers more capacity and faster access times than CD-ROMs. This firm also remarkets the Hitachi CD-ROM. The cost of preparing the master copy from which CD-ROM replica copies are made has decreased to under \$5,000, affordable for even smaller firms. Replicated disk prices at the OEM level are \$4-5 per disk.

Marketing trends

Because of Japanese dominance in the consumer electronics field, most of the CD-ROMs produced will be made by Japanese suppliers enjoying an

experience and cost advantage over other competitors. 1986 world-wide unit shipments of about 36,000 units will rise rapidly to over 330,000 units in 1988. This increasing volume will attract numerous fringe competitors, depressing prices much as the prices of floppy disks are now depressed. The CD-ROM, while somewhat more complex than a floppy disk drive, is not so difficult to make as to discourage an ambitious market entrant.

Personal computers and single user workstations will provide the dominant attachment opportunities for CD-ROMs in the next few years. While there will be some OEM sales, the strongest distribution channel in 1986 will be the aftermarket subsystem manufacturer. As many of the drives will come equipped with an IBM PC interface, many retail dealers will be interested in offering the product once sufficient database and supporting software products become available.

Strong OEM demand depends upon the eventual availability of suitable software. A second factor that may delay market development is the current saturation of media replication facilities with entertainment products. This shortage will ease significantly over the next year as new facilities go into production.

Technical trends

The technology in this product group is relatively stable, as it derives from the consumer CD player for the most part. The areas receiving the most attention are:

- * Standards for file formats, so that disks can be used on any small computing system.
- * Development of software to support use with major operating systems and application programs.

The existence of the Sony/Philips defacto standard for CD-ROM establishes a basis for CD-ROM disk interchangeability and provides a mechanism for identification of a disk and files upon the disk. It is less likely that there will be formal standardization of file size or structure, although some defacto standard might well evolve (especially if IBM adopts the CD-ROM as a computer peripheral). The National Information Standards Organization (ANSI Z39) is also working on format interchange standards for CD-ROM.

Most CD-ROMs will be offered with SCSI interfaces and host adapters to the IBM PC family. System integrators will have opportunities to attach the CD-ROM to other processors or to the IBM PC family if additional support software is required.

Applications

The dissemination of large amounts of static or slowly changing data in machine readable format is a logical role for optical drives, especially for the CD-ROM format. The low cost of mass replicated media and the ability of the drive to fit into the user and operating environments of personal computers and other small systems make this an attractive option.

Read-only drives will appear primarily on micro-based systems. Use with multi-user minicomputers will be nominal; direct attachment to mainframes will not occur due to cost-performance mismatch. However, CD-ROMs will be connected to large processors through microcomputer based file servers to provide access to CD-ROM data bases for mainframe users. This will raise the same site license issues for electronic publishers that are currently debated by software providers.

Materials likely to appear in CD-ROM format will be concentrated in one of two application groups:

Electronic publishing

- * Large publicly available databases, such as those compiled by economists for use with econometric models.
- * Indexed textual databases, such as information on drug toxicology, legal case citations, or bibliographies.
- * Maps, including those used for on-board vehicle navigation. Such systems could be used eventually in personal vehicles as well as commercial aircraft, ships and military vehicles.

Intracompany data distribution

- * Directories, etc. for large organizations
- * Catalogs, parts lists and product data
- * Training materials and service manuals

Forecasting assumptions

1. CD-ROM players will be in production status at Sony, Hitachi, and Philips by the end of 1985.
2. A formatted disk interchange standard for CD-ROM will be available by 1987. Until available, end user distribution of data bases on CD-ROM will be retarded.
3. Japanese suppliers will dominate the CD-ROM hardware market. There will be no significant U.S. production. If IBM enters this market, its CD-ROMs will be purchased offshore.
4. Increasing production volume and competition will reduce the quoted OEM high volume price (less controller and software) to \$200 by 1987. Most drives will have on-board controllers, adding \$50 to 100 to the price.
5. There will be a significant demand for CD-ROMs by subsystem integrators who will add host adaptors and other peripheral devices to create memory subsystems.
6. CD-ROMs will ultimately appear on approximately 5% of the installed PC base by 1990.

TABLE 66
 READ-ONLY OPTICAL DISK DRIVES
 UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		1985		1986		Forecast		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	.2	.2	.5	.5	1.3	1.4	5.0	5.4
TOTAL U.S. NON-CAPTIVE	--	--	.2	.2	.5	.5	1.3	1.4	5.0	5.4
TOTAL U.S. SHIPMENTS	--	--	.2	.2	.5	.5	1.3	1.4	5.0	5.4
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	4.0	--	18.0	--	24.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	1.6	3.7	17.4	36.0	88.0	159.0	190.0	325.0
TOTAL NON-U.S. SHIPMENTS	--	--	1.6	3.7	17.4	40.0	88.0	177.0	190.0	349.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	--	--	1.8	3.9	17.9	40.5	89.3	178.4	195.0	354.4
Cumulative Shipments										
IBM	--	--	--	--	--	--	--	--	--	--
Non-IBM	--	--	1.8	3.9	19.7	44.4	109.0	222.8	304.0	577.2
WORLDWIDE TOTAL	--	--	1.8	3.9	19.7	44.4	109.0	222.8	304.0	577.2

TABLE 67
 READ-ONLY OPTICAL DISK DRIVES
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	1.6	1.6	3.5	3.5	5.1	5.2	8.4	8.6
TOTAL U.S. NON-CAPTIVE	--	--	1.6	1.6	3.5	3.5	5.1	5.2	8.4	8.6
TOTAL U.S. REVENUES	--	--	1.6	1.6	3.5	3.5	5.1	5.2	8.4	8.6
Non-U.S. Manufacturers	-----									
Captive	--	--	--	--	--	7.2	--	28.8	--	28.8
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	2.2	5.3	11.8	24.4	27.3	49.3	41.8	71.5
TOTAL NON-U.S. REVENUES	--	--	2.2	5.3	11.8	31.6	27.3	78.1	41.8	100.3
Worldwide Recap	-----									
TOTAL WORLDWIDE REVENUES	--	--	3.8	6.9	15.3	35.1	32.4	83.3	50.2	108.9
OEM Average Price (\$000)	--	--	2.111	1.769	.855	.764	.363	.340	.257	.242

TABLE 68
 READ-ONLY OPTICAL DISK DRIVES
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1984		Forecast							
	Shipments		1985		1986		1987		1988	
	12"	4.72"	12"	4.72"	12"	4.72"	12"	4.72"	12"	4.72"
U.S. MANUFACTURERS										
OEM	--	--	.2	--	.5	--	.8	.6	1.0	4.4
TOTAL U.S. SHIPMENTS	--	--	.2	--	.5	--	.8	.6	1.0	4.4
NON-U.S. MANUFACTURERS										
Captive	--	--	--	--	--	4.0	--	18.0	--	24.0
OEM	--	--	--	3.7	--	36.0	--	159.0	--	325.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	3.7	--	40.0	--	177.0	--	349.0
WORLDWIDE RECAP										
Total Shipments	--	--	.2	3.7	.5	40.0	.8	177.6	1.0	353.4
ANNUAL SHARE, BY DIAMETER	--	--	5.1%	94.9%	1.2%	98.8%	.4%	99.6%	.3%	99.7%

TABLE 69
 READ-ONLY OPTICAL DISK DRIVES
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984		Forecast							
	12"	4.72"	12"	4.72"	12"	4.72"	12"	4.72"	12"	4.72"
U.S. MANUFACTURERS										
OEM	--	--	1.6	--	3.5	--	4.8	.4	6.0	2.6
TOTAL U.S. REVENUES	--	--	1.6	--	3.5	--	4.8	.4	6.0	2.6
NON-U.S. MANUFACTURERS										
Captive	--	--	--	--	--	7.2	--	28.8	--	28.8
OEM	--	--	--	5.3	--	24.4	--	49.3	--	71.5
TOTAL NON-U.S. REVENUES	--	--	--	5.3	--	31.6	--	78.1	--	100.3
WORLDWIDE RECAP										
Total Revenues	--	--	1.6	5.3	3.5	31.6	4.8	78.5	6.0	102.9
ANNUAL SHARE, BY DIAMETER	--	--	23.2%	76.8%	10.0%	90.0%	5.8%	94.2%	5.5%	94.5%

READ/WRITE OPTICAL DISK DRIVES LESS THAN 1 GIGABYTE

Two types of drives fit into this group: Write Once Read Many, (WORM) and Erasable. Products in this group will typically be used with small computer systems of the mini and micro class and with many intelligent workstations.

Market status

1985 unit shipments will be under 2,000 units, with production from ISI and Optotech of 5.25" units expected to commence in the fourth quarter. 1986 will see nominal shipment levels of these products, but design-in cycles and software development time will postpone high volume shipments until 1987 and after. Media availability is currently a limiting factor on shipment growth. By 1986, sufficient capacity should be available to remove this restriction.

Almost all products shipped through 1987 will be write-once types. Drives using erasable media based upon magneto-optical technology are expected to begin modest quantity shipments in 1987 at the earliest. Erasable products are still in a prototype status. Even where announcements have been made, (Verbatim's 3.5" drive is an example), these releases describe erasable drive technology capability rather than specific products.

Marketing trends

Shipments of disk drives in this class will begin modestly with approximately 20,000 units in 1986. By 1988, shipments will grow to almost 200,000 units. The preponderance of early sales will go to the

add-on market; sub-system integrators will provide a market for the 5.25" drives that make up the majority of products in this category. Most of the 5.25" units will be provided by U.S. firms. Because initial quantities are modest, Japanese firms, while developing and announcing 5.25" optical disk drive products, will defer strong efforts to enter the U.S. market until demand is stronger. Instead, Japanese producers will concentrate on 8" drives in this capacity range that can be used in office automation systems produced by other parts of their highly integrated corporations.

By 1988, disk drives using readily available erasable media will begin to displace write-once disk drives. It is also highly probable that 3.5" drives will be available in the package envelope of the 5.25" disk drives in the same time frame.

During the next three years, it is unlikely that IBM will be in production of any optical disk drive. However, it is possible that IBM may choose to remarket a product in this class as an adjunct to its family of PC products.

Technical trends

Major issues for the small drives include media technology, access times, media lifetime error rates, erasability, and software. Other significant issues are track following and servo control and substrate materials. Most of these are also issue areas for larger drives as well, and comments in this section also apply to larger drives, unless otherwise noted.

Writable 4.72" media? There have been some stirrings in the industry regarding the possible availability of writable 4.72" format media.

While such a product may soon appear, it may well be unwelcome to the publishers of data in CD-ROM format. The reason? Availability of writable CD format media would make piracy of CD-ROM published material relatively easy and discourage publishers who might otherwise be early users of this format. Electronic publishing, potentially the major primary demand creator for both CD-ROM drives and media, could be delayed.

Media technology: A variety of optical media technologies and constructions are in use, creating interchange problems and confusion. At present, pit forming or bubble forming writing methods are in the majority. In the future, writing using the phase change between amorphous and crystalline state may become common, and a write-once dye/polymer based media design is also expected to be in use by late 1986.

Standard media designs will eventually evolve. The creation of interchange standards will hasten the use of common design, which in turn, will promote market acceptance. The surviving designs will be those with low manufacturing cost solutions.

Access times: One of the major limitations of optical drives is average access time, which exceeds 100 milliseconds on all products but the promised Storage Technology 7640. Such long access times make optical disks unattractive as competitors for magnetic disks in environments other than single user desktop computers. Manufacturers of smaller drives are targeting access times of under 100 ms for future products. Evolving optical head designs of lower mass, plus the relatively short head travel distances used on small diameter drives, offer the prospect of average access times in the 50 ms range by 1987.

Even though access times will improve, the amount of data readily available on an optical disk drive will not match that available on magnetic disks. Magnetic disks make a cylinder of data available with a short delay for head switching to access tracks in the cylinder. Optical drives must move the head--usually a more time consuming operation.

Media lifetime: While accelerated life tests seem to indicate that media lifetime of 10 years or more is achievable, this aspect of media performance will remain unproven until actually demonstrated, limiting the use of optical recording for archival records.

Error rate: Over the next several years, the inherent raw defect rate of the media will be inadequate for EDP usage. VLSI based error correcting code techniques are being used to improve the

observed error rate to acceptable levels. While this results in a reduction of data capacity on the disk to accommodate the redundancy needed by ECC methods, the loss may be as little as 8%, depending upon the ECC technique used.

Erasability: Most erasable media development to date has been done using magneto-optical (M-O) techniques, but this may not be the long range solution. While progress in commercializing erasable phase change and other types of erasable recording trails progress in M-O recording, the high cost of fabricating M-O structures make M-O a dubious long term choice as the preferred erasable media.

Provided that an adequate number of erase cycles can be demonstrated, it is likely that the second generation of erasable media will make use of phase change techniques. Phase change media may permit the interchange of write-once and erasable media on a single drive, something that is not inherent to magneto-optical recording. The large scale use of erasable phase change media may begin as early as 1988.

Another form of media, dye/polymer, may eventually become a commercially significant form of erasable optical media. Now in R&D status, this type of media is less subject to degradation problems and uses inexpensive materials. However, its capability to provide an adequate number of write/erase cycles requires more development. Dye/polymer media is likely to be solvent coatable and relatively inexpensive to produce, may operate with existing drives (except those configured for magneto-optics), but is technically difficult and will not be commercially available until 1990 or later. This form of media probably requires the least protection from environmental influences, enhancing its desirability as a low cost solution to the erasability problem.

Packaging: Optical disk drives using 4.72" or 5.25" disks will be packaged to conform with the envelope of a full height 5.25" floppy disk drive, permitting use in most personal computers. Half height designs are planned and may be available after 1987.

Military interest is spurring the design of ruggedized optical drives. At least 3 firms are actively engaged in pursuing this product line.

Track following: Most optical disk drive units make use of a pre-grooved substrate surface to establish track location. The desire for minimal media cost may eventually result in the wide use of drives capable of using grooveless media, even though the drive will be more expensive. ISI is the first firm to market such a product.

Substrates: Glass is giving way to plastic in order to reduce media cost and improve manufacturability. Polycarbonate appears to be the material of choice, displacing PMMA. Epoxy casting, which offers low optical distortion, is also being evaluated.

Standards: There are not yet any optical media or drive standards, but ANSI X3B11, ECMA TC31, ISO TC91/SC23 are all involved in standardization programs for unrecorded media. Standardization efforts are currently concentrated upon the 130 mm media size, and a standard may be in place by 1987. It is unlikely that there will be early standardization of the 300 mm media size due to the variety of existing designs already in production.

No standard device level interface for optical drives exists, but there is a strong grass roots effort to prepare an optical drive version of the ESDI standard. At the system level, SCSI appears to have the status of a defacto standard, and the IBM PC interface will have this status for both CD-ROM and read/write small drives.

Software: Read-write optical disk drives require specific supporting software, including drivers, operating system utilities, and application programs.

Basic software must address problems presented by the nature of the optical disk drive:

- * More storage capacity is available than small computer operating systems can handle.
- * Write-once disks require non standard file management utilities.
- * Magneto-optical disks require modified system software to handle the overwrite requirement.

Driver and operating system utilities specific to optical disk drives will be provided by drive vendors for widely used systems such as the IBM PC. System integrators and OEMs will provide system support on less widely used processors.

Application programs frequently will be supplied in the form of object code that is resident on the optical disk itself. The large capacity of the optical disk may permit the inclusion of program versions for several types of popular machines. Software suppliers will probably have to face the choice of distributing source code to system integrators and OEMs vs. remastering (for CD-ROM) or maintaining a significant ongoing support effort to provide support for a complete range of systems. Most will choose to let other organizations bear support costs.

All of the above represent development that requires time, making software one of the factors that will delay high volume shipments of optical drives until 1987 or later.

Applications

Optical drives under 1 gigabyte will find their first applications as save-restore devices in microcomputer and minicomputer systems where tape interchange isn't required. However, the high price of the media (\$100 to \$200 compared to \$15 to \$20 for 9 track tape) will limit initial acceptance. An optical disk offering 30-60 megabyte of capacity at a price approximating \$20 might well be welcomed as the next step in the evolution of media for archival storage: Most tape users consume only a fraction of tape capacity and store only one dataset per media unit. This practice may carry over as optical memory comes into use.

Follow-on applications will include reference level storage, a new level in the storage hierarchy. Reference storage is defined as files that change infrequently but that must be occasionally updated. On smaller systems, as much as 70% of disk file contents may fit this definition. Optical drives, slower than Winchester disks but with tape-like capacity, fit this niche well.

The price/performance characteristics of 5.25" and 8" optical drives are consistent with use on both micro and mini-based systems. Some of the larger capacity units may see service as peripherals on smaller mainframes if suitable controllers are developed.

Specific applications include:

Save-restore operations

- * Save-restore disk data backup.
- * Archival storage of files.

Reference level storage

- * Storage of programs, freeing up fixed magnetic disk drives for data.

- * Storage of data bases frequently used but infrequently changed.

Data distribution

- * Production and distribution of databases in quantities too small to warrant mass replication costs or where replication delays are too long for timeliness.

Forecasting assumptions

1. IBM will not announce an IBM made optical disk drive in this class until 1988 or later.
2. Erasable media will be available in production quantities in 1987; write-once media will be readily available in 1986.
3. Japanese products will become available on an OEM basis in 1986, but U.S. producers of 5.25" drives will represent the bulk of production until 1988. After 1988, increasing demand will inspire higher levels of Japanese production and marketing efforts.
4. Basic system software support on the IBM PC family will be supplied by manufacturers of drives in 1986. Support on mini-computers will follow in 1987.
5. Most media interchange specifications will be standardized by 1987.
6. The small system add-on market will be the earliest large major distribution opportunity for this class of drive.

TABLE 70
 READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE
 UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		-----Forecast-----							
	Shipments		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	1.5	1.5	10.8	13.0	51.5	62.1	125.0	148.0
TOTAL U.S. NON-CAPTIVE	--	--	1.5	1.5	10.8	13.0	51.5	62.1	125.0	148.0
TOTAL U.S. SHIPMENTS	--	--	1.5	1.5	10.8	13.0	51.5	62.1	125.0	148.0
Non-U.S. Manufacturers										
Captive	--	--	--	.2	.1	2.0	2.0	6.0	4.0	9.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	--	--	1.1	5.5	5.2	14.1	19.4	38.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	.2	1.2	7.5	7.2	20.1	23.4	47.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	--	--	1.5	1.7	12.0	20.5	58.7	82.2	148.4	195.0
Cumulative Shipments										
IBM	--	--	--	--	--	--	--	--	--	--
Non-IBM	--	--	1.5	1.7	13.5	22.2	72.2	104.4	220.6	299.4
WORLDWIDE TOTAL	--	--	1.5	1.7	13.5	22.2	72.2	104.4	220.6	299.4

TABLE 71
 READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1984		-----Forecast-----							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	1.9	1.9	14.1	17.1	71.7	88.6	118.6	142.4
TOTAL U.S. NON-CAPTIVE	--	--	1.9	1.9	14.1	17.1	71.7	88.6	118.6	142.4
TOTAL U.S. REVENUES	--	--	1.9	1.9	14.1	17.1	71.7	88.6	118.6	142.4
Non-U.S. Manufacturers										
Captive	--	--	--	1.8	.9	18.0	18.0	54.0	32.0	72.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	--	--	5.1	26.0	16.3	46.3	36.0	72.9
TOTAL NON-U.S. REVENUES	--	--	--	1.8	6.0	44.0	34.3	100.3	68.0	144.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	--	--	1.9	3.7	20.1	61.1	106.0	188.9	186.6	287.3
OEM Average Price(\$000)	--	--	1.267	1.267	1.613	2.330	1.552	1.770	1.071	1.158

TABLE 72
 READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1984 Shipments			Forecast									
	8"	5.25"	3.5"	1985		1986		1987			1988		
	8"	5.25"	3.5"	8"	5.25"	8"	5.25"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS													
IBM Captive	--	--	--	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	--	--	--	--	1.5	.5	12.5	5.1	54.5	2.5	10.0	122.0	16.0
TOTAL U.S. SHIPMENTS	--	--	--	--	1.5	.5	12.5	5.1	54.5	2.5	10.0	122.0	16.0
NON-U.S. MANUFACTURERS													
Captive	--	--	--	.2	--	2.0	--	6.0	--	--	9.0	--	--
OEM	--	--	--	--	--	5.1	.4	9.0	4.5	.6	13.0	20.0	5.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	.2	--	7.1	.4	15.0	4.5	.6	22.0	20.0	5.0
WORLDWIDE RECAP													
Total Shipments	--	--	--	.2	1.5	7.6	12.9	20.1	59.0	3.1	32.0	142.0	21.0
ANNUAL SHARE, BY DIAMETER	--	--	--	11.8%	88.2%	37.2%	62.8%	24.5%	71.9%	3.6%	16.4%	72.9%	10.7%

TABLE 73
 READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984			Forecast									
	8"	5.25"	3.5"	1985		1986		1987			1988		
Revenues	8"	5.25"	3.5"	8"	5.25"	8"	5.25"	8"	5.25"	3.5"	8"	5.25"	3.5"
U.S. MANUFACTURERS													
IBM Captive	--	--	--	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--	--	--	--
OEM	--	--	--	--	1.9	4.0	13.1	35.7	49.1	3.8	41.0	85.4	16.0
TOTAL U.S. REVENUES	--	--	--	--	1.9	4.0	13.1	35.7	49.1	3.8	41.0	85.4	16.0
NON-U.S. MANUFACTURERS													
Captive	--	--	--	1.8	--	18.0	--	54.0	--	--	72.0	--	--
OEM	--	--	--	--	--	25.5	.5	40.6	4.7	1.0	53.3	14.6	5.0
TOTAL NON-U.S. REVENUES	--	--	--	1.8	--	43.5	.5	94.6	4.7	1.0	125.3	14.6	5.0
WORLDWIDE RECAP													
Total Revenues	--	--	--	1.8	1.9	47.5	13.6	130.3	53.8	4.8	166.3	100.0	21.0
ANNUAL SHARE, BY DIAMETER	--	--	--	48.7%	51.3%	77.8%	22.2%	69.1%	28.5%	2.4%	58.0%	34.8%	7.2%

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

These products are most likely to be used with large mini-computers and mainframes or in specialized imaging or archiving applications.

Market status

The growth of this segment will be significant, but not as impressive as growth in the small diameter segment. Most early usage will be imaging systems, in document filing systems or within government agencies. Drive library units (jukeboxes) are becoming available for this product class, allowing the creation of on-line mass storage units.

At present, most of the 5,000 unit production in 1985 is represented by Japanese products used on a captive basis. The Japanese producers are expected to continue to manufacture the majority of this product class because of its suitability for use in systems capable of storing documents produced in Asian character sets.

Marketing trends

Because this class of optical disk drive will be used primarily on larger systems or in more specialized applications, shipment growth will be smaller for this category than for other optical disk drive categories. Unit shipments will increase from about 16,000 units in 1986 to almost 80,000 units in 1988. Applications will continue to be concentrated in image processing and archiving where the higher price and lower performance of these devices is acceptable.

At least one U.S. firm is expected to be in limited production of a 14" write-once disk drive in 1986. This unit will be targeted to image processing; most use will be on a captive basis. The first unit in this

class with performance suitable for EDP use may be the Storage Technology product. Beta site shipments of this unit will probably occur in 1986. If successful, the STC product should reawaken interest among potential end users of this product class. While IBM is understood to have an optical disk drive development program underway, no production is anticipated prior to 1989.

Technical trends

Almost all of the released products in this group have excessive average access times and use complex optical head assemblies. Considerable work is being done by existing manufacturers to reduce product complexity and to improve access time. Even so, it will be several years before typical average access times are below 100 ms for these products.

Most of the effort in the over 1 gigabyte group is aimed at the 12" diameter disk class, but 14" is also going to be represented. Storage Technology is developing a 4 gigabyte 14" drive, and one (possibly two) other entries are expected to be on the market by 1987.

Unless IBM announces a product in this group, standards for very high capacity media will take longer to materialize, because the initial products are largely incompatible and the initial product designs are already established.

Large drives will frequently be part of disk library subsystems that permit the contents of many optical disks to be available on-line. These subsystems will be targeted at the IBM 3850 mass storage system. Disk libraries will make from 10 to over 100 disks available to a single drive; average access times will be approximately 1/4 to 3/4 minute, but the services of a mount/de-mount operator will not be required.

Applications

Optical drives in the over 1 gigabyte class will be used mostly for medical or industrial imaging, archival storage with mainframes, or to accumulate transaction data that must be stored for future reference but is not needed for current operations. The high capacity drive will also have a major role in acquiring high volume digitized data from real time inputs and storing it for subsequent analysis.

Mainframes and minicomputers will become hosts for the large optical drives, as they have the computing power needed to process or control the large amounts of data stored on optical drives. Tape and microfilm systems may be heavily impacted by this form of storage.

Large numbers of documents can be stored on optical disks of this size, making them attractive for systems that store and manipulate office documents, engineering drawings, technical specifications and reference materials. The electronic form of storage permits distribution electronically, saving time and reducing the possibility of errors.

Typical specific usage will include:

Engineering and manufacturing systems

- * Centralized drawing/document storage and distribution.
- * Document storage for computer integrated manufacturing.
- * Document storage and dissemination for construction projects.

Record management

- * Personnel records.
- * Tax records and tax rolls.
- * X-ray and scanner images.
- * Social Security and other government records.
- * Large library index files.

Save-restore operations

- * Disk backup.
- * Archival storage.

Office automation

- * Storage and dissemination of office documents.
- * Storage of legal documents incorporating signatures and other personal identification.

Transaction audit trails

- * Records of reservations, bank transactions, etc.
- * Secure area access records.

Data acquisition

- * Capture of data from scanners, seismic detectors or other imaging devices.
- * Capture of data having military or intelligence significance.

Forecasting assumptions

1. No IBM-produced units will be shipped until after 1988.
2. Technical difficulties will delay availability of erasable media for this product group until 1988 or later.
3. There will be an adequate supply of write-once media for most products in this group by mid 1986.
4. Generally recognized media interchange standards for this product group will not exist until 1988 or until IBM introduces an optical drive product in the 1 gigabyte class.
5. Products in this class will be used primarily with mainframes, large minicomputers, and document storage systems.
6. System support software for these products will be done by system manufacturers. Most software projects will be time consuming, delaying the widespread appearance of optical memory on mainframes until 1987, or later.

TABLE 74
 READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE
 UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1984		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	.1	.1	1.0	1.1	1.5	2.0
TOTAL U.S. CAPTIVE	--	--	--	--	.1	.1	1.0	1.1	1.5	2.0
PCM	--	--	--	--	--	--	.4	.4	.8	.8
OEM	.1	.2	1.3	1.6	3.0	4.0	12.3	14.9	18.2	22.7
TOTAL U.S. NON-CAPTIVE	.1	.2	1.3	1.6	3.0	4.0	12.7	15.3	19.0	23.5
TOTAL U.S. SHIPMENTS	.1	.2	1.3	1.6	3.1	4.1	13.7	16.4	20.5	25.5
Non-U.S. Manufacturers	-----									
Captive	--	1.6	--	2.6	.1	6.8	1.2	17.1	3.0	26.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	.1	.2	.2	.8	1.2	4.8	3.9	11.3	10.3	27.5
TOTAL NON-U.S. SHIPMENTS	.1	1.8	.2	3.4	1.3	11.6	5.1	28.4	13.3	53.9
Worldwide Recap	-----									
TOTAL WORLDWIDE SHIPMENTS	.2	2.0	1.5	5.0	4.4	15.7	18.8	44.8	33.8	79.4
Cumulative Shipments	-----									
IBM	--	--	--	--	--	--	--	--	--	--
Non-IBM	.2	2.4	1.7	7.4	6.1	23.1	24.9	67.9	58.7	147.3
WORLDWIDE TOTAL	.2	2.4	1.7	7.4	6.1	23.1	24.9	67.9	58.7	147.3

TABLE 75
 READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE
 REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)									
	1984		Forecast							
	Revenues		1985		1986		1987		1988	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	1.5	1.5	15.0	16.5	22.5	30.0
TOTAL U.S. CAPTIVE	--	--	--	--	1.5	1.5	15.0	16.5	22.5	30.0
PCM	--	--	--	--	--	--	52.0	52.0	104.0	104.0
OEM	1.2	1.9	10.8	13.5	22.5	30.0	90.4	108.6	121.4	149.8
TOTAL U.S. NON-CAPTIVE	1.2	1.9	10.8	13.5	22.5	30.0	142.4	160.6	225.4	253.8
TOTAL U.S. REVENUES	1.2	1.9	10.8	13.5	24.0	31.5	157.4	177.1	247.9	283.8
Non-U.S. Manufacturers										
Captive	--	24.1	--	37.3	1.2	84.7	14.4	211.6	33.4	298.8
PCM	--	--	--	--	--	--	--	--	--	--
OEM	1.4	3.0	2.8	10.2	8.9	35.8	27.1	80.4	63.7	173.1
TOTAL NON-U.S. REVENUES	1.4	27.1	2.8	47.5	10.1	120.5	41.5	292.0	97.1	471.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2.6	29.0	13.6	61.0	34.1	152.0	198.9	469.1	345.0	755.7
OEM Average Price (\$000)	13.000	12.250	9.067	9.875	7.476	7.477	7.253	7.214	6.495	6.432

TABLE 76
 READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE
 WORLDWIDE SHIPMENTS (000)
 BREAKDOWN BY DISK DIAMETER

	1984 Shipments 12"	Forecast										
		1985		1986			1987			1988		
		12"	8"	14"	12"	8"	14"	12"	8"	14"	12"	8"
U.S. MANUFACTURERS												
IBM Captive	--	--	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	.1	--	--	1.1	--	--	2.0	--	--
PCM	--	--	--	--	--	--	.4	--	--	.8	--	--
OEM	.2	1.6	--	--	4.0	--	.1	14.8	--	.2	22.5	--
TOTAL U.S. SHIPMENTS	.2	1.6	--	.1	4.0	--	1.6	14.8	--	3.0	22.5	--
NON-U.S. MANUFACTURERS												
Captive	1.6	2.6	--	--	6.4	.4	--	13.1	4.0	--	18.0	8.4
OEM	.2	.6	.2	--	4.2	.6	--	8.3	3.0	--	21.5	6.0
TOTAL NON-U.S. SHIPMENTS	1.8	3.2	.2	--	10.6	1.0	--	21.4	7.0	--	39.5	14.4
WORLDWIDE RECAP												
Total Shipments	2.0	4.8	.2	.1	14.6	1.0	1.6	36.2	7.0	3.0	62.0	14.4
ANNUAL SHARE, BY DIAMETER	100.0%	96.1%	3.9%	.6%	93.1%	6.3%	3.6%	80.9%	15.5%	3.8%	78.2%	18.0%

TABLE 77
 READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE
 WORLDWIDE REVENUES (\$M)
 BREAKDOWN BY DISK DIAMETER

	1984 Revenues 12"	Forecast										
		1985		1986			1987			1988		
		12"	8"	14"	12"	8"	14"	12"	8"	14"	12"	8"
<u>U.S. MANUFACTURERS</u>												
IBM Captive	--	--	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	1.5	--	--	16.5	--	--	30.0	--	--
PCM	--	--	--	--	--	--	52.0	--	--	104.0	--	--
OEM	1.9	13.5	--	--	30.0	--	5.0	103.6	--	8.0	141.8	--
TOTAL U.S. REVENUES	1.9	13.5	--	1.5	30.0	--	73.5	103.6	--	142.0	141.8	--
<u>NON-U.S. MANUFACTURERS</u>												
Captive	24.1	37.3	--	--	79.3	5.4	--	157.2	54.4	--	198.0	100.8
OEM	3.0	8.0	2.2	--	31.0	4.8	--	56.4	24.0	--	131.1	42.0
TOTAL NON-U.S. REVENUES	27.1	45.3	2.2	--	110.3	10.2	--	213.6	78.4	--	329.1	142.8
<u>WORLDWIDE RECAP</u>												
Total Revenues	29.0	58.8	2.2	1.5	140.3	10.2	73.5	317.2	78.4	142.0	470.9	142.8
ANNUAL SHARE, BY DIAMETER	100.0%	96.5%	3.5%	1.0%	92.4%	6.6%	15.7%	67.7%	16.6%	18.8%	62.4%	18.8%

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. Most of the listed drives are still in production, but some older IBM drives are listed for reference.

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

Generic type

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

Technology type

IBM drive model numbers are also used as a general guide to type of heads and recording disks when appropriate, using a broad interpretation of IBM specifications, since later drives frequently use higher track and linear densities.

OEM prices

The 100 unit price is given for most OEM drives sold in the United States. 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.

Interfaces

Specific interfaces available are indicated for most drives, using references to manufacturers' own unique interfaces or to de facto industry standards where applicable. 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.

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.

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.

1985 DISK/TREND product groups for rigid magnetic disk drives

- | | |
|---------------------------|---|
| REMOVABLE MAGNETIC MEDIA: | 1. Disk cartridge drives, less than 12 MB |
| | 2. Disk cartridge drives, more than 12 MB |
| | 3. Disk pack drives, less than 100 MB |
| | 4. Disk pack drives, more than 100 MB |
| FIXED MAGNETIC MEDIA: | 5. Fixed disk drives, less than 30 MB |
| | 6. Fixed disk drives, 30-100 MB |
| | 7. Fixed disk drives, 100-300 MB |
| | 8. Fixed disk drives, 300-500 MB |
| | 9. Fixed disk drives, more than 500 MB |

MANUFACTURER	ADVANCED STORAGE TECHNOLOGY	ADVANCED STORAGE TECHNOLOGY	ADVANCED STORAGE TECHNOLOGY	ADVANCED STORAGE TECHNOLOGY	ALPHA DATA
DRIVE	AST 28060	AST 38095	AST 28100	AST 38158	Atlas
DISK/TREND GROUP	6	6	7	7	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	14"
Recording medium	Sputtered	Sputtered	Sputtered	Sputtered	Plated
DRIVE: Technology type	3370	3370	3370	3370	Special
Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	ST412	ESDI	ST412	ESDI	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 60	U: 95	U: 100	U: 158	U: 160.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 21,000	U: 10,416	U: 21,000	U: 20,160
Data surfaces per spindle	3	3	5	5	5
Heads per data surface	1	1	1	1	10
Tracks per surface	1920	1500	1920	1500	1600
Track density (TPI)	1600	1330	1600	1330	540
Maximum linear density (BPI)	11335	21300*	11335	21300*	600
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	30	30	30	18
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	26.3*
Data transfer rate (KBytes/sec)	625	1250	625	1250	1209
FIRST CUSTOMER SHIPMENT	11/85	11/85	11/85	11/85	3Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$5,995
COMMENTS	1.625" High	*2,7 RLL Code 1.625" High	1.625" High	*2,7 RLL Code 1.625" High	*Access is faster when no head movement is required

RSPEC-5

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	AMCODYNE
DRIVE	DRA010A	DRA020A	DRLO10A	DRM020A	7110 Arapahoe
DISK/TREND GROUP	5	5	5	5	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	8" Cartridge
Nominal disk diameter	130 mm OD	130 mm OD	95 mm OD	95 mm OD	200 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID Plated	25 mm ID Plated	63.5 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 12.75	U: 25.5	U: 12.75	U: 25.5	U: 26.9
REMOVABLE	--	--	--	--	U: 26.9
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 20,928
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	306	612	306	612	644
Track density (TPI)	360	720	640	875	550
Maximum linear density (BPI)	8944	8944	10913	12350	7324 FRPI 10986 BPI* 3523
Rotational speed (RPM)	3600	3600	3600	3600	
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Linear, Voice Coil
Average positioning time (msec)	80 (including settling)	80 (including settling)	80 (including settling)	80 (including settling)	35
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.45
Average access time (msec)	88.3	88.3	88.3	88.3	43.45
Data transfer rate (KBytes/sec)	625	625	625	625	1229
FIRST CUSTOMER SHIPMENT	6/85	8/85	4/85	8/85	1Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$3,175
COMMENTS	1.625" High	1.625" High	1.625" High	1.625" High	Embedded Servo *2,7 RLL Code

MANUFACTURER	AMPEX	AMPEX	AMPEX	AMPEX	AMPEX
DRIVE	DFR-932	DFR-964	DFR-996	DM-9300	DM-9300A
DISK/TREND GROUP	2	2	2	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	CMD	CMD	CMD	3336-11	3336-11
Nominal disk diameter	14"	14"	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3330-11	3330-11	3330-11	3336-11	3336-11
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SMD	SMD	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 16.289	U: 48.868	U: 81.446	--	--
REMOVABLE	U: 16.289	U: 16.289	U: 16.289	U: 312.0	U: 315.0
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	1 Fixed 1 Removable	3 Fixed 1 Removable	5 Fixed 1 Removable	19	19
Heads per data surface	2 Fixed 1 Removable	2 Fixed 1 Removable	2 Fixed 1 Removable	1	1
Tracks per surface	823	823	823	815	823
Track density (TPI)	367 Fixed 384 Removable	367 Fixed 384 Removable	367 Fixed 384 Removable	370	384
Maximum linear density (BPI)	6274 Fixed 6038 Removable	6274 Fixed 6038 Removable	6274 Fixed 6038 Removable	6038	6038
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Fix: Rotary VC Rem: Linear VC	Fix: Rotary VC Rem: Linear VC	Fix: Rotary VC Rem: Linear VC	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	30	30	30	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	38.3	36.3	36.3
Data transfer rate (KBytes/sec)	1209	1209	1209	1209	1209
FIRST CUSTOMER SHIPMENT	4Q79	4Q79	4Q79	5/76	3Q80
U.S. OEM PRICE FOR 100 UNITS	\$4,525	\$5,145	\$5,700	\$10,365	\$10,365
COMMENTS	Mfg. by Toshiba	Mfg. by Toshiba	Mfg. by Toshiba		

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MANUFACTURER	AMPEX	AMPEX	AMPEX	AMPEX	AMPEX
DRIVE	PTD-930X Parallel Transfer Drive	PYXIS 13	PYXIS 27	165 Capricorn 165E Capricorn	330 Capricorn
DISK/TREND GROUP	4	5	5	7	8
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	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3330-11	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Special	ST412	ST412	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	U: 13.33	U: 26.67	U: 165.9	U: 330.3
REMOVABLE	U: 312.177	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 10,417	U: 10,417	U: 20,160	U: 20,160
Data surfaces per spindle	19	4	8	5	8
Heads per data surface	1	1	1	2	2
Tracks per surface	815	320	320	1646	2048
Track density (TPI)	384	360	360	960	960
Maximum linear density (BPI)	6038	8720	8720	5950	6250
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil 28	Rotary, Stepping Motor 90 (including settling)	Rotary, Stepping Motor 90 (including settling)	Linear, Voice Coil 21	Linear, Voice Coil 21
Average positioning time (msec)	8.3	8.3	8.3	8.3	8.3
Average rotational delay (msec)	36.3	98.3	98.3	29.3	29.3
Data transfer rate (KBytes/sec)	1209	625	625	1209	1209
FIRST CUSTOMER SHIPMENT	11/78	5/82	5/82	3Q81	3Q81
U.S. OEM PRICE FOR 100 UNITS	\$55,000	\$655	\$920	\$5,155	\$7,050
COMMENTS	Up to 9 track parallel data transfer	Manufactured under Rodime license	Manufactured under Rodime license	165E emulates DM-9160	

1985 DISK/TREND REPORT

MANUFACTURER	AMPEX	AMPEX	AMPEX	ATASI	ATASI
DRIVE					
	A-330	A-660	A-825	3046	3051
DISK/TREND GROUP	8	9	9	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modifed 3350	Modifed 3350	Modifed 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Mod.SMD, SCSI	Mod. SMD, SCSI	Mod. SMD, SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	--	--	U: 46.3	U: 51.3
REMOVABLE	U: 330.3	U: 660.6	U: 825.7	--	--
Capacity per track (Bytes)	U: 40,320	U: 40,320	U: 40,320	U: 10,416	U: 10,416
Data surfaces per spindle	4	8	10	7	7
Heads per data surface	2	2	2	1	1
Tracks per surface	2048	2048	2048	635	704
Track density (TPI)	960	960	960	790	800
Maximum linear density (BPI)	12500*	12500*	12500*	8701	9053
Rotational speed (RPM)	2766	2766	2766	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil 18	Linear, Voice Coil 18	Linear, Voice Coil 18	Linear, Voice Coil 33	Linear, Voice Coil 33
Average positioning time (msec)	10.8	10.8	10.8	8.3	8.3
Average rotational delay (msec)	10.8	10.8	10.8	8.3	8.3
Average access time (msec)	28.8	28.8	28.8	41.3	41.3
Data transfer rate (KBytes/sec)	1859	1859	1859	625	625
FIRST CUSTOMER SHIPMENT	12/84	12/84	12/84	11/82	1/85
U.S. OEM PRICE FOR 100 UNITS	\$5,895	\$7,195	\$8,250	\$1,300	\$1,300
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code		

MANUFACTURER	ATASI	BASF	BASF	BASF	BASF
DRIVE					
	3085	6185	6188	6188R-12	6188R-25
DISK/TREND GROUP	6	5	5	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 Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 85.3	U: 27.5	U: 15.0	U: 12.7	U: 25.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	8	6	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	440	360	612	612
Track density (TPI)	1029	508	406	585	585
Maximum linear density (BPI)	9716	8853	8900	9800	9800
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	29	142 (including settling)	93 (including settling)	93 (including settling)	93 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.3	150.3	101.3	101.3	101.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q85	1983	1984	4Q85	4Q85
U.S. OEM PRICE FOR 100 UNITS	\$1,700	--	--	--	--
COMMENTS			1.6" High		

MANUFACTURER	BASF	BASF	BASF	BULL	BULL
DRIVE	6190-52	6190-73	6190-94	D120 D122 Cynthia	D140 D142 Cynthia
DISK/TREND GROUP	6	6	6	1	2
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Special Cartridge	Special Cartridge
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	10.5" OD	10.5" OD
Recording medium	40 mm ID Plated	40 mm ID Plated	40 mm ID Plated	6.6" ID Oxide Coated	6.6" ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	3330-11	3330-11
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	Cynthia	Cynthia
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 52	U: 73	U: 94	--	F: 10.0
REMOVABLE	--	--	--	F: 10.0	F: 10.0
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	F: 12,800	F: 12,800
Data surfaces per spindle	5	7	9	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1000	1000	1000	392	392
Track density (TPI)	1000	1000	1000	500	500
Maximum linear density (BPI)	10000	10000	10000	4750	4750
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice coil	Rotary, Voice coil	Rotary, Voice coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	30	30	30	50	50
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	38.3	58.3	58.3
Data transfer rate (KBytes/sec)	625	625	625	920	920
FIRST CUSTOMER SHIPMENT	3Q85	3Q85	3Q85	7/78	4Q79
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$1,890	\$2,675
COMMENTS				Embedded Servo	Embedded Servo

MANUFACTURER	BULL	BULL	BULL	BULL	BULL
DRIVE	D520 Cynthia	D145 Cynthia	D506 Cynthia	D510 Cynthia	D160/4 D162/4 Cynthia
DISK/TREND GROUP	2	2	5	5	6
MARKET	OEM	OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	5.25" Cartridge	Special Cartridge	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	10.5" OD 6.6" ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	10.5" OD 6.6" ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3330-11	Modified 3350	Modified 3350	3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	ST412, DMA	SASI	ST412	ST412	Cynthia
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 10.485	F: 10.0	U: 6.38	U: 12.76	F: 60.21
REMOVABLE	F: 10.485	F: 10.0	--	--	--
Capacity per track (Bytes)	F: 8,192	F: 12,800	U: 10,416	U: 10,416	F: 12,800
Data surfaces per spindle	4	4	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	640	392	306	306	1176
Track density (TPI)	860	500	345	345	900
Maximum linear density (BPI)	9200	4750	9074	9074	4850
Rotational speed (RPM)	3400	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)	Linear, Voice Coil
Average positioning time (msec)	40	50	85	85	40
Average rotational delay (msec)	8.8	8.3	8.3	8.3	8.3
Average access time (msec)	48.8	58.3	93.3	93.3	48.3
Data transfer rate (KBytes/sec)	625	920	625	625	920
FIRST CUSTOMER SHIPMENT	2Q84	8/82	1983	1983	3Q81
U.S. OEM PRICE FOR 100 UNITS	\$1,590	\$3,515	--	--	\$2,850
COMMENTS	Embedded Servo	Embedded Servo	Mfg. under Seagate license	Mfg. under Seagate license	Embedded Servo

MANUFACTURER	BULL	BULL	BULL	BULL	BULL
DRIVE	D160/6 D162/6 Cynthia	D530	D550	D570	D585
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	10.5" OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	6.6" ID Oxide Coated	40 mm ID Plated	40 mm ID Plated	40 mm ID Plated	40 mm ID Plated
DRIVE: Technology type	3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Cynthia	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 90.31	U: 30.8	U: 51.4	U: 72.0	U: 85.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,800	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	6	3	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1176	987	987	987	1166
Track density (TPI)	900	960	960	960	1047
Maximum linear density (BPI)	4850	9920	9920	9920	10526
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	40	30	30	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	38.3	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	920	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q81	4Q83	4Q83	4Q83	1Q85
U.S. OEM PRICE FOR 100 UNITS	\$3,100	\$1,450	\$1580	\$1850	\$1930
COMMENTS	Embedded Servo	Mfg. Under Vertex Peripherals License	Mfg. Under Vertex Peripherals License	Mfg. Under Vertex Peripherals License	Mfg. Under Vertex Peripherals License

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MANUFACTURER	BULL	BURROUGHS	BURROUGHS	BURROUGHS	BURROUGHS
DRIVE	D160/8 D162/8 Cynthia	9484-13	MD-3	MD-4	9494-12
DISK/TREND GROUP	7	4	7	7	9
MARKET	OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	3336-11	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 6.6" ID	14"	210 mm OD 100 mm ID	210 mm OD 100 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3350	3330-11	Modified 3350	Modified 3350	3380
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Thin Film
Interface	Cynthia	Burroughs	Burroughs	Burroughs	Burroughs
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 120.42	--	(3 Spindles) F: 405	(4 Spindles) F: 528	F: 870
REMOVABLE	--	F: 252	--	--	--
Capacity per track (Bytes)	F: 12,800	F: 16,200	F: 16,384	F: 16,000	F: 32,781
Data surfaces per spindle	8	19	10	10	15
Heads per data surface	1	1	1	1	2
Tracks per surface	1176	815	833	833	1768
Track density (TPI)	900	384	900	900	806
Maximum linear density (BPI)	4850	6060	9000	9000	15240 BPI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear Voice Coil
Average positioning time (msec)	40	28.50	28	28	16
Average rotational delay (msec)	8.3	8.33	8.3	8.3	8.3
Average access time (msec)	48.3	36.83	36.3	36.3	24.3
Data transfer rate (KBytes/sec)	920	1209	1210	1210	3000
FIRST CUSTOMER SHIPMENT	3Q81	1Q83	12/84	12/84	1Q85
U.S. OEM PRICE FOR 100 UNITS	\$3,350	--	--	--	--
COMMENTS	Embedded Servo	B2900 B7900 B7800 B4900 A3,A9,A15 V300	XE5XX Mfg. by Toshiba	A3,A9,V300 B4500 Mfg. by Toshiba	B7900 B4900 A9,A15,V300 Drive has two spindles

MANUFACTURER	CENTURY DATA SYSTEMS	CENTURY DATA SYSTEMS	CENTURY DATA SYSTEMS	CENTURY DATA SYSTEMS	CENTURY DATA SYSTEMS
DRIVE	C2075	C2120	T306 Trident	M160 Marksman	AMS 315
DISK/TREND GROUP	2	2	4	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	8" Cartridge	8" Cartridge	3330-11	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	14"	14"	14"
Recording medium	63.5 mm ID Oxide Coated	63.5mm ID Hi Den/Oxi Coat	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3330-11	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SMD	T300: Trident T302/6: SMD	Marksman, SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 53.5	U: 87.8	--	--	U: 315.2
REMOVABLE	U: 26.7	U: 35.1	U: T300: 312.1	U: 160.7	--
Capacity per track (Bytes)	U: 20,790	U: 20,790	U: 20,160	U: 32,000	U: 20,160
Data surfaces per spindle	6	7	19	3	9.5
Heads per data surface	1	1	1	2	2
Tracks per surface	644	845	T300: 815 T302/6: 823	1690	1646
Track density (TPI)	555	727	T300: 370 T302/6: 384	712	712
Maximum linear density (BPI)	11761*	11,761*	6060	10000	6363
Rotational speed (RPM)	3600	3352	3600	2400	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Band, Torque Motor	Linear, Voice Coil
Average positioning time (msec)	30	32	30	50	25
Average rotational delay (msec)	8.3	8.95	8.3	12.5	8.3
Average access time (msec)	38.3	40.95	38.3	62.5	33.3
Data transfer rate (KBytes/sec)	1300	1209	1209	1280	1209
FIRST CUSTOMER SHIPMENT	3/82	3/85	8/76	1Q82	11/82
U.S. OEM PRICE FOR 100 UNITS	\$3,450	\$3650	\$10,255	\$4,050	\$6,780
COMMENTS	* 2,7 RLL Code Embedded Servo	*2,7 RLL Code			

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	CENTURY DATA SYSTEMS	CENTURY DATA SYSTEMS	CENTURY DATA SYSTEMS	CENTURY DATA SYSTEMS	COGITO SYSTEMS
MANUFACTURER					
DRIVE	C2400	C2476	AMS 513	AMS 571	CG912
DISK/TREND GROUP	8	8	9	9	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	14"	14"	130 mm OD
Recording medium	63.5mm ID Hi Den/Oxi Coat	63.5mm ID Hi Den/Oxi Coat	Oxide Coated	Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	3370	3370	Modified 3350	3370	Modified 3350
Heads	Thin Film	Thin Film	Ferrite	Thin Film	Ferrite
Interface	SMD	Modified SMD	SMD	Modified SMD	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 408	U: 475.9	U: 513.7	U: 615	U: 12.76
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 28,160	U: 32,064	U: 33,012	U: 10,416
Data surfaces per spindle	12	10	9.5	9.5	4
Heads per data surface	2	2	2	2	1
Tracks per surface	845	845	1690	1882	306
Track density (TPI)	960	1143	712	800	345
Maximum linear density (BPI)	9500	17,900*	10000	10295	8783
Rotational speed (RPM)	3600	3961	2400	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor
Average positioning time (msec)	15	15	25	19	85 (including settling)
Average rotational delay (msec)	8.3	7.57	12.5	8.3	8.3
Average access time (msec)	23.3	22.57	37.5	27.3	93.3
Data transfer rate (KBytes/sec)	1209	1859	1280	1980	625
FIRST CUSTOMER SHIPMENT	5/85	3/85	1/83	8/83	6/83
U.S. OEM PRICE FOR 100 UNITS	\$6610	\$7450	\$7,200	\$9,000	\$265
COMMENTS		*2,7 RLL Code			1.625" High

1985 DISK/TREND REPORT

MANUFACTURER	COGITO SYSTEMS	COMPUTER MEMORIES	COMPUTER MEMORIES	COMPUTER MEMORIES	COMPUTER MEMORIES
DRIVE	PT 925	CM-3426	CM-4426	CM-6426	CM-6640
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 Plated/Sputter	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.52	U: 25.63	U: 26.6	U: 26.68	U: 40
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	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	612	615	640	640	640
Track density (TPI)	527	690	695	720	720
Maximum linear density (BPI)	11000	8765	9687	9275	9275
Rotational speed (RPM)	3600	3600	3573	3573	3573
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	85 (including settling)	85 (including settling)	40 (including settling)	40 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.39	8.39
Average access time (msec)	93.3	93.3	48.3	48.39	48.39
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	4Q85	2Q84	2Q85	4Q82	1Q83
U.S. OEM PRICE FOR 100 UNITS	\$365	\$660	\$965	\$925	\$1,010
COMMENTS	1.625" High	1.625" High	1.625" High		

1985 DISK/TREND REPORT

MANUFACTURER	COMPUTER MEMORIES	COMPUTER MEMORIES	CONTROL DATA ^M	CONTROL DATA ^O	CONTROL DATA ^O
DRIVE	CM-6853	CM-7885	280-10 280-20	9448-32 Phoenix or CMD	9448-64 Phoenix or CMD
DISK/TREND GROUP	6	6	2	2	2
MARKET	OEM	OEM	PCM	OEM, Captive	OEM, Captive
MEDIA: Generic type	Fixed	Fixed	Cartridge Module Drive 14"	Cartridge Module Drive 14"	Cartridge Module Drive 14"
Nominal disk diameter	130 mm OD	130 mm OD			
	40 mm ID	40 mm ID			
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3330-11	3330-11	3330-11
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	IBM Series 1	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 53.3	U: 85.3	F: 64.5	U: 16.289	U: 48.869
REMOVABLE	--	--	F: 13.3	U: 16.289	U: 16.289
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 16,384	U: 20,160	U: 20,160
Data surfaces per spindle	8	8	5 Fixed 1 Removable	1 Fixed 1 Removable	3 Fixed 1 Removable
Heads per data surface	1	1	1	1	1
Tracks per surface	640	1024	814	823	823
Track density (TPI)	750	1173	384	384	384
Maximum linear density (BPI)	9275	9275	6038	6038	6038
Rotational speed (RPM)	3573	3573	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	39 (including settling)	30 (including settling)	30	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	47.3	38.3	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	625	625	1209	1209	1209
FIRST CUSTOMER SHIPMENT	2Q85	3Q85	4/82	9/78	9/78
U.S. OEM PRICE FOR 100 UNITS	\$1110	\$1640	--	--	--
COMMENTS				Separate Servo surface for fixed and removable disks	Separate Servo surface for fixed and removable disks

MANUFACTURER	CONTROL DATA \emptyset	CONTROL DATA \emptyset	CONTROL DATA M	CONTROL DATA T	CONTROL DATA T
DRIVE	9448-96 Phoenix or CMD	9457 Lark	270-10 270-20 271-10	9710 RSD	9762 SMD
DISK/TREND GROUP	2	2	3	3	3
MARKET	OEM, Captive	OEM, Captive	PCM	OEM	OEM, Captive
MEDIA: Generic type	Cartridge Module Drive	Lark Module Drive	Storage Module Drive	Removable Storage Drive	Storage Module Drive
Nominal disk diameter	14"	195 mm OD 100 mm ID	14"	230 mm OD 100 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3330-11	Modified 3350	3330-11	Modified 3350	3330-11
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	LDI, SMD	IBM Series 1	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 81.446	U: 25.0	--	--	--
REMOVABLE	U: 16.289	U: 25.0	U: 63.2	U: 82.9	U: 82.9
Capacity per track (Bytes)	U: 20,160	U: 20,672	U: 15,360	U: 20,160	U: 20,160
Data surfaces per spindle	5 Fixed 1 Removable	4	5	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	823	606	823	823	823
Track density (TPI)	384	715	384	550	384
Maximum linear density (BPI)	6038	6774 FRPI 10161 BPI 3510	6038	10000*	6038
Rotational speed (RPM)	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)	30	35	30	30	30
Average rotational delay (msec)	8.3	8.55	8.3	8.3	8.3
Average access time (msec)	38.3	43.55	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	1209	1209	1209	1209	1209
FIRST CUSTOMER SHIPMENT	9/78	4Q82	1978	1Q83	3/75
U.S. OEM PRICE FOR 100 UNITS	--	\$3,440	--	\$4,915	\$6,715
COMMENTS	Separate Servo surface for fixed and removable disks	Embedded Servo		*2,7 RLL Code	

1985 DISK/TREND REPORT

RSPEC-19

MANUFACTURER	CONTROL DATA M	CONTROL DATA †	CONTROL DATA M	CONTROL DATA M	CONTROL DATA M
DRIVE	270-30	9766 SMD	230-10 240-10	230-15 240-15	518
DISK/TREND GROUP	4	4	5	5	5
MARKET	PCM	OEM, Captive	PCM	PCM	PCM
MEDIA: Generic type	3336-11	3336-11	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	14"	130 mm OD 40 mm ID Oxide Coated
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3330-11	3330-11	3350	3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM Series 1	SMD	IBM Series 1	IBM Series 1	IBM PC
CAPACITY/RECORDING DENSITY			1.48 MB Fixed Head Option F: 9.3	1.48 MB Fixed Head Option F: 13.9	F: 18.1
Total capacity (MBytes) FIXED	--	--			
REMOVABLE	F: 240.1	U: 315.2	--	--	--
Capacity per track (Bytes)	F: 15,360	U: 20,160	F: 15,360	F: 15,360	F: 8,704
Data surfaces per spindle	19	19	1	1.5	3
Heads per data surface	1	1	2	2	1
Tracks per surface	823	823	606	606	697
Track density (TPI)	384	384	296	296	800
Maximum linear density (BPI)	6038	6038	6220	6220	8730
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	30	25	25	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	33.3	33.3	48.3
Data transfer rate (KBytes/sec)	1209	1209	1209	1209	625
FIRST CUSTOMER SHIPMENT	1978	3/76	1Q79	2Q79	1Q84
U.S. OEM PRICE FOR 100 UNITS	--	\$12,355	--	--	--
COMMENTS					

1985 DISK/TREND REPORT

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	9415-321 Wren I	9415-521 Wren I	9415-528 Wren I	530 630	9415-335 Wren I
DISK/TREND GROUP	5	5	5	6	6
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	PCM	Captive, 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	40 mm ID	40 mm ID	40 mm ID	40 mm ID
DRIVE: Technology type	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
Heads	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Interface	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
CAPACITY/RECORDING DENSITY	Finch	ST412	ST412	IBM PC	Finch
Total capacity (MBytes) FIXED	U: 21.0	U: 21.0	U: 28.0	F: 30.2	U: 36.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,080	U: 10,080	U: 10,080	F: 8,704	U: 10,080
Data surfaces per spindle	3	3	4	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	697	697	697	697	697
Track density (TPI)	800	800	800	800	800
Maximum linear density (BPI)	8730	8730	8730	8730	8730
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Actuator type	40	40	40	40	40
Average positioning time (msec)	40	40	40	40	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	8.3	8.3	8.3	8.3	8.3
Data transfer rate (KBytes/sec)	48.3	48.3	48.3	48.3	48.3
FIRST CUSTOMER SHIPMENT	605	605	605	625	605
U.S. OEM PRICE FOR 100 UNITS	2Q83	2Q83	2Q83	1Q84	2Q83
COMMENTS	\$1,105	\$1105	\$1175	--	\$1,225

1985 DISK/TREND REPORT

RSPEC-21

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
	9415-536 Wren I	94155-48 Wren II	94155-67 Wren II	94155-86 Wren II	94156-48 Wren II
	6	6	6	6	6
	Captive, OEM	OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
	ST412	ST412	ST412	ST412	ESDI
	U: 36.0	U: 48.1	U: 67.4	U: 86.7	U: 48.1
	--	--	--	--	--
	U: 10,080	U: 10,416	U: 10,416	U: 10,416	U: 10,416
	5	5	7	9	5
	1	1	1	1	1
	697	925	925	925	925
	800	960	960	960	960
	8730	9540	9540	9540	9540
	3600	3600	3600	3600	3600
	Rotary, Voice Coil 40	Rotary, Voice Coil 30	Rotary, Voice Coil 30	Rotary, Voice Coil 30	Rotary, Voice Coil 30
	40	30	30	30	30
	8.3	8.3	8.3	8.3	8.3
	48.3	38.3	38.3	38.3	38.3
	605	625	625	625	625
	2Q83	2Q84	2Q84	2Q84	2Q84
	\$1225	\$1270	\$1455	\$2,255	\$1270

1985 DISK/TREND REPORT

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA	CONTROL DATA
DRIVE	94156-67 Wren II	94156-86 Wren II	231 241	9715-160 FSD	9730-160 MMD
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	PCM	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	14"	230 mm OD 100 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3350	Modified 3350	Modified 3350
Heads	Ferrite	Thin Film	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	IBM Series 1	SMD	SMD
CAPACITY/RECORDING DENSITY					0.96 or 1.93 MB Fixed Head Option
Total capacity (MBytes) FIXED	U: 67.4	U: 86.7	F: 126.4	U: 165.9	U: 165.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 15,360	U: 20,160	U: 20,160
Data surfaces per spindle	7	9	5	10	5
Heads per data surface	1	1	2	1	2
Tracks per surface	925	925	1646	823	1646
Track density (TPI)	960	960	680	550	680
Maximum linear density (BPI)	9540	9540	6220	10000*	6220
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	30	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	625	625	1209	1209	1209
FIRST CUSTOMER SHIPMENT	2Q84	2Q84	5/83	4Q82	2Q79
U.S. OEM PRICE FOR 100 UNITS	\$1455	\$2,255	--	\$4,960	\$5,785
COMMENTS				*2,7 RLL Code	

1985 DISK/TREND REPORT

RSPEC-23

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	CONTROL DATA T	CONTROL DATA T	CONTROL DATA T	CONTROL DATA T	CONTROL DATA T
	9715-340 FSD	9720 EMD	885-42	9715-500 FSD	9771 XMD
	8	8	9	9	9
	OEM	OEM	Captive	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	230 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	14" Oxide Coated	230 mm OD 100 mm ID Oxide Coated	14" Oxide Coated
	3380	3370	Modified 3350	3380	3380
	Thin Film	Thin Film	Ferrite	Thin Film	Thin Film
	SMD	SMD, SMD-E	CDC	Modified SMD	Modified SMD
	U: 344.0	U: 368.0	U: 673.0	U: 516.0	U: 825.0
	--	--	--	--	--
	U: 20,160	U: 30,240	U: 20,160	U: 30,240	U: 50,400
	12	10	20	12	8
	2	1	2	2	2
	1422	1217	1686	1422	2046
	960	960	660	960	960
	9492	15185*	6350	15159*	15400*
	3600	3600	3600	3600	2160
	Linear, Voice Coil 20	Rotary, Voice Coil 18	Linear, Voice Coil 25	Linear, Voice Coil 20	Linear, Voice Coil 16
	20	18	25	20	16
	8.3	8.3	8.3	8.3	13.89
	28.3	26.3	33.3	28.3	29.89
	1209	1815	4788	1825	1825
	4Q83	11/85	1982	4Q83	3Q83
	\$6,490	\$4850	--	\$7,290	\$10,660
		*2,7 RLL Code	Cyber 865 & 875 4 track parallel data transfer. Drive has two spindles.	*2,7 RLL Code	*2,7 RLL Code

1985 DISK/TREND REPORT

MANUFACTURER	CONTROL DATA	CONTROL DATA	CONTROL DATA	DATA GENERAL	DATA GENERAL
DRIVE	9772 XMD-II	9775 FMD	9797	6060	6061
DISK/TREND GROUP	9	9	9	4	4
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed Module Drive	Fixed	3336-1	3336-11
Nominal disk diameter	14"	14"	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370	Modified 3350	3330-11	3330-11	3330-11
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD-E	SMD	Special	Data General	Data General
CAPACITY/RECORDING DENSITY		1.9 MB Fixed Head Option			
Total capacity (MBytes) FIXED	U: 858.0	U: 675.0	U: 651.6	--	--
REMOVABLE	--	--	--	F: 95.957	F: 190.280
Capacity per track (Bytes)	U: 50,400	U: 20,160	U: 20,160	F: 12,288	F: 12,288
Data surfaces per spindle	8	20	40	19	19
Heads per data surface	2	2	1	1	1
Tracks per surface	2128	1686	822	411	815
Track density (TPI)	960	660	384	192	370
Maximum linear density (BPI)	15400*	6350	6000	4040	4040
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)	16	25	50	35	35
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	33.3	58.3	43.3	43.3
Data transfer rate (KBytes/sec)	3000	1209	4840	806	806
FIRST CUSTOMER SHIPMENT	10/85	4/80	1977	1976	1976
U.S. OEM PRICE FOR 100 UNITS	\$9475	\$15,155	--	--	--
COMMENTS	*2,7 RLL Code		4 track parallel data transfer		

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	DATA GENERAL	DATA GENERAL	DATA GENERAL	DATA GENERAL	DATA GENERAL
	6122	6100 6103 6104 6105	6220 6225	6222 6227	6234
	4	5	5	5	6
	Captive	Captive	Captive	Captive	Captive
	3336-11	Fixed	Fixed	Fixed	Fixed
	14"	14"	200 mm OD 63.5 mm OD	200 mm OD 63.5 mm OD	14"
	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
	3330-11	3340	3350	3350	3350
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	Data General	Data General	Data General	Data General	Data General
	--	F: 25.16	F: 5.0	F: 15.0	F: 50.7
	F: 277.491	--	--	--	--
	F: 17,920	F: 16,384	F: 10,240	F: 10,240	F: 22,016
	19	4	2	6	6
	1	2	1	1	2
	815	384	245	245	384
	370	166	200	200	166
	6060	5760	6500	6500	7678
	3600	2964	3155	3155	2385
	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
	35	60 (including settling)	66 (including settling)	66 (including settling)	60 (including settling)
	8.3	10.1	9.5	9.5	12.5
	43.3	70.1	75.5	75.5	72.5
	1209	910.6	625	625	971
	1Q80	4Q79	9/82	9/82	3/83
	--	--	--	--	--

	DATA GENERAL	DATA GENERAL	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
MANUFACTURER					
DRIVE	6236 6237	6239 6290 6240	RL02	RC25	RA60
DISK/TREND GROUP	8	9	1	2	4
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	5440	Special Cartridge 8"	Special Disk Pack 14"
Nominal disk diameter	14"	14"	14"		
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3330-1	Modified 3350	Modified 3330
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Data General	Data General	Unibus, LSI-11	Unibus,Q-Bus	Unibus
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 354.1	F: 592.2	--	F: 26	--
REMOVABLE	--	--	F: 10.48	F: 26	F: 205.0
Capacity per track (Bytes)	F: 28,672	F: 38,400	F: 10,240	F: 15,872	F: 21,504
Data surfaces per spindle	8	8	2	4	6
Heads per data surface	2	2	1	1	1
Tracks per surface	1572	1956	512	821	1600
Track density (TPI)	714	800	250	1000	779
Maximum linear density (BPI)	10438*	14154*	3725	12350	7251 FRPI 9668 BPI
Rotational speed (RPM)	3000	2940	2400	2850	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	20	21	55	35	41.7
Average rotational delay (msec)	10	10.2	12.5	10.5	8.3
Average access time (msec)	30	31.2	67.5	45.5	50.0
Data transfer rate (KBytes/sec)	1680	2200	512.5	1250	1980
FIRST CUSTOMER SHIPMENT	9/83	2/85	1979	4Q83	3Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code 6237-3 Spindles	*2,7 RLL Code 6239-1 Spindles 6290-2 Spindles 6240-3 Spindles	Embedded Servo	Embedded Servo	Embedded Servo

1985 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DISC TECH ONE	DISC TECH ONE
RA80	RM80	RA81	5014	5019
7	7	8	5	5
Captive	Captive	Captive	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
14"	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Unibus	Massbus	Unibus	ST412	ST412
F: 121.0	F: 124.0	F: 456.0	U: 12.75	U: 19.13
--	--	--	--	--
F: 15,872	F: 16,384	F: 26,112	U: 10,416	U: 10,416
7	7	7	4	6
2	2	2	1	1
1092	1122	2496	306	306
478	478	960	383	383
6339	6339	8550 FRPI 11400 BPI	8944	8944
3600	3600	3600	3600	3600
Rotary, Voice Coil 25	Rotary, Voice Coil 25	Rotary, Voice Coil 28	Rotary, Band, Stepping Motor 90 (including settling)	Rotary, Band, Stepping Motor 90 (including settling)
8.3	8.3	8.3	8.3	8.3
33.3	33.3	36.3	98.3	98.3
1200	1200	2200	625	625
1/82	1981	9/82	3Q84	3Q84
--	--	--	\$385(2500)	\$420(2500)
		Embedded Servo	Previously Disctron Product	Previously Disctron Product

MANUFACTURER	DISC TECH ONE	DISC TECH ONE	DISC TECH ONE	DISC TECH ONE	DISC TECH ONE
DRIVE	5026	8533	3306	4160	4230
DISK/TREND GROUP	5	6	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ANSI X3T9/1226	SMD, Priam	SMD	Priam Stan.
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.5	U: 60	U: 83.95	U: 165.9	U: 232.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 17,920	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	8	4	5	5	7
Heads per data surface	1	1	2	2	2
Tracks per surface	306	838	704	1646	1664
Track density (TPI)	383	693	286	706	706
Maximum linear density (BPI)	8944	8555	6122	6270	6270
Rotational speed (RPM)	3600	3125	2964	3600	2964
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	90 (including settling)	29	38	38	38
Average rotational delay (msec)	8.3	9.6	10.12	8.3	10.1
Average access time (msec)	98.3	38.6	48.12	46.3	48.1
Data transfer rate (KBytes/sec)	625	933.3	1000	1209	1209
FIRST CUSTOMER SHIPMENT	3Q84	1/82	7/77	1Q83	2/84
U.S. OEM PRICE FOR 100 UNITS	\$575(2500)	\$2,500	\$3,500	\$4,000	\$5,000
COMMENTS	Previously Disctron Product	Previously 3M Product			

1985 DISK/TREND REPORT

RSPEC-29

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	DISC TECH ONE	DISCTRON	DISCTRON	EPSON	EPSON
	4300	DP-100	DP-400	HD-830	HD-850
	8	1	6	5	5
	OEM	OEM	OEM	OEM	OEM
	Fixed	8" Cartridge	Fixed	Fixed	Fixed
	14"	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
	Oxide Coated	Oxide Coated	Oxide Coated	Plated	Plated
	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
	Ferrite	Ferrite Modified	Ferrite Modified	Ferrite	Ferrite
	SMD	SA 1000	SA 1000	ST412	ST412
	U: 301.0	--	U: 46.4	U: 12.8	U: 12.8
	--	U: 11.6	--	--	--
	U: 25,872	U: 13,440	U: 13,440	U: 10,416	U: 10,416
	7	2	4	2	2
	2	1	1	1	2
	1664	426	864	612	612
	706	478	640	600	600
	8072	6968	8325	9700	10000
	2964	3600	3600	3600	3600
	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
	38	60	60	85 (including settling)	55 (including settling)
	10.1	8.3	8.3	8.3	8.3
	48.1	68.3	68.3	93.3	63.3
	1278	875	875	625	625
	1Q83	4/81	4/82	8/85	8/85
	\$5,000	\$1,580	\$1,770	--	--
		Embedded Servo	Embedded Servo	1.625" High	1.625" High

1985 DISK/TREND REPORT

MANUFACTURER	EPSON	FUJITSU, LTD.	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD
DRIVE	HD-860	F6417	M2220A	M2223A	M2224A
DISK/TREND GROUP	5	2	5	5	5
MARKET	OEM	Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Special Cartridge	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Plated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3330-11	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	Fujitsu	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.6	--	U: 6.37	U: 12.74	U: 19.12
REMOVABLE	--	F: 67.6	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 16,736	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	5	2	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	612	808	306	306	306
Track density (TPI)	600	370	450	450	450
Maximum linear density (BPI)	9700	5636	12500	12500	12500
Rotational speed (RPM)	3600	2400	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	30	88 (including settling)	88 (including settling)	88 (including settling)
Average rotational delay (msec)	8.3	12.5	8.3	8.3	8.3
Average access time (msec)	93.3	42.5	96.3	96.3	96.3
Data transfer rate (KBytes/sec)	625	717	625	625	625
FIRST CUSTOMER SHIPMENT	8/85	4Q79	9/85	9/85	9/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$500	\$625
COMMENTS	1.625" High		1.625" High	1.625" High	1.625" High

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	FUJITSU, LTD	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD
	M2230AS/B	M2230AT M2230BT	M2231A/B	M2232A/B	M2233AS/B
	5	5	5	5	5
	OEM	Captive,OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
	Ferrite AS=ST412 B=SA4000	Ferrite ST412/SA4000	Ferrite A = ST412 B = SA4000	Ferrite A = ST412 B = SA4000	Ferrite AS=ST412 B=SA4000
	U: 6.66	U: 6.66	U: 6.66	U: 10.0	U: 13.3
	--	--	--	--	--
	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
	2	2	4	6	4
	1	1	1	1	1
	320	320	160	160	320
	300	300	254	254	300
	10,200	10200	8020	8020	10,200
	3600	3600	3600	3600	3600
	Rotary, Stepping Motor 83 (including settling)	Rotary,Band, Stepping Motor 95 (including settling)	Rotary, Stepping Motor 95 (including settling)	Rotary, Stepping Motor 95 (including settling)	Rotary, Stepping Motor 83 (including settling)
	8.3	8.3	8.3	8.3	8.3
	91.3	103.3	103.3	103.3	91.3
	625	625	625	625	625
	4/83	5/84	7/82	7/82	4/83
	--	--	--	--	--
		1.625" High			

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2233AT M2233BT	M2234AS/B	M2235AS	M2301B/K	M2301BE/KE
DISK/TREND GROUP	5	5	5	5	5
MARKET	Captive,OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	200 mm OD 100 mm ID	200 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	3340	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412/SA4000	AS=ST412 B=SA4000	AS=ST412 B=SA4000	B=SA4000, K= Bidirectional	BE=SA4000, KE= Bidirectional
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 13.33	U: 20.0	U: 20.0	U: 11.712	U: 11.87
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 12,000	U: 24,320
Data surfaces per spindle	4	6	6	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	320	244	244
Track density (TPI)	300	300	300	195	195
Maximum linear density (BPI)	10200	10,200	10,200	6100	12360
Rotational speed (RPM)	3600	3600	3600	2964	2964
PERFORMANCE					
Actuator type	Rotary,Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	95 (including settling)	83 (including settling)	83 (including settling)	70 (including settling)	70 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	10.1	10.1
Average access time (msec)	103.3	91.3	91.3	80.1	80.1
Data transfer rate (KBytes/sec)	625	625	625	593	1200
FIRST CUSTOMER SHIPMENT	5/84	4/83	10/83	7/80	9/82
U.S. OEM PRICE FOR 100 UNITS	\$480	\$700	\$740	--	--
COMMENTS	1.625" High				

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD.
DRIVE	M2302B/K	M2302BE/KE	M2241AS M2241B	M2242AS M2242B	M2243AS M2243B
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	Captive,OEM	Captive,OEM	Captive,OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 100 mm ID	200 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3340	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite B=SA4000, K= Bidirectional	Ferrite BE=SA4000, KE= Bidirectional	Ferrite ST412/SA4000	Ferrite ST412/SA4000	Ferrite ST412/SA4000
Interface					
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 23.424	U: 23.74	U: 31.4	U: 54.9	U: 86.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 12,000	U: 24,320	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	8	4	4	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	244	244	754	754	754
Track density (TPI)	195	195	760	760	760
Maximum linear density (BPI)	6100	12360	10200	10200	10200
Rotational speed (RPM)	2964	2964	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	70 (including settling)	70 (including settling)	35	35	35
Average rotational delay (msec)	10.1	10.1	8.3	8.3	8.3
Average access time (msec)	80.1	80.1	43.3	43.3	43.3
Data transfer rate (KBytes/sec)	593	1200	625	625	625
FIRST CUSTOMER SHIPMENT	7/80	9/82	5/84	5/84	5/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$1625	\$1865
COMMENTS					

1985 DISK/TREND REPORT

MANUFACTURER	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD.	FUJITSU, LTD
DRIVE					
	M2244E	M2245E	M2246E	M2303BE/KE	M2311K/S
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive,OEM	Captive,OEM	Captive,OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	200 mm OD	200 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI	B=SA4000, K= Bidirectional	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 85.8	U: 120.0	U: 171.7	U: 47.47	U: 48.25
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	U: 20,864	U: 20,864	U: 24,320	U: 20,480
Data surfaces per spindle	5	7	10	8	4
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	823	244	589
Track density (TPI)	850	850	850	195	720
Maximum linear density (BPI)	20,400*	20,400*	20,400*	12360	9550
Rotational speed (RPM)	3600	3600	3600	2964	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	28	28	28	70 (including settling)	20
Average rotational delay (msec)	8.3	8.3	8.3	10.1	8.3
Average access time (msec)	36.3	36.3	36.3	80.1	28.3
Data transfer rate (KBytes/sec)	1,250	1,250	1,250	1200	1229
FIRST CUSTOMER SHIPMENT	3Q85	3Q85	3Q85	9/82	4/81
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code		

MANUFACTURER	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD.
DRIVE					
	M2312K/S	M2321K/S	M2284	M2322K/S	M2331K/KS
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	210 mm OD	14"	210 mm OD	210 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD, SCSI	SMD, SCSI	SMD	SMD, SCSI	MOD, SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 84.44	U: 84.2	U: 168.6	U: 168.5	U: 168.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	U: 20,480	U: 20,480	U: 20,480	U: 40,960
Data surfaces per spindle	7	5	5	10	5
Heads per data surface	1	1	2	1	1
Tracks per surface	589	823	1646	823	823
Track density (TPI)	720	683	680	683	683
Maximum linear density (BPI)	9550	9867	6580	9867	19734*
Rotational speed (RPM)	3600	3600	2964	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	20	27	20	20
Average rotational delay (msec)	8.3	8.3	10.12	8.3	8.3
Average access time (msec)	28.3	28.3	37.12	28.3	28.3
Data transfer rate (KBytes/sec)	1229	1229	1012	1229	2458
FIRST CUSTOMER SHIPMENT	4/81	11/83	4Q79	11/83	11/84
U.S. OEM PRICE FOR 100 UNITS	\$2,850	--	\$4,775	\$3600	
COMMENTS					*2,7 RLL Code

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD	FUJITSU, LTD.	FUJITSU, LTD
DRIVE	F493	F6421	M2294K/N	M2333K/KS	M2350A
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	10.5" OD 4" ID	14"	210 mm OD 100 mm ID	10.5" OD 4" ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Fujitsu	Fujitsu	SMD	MOD SMD, SCSI	Modified SMD
CAPACITY/RECORDING DENSITY	1.144 MB Fixed Head Option	1.607 or 1.144 MB Fixed Head Option			
Total capacity (MBytes) FIXED	F: 317.5	F: 446/317.5	U: 335.5	U: 337.1	U: 473.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,069	F: 26,793/ 19,069	U: 20,480	U: 40,960	U: 28,160
Data surfaces per spindle	15	10	8	10	10
Heads per data surface	2	2	2	1	2
Tracks per surface	1110	1680	2048	823	1684
Track density (TPI)	480	880	858	683	880
Maximum linear density (BPI)	6362	12790	6500	19734*	12790
Rotational speed (RPM)	3600	3961	2964	3600	3961
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	18	27	20	18
Average rotational delay (msec)	8.3	7.5	10.12	8.3	7.5
Average access time (msec)	28.3	25.5	37.12	28.3	25.5
Data transfer rate (KBytes/sec)	1198	1859	1012	2458	1.86/7.44/9.3
FIRST CUSTOMER SHIPMENT	4Q79	3Q81	5/83	11/84	2/84
U.S. OEM PRICE FOR 100 UNITS	--	--	\$5,800	\$4,350	\$25,000 QTY 10
COMMENTS	Drive has two spindles	Drive has four spindles		*2,7 RLL Code	Parallel data transfer, 4 or 5 channels

MANUFACTURER	FUJITSU, LTD.	FUJITSU, LTD.	FUJITSU, LTD	FUJITSU, LTD	FUJITSU, LTD
DRIVE	M2351A	F6425	F6425K4/L4	F6425M4/N4	M2298K/N
DISK/TREND GROUP	8	9	9	9	9
MARKET	OEM	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD	10.5" OD	10.5" OD	10.5" OD	14"
Recording medium	4" ID Oxide Coated	4" ID Oxide Coated	4.0" ID Oxide Coated	4.0" ID Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Special	Special	Special	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Fujitsu	Fujitsu	Fujitsu	Modified SMD
CAPACITY/RECORDING DENSITY	1.69 MB Fixed Head Option				
Total capacity (MBytes) FIXED	U: 474.214	F: 630.0	F: 630.0	F: 1,260.0	U: 671
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 28,160	F: 47,476	F: 47,476	F: 47,476	U: 40,960
Data surfaces per spindle	10	8	8	12	8
Heads per data surface	2	2	2	2	2
Tracks per surface	1684	1770	1770	2360	2048
Track density (TPI)	880	905	905	1160	858
Maximum linear density (BPI)	12790	24420*	24,420*	24,491*	8,667 FCI 13,000 BPI
Rotational speed (RPM)	3961	3620	3620	3620	2722
PERFORMANCE					
Actuator type	Rotary, Voice Coil 18	Rotary, Voice Coil 15	Rotary, Voice Coil 15	Rotary, Voice Coil 17	Rotary, Voice Coil 27
Average positioning time (msec)	7.5	8.3	8.3	8.3	11
Average rotational delay (msec)	25.5	23.3	23.3	25.3	38
Data transfer rate (KBytes/sec)	1859	3000	3,000	3,000	1859
FIRST CUSTOMER SHIPMENT	3/82	3Q83	3Q86	3Q86	10/84
U.S. OEM PRICE FOR 100 UNITS	\$8,500	--	--	--	\$7.045
COMMENTS		*2,7 RLL Code Drive has four spindles	*2,7 RLL Code Drive has four spindles	*2,7 RLL Code Drive has four spindles	

MANUFACTURER	FUJITSU, LTD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	M2361A	7906	7907A	7920	7935H
DISK/TREND GROUP	9	2	2	3	4
MARKET	OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	2315	8" Cartridge	Special SMD	Special Disk Pack
Nominal disk diameter	10.5" OD 4.0" ID	14"	200 mm OD 63.5 mm ID	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3330-1	3370 (Ferrite)	3330-11	Modified 3330
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	HPIB	HPIB	HPIB	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 689.8	F: 9.38	F: 20.5	--	--
REMOVABLE	--	F: 9.38	F: 20.5	F: 50.07	F: 404.4
Capacity per track (Bytes)	U: 40,960	F: 12,288	F: 16,384	F: 12,288	F: 23,552
Data surfaces per spindle	10	3	4	5	13
Heads per data surface	2	1	1	1	2
Tracks per surface	1684	812 Fixed 406 Removable	644	815	1321
Track density (TPI)	880	384 Fixed 192 Removable	550	384	625
Maximum linear density (BPI)	18,620*	4860	7324 FRPI 10986 BPI*	4680	8320*
Rotational speed (RPM)	3600	3600	3523	3600	2700
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	18	25	30	25	24.0
Average rotational delay (msec)	8.3	8.3	8.45	8.3	11.1
Average access time (msec)	26.3	33.3	38.45	33.3	35.1
Data transfer rate (KBytes/sec)	2,458	937.5	1229	937.5	1000
FIRST CUSTOMER SHIPMENT	2Q85	3/78	7/85	3/77	4/83
U.S. OEM PRICE FOR 100 UNITS	\$9,775	--	--	--	--
COMMENTS	*2,7 RLL Code		*2,7 RLL Code Embedded Servo Disk Drive Mfg. By Amcodyne		*Uses RLL Code

1985 DISK/TREND REPORT

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MANUFACTURER	HEWLETT-PACKARD ^D	HEWLETT-PACKARD ^D	HEWLETT-PACKARD ^G	HEWLETT-PACKARD ^D	HEWLETT-PACKARD ^D
DRIVE	7911	7941A 7942A	97501A	7912	7945A 7946A
DISK/TREND GROUP	5	5	5	6	6
MARKET	Captive	Captive	Captive, OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	130 mm OD 40 mm ID	95 mm OD 25 mm ID	14"	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Plated	Sputtered	Oxide Coated	Plated
DRIVE: Technology type	3350	3370 (Ferrite)	3370 (Ferrite)	3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	HPIB	HPIB	HP	HPIB	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 28.1	F: 23.789	F: 10	F: 65.6	F: 55,508
REMOVABLE	--	--		--	--
Capacity per track (Bytes)	F: 16,384	F: 8,129	F: 7,168	F: 16,384	F: 8,129
Data surfaces per spindle	1.5	3	2	3.5	7
Heads per data surface	2	1	1	2	1
Tracks per surface	1144	968	698	1144	968
Track density (TPI)	478	960	1100	478	960
Maximum linear density (BPI)	6161	9897	12000	6161	9897
Rotational speed (RPM)	3600	3600	3000	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Band Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	26.7	30	75 (including settling)	26.7	30
Average rotational delay (msec)	8.3	8.3	10	8.3	8.3
Average access time (msec)	35.0	38.3	85	35.0	38.3
Data transfer rate (KBytes/sec)	983	625	500	983	625
FIRST CUSTOMER SHIPMENT	10/81	6/84	3/85	10/81	10/84
U.S. OEM PRICE FOR 100 UNITS	--	--	\$475	--	--
COMMENTS		7942A Includes Tape Cartridge Drive Disk Drive Mfg. By Priam	2.0" High Embedded Servo		7946A Includes Tape Cartridge Drive Disk Drive Mfg. By Priam

1985 DISK/TREND REPORT

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	7914	7933H	DK301-1	DK301-2	DK502-1
DISK/TREND GROUP	7	8	5	5	5
MARKET	Captive	Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3350	Modified 3330	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	HPIB	HPIB	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 132.1	F: 404.4	U: 12.7	U: 19.1	U: 13.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 23,552	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	3.5	13	4	6	4
Heads per data surface	2	2	1	1	1
Tracks per surface	2288	1321	306	306	320
Track density (TPI)	910	625	485	485	360
Maximum linear density (BPI)	6161	8320*	12600	12600	9260
Rotational speed (RPM)	3600	2700	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	26.7	24.0	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	11.1	8.3	8.3	8.3
Average access time (msec)	35.0	35.1	93.3	93.3	93.3
Data transfer rate (KBytes/sec)	983	1000	625	625	625
FIRST CUSTOMER SHIPMENT	2/83	12/81	6/85	6/85	10/83
U.S. OEM PRICE FOR 100 UNITS	--	--	\$550	\$675	--
COMMENTS		*Uses RLL Code	1.625" High	1.625" High	Mfg. by Tokico

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MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK502-2	DK502-3	DK503-1	DK503-2	DK505-2
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: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 20.0	U: 26.6	U: 6.7	U: 13.3	U: 25.62
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	6	8	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	320	320	615
Track density (TPI)	360	360	360	360	670
Maximum linear density (BPI)	9260	9260	9260	9260	9490
Rotational speed (RPM)	3600	3600	3600	3600	3550
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.45
Average access time (msec)	93.3	93.3	93.3	93.3	93.45
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	10/83	10/83	10/83	10/83	3/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$625	\$875
COMMENTS	Mfg. by Tokico	Mfg. by Tokico	1.625" High Mfg. by Tokico	1.625" High Mfg. by Tokico	1.625" High

1985 DISK/TREND REPORT

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK811-2	DK 811-4	DK 811-8	DK511-3	DK511-5
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	210 mm OD	210 mm OD	210 mm OD	130 mm OD	130 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	3350	3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	Modified SMD	ST412, SCSI	ST412, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 24.0 F: 20.0	U: 48.0 F: 40.0	U: 89.1 F: 71.1	U: 36.4	U: 51.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,800	F: 12,800	F: 12,800	U: 10,416	U: 10,416
Data surfaces per spindle	3	6	11	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	521	521	526	699	699
Track density (TPI)	480	480	480	784	784
Maximum linear density (BPI)	7495	7495	7495	9340	9340
Rotational speed (RPM)	3521	3521	3521	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	30	30
Average rotational delay (msec)	8.5	8.5	8.5	8.3	8.3
Average access time (msec)	33.5	33.5	33.5	38.3	38.3
Data transfer rate (KBytes/sec)	904	904	904	625	625
FIRST CUSTOMER SHIPMENT	10/80	10/80	3/82	1Q84	1Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$1350	\$1650
COMMENTS					

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MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

Heads

Interface

CAPACITY/RECORDING DENSITY

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Rotational speed (RPM)

PERFORMANCE

Actuator type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

U.S. OEM PRICE FOR 100 UNITS

COMMENTS

HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DK511-8	DK512-8	DK812S-5	DK812S-8	DK512-12
6	6	6	6	7
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
Modified 3350	3370 (Ferrite)	Modified 3350	Modified 3350	3370 (Ferrite)
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
ST412, SCSI	ESDI	SMD	SMD	ESDI
U: 85.7	U: 85.7	U: 51	U: 85	U: 120.0
--	--	--	--	--
U: 10,416	U: 20,944	U: 20,672	U: 20,672	U: 20,944
10	5	3	5	7
1	1	1	1	1
823	823	823	823	823
925	925	760	760	925
9250	18500*	6433 FCI 9650 BPI 3510	6433 FCI 9650 BPI 3510	18500*
3600	3482			3482
Rotary, Voice Coil 23	Rotary, Voice Coil 23	Rotary, Voice Coil 25	Rotary, Voice Coil 25	Rotary, Voice Coil 23
8.3	8.6	8.5	8.5	8.6
31.3	31.6	33.5	33.5	31.6
625	1209	1209	1209	1209
--	3/85	7/83	7/83	3/85
\$2275	\$2475	\$2175	\$2650	\$2775
	*RLL Code			*RLL Code

1985 DISK/TREND REPORT

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE	DK512-17	DK812S-12	DK812S-17	DK814S-17	DK814S-24
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	210 mm OD	210 mm OD	210 mm OD	210 mm OD
Recording medium	40 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SMD	SMD	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 171.4	U: 119	U: 170.1	U: 170	U: 238
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,944	U: 20,672	U: 20,672	U: 32,768	U: 32,768
Data surfaces per spindle	10	7	10	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	823	823	823
Track density (TPI)	925	760	760	800	800
Maximum linear density (BPI)	18500*	6433 FCI 9650 BPI	6433 FCI 9650 BPI	18500*	18500*
Rotational speed (RPM)	3482	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)	23	25	25	20	20
Average rotational delay (msec)	8.6	8.5	8.5	11.4	11.4
Average access time (msec)	31.6	33.5	33.5	31.4	31.4
Data transfer rate (KBytes/sec)	1209	1209	1209	1815	1815
FIRST CUSTOMER SHIPMENT	3/85	6/83	6/83	12/84	12/84
U.S. OEM PRICE FOR 100 UNITS	\$3075	\$3100	\$3725	\$4325	\$4650
COMMENTS	*RLL Code			*RLL Code	*RLL Code

RSPEC-45

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.	HITACHI, LTD.
DRIVE					
	DK814S-34	DKU-80	DK815-5	DKU-97I	DKU-97S
DISK/TREND GROUP	8	8	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	8" Nominal	224 mm OD	14"	14"
Recording medium	100 mm ID Oxide Coated	Oxide Coated	100 mm ID Hi Dens-Oxide	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)		3370 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	IBM, SMD	Mod. SMD	IBM	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 340	U: 427.7	U: 525.38	F: 635.0	U: 697.059
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 32,768	U: 26,880	U: 30,240	F: 19,069	U: 20,672
Data surfaces per spindle	10	13	14	20	20
Heads per data surface	1	2	1	2	2
Tracks per surface	823	1224	1241	1666	1682
Track density (TPI)	800		885	720	720
Maximum linear density (BPI)	18500*		14585*	6425	6425
Rotational speed (RPM)	2632	3000	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)	20	18	18	20/18	20
Average rotational delay (msec)	11.4	10.0	8.3	8.3	8.3
Average access time (msec)	31.4	28.0	26.3	28.3/26.3	28.3
Data transfer rate (KBytes/sec)	1815	1344	1815	1198	1240
FIRST CUSTOMER SHIPMENT	12/84	11/83	11/84	1/81	9/83
U.S. OEM PRICE FOR 100 UNITS	\$5250	--	\$8000	--	--
COMMENTS	*RLL Code		*2,7 RLL Code	Drive has two spindles	

1985 DISK/TREND REPORT

MANUFACTURER	HITACHI, LTD.	HITACHI, LTD.	IBIS	IBM	IBM
DRIVE	DKU-98I H-8598-12 H-8598-22	H-8576-12 H-8576-22	1400	4952-30D 4954-30D 4956-30D 4965-30D	5160-087 5160-589
DISK/TREND GROUP	9	9	9	5	5
MARKET	Captive, OEM	Captive	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Plated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3380	Modified 3350	Special	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	IBM	IBM	Custom	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 1260	F: 635.0	U: 1,409.0	F: 30.84	F: 10.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 19,069	U: 49,728	F: 17,408	F: 8,704
Data surfaces per spindle	20	20	16	4	4
Heads per data surface	2	2	2	1	1
Tracks per surface	1328 (Physical)	1666	1776	443	306
Track density (TPI)	600	720	769	523	350
Maximum linear density (BPI)	15240*	6425	15294	6875 FRPI 10312 BPI 3151	9150
Rotational speed (RPM)	3600	3600	3600		3600
PERFORMANCE					
Actuator type	Dual Rotary, Voice Coil	Dual Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Band, Stepping Motor
Average positioning time (msec)	16	20	16	35	75 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	9.51	8.3
Average access time (msec)	24.3	28.3	24.3	44.51	83.3
Data transfer rate (KBytes/sec)	3000	1198	Up To 12,000	1250	625
FIRST CUSTOMER SHIPMENT	4Q82	4Q80	4Q83	9/83	7/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*RLL Code Drive has two spindles	Drive has two spindles	Drive has one spindle, with two actuators. Up to 4 track parallel data transfer.	Series/1 Embedded Servo 64 KB Cache	PC XT. Also used with other systems based on PC XT

RSPEC-47

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

IBM	IBM	IBM	IBM	IBM
5161-001/2/3	5170-099 5170-599	5247-011	5525-020 5525-030	8101-A11
5	5	5	5	5
Captive	Captive	Captive	Captive	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated
Modified 3350	Modified 3350	3350	Piccolo	Piccolo
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
IBM	IBM, ST412	IBM	IBM	IBM
F: 10.6	F: 21.4	F: 15.4	F: 29.327360	F: 29.327360
--	--	--	--	--
F: 8,704	F: 8,704	F: 17,408	F: 16,384	F: 16,384
4	4	2	5	5
1	1	1	1	1
306	614	443	359	359
350	815	523	450	450
9150	9398	6875 FRPI 10312 BPI 3151	8530	8530
3600	3600		3125	3125
Rotary, Band, Stepping Motor 75 (including settling)	Rotary, Voice Coil 40	Linear, Voice Coil 38	Rotary, Voice Coil 27	Rotary, Voice Coil 27
8.3	8.3	9.51	9.6	9.6
83.3	48.3	49.51	36.6	36.6
625	625	1250	1031	1031
7/84	4/85	9/82	2/80	3Q79
--	--	--	--	--
Expansion Unit for PC, PC XT and 3270 PC	System Unit for PC AT	Embedded Servo Shared storage for Datamaster	5520 Admin. System	8100 System

1985 DISK/TREND REPORT

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8130-A21 8130-A31 A41, A51 A61, A71	8130-A22 8140-A32 A42, A52 A62, A72	3310-A1 3310-A2 3310-B1 3310-B2	4954-60D 4956-60D,E 4965-60D	4963-58A 4963-58B
DISK/TREND GROUP	5	5	6	6	6
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	210 mm OD	210 mm OD	210 mm OD	210 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	Piccolo	Piccolo	Piccolo	Modified 3350	Piccolo
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY		.131072 MB Fixed Heads			0.131 MB Fixed Heads
Total capacity (MBytes) FIXED	F: 29.327360	F: 23.461888	F: 64.520192	F: 61.6	F: 58.654720
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 16,384	F: 17,408	F: 16,384
Data surfaces per spindle	5	5	11	4	11
Heads per data surface	1	1	1	1	1
Tracks per surface	359	359	359	886	359
Track density (TPI)	450	450	450	1000	450
Maximum linear density (BPI)	8530	8530	8530	6875 FRPI 10312 BPI	8530
Rotational speed (RPM)	3125	3125	3125	3151	3125
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	27	27	35	27
Average rotational delay (msec)	9.6	9.6	9.6	9.51	9.6
Average access time (msec)	36.6	36.6	36.6	44.51	36.6
Data transfer rate (KBytes/sec)	1031	1031	1031	1250	1031
FIRST CUSTOMER SHIPMENT	3Q79	3Q79	3/79	1Q84	2/79
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	8100 System	8100 System	4331	Series/1 Embedded Servo	Series/1

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4963-64A 4963-64B	5247-012	5360-AX1	5360-AX2	5362-X
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	210 mm OD	210 mm OD	210 mm OD	210 mm OD	210 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	Piccolo	3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY			(2 Spindles)		
Total capacity (MBytes) FIXED	F: 64.520192	F: 30.84	F: 30.84	F: 61.69	F: 61.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 17,408	F: 17,408	F: 17,408	F: 17,920
Data surfaces per spindle	11	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	359	443	443	443	886
Track density (TPI)	450	523	523	523	1000
Maximum linear density (BPI)	8530	6875 FRPI 10312 BPI	6875 FRPI 10312 BPI	6875 FRPI 10312 BPI	6875 FRPI 10312 BPI
Rotational speed (RPM)	3125	3151	3151	3151	3151
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	27	38	38	38	38
Average rotational delay (msec)	9.6	9.51	9.5	9.5	9.51
Average access time (msec)	36.6	47.51	47.5	47.5	47.51
Data transfer rate (KBytes/sec)	1031	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2/79	9/82	7/83	7/83	1Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Series/1	Embedded Servo Shared storage for Datamaster	System/36 Embedded Servo	System/36 Embedded Servo	System/36 Embedded Servo

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5364	5381- All Models	5525-040 5525-050	676	680
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	210 mm OD	210 mm OD	210 mm OD	210 mm OD
Recording medium	40 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Piccolo	Piccolo	Modified 3350	Piccolo
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM, ST412	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 41.92	F: 64.520192	F: 64.520192	F: 31.8 U: 38.6	F: 64.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,192	F: 16,384	F: 16,384	F: 17,920 U: 21,700	F: 16,384
Data surfaces per spindle	7	11	11	4	11
Heads per data surface	1	1	1	1	1
Tracks per surface	733	359	359	445	358
Track density (TPI)	815	450	450	523	450
Maximum linear density (BPI)	9398	8530	8530	6875 FRPI 10312 BPI	8530
Rotational speed (RPM)	3600	3125	3125	3151	3125
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	40	27	27	38	27
Average rotational delay (msec)	8.3	9.6	9.6	9.51	9.6
Average access time (msec)	48.3	36.6	36.6	47.51	36.6
Data transfer rate (KBytes/sec)	625	1031	1031	1250	1031
FIRST CUSTOMER SHIPMENT	6/85	8/79	11/80	12/82	1/82
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$2,750	\$4,375
COMMENTS	System Unit for System/36 PC	System/38 5381 Processor available with up to six disk spindles	5520 Admin. System -050 Model is Dual Spindle	Embedded Servo	Embedded Servo

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

IBM	IBM	IBM	IBM	IBM
8101-A13	8130-A23 8130-B23 8140-A33 A43, A53 A63, A73	8130-A24 8130-B24 8140-A34 A44, A54 A64, A74	8140-B51 B61 B71	8140-B52 B62 B72
6	6	6	6	6
Captive	Captive	Captive	Captive	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated
Piccolo	Piccolo	Piccolo	Piccolo	Piccolo
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
IBM	IBM	IBM	IBM	IBM
F: 64.520192	F: 64.520192	.131072 MB Fixed Heads F: 58.654720	.131072 MB Fixed Heads F: 58.654720	.131072 MB Fixed Heads (2 spindles) F: 123.174912
--	--	--	--	--
F: 16,384	F: 16,384	F: 16,384	F: 16,384	F: 16,384
11	11	11	11	11
1	1	1	1	1
359	359	359	359	359
450	450	450	450	450
8530	8530	8530	8530	8530
3125	3125	3125	3125	3125
Rotary, Voice Coil 27	Rotary, Voice Coil 27	Rotary, Voice Coil 27	Rotary, Voice Coil 27	Rotary, Voice Coil 27
9.6	9.6	9.6	9.6	9.6
36.6	36.6	36.6	36.6	36.6
1031	1031	1031	1031	1031
3Q79	3Q79	3Q79	4Q80	4Q80
--	--	--	--	--
8100 System	8100 System	8100 System	8100 System	8100 System

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4967-2CA 4967-2CB	5360-BX3	3370-A1 3370-A11 3370-B1 3370-B11	3370-A02 3370-A12 3370-B02 3370-B12	3375-A1 3375-B1 3375-D1
DISK/TREND GROUP	7	7	9	9	9
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370	3370	3370
Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY			1.144 MB Fixed Head Option		
Total capacity (MBytes) FIXED	F: 200.202	F: 200.202	F: 571.392	F: 729.858	F: 819.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,088	F: 25,088	F: 31,744	F: 31,744	F: 35,616
Data surfaces per spindle	7	7	12	12	12
Heads per data surface	2	2	2	2	2
Tracks per surface	1140	1140	1500	1916	1918
Track density (TPI)	485	485	635	800	800
Maximum linear density (BPI)	9751	9751	8128 FRPI 12134 BPI	8128 FRPI 12134 BPI	8128 FRPI 12134 BPI
Rotational speed (RPM)	2964	2964	2964	2964	2964
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	25	25	20	19	19
Average rotational delay (msec)	10.1	10.1	10.1	10.1	10.1
Average access time (msec)	35.1	35.1	30.1	29.1	29.1
Data transfer rate (KBytes/sec)	1500	1500	1859	1859	1859
FIRST CUSTOMER SHIPMENT	7/83	7/83	10/79	2Q84	3Q81
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Series/1 384 KB Cache	System/36 5360-BX4 uses 2 spindles, with total 400.4 MB	43X1 Series System/38	4341 4361 4381 System/38	4331 4341 303X Series

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MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	IBM	IBM	IBM	ISOT	ISOT
	3380-A4 3380-AA4 3380-B4	3380-AD4 3380-BD4	3380-AE4 3380-BE4	ES 5061	CM 5400-00 CM 5400-01
	9	9	9	--	1
	Captive	Captive	Captive	OEM	OEM
	Fixed	Fixed	Fixed	2316	5440
	14"	14"	14"	14"	14"
	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
	3380	3380	3380 x 2	2314	2314
	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
	IBM	IBM	IBM		Various Options
	F: 1,260.4878	F: 1,260.4878	F: 2,520.9756	--	U: 3.125
	--	--	--	F: 29	U: 3.125
	F: 47,476	F: 47,476	F: 47,476	F: 7,294	U: 7,812
	15	15	15	20	4
	2	2	2	1	1
	1770	1770	3540	203	204
	800	*	*	100	100
	10160 FRPI 15240 BPI 3620	*	*	2200	2200
	3620	3620	3620	2400	2400/1500
	Dual, Linear, Voice Coil 16	Dual, Linear Voice Coil 15	Dual, Linear Voice Coil 17	Linear, Voice Coil 50	Linear, Voice Coil 50
	8.3	8.3	8.3	12.5	12.5/20
	24.3	23.3	25.3	62.5	62.5/70
	3000	3000	3000	312	312/195
	4Q81	2/85	7/85	1976	1979
	--	--	--	--	--
	303X Series 370/158, 158-3 370/168, 168-3 Drive has two spindles	*not announced Drive has two spindles	*not announced Drive has two spindles		

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MANUFACTURER	ISOT	ISOT	ISOT	ISOT	ISOT
DRIVE	CM 5400-02 CM 5400-03	CM 5410	CM 5412	ES 5066 ES 5067.01 ES 5067.02	ES 5067
DISK/TREND GROUP	1	1	3	4	4
MARKET	OEM	Captive OEM	OEM	OEM	OEM
MEDIA: Generic type	5440	5440	SMD	3336-1	3336-11
Nominal disk diameter	14"	14"	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	2314	2314	3330-11	3330-1	3330-11
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Various Options	Various Options	SMD		
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	U: 5.75	--	--	--
REMOVABLE	U: 3.125	U: 5.75	U: 80	F: 100	F: 200
Capacity per track (Bytes)	U: 7,812	U: 7,812	U: 20,160	F: 13,030	F: 13,030
Data surfaces per spindle	4	4	5	19	19
Heads per data surface	1	1	1	1	1
Tracks per surface	204	406	823	411	815
Track density (TPI)	100	200	400	192	370
Maximum linear density (BPI)	2200	2200	6060	4040	4040
Rotational speed (RPM)	2400/1500	2400/1500	2400/3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil 50	Linear, Voice Coil 50	Linear, Voice Coil 45	Linear, Voice Coil 30	Linear, Voice Coil 30
Average positioning time (msec)	12.5/20	12.5	12.5/8.3	8.3	8.3
Average rotational delay (msec)	62.5/70	62.5	57.5/53.3	38.3	38.3
Data transfer rate (KBytes/sec)	312/195	312/195	806/1209	806	806
FIRST CUSTOMER SHIPMENT	1979	1982	1983	1980	1981
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS					

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MANUFACTURER	JOSEPHINE COUNTY TECHNOLOGY	JOSEPHINE COUNTY TECHNOLOGY	JOSEPHINE COUNTY TECHNOLOGY	LAPINE TECHNOLOGY	LAPINE TECHNOLOGY
DRIVE	JCT-100	JCT-105	JCT-110	3512 Ranger	3525 Titan
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID Sputtered	25 mm ID Sputtered
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 5.2	U: 7.0	U: 14.0	U: 12.75	U: 25.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 11,504	U: 11,504	U: 11,504	U: 10,416	U: 10,416
Data surfaces per spindle	2	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	226	306	306	306	612
Track density (TPI)	200	270	270	600	900
Maximum linear density (BPI)	7690	7690	7690	11200	11700
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	110 (including settling)	150 (including settling)	150 (including settling)	66 (including settling)	68 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	118.3	158.3	158.3	74.3	76.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	6/84	9/84	6/85	2/85	8/85
U.S. OEM PRICE FOR 100 UNITS	\$255	\$324	\$378	\$400	\$550
COMMENTS	1.625" High	1.625" High	1.625" High	3065 is ruggedized model	3265 is ruggedized model

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	JU-104	JU-603	JU-614	JU-615	JU-616
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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Sputtered	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 13.3	U: 10.0	U: 13.3	U: 20.0	U: 26.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	6	4	6	8
Heads per data surface	1	1	1	1	1
Tracks per surface	320	160	320	320	320
Track density (TPI)	506	256	360	360	360
Maximum linear density (BPI)	12100	7900	9100	9100	9100
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	95 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	103.3	93.3	93.3	93.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	9/85	1Q83	1Q84	1Q84	1Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS					

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MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MAXTOR	MAXTOR	MAXTOR
DRIVE	JU-662	JU-664	XT-1085	XT-2085	EXT-4125
DISK/TREND GROUP	5	5	6	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	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 Plated	40 mm ID Plated	40 mm ID Plated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 6.7	U: 13.3	U: 85.32	U: 89.24	U: 127.35
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 20,832
Data surfaces per spindle	2	4	8	7	5
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	1024	1224	1224
Track density (TPI)	320	320	1000	1022	1022
Maximum linear density (BPI)	9280	9280	9934	11155	22310 BPI 14873 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	95 (including settling)	95 (including settling)	28	30	29
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	103.3	103.3	36.3	38.3	37.3
Data transfer rate (KBytes/sec)	625	625	625	625	1250
FIRST CUSTOMER SHIPMENT	3Q84	3Q84	2Q83	3Q84	4Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	\$1,890	\$2,080	\$2,535
COMMENTS	1.625" High	1.625" High			

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MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	XT-1105	XT-1140	XT-2140	XT-2190	EXT-4175
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	Plated	Plated	Plated	Plated	Plated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 105.27	U: 143.55	U: 140.24	U: 191.24	U: 178.48
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 20,832
Data surfaces per spindle	11	15	11	15	7
Heads per data surface	1	1	1	1	1
Tracks per surface	918	918	1224	1224	1224
Track density (TPI)	1000	1000	1022	1022	1022
Maximum linear density (BPI)	9280	9280	11155	11155	22310 BPI 14873 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	27	30	30	29
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	35.3	38.3	38.3	37.3
Data transfer rate (KBytes/sec)	625	625	625	625	1250
FIRST CUSTOMER SHIPMENT	2Q83	2Q83	3Q84	3Q84	4Q84
U.S. OEM PRICE FOR 100 UNITS	\$2,660	\$3,430	\$2,930	\$3,775	\$3,550
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MEGAVAULT	MEGAVAULT	MEGAVAULT
DRIVE					
	EXT-4280	EXT-4380	MV83	MV166	MV212
DISK/TREND GROUP	7	8	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	40 mm ID Plated	40 mm ID Plated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	SMD, SCSI	SMD, SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 280.48	U: 382.48	U: 83.0	U: 166.0	U: 212.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	11	15	5	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	823	1024	1316
Track density (TPI)	1022	1022	600	960	960
Maximum linear density (BPI)	22310 BPI	22310 BPI	8850 FRPI	8850 FRPI	8850 FRPI
Rotational speed (RPM)	14873 FCI 3600	14873 FCI 3600	11500 BPI 3600	11500 BPI 3600	11500 BPI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	29	29	38	38	38
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.3	37.3	46.3	38.3	46.3
Data transfer rate (KBytes/sec)	1250	1250	1209	1209	1209
FIRST CUSTOMER SHIPMENT	4Q84	4Q84	4/82	1984	8/83
U.S. OEM PRICE FOR 100 UNITS	\$4,960	\$6,165	\$1950	\$2120	\$2,120
COMMENTS					

MANUFACTURER	MEGAVULT	MEGAVULT	MEGAVULT	MEGAVULT	MEMOREX
DRIVE	MVP132 PRAM	MVP212 PRAM	MV330	MV660	3680
DISK/TREND GROUP	7	7	8	9	9
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	200 mm OD	200 mm OD	14"
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3380
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	SMD, ANSI, SCSI	SMD, ANSI, SCSI	SMD, SCSI	SMD, SCSI	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 132.0	U: 212.0	U: 338	U: 671	F: 1260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 20,480	U: 30,720	F: 47,476
Data surfaces per spindle	8	8	13	13	15
Heads per data surface	1	1	1	1	2
Tracks per surface	823	1316	1272	1680	1,768
Track density (TPI)	600	960	1000	1034	806
Maximum linear density (BPI)	8850 FRPI 11500 BPI	8850 FRPI 11500 BPI	11057	19557*	15,240*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual Linear, Voice Coil
Average positioning time (msec)	38	38	18	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	46.3	46.3	26.3	26.3	24.3
Data transfer rate (KBytes/sec)	4825 (4 tracks)	4825 (4 tracks)	1228	1838	3000
FIRST CUSTOMER SHIPMENT	7/82	11/83	1986	1986	8/83
U.S. OEM PRICE FOR 100 UNITS	\$7,500	\$8,500	--	--	--
COMMENTS	4 Track parallel data transfer	4 Track parallel data transfer		*1,7,3,2 RLL	PCM 3380 Drive has one spindle *2,7 RLL Code

MANUFACTURER	MEMOREX	MEMOREX	MEMOREX	MEMOREX	MICRO STORAGE
DRIVE	3680 HDP	3690	3690-2	3695	MS 212
DISK/TREND GROUP	9	9	9	9	2
MARKET	PCM	PCM	PCM	PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	5.25" Cartridge
Nominal disk diameter	14"	14"	14"	14"	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Sputtered
DRIVE: Technology type	3380	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	IBM	IBM	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 1260	F: 571.3	F: 729.8	F: 819.7	--
REMOVABLE	--	--	--	--	U: 12.9
Capacity per track (Bytes)	F: 47,476	F: 31,744	F: 31,744	F: 35,616	U: 10,416
Data surfaces per spindle	15	12	12	12	2
Heads per data surface	2	2	2	2	1
Tracks per surface	1768	1,500	1916	1918	620
Track density (TPI)	806	635	810	810	556
Maximum linear density (BPI)	15,240*	12,128*	12128*	12128*	10,900
Rotational speed (RPM)	3600	2964	2964	2964	3524
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Band, Stepping Motor
Average positioning time (msec)	16	20	19	19	95 (including settling)
Average rotational delay (msec)	8.3	10.1	10.12	10.12	8.51
Average access time (msec)	24.3	30.1	29.12	29.12	103.51
Data transfer rate (KBytes/sec)	3000	1859	1859	1859	625
FIRST CUSTOMER SHIPMENT	3Q85	9/82	2Q85	4Q83	6/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$785
COMMENTS	PCM 3380 *2,7 RLL Code Drive has eight spindles	PCM 3370 *2,7 RLL Code Mfg. By Nippon Peripherals	PCM 3370 *2,7 RLL Code Mfg. by Nippon Peripherals	PCM 3375 *2,7 RLL Code Mfg. by Nippon Peripherals	Embedded Servo

MANUFACTURER	MICROCOMPUTER MEMORIES	MICROCOMPUTER MEMORIES	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	M-112	M-125	1323	1323A	1324
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	96 mm OD	96 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Oxide/Plated	40 mm ID Oxide/Plated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 12.75	U: 25.5	U: 42.7	U: 53.3	U: 64.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	8	4	5	6
Heads per data surface	1	1	1	1	1
Tracks per surface	306	306	1024	1024	1024
Track density (TPI)	588	588	1000	1000	1000
Maximum linear density (BPI)	10943	10943	9824	9824	9824
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	75 (including settling)	75 (including settling)	28	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	83.3	83.3	36.3	36.3	36.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	5/84	1/85	2Q84	2Q84	2Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	\$930 (1000)	\$995 (1000)	\$1035 (1000)
COMMENTS	1.625" x 4.0" x 5.75". Also available in 5.25" Half High and Full Size Form Factor	1.625" x 4.0" x 5.75". Also available in 5.25" Half High and Full Size Form Factor			

RSPEC-63

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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
	1324A	1325	1353	1373	1353A
	6	6	6	6	7
	OEM	OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Plated	130 mm OD 40 mm ID Plated	130 mm OD 40 mm ID Plated
	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	ST412	ST412	ESDI	SCSI	ESDI
	U: 74.7	U: 85.3	U: 85.3	F: 77.0	U: 106.7
	--	--	--	--	--
	U: 10,416	U: 10,416	U: 20,832	F: 19,456	U: 20,832
	7	8	4	4	5
	1	1	1	1	1
	1024	1024	1024	1024	1024
	1000	1000	1000	1000	1000
	9824	9824	19794*	19794*	19794*
	3600	3600	3600	3600	3600
	Rotary, Voice Coil 28	Rotary, Voice Coil 28	Rotary, Voice Coil 28	Rotary, Voice Coil 28	Rotary, Voice Coil 28
	8.3	8.3	8.3	8.3	8.3
	36.3	36.3	36.3	36.3	36.3
	625	625	1250	1250	1250
	2Q84	2Q84	3Q85	1Q86	3Q85
	\$1055 (1000)	\$1095 (1000)	\$1195 (1000)	\$1295 (1000)	\$1495 (1000)
			*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

1985 DISK/TREND REPORT

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1354	1354A	1355	1374	1375
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	Plated	Plated	Plated	Plated	Plated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 128.0	U: 149.3	U: 170.6	F: 115.5	F: 154.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	U: 20,832	F: 19,456	F: 19,456
Data surfaces per spindle	6	7	8	6	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1024	1024
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 28	Rotary, Voice Coil 28	Rotary, Voice Coil 28	Rotary, Voice Coil 28	Rotary, Voice Coil 28
Average positioning time (msec)	8.3	8.3	8.3	8.3	8.3
Average rotational delay (msec)	36.3	36.3	36.3	36.3	36.3
Average access time (msec)	1250	1250	1250	1250	1250
Data transfer rate (KBytes/sec)	3Q85	3Q85	3Q85	1Q86	1Q86
FIRST CUSTOMER SHIPMENT	\$1510 (1000)	\$1540 (1000)	\$1595 (1000)	\$1610 (1000)	\$1695 (1000)
U.S. OEM PRICE FOR 100 UNITS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code
COMMENTS					

1985 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MILTOPE
	HH-312	HH-325	HH-612	HH-725	RDS-10
	5	5	5	5	2
	OEM	OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Special
	95 mm OD 25 mm ID Sputtered	95 mm OD 25 mm ID Sputtered	130 mm OD 40 mm ID Plated	130 mm OD 40 mm ID Plated/Sputt'd	95 mm OD 25 mm ID Plated
	Modified 3370	3370 (Ferrite)	Modified 3350	Modified 3350	3370 (Ferrite)
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	ST412	ST412	ST412	ST412	ST412/SCSI
	U: 12.76	U: 25.52	U: 12.76	U: 25.52	--
	--	--	--	--	F: 10
	U: 10,416	U: 10,416	U: 10,416	U: 10,416	--
	4	4	2	4	2
	1	1	2	2	1
	306	612	612	612	829
	648	855	648	648	1186
	11000	13014	9680	9680	11240
	3550	3550	3550	3550	3600
	Band, Stepping Motor 70 (including settling)	Band, Stepping Motor 80 (including settling)	Band, Stepping Motor 70 (including settling)	Band, Stepping Motor 80 (including settling)	Rotary, Voice Coil 35
	8.45	8.45	8.45	8.45	8.3
	78.45	88.45	78.45	88.45	43.3
	625	625	625	625	625
	4Q84	3/85	9/83	6/84	1Q86
	\$325 (2500)	\$475 (2500)	\$325 (2500)	\$425 (2500)	\$15,000
	1.625" High Embedded Servo	1.625" High Embedded Servo	1.625" High Embedded Servo	1.625" High Embedded Servo	Sold as militarized subsystem

ST 2045 240
 5/84

MANUFACTURER	MILTOPE	MILTOPE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE					
	RDS-15	RDS-86	3212	3425	8425
DISK/TREND GROUP	2	2	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Special	Special	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	130 mm OD	95 mm OD
Recording medium	40 mm ID Plated	40 mm ID Plated	40 mm ID High Dens.Oxide	40 mm ID High Dens.Oxide	25 mm ID Plated/Sputter
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	Modified 3350	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412/SCSI	ST412/SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	--	U: 12.8	U: 25.5	U: 25.6
REMOVABLE	U: 21	U: 85.9	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	8	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	669	1031	612	612	615
Track density (TPI)	680	1000	588	588	804
Maximum linear density (BPI)	9890	9824	10030	10030	13412
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion Stepping Motor
Average positioning time (msec)	40	40	85 (including settling)	85 (including settling)	68 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	48.3	93.3	93.3	76.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	5/84	1Q86	1Q84	8/84	3Q84
U.S. OEM PRICE FOR 100 UNITS	\$21,500	\$24,500	\$375	\$495	\$590
COMMENTS	Sold as militarized subsystem	Sold as militarized subsystem	1.625" High	1.625" High	1.625" High

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE					
	6032	6053	6085	M2860-1	MR321
DISK/TREND GROUP	6	6	6	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	200 mm OD	95 mm OD
Recording medium	40 mm ID High Dens.Oxide	40 mm ID High Dens.Oxide	40 mm ID High Dens.Oxide	63.5 mm ID Oxide Coated	25 mm ID Plated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3330-11	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite Trident, SMD, SA1000	Ferrite
Interface	ST412	ST412	ST412		ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 32.0	U: 53.3	U: 85.3	U: 21.73	U: 12.75
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 13,440	U: 10,416
Data surfaces per spindle	3	5	8	3	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	549	615
Track density (TPI)	1000	1000	1000	480	821
Maximum linear density (BPI)	9950	9950	9950	7300	13840
Rotational speed (RPM)	3600	3600	3600	3600	3536
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Band, Stepping Motor
Average positioning time (msec)	28	28	28	35	70 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.48
Average access time (msec)	36.3	36.3	36.3	43.3	78.48
Data transfer rate (KBytes/sec)	625	625	625	806	625
FIRST CUSTOMER SHIPMENT	4Q84	4Q84	4Q84	1981	1Q86
U.S. OEM PRICE FOR 100 UNITS	\$875	\$1125	\$1530	--	--
COMMENTS					1.625" High Embedded Servo

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MR322	MR521	MR522	M2860-2	M2860-3
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	200 mm OD	200 mm OD
Recording medium	25 mm ID Plated	40 mm ID Plated	40 mm ID Plated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	3330-11	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite Trident, SMD, SA1000	Ferrite
Interface	ST412	ST412	ST412	SA1000	SMD, Trident
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.5	U: 12.75	U: 25.5	U: 50.71	U: 85.37
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 13,440	U: 20,160
Data surfaces per spindle	4	2	4	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	615	612	612	549	621
Track density (TPI)	821	690	690	480	546
Maximum linear density (BPI)	13840	9201	9201	7300	10900
Rotational speed (RPM)	3536	3536	3536	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	70 (including settling)	85 (including settling)	85 (including settling)	35	30
Average rotational delay (msec)	8.48	8.48	8.48	8.3	8.3
Average access time (msec)	78.48	93.48	93.48	43.3	38.3
Data transfer rate (KBytes/sec)	625	625	625	806	1209
FIRST CUSTOMER SHIPMENT	1Q86	4/84	6/84	1981	9/82
U.S. OEM PRICE FOR 100 UNITS	--	\$450	\$675	--	--
COMMENTS	1.625" High Embedded Servo	1.625" High	1.625" High		

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MR533	MR535	M4870F	MR5310	MR4875
DISK/TREND GROUP	6	6	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	210 mm OD	130 mm OD	210 mm OD
Recording medium	40 mm ID Plated	40 mm ID Plated	100 mm ID Oxide Coated	40 mm ID Plated	100 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	3370 (Ferrite)	3370
Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ST412	ST412	SMD	SCSI/EDSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 30.33	U: 50.55	U: 251.4	U: 101.1	U: 408.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 20,480	U: 20,832	U: 30,720
Data surfaces per spindle	3	5	12	5	13
Heads per data surface	1	1	1	1	1
Tracks per surface	971	971	1023	971	1023
Track density (TPI)	1028	1028	1000	1028	1000
Maximum linear density (BPI)	9358	9358	10000	18716*	14100
Rotational speed (RPM)	3600	3600	3544	3600	3544
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	38	38	20	38	20
Average rotational delay (msec)	8.3	8.3	8.47	8.3	8.47
Average access time (msec)	46.3	46.3	28.47	46.3	28.47
Data transfer rate (KBytes/sec)	625	625	1209	1250	1814
FIRST CUSTOMER SHIPMENT	10/85	10/85	4/84	4/86	3Q85
U.S. OEM PRICE FOR 100 UNITS	--	--	\$6,000	--	--
COMMENTS	1.625" High	1.625" High		1.625" High *2,7 RLL Code	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	N7745	D3116	D3126	D5124	D5126
DISK/TREND GROUP	4	5	5	5	5
MARKET	Captive	OEM	OEM, Captive	OEM, Captive	OEM
MEDIA: Generic type	3336-11	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	95 mm OD 25 mm ID Plated	95 mm OD 25 mm ID Plated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
Recording medium	Oxide Coated				
DRIVE: Technology type	3330-11	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	NEC	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	U: 12.81	U: 25.62	U: 12.91	U: 25.62
REMOVABLE	F:200	--	--	--	--
Capacity per track (Bytes)	F: 13,030	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	19	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	815	615	615	310	615
Track density (TPI)	370	750	750	350	700
Maximum linear density (BPI)	4040	15000	15000	9000	9000
Rotational speed (RPM)	3600	3564	3564	3600	3564
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Band, Stepping Motor	Linear, Band, Stepping Motor	Band, Stepping Motor	Linear, Band, Stepping Motor
Average positioning time (msec)	30	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.4	8.4	8.3	8.4
Average access time (msec)	38.3	93.4	93.4	93.3	93.4
Data transfer rate (KBytes/sec)	806	625	625	625	625
FIRST CUSTOMER SHIPMENT	11/75	7/85	7/85	3/84	10/84
U.S. OEM PRICE FOR 100 UNITS	--	--	\$387 (1000)	\$350 (1000)	\$430 (1000)
COMMENTS				1.625" High	1.625" High

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5224	D5244	D1220 N7722	D1245 N7723	D2246 N7726
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM, Captive	OEM, Captive	Captive, OEM	Captive, 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	14"	14"	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3350	3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SMD	SMD	SMD
CAPACITY/RECORDING DENSITY			0.48/0.96 MB Fixed Head Option	0.48/0.96 MB Fixed Head Option	
Total capacity (MBytes) FIXED	U: 12.91	U: 25.83	U: 41.5	U: 84.8	U: 85.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 19,968	U: 19,968	U: 20,480
Data surfaces per spindle	4	8	2	4	6
Heads per data surface	1	1	2	2	1
Tracks per surface	310	310	1040	1040	692
Track density (TPI)	350	350	480	480	720
Maximum linear density (BPI)	9000	9000	6370	6370	9040
Rotational speed (RPM)	3600	3600	3600	3600	3510
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	85 (including settling)	40	29	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.55
Average access time (msec)	93.3	93.3	48.3	37.3	33.55
Data transfer rate (KBytes/sec)	625	625	1198	1198	1198
FIRST CUSTOMER SHIPMENT	4/83	5/83	9/78	9/80	5/82
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$2,390
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2247	D5146	D1280 N7728	D2247E	D2257 N7729
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	130 mm OD	14"	210 mm OD	210 mm OD
Recording medium	100 mm ID Oxide Coated	40 mm ID Oxide Coated	Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	ST412	SMD	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 82.9	U: 51.24	U: 180.6	U: 104.8	U: 167.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 10,416	U: 19,968 F: 19,069	U: 20,480	U: 20,480
Data surfaces per spindle	5	8	6	5	8
Heads per data surface	1	1	2	1	1
Tracks per surface	823	615	1508	1024	1024
Track density (TPI)	960	700	680	960	720
Maximum linear density (BPI)	8670	9000	6400	9420	9420
Rotational speed (RPM)	3600	3564	3600	3510	3510
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18.5	85 (including settling)	25	20	20
Average rotational delay (msec)	8.3	8.4	8.3	8.55	8.55
Average access time (msec)	26.8	93.4	33.3	28.55	28.55
Data transfer rate (KBytes/sec)	1209	625	1198	1198	1198
FIRST CUSTOMER SHIPMENT	5/83	6/85	3/82	5/83	5/83
U.S. OEM PRICE FOR 100 UNITS	\$2,600	--	--	--	\$2,940
COMMENTS		1.625" High			N7729 has two spindles per drive

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2268	D2332 N7737	JS4380N	D2352 N7738	N7755
DISK/TREND GROUP	8	8	8	9	9
MARKET	OEM	OEM	Captive	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	230 mm OD	210 mm OD	230 mm OD	14"
Recording medium	100 mm ID Oxide Coated	100 mm ID Plated	100 mm ID Plated	100 mm ID Plated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SMD	Special	Modified SMD	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 337.1	U: 337.1	U: 402 Per Spindle U: 3,200 Total	U: 523.9	F: 635.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 20,480	U: 25,520	U: 36,288	F: 19,069
Data surfaces per spindle	10	10	13	9.5	15
Heads per data surface	1	2	2	2/1	2
Tracks per surface	823	1646	1226	1520	2244
Track density (TPI)	780	1080	1080	1020	960
Maximum linear density (BPI)	18900*	10500	13840	18600*	6400
Rotational speed (RPM)	2720	3544	3000	3070	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	20	15	18	15	20
Average rotational delay (msec)	11	8.47	10	9.8	8.3
Average access time (msec)	31	23.47	28	24.8	28.3
Data transfer rate (KBytes/sec)	1859	1209	1344	1859	1198
FIRST CUSTOMER SHIPMENT	6/85	6/85	3/82	1/85	1979
U.S. OEM PRICE FOR 100 UNITS	\$4120	--	--	\$6715	--
COMMENTS	*2,7 RLL Code		8 spindles per drive	*2,7 RLL Code	Drive has two spindles

MANUFACTURER	NEC	NEC	NEC	NEWBURY DATA	NEWBURY DATA
DRIVE	N7756	N7761	N7765	505	320 PENNY
DISK/TREND GROUP	9	9	9	1	5
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	5.25" Cartridge	Fixed
Nominal disk diameter	230 mm OD	14"	14"	130 mm OD	95 mm OD
Recording medium	100 mm ID Plated	Oxide Coated	Oxide Coated	40 mm ID Oxide Coated	25 mm ID Plated
DRIVE: Technology type	Modified 3350	3380	3380	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Thin Film	Thin Film	Ferrite	Ferrite
Interface	NEC	NEC	NEC	Modified SA 1000	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 486.2	F: 672.2	F: 1344.9	U: 6.4	U: 25.5
REMOVABLE	--	--	--	U: 6.4	--
Capacity per track (Bytes)	F: 32,288	F: 47,476	F: 47,476	U: 10,032	U: 10,416
Data surfaces per spindle	9.5	5	6	4	4
Heads per data surface	2/1	2	2	1	1
Tracks per surface	1520	1770	2982	320	612
Track density (TPI)	1000	800	1200	454	980
Maximum linear density (BPI)	18600*	10133 FRPI 15300 BPI*	16100*	8738	12673
Rotational speed (RPM)	3070	3620	3620	3443	3578
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	16	17	40	40
Average rotational delay (msec)	9.8	8.3	8.3	8.7	8.38
Average access time (msec)	24.8	24.3	25.3	48.7	48.38
Data transfer rate (KBytes/sec)	1860	3000	3000	625	625
FIRST CUSTOMER SHIPMENT	3Q84	1983	9/86	3Q83	3Q85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Drive has two spindles	*2,7 RLL Code 4 spindles per drive	*2,7 RLL Code 4 spindles per drive	Embedded servo Licensed from DMA Systems	

1985 DISK/TREND REPORT

MANUFACTURER	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NEWBURY DATA	NIPPON ELECTRIC INDUSTRY
DRIVE	340 PENNY	1065	1105	1140	RD-3127
DISK/TREND GROUP	6	6	7	7	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 ID Plated	40 mm ID Plated	40 mm ID Plated	40 mm ID Plated	40 mm ID Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST 412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 50.1	U: 66.93	U: 105.18	U: 143.43	U: 12.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	8	7	11	15	2
Heads per data surface	1	1	1	1	1
Tracks per surface	612	918	918	918	612
Track density (TPI)	980	980	980	980	706
Maximum linear density (BPI)	12673	9875	9875	9875	9000
Rotational speed (RPM)	3578	3600	3600	3600	3545
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor
Average positioning time (msec)	40	30	30	30	85 (including settling)
Average rotational delay (msec)	8.38	8.3	8.3	8.3	8.46
Average access time (msec)	48.38	38.3	38.3	38.3	93.46
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	3Q85	4Q84	4Q84	4Q84	1Q85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		Licensed from Maxtor	Licensed from Maxtor	Licensed from Maxtor	1.625" High

MANUFACTURER	NIPPON ELECTRIC INDUSTRY	NIPPON ELECTRIC INDUSTRY	NIPPON ELECTRIC INDUSTRY	NIPPON ELECTRIC INDUSTRY	NIPPON ELECTRIC INDUSTRY
DRIVE	RD-3255	RD-4064	RD-4127	RD-4191	RD-4255
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST 412	ST412	ST 412	ST412	ST 412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.5	U: 6.4	U: 12.7	U: 19.1	U: 25.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	2	4	6	8
Heads per data surface	1	1	1	1	1
Tracks per surface	612	306	306	306	306
Track density (TPI)	706	400	400	400	400
Maximum linear density (BPI)	9000	8500	8500	8500	8500
Rotational speed (RPM)	3545	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	8.46	8.3	8.3	8.3	8.3
Average access time (msec)	93.46	93.3	93.3	93.3	93.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	1Q85	7/83	7/83	7/83	7/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	1.625" High				

RSPEC-77

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	NIPPON ELECTRIC INDUSTRY	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD
	RD-4510	NP02-13	NP02-26S	NP03-13	NP03-20
	6	5	5	5	5
	OEM	OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	95 mm OD 25 mm ID Oxide Coated	95 mm OD 25 mm ID Oxide Coated
	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	ST412	ST412	ST412	ST412	ST412
	U: 51.0	U: 13.33	U: 26.6	U: 12.7	U: 19.1
	--	--	--	--	--
	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
	8	4	4	4	6
	1	1	1	1	1
	612	320	640	306	306
	750	298	596	450	450
	9000	10200	10200	12500	12500
	3600	3600	3543	3600	3600
	Band, Stepping Motor 85 (including settling)	Rotary, Stepping Motor 95 (including settling)	Rotary, Stepping Motor 95 (including settling)	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)
	8.3	8.3	8.5	8.3	8.3
	93.3	103.3	103.5	93.3	93.3
	625	625	625	625	625
	4Q85	8/83	2/85	2/85	2/85
	--	--	--	--	--
		1.625" High	1.625" High		

1985 DISK/TREND REPORT

MANUFACTURER	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD
DRIVE					
	NP04-13T	NP04-20T	NP04-26F	NP04-36	NP04-50
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	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 Plated	40 mm ID Plated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 13.33	U: 20.0	U: 26.66	U: 36.4	U: 50.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	6	8	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	320	320	320	699	699
Track density (TPI)	298	298	298	754	754
Maximum linear density (BPI)	10200	10200	10200	9375	9375
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	95 (including settling)	95 (including settling)	95 (including settling)	45	45
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	103.3	103.3	103.3	53.3	53.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	2/83	2/83	5/83	11/83	11/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS					

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type
 Nominal disk diameter
 Recording medium

DRIVE: Technology type
 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

	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD
	NP04-85	NP25-A2 NP25-B2 NP25-C2	NP37-A01 NP37-B01	NP37-A02 NP37-B02 NP37-C02	NP38-AA4 NP38-A04 NP38-B04
	6	8	9	9	9
	OEM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
	Fixed	Fixed	Fixed	Fixed	Fixed
	130 mm OD 40 mm ID Plated	14" Oxide Coated	14" Oxide Coated	14" Oxide Coated	14" Oxide Coated
	Modified 3350	3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	ST412	IBM	IBM, Special	IBM	IBM
		1.144 MB Fixed Head Option			
	U: 86.3	F: 317.499	U: 680,988 F: 571.392	F: 729.858	F: 1260.5
	--	--	--	--	--
	U: 10,416	F: 19,069	F: 31,744	F: 31,744	F: 47,476
	11	15	12	12	16
	1	2	2	2	2/1
	754	1110	1500	1916	1770
	831	480	635	810	800
	9600	6425	12128*	12128*	15293*
	3600	3600	2964	2964	3600
	Rotary, Voice Coil	Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
	30	20	20	19	16
	8.3	8.3	10.12	10.12	8.3
	38.3	28.3	30.12	29.12	24.3
	625	1198	1859	1859	3000
	4/85	1977	1982	8/84	1985
	--	--	--	--	--
		PCM 3350	PCM 3370 *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code Drive has two spindles

MANUFACTURER	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON PERIPHERALS LTD	NIPPON SYSTEMHOUSE	NIPPON SYSTEMHOUSE
DRIVE	NP75-A01 NP75-B01 NP75-C01	NP75S-1	NP75S-2	SQ306RD	SQ325F
DISK/TREND GROUP	9	9	9	1	5
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	3.9" Cartridge	Fixed
Nominal disk diameter	14"	14"	14"	100 mm OD 40 mm ID Plated	100 mm OD 40 mm ID Plated
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated		
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	SMD	SMD	ST 412	ST 412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	F: 819.7	U: 868.848 F: 756.548	U: 868.848 F: 756.548	--	U: 25.5
REMOVABLE	--	--	--	U: 6.38	--
Capacity per track (Bytes)	F: 35,616	U: 37,632	U: 37,632	U: 10,416	U: 10,416
Data surfaces per spindle	12	12	12	2	4
Heads per data surface	2	2	2	1	1
Tracks per surface	1918	1924	1924	306	612
Track density (TPI)	810	810	810	435	764
Maximum linear density (BPI)	12128*	12128*	12128*	12186	12223
Rotational speed (RPM)	2964	2964	1913	3547	3547
PERFORMANCE					
Actuator type	Dual, Linear Voice Coil	Dual Linear, Voice Coil	Dual, Linear, Voice Coil	Band, Stepping Motor 90 (including settling)	Band, Stepping Motor 90 (including settling)
Average positioning time (msec)	19	19	19	8.46	8.46
Average rotational delay (msec)	10.12	10.12	15.7	8.46	8.46
Average access time (msec)	29.12	29.12	34.7	98.46	98.46
Data transfer rate (KBytes/sec)	1859	1859	1200	625	625
FIRST CUSTOMER SHIPMENT	9/84	9/84	1985	10/84	5/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PCM 3375 *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	Licensed by Syquest Technology. Embedded Servo 1.625" High 4.8" Wide	Licensed by Syquest Technology. Embedded Servo 1.625" High 4.8" Wide

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	NIPPON SYSTEMHOUSE	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
	SQ338F	8204X	8208X	8210X	8212X
	6	6	7	7	8
	OEM	OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	100 mm OD 40 mm ID Plated	200 mm OD 63.5 mm ID Oxide Coated	200 mm OD 63.5 mm ID Oxide Coated	200 mm OD 63.5 mm ID Oxide Coated	200 mm OD 63.5 mm ID Oxide Coated
	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	ST 412	SMD, SCSI	SMD, SCSI	SMD, SCSI	SMD, SCSI
	U: 38.2	F: 71.8 U: 93.7	F: 144 U: 187.3	F: 180 U: 234.2	F: 265 U: 350.2
	--	-	--	--	--
	U: 10,416	U: 21,912 F: 16,640 4	U: 21,912 F: 16,640 8	U: 21,912 F: 16,640 10	U: 21,912
	6	4	8	10	12
	1	1	1	1	1
	612	1069	1069	1069	1332
	764	1039	1039	1039	1280
	12223	10238	10238	10238	10238
	3547	3313	3313	3313	3313
	Band, Stepping Motor 90 (including settling)	Rotary, Torque Motor 20 (256 Byte sector)	Rotary, Torque Motor 20 (256 Byte sector)	Rotary, Torque Motor 20 (256 Byte sector)	Rotary, Torque Motor 22
	8.46	9.0	9.0	9.0	9.0
	98.46	29.0	29.0	29.0	31.0
	625	1209	1209	1209	1209
	5/85	9/83	9/83	9/83	6/85
	--	--	\$3320	\$3450	\$3950
	Licensed by Syquest Technology. Embedded Servo 1.625" High 4.8" Wide	Embedded Servo	Embedded Servo	Embedded Servo	Embedded Servo

MANUFACTURER	NORTHERN TELECOM	OLIVETTI PERIPHERAL EQUIPMENT	OLIVETTI PERIPHERAL EQUIPMENT	OLIVETTI PERIPHERAL EQUIPMENT	OLIVETTI PERIPHERAL EQUIPMENT
DRIVE	8310	HD 512/3	HD 563/11	HD 563/12	HD 563/13
DISK/TREND GROUP	8	5	5	5	5
MARKET	OEM	OEM	OEM, Captive	OEM, Captive	OEM, Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	63.5 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	3370	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Mod. SMD	Olivetti	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 378.6	U: 21.7	U: 6.38	U: 12.76	U: 19.14
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 34,300	U: 10,080	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	10	5	2	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1104	430	306	306	306
Track density (TPI)	1056	605	345	345	345
Maximum linear density (BPI)	16200 BPI	8166	9074	9074	9074
Rotational speed (RPM)	10800 FRPI 3313	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	20 (256 Byte sector)	26	85 (including settling)	85 (including settling)	85 (including settling)
Average rotational delay (msec)	9.0	8.3	8.3	8.3	8.3
Average access time (msec)	29.0	34.3	93.3	93.3	93.3
Data transfer rate (KBytes/sec)	1895	605	625	625	625
FIRST CUSTOMER SHIPMENT	6/85	1982	1983	1983	1983
U.S. OEM PRICE FOR 100 UNITS	\$4,100	--	--	--	--
COMMENTS	Embedded Servo				

1985 DISK/TREND REPORT

RSPEC-83

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	OLIVETTI PERIPHERAL EQUIPMENT	OLIVETTI PERIPHERAL EQUIPMENT	OLIVETTI PERIPHERAL EQUIPMENT	OLIVETTI PERIPHERAL EQUIPMENT	OLIVETTI PERIPHERAL EQUIPMENT
	HD 661/11	HD 661/12	HD 662/11	HD 662/12	HD 670/12
	5	5	5	5	5
	OEM, Captive	OEM, Captive	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
	3350	3350	Modified 3350	Modified 3350	Modified 3350
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	ST412	ST412	ST412	ST412	ST412
	U: 6.375	U: 12.75	U: 12.75	U: 25.52	U: 25.52
	--	--	--	--	--
	U: 10,417	U: 10,417	U: 10,417	U: 10,417	U: 10,417
	2	4	2	4	4
	1	1	1	1	1
	306	306	612	612	612
	345	345	690	690	690
	8952	8952	8952	8952	8952
	3600	3600	3573	3573	3573
	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 40 (including settling)
	8.3	8.3	8.39	8.39	8.39
	93.3	93.3	93.39	93.39	48.39
	625	625	625	625	625
	2Q84	2Q84	2Q85	2Q85	3Q85
	--	--	--	--	--
	1.625" High	1.625" High	1.625" High	1.625" High	1.625" High

MANUFACTURER	OTARI ELECTRIC CO., LTD.	OTARI ELECTRIC CO., LTD.	OTARI ELECTRIC CO., LTD.	OTARI ELECTRIC CO., LTD.	OTARI ELECTRIC CO., LTD.
DRIVE	C-214	C-226	C-507	C-514	C-519
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 Plated	40 mm ID Plated	40 MM ID Oxide Coated	40 MM ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 12.75	U: 25.5	U: 6.38	U: 12.75	U: 19.13
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,417	U: 10,417	U: 10,417
Data surfaces per spindle	2	4	2	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	612	612	306	306	306
Track density (TPI)	650	650	383	383	383
Maximum linear density (BPI)	10300	10300	8944	8944	8944
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	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)	90 (including settling)	90 (including settling)	90 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	93.3	98.3	98.3	98.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	9/85	9/85	1/83	1/83	1/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	1.625" High	1.625" High	Licensed By Discron	Licensed By Discron	Licensed By Discron

MANUFACTURER	OTARI ELECTRIC CO., LTD.	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERSCI	PERSCI
DRIVE	C-526	PT-325	PT-338	VF-2221 VT-2221	VF-2222 VT-2222
DISK/TREND GROUP	5	5	6	1	1
MARKET	OEM	OEM	OEM	OEM, Captive	OEM, Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	2315/5440	2315/5440
Nominal disk diameter	130 mm OD	95 mm OD	95 mm OD	14"	14"
Recording medium	40 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	2314	2314
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	Various Options	Various Options
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.5	U: 25.47	U: 38.2	U: 6.25	U: 6.25
REMOVABLE	--	--	--	U: 6.25	U: 6.25
Capacity per track (Bytes)	U: 10,417	U: 10,404	U: 10,404	U: 7,812	U: 7,812
Data surfaces per spindle	8	4	6	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	306	612	612	408	408
Track density (TPI)	383	983	983	200	200
Maximum linear density (BPI)	8944	12000	12000	200	200
Rotational speed (RPM)	3600	3573	3573	1500	2400
PERFORMANCE					
Actuator type	Rotary, Band Stepping Motor	Linear, DC Motor	Linear, DC Motor	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	90 (including settling)	40 (including settling)	40 (including settling)	35	35
Average rotational delay (msec)	8.3	8.4	8.4	20	12.5
Average access time (msec)	98.3	48.4	48.4	55	47.5
Data transfer rate (KBytes/sec)	625	625	625	195	312.5
FIRST CUSTOMER SHIPMENT	1/83	1986	1986	2Q80	2Q80
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Licensed By Discatron	Embedded Servo	Embedded Servo		

MANUFACTURER	PERSCI	PERTEC	PERTEC	PERTEC	PRIAM
DRIVE	VT-2422	DX199	DX265	DX332	803
DISK/TREND GROUP	2	7	7	8	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	5440	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: Technology type	2314	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Various Options	ANSI, SMD	ANSI, SMD	ANSI, SMD	Priam, SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 12.5	U: 199	U: 265	U: 332	U: 85.68
REMOVABLE	U: 12.5	--	--	--	--
Capacity per track (Bytes)	U: 15,625	U: 20,160	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	4	6	8	10	5
Heads per data surface	1	1	1	1	1
Tracks per surface	408	1649	1649	1649	850
Track density (TPI)	200	1083	1083	1083	960
Maximum linear density (BPI)	4400	12022*	12022*	12022*	9167
Rotational speed (RPM)	2400	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	35	22	22	22	35
Average rotational delay (msec)	12.5	8.3	8.3	8.3	8.3
Average access time (msec)	47.5	30.3	30.3	30.3	43.3
Data transfer rate (KBytes/sec)	625	1208	1208	1208	1209
FIRST CUSTOMER SHIPMENT	2Q80	4/85	4/85	4/85	9/83
U.S. OEM PRICE FOR 100 UNITS	--	\$3600	\$3850	\$4100	\$2,950
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE					
	3450	6650	7050	V130	V150
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	200 mm OD	14"	200 mm OD	130 mm OD	130 mm OD
Recording medium	63.5 mm ID Oxide Coated	Oxide Coated	63.5 mm ID Oxide Coated	40 mm ID Plated	40 mm ID Plated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Priam, SMD	Priam, SMD	Priam, SMD	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 35.28	U: 67.9	U: 70.49	U: 30.8	U: 51.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 13,440	U: 20,160	U: 13,400	U: 10,416	U: 10,416
Data surfaces per spindle	5	1.5	5	3	5
Heads per data surface	1	2/1	1	1	1
Tracks per surface	525	2242	1049	987	987
Track density (TPI)	480	960	960	960	960
Maximum linear density (BPI)	6597	6430	6597	9897	9897
Rotational speed (RPM)	3600	3100	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	42	46	42	30	30
Average rotational delay (msec)	8.3	9.7	8.3	8.3	8.3
Average access time (msec)	50.3	55.7	50.3	38.3	38.3
Data transfer rate (KBytes/sec)	806	1040	806	625	625
FIRST CUSTOMER SHIPMENT	4Q80	3Q80	4Q81	4Q83	4Q83
U.S. OEM PRICE FOR 100 UNITS	\$2,325	\$2,660	\$2,850	\$1,450	\$1,580
COMMENTS					

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE	V170	V185	15450	514	519
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"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Plated	Plated	Oxide Coated	Plated/Sputtered	Plated/Sputtered
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	Modified 3350	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	Priam, SMD	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 72.0	U: 85.0	U: 158.5	U: 140.2	U: 191.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 20,160	U: 10,416	U: 10,416
Data surfaces per spindle	7	7	3.5	11	15
Heads per data surface	1	1	2/1	1	1
Tracks per surface	987	1166	2242	1224	1224
Track density (TPI)	960	1000	960	1070	1070
Maximum linear density (BPI)	9897	10979	6430	10924	10924
Rotational speed (RPM)	3600	3600	3100	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	30	30	46	20	20
Average rotational delay (msec)	8.3	8.3	9.7	8.3	8.3
Average access time (msec)	38.3	38.3	55.7	28.3	28.3
Data transfer rate (KBytes/sec)	625	625	1040	625	625
FIRST CUSTOMER SHIPMENT	4Q83	3Q84	3Q81	1Q86	1Q86
U.S. OEM PRICE FOR 100 UNITS	\$1,850	\$1,930	\$3,895	\$2,270	\$2,475
COMMENTS					

MANUFACTURER	PRIAM	PRIAM	PRIAM	QUANTUM	QUANTUM
DRIVE	806	807	808	Q520	Q2010
DISK/TREND GROUP	7	8	9	5	5
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	130 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Plated	63.5 mm ID Oxide Coated	40 mm ID Oxide Coated	63.5 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	3350	3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Priam,SMD,SCSI	Priam,SMD,SCSI	Priam, Mod. SMD	ST412	SA1000
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 188.5	U: 344	U: 516	U: 21.33	U: 10.66
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 30,240	U: 10,416	U: 10,400
Data surfaces per spindle	11	11	12	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	850	1552	1422	512	512
Track density (TPI)	960	1040	1040	591	345
Maximum linear density (BPI)	9167	12096	18144*	9200	6600
Rotational speed (RPM)	3600	3600	3600	3529	3000
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	20	25	25	45	50
Average rotational delay (msec)	8.3	8.3	8.3	8.5	10
Average access time (msec)	28.3	33.3	33.3	53.5	60
Data transfer rate (KBytes/sec)	1210	1210	1810	625	543
FIRST CUSTOMER SHIPMENT	5/84	6/84	3Q84	4/83	1Q81
U.S. OEM PRICE FOR 100 UNITS	\$3,280	\$4,105	\$4,630	\$1,245	\$1,350
COMMENTS			*2,7 RLL Code		

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	Q2020	Q530	Q540	Q2030	Q2040
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	200 mm OD	130 mm OD	130 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated
DRIVE: Technology type	3350	3350	3350	3350	3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SA1000	ST412	ST412	SA1000	SA1000
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 21.33	U: 31.99	U: 42.66	U: 32.0	U: 42.66
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,400	U: 10,416	U: 10,416	U: 10,400	U: 10,400
Data surfaces per spindle	4	6	8	6	8
Heads per data surface	1	1	1	1	1
Tracks per surface	512	512	512	512	512
Track density (TPI)	345	591	591	345	345
Maximum linear density (BPI)	6600	9200	9200	6600	6600
Rotational speed (RPM)	3000	3529	3529	3000	3000
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	55	45	45	60	65
Average rotational delay (msec)	10	8.5	8.5	10	10
Average access time (msec)	65	53.5	53.5	70	75
Data transfer rate (KBytes/sec)	543	625	625	543	543
FIRST CUSTOMER SHIPMENT	1Q81	4/83	4/83	1Q81	1Q81
U.S. OEM PRICE FOR 100 UNITS	\$1,625	\$1,365	\$1,485	\$1,950	\$2,275
COMMENTS					

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	QUANTUM	QUANTUM	QUANTUM	RICOH	RODIME
	Q2080	Q250	Q280	RH5130	201
	6	6	6	2	5
	OEM	OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	5.25" Cartridge	Fixed
	200 mm OD 63.5 mm ID Oxide Coated	130 mm OD 40 mm ID Sputtered	130 mm OD 40 mm ID Sputtered	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
	3350	3370(Ferrite)	3370(Ferrite)	Modified 3350	Modified 3350
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	SA1000	SCSI	SCSI	ST412	ST412
	U: 85.45	F: 53.4	F: 80.1	U: 12.75	U: 6.67
	--	--	--	--	--
	U: 10,416	F: 16,384	F: 16,384	U: 10,416	U: 10,416
	7	4	6	2	2
	1	1	1	1	1
	1172	815	815	612	320
	789	876	876	612	356
	6600	20000 BPI* 15000 FCI	20000 BPI* 15000 FCI	10894	8720
	3000	3600	3600	3473	3600
	Rotary, Torque Motor 40	Rotary, Torque Motor 30	Rotary, Torque Motor 30	Rack & Pinion, Stepping Motor 98 (including settling)	Rotary, Band, Stepping Motor 90 (including settling)
	10	8.3	8.3	8.6	8.3
	50	38.3	38.3	106.6	98.3
	543	1250	1250	625	625
	11/82	12/85	12/85	3Q85	6/82
	\$2,800	--	\$995 (1000)	--	--
		*1,7 RLL Code 1.625" High Embedded Servo	*1,7 RLL Code 1.625" High Embedded Servo	1.625" High Embedded Servo DMA License	

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	201E	202	202E	203	204
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: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 13.33	U: 13.33	U: 26.67	U: 20.0	U: 26.67
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	2	4	4	6	8
Heads per data surface	1	1	1	1	1
Tracks per surface	640	320	640	320	320
Track density (TPI)	600	356	600	356	356
Maximum linear density (BPI)	10300	8720	10300	8720	8720
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	55 (including settling)	90 (including settling)	55 (including settling)	90 (including settling)	90 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	63.3	98.3	63.3	98.3	98.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	4/84	6/82	4/84	6/82	6/82
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS					

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

	RODIME	RODIME	RODIME	RODIME	SEAGATE TECHNOLOGY
	251 351	252 352	203E	204E	ST212
	5	5	6	6	5
	OEM	OEM	OEM	OEM	OEM
	Fixed	Fixed	Fixed	Fixed	Fixed
	96 mm OD 40 mm ID Oxide/Plated	96 mm OD 40 mm ID Oxide/Plated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
	Modified 3350	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)
	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
	ST412	ST412	ST412	ST412	ST412
	U: 6.38	U: 12.75	U: 40.0	U: 53.34	U: 12.76
	--	--	--	--	--
	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
	2	4	6	8	2
	1	1	1	1	2
	306	306	640	640	612
	600	600	600	600	550
	11200	11200	10300	10300	10568
	3600	3600	3600	3600	3600
	Rotary, Band, Stepping Motor 85 (including settling)	Rotary, Band, Stepping Motor 85 (including settling)	Rotary, Band, Stepping Motor 55 (including settling)	Rotary, Band, Stepping Motor 55 (including settling)	Linear, Band, Stepping Motor 65 (including settling)
	8.3	8.3	8.3	8.3	8.3
	93.3	93.3	63.3	63.3	73.3
	625	625	625	625	625
	9/83	9/83	4/83	4/83	4Q84
	--	--	--	--	--
	250 Series uses frame to match half high 5.25" form factor	250 series uses frame to match half high 5.25" form factor			1.625" High

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SIEMENS
DRIVE	ST225	ST4026	ST4038	ST4051	1100
DISK/TREND GROUP	5	5	6	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	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	Sputtered	Plated
DRIVE: Technology type	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)	3370
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	ST412	ST412	ST412	ST412	ANSI, ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.62	U: 25.62	U: 38.17	U: 50.88	U: 102.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 21,000
Data surfaces per spindle	4	4	5	5	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	733	977	1224
Track density (TPI)	588	625	750	960	1207
Maximum linear density (BPI)	9827	9617	9617	9720	19077 (BPI) 12718 (FCI)
Rotational speed (RPM)	3600	3600	3600	3600	3571
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	65 (including settling)	40 (including settling)	40 (including settling)	40 (including settling)	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.4
Average access time (msec)	73.3	48.3	48.3	48.3	33.4
Data transfer rate (KBytes/sec)	625	625	625	625	1250
FIRST CUSTOMER SHIPMENT	10/84	11/84	1/85	1/85	4Q85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$2425
COMMENTS	1.625" High				

MANUFACTURER	SIEMENS	SIEMENS	SORD	SORD	STORAGE TECHNOLOGY CORPORATION
DRIVE	1200	1300	HD-503	HD-513	8380-A4 8380-AA4 8380-B4
DISK/TREND GROUP	7	8	5	5	9
MARKET	OEM	OEM	OEM, Captive	OEM, Captive	PCM, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Plated	Plated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	3370	3370	Modified 3350	Modified 3350	3380
Heads	Thin Film	Thin Film	Ferrite	Ferrite	Thin Film
Interface	ANSI, ESDI	ANSI, ESDI	ST412	ST412	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 205.6	U: 308.4	U: 10.0	U: 27.5	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 21,000	U: 21,000	U: 10,416	U: 10,416	F: 47,476
Data surfaces per spindle	8	12	6	6	15
Heads per data surface	1	1	1	1	2
Tracks per surface	1224	1224	160	440	1770
Track density (TPI)	1207	1207	254	508	800
Maximum linear density (BPI)	19077 (BPI) 12718 (FCI)	19077 (BPI) 12718 (FCI)	7690	8853	10160 FRPI 15240 BPI
Rotational speed (RPM)	3571	3571	3600	3600	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Dual, Linear, Voice Coil
Average positioning time (msec)	25	25	76 (including settling)	127 (including settling)	16
Average rotational delay (msec)	8.4	8.4	8.3	8.3	8.3
Average access time (msec)	33.4	33.4	84.3	135.3	24.3
Data transfer rate (KBytes/sec)	1250	1250	625	625	3000
FIRST CUSTOMER SHIPMENT	4Q85	4Q85	2/83	5/84	1983
U.S. OEM PRICE FOR 100 UNITS	\$3427	\$3825	--	--	--
COMMENTS					PCM 3380 Drive has two spindles

MANUFACTURER	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	8380-BE4	8650-A2 8650-B2	SQ306RD	SQ312RD	SQ325F
DISK/TREND GROUP	9	9	1	2	5
MARKET	PCM, OEM	PCM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	3.9" Cartridge	QPAK SQ200	Fixed
Nominal disk diameter	14"	14"	100 mm OD 40 mm ID Plated	100 mm OD 40 mm ID Plated	100 mm OD 40 mm ID Plated
Recording medium	Oxide Coated	Oxide Coated			
DRIVE: Technology type	3380 x 2	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY		1.144 MB Fixed Head Option			
Total capacity (MBytes) FIXED	F: 2.52	F: 635	--	--	U: 25.5
REMOVABLE	--	--	U: 6.38	U: 12.75	--
Capacity per track (Bytes)	F: 47,476	F: 19,069	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	15	15	2	2	4
Heads per data surface	2	2	1	1	1
Tracks per surface	3540	2220	306	612	612
Track density (TPI)	*	957	435	740	764
Maximum linear density (BPI)	*	6425	12186	12400	12223
Rotational speed (RPM)	3620	3600	3547	3547	3547
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor 90 (including settling)	Band, Stepping Motor 90 (including settling)	Band, Stepping Motor 90 (including settling)
Average positioning time (msec)	17	18	90	90	90
Average rotational delay (msec)	8.3	8.3	8.46	8.46	8.46
Average access time (msec)	25.3	26.3	98.46	98.46	98.46
Data transfer rate (KBytes/sec)	3000	1198	625	625	625
FIRST CUSTOMER SHIPMENT	4Q86	5/79	9/82	7/84	6/84
U.S. OEM PRICE FOR 100 UNITS	--	--	\$710	\$875	\$850
COMMENTS	PCM 3380-BE4 *not announced Drive has two spindles	PCM 3350 Drive has two spindles	Embedded Servo 1.625" High 4.8" Wide	Embedded Servo 1.625" High 4.8" Wide	Embedded Servo 1.625" High 4.8" Wide

MANUFACTURER	SYQUEST TECHNOLOGY	TANDON	TANDON	TANDON	TANDON
DRIVE	SQ338F	TM502	TM503	TM252	TM362
DISK/TREND GROUP	6	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	100 mm OD	130 mm OD	130 mm OD	130 mm OD	95 mm OD
Recording medium	40 mm ID Plated	40 mm ID Plated	40 mm ID Plated	40 mm ID Plated	25 mm ID Plated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 38.2	U: 12.75	U: 19.14	U: 12.75	U: 25.62
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	6	4	6	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	612	306	306	306	615
Track density (TPI)	764	345	345	345	804
Maximum linear density (BPI)	12223	9074	9074	9074	13739
Rotational speed (RPM)	3547	3600	3600	3600	3568
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Band Stepping Motor	Rotary, Band Stepping Motor	Rotary, Band Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	90 (including settling)	206 (including settling)	206 (including settling)	100 (including settling)	80 (including settling)
Average rotational delay (msec)	8.46	8.3	8.3	8.3	8.4
Average access time (msec)	98.46	214.3	214.3	108.3	88.4
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	5/84	9/82	9/82	7/83	4/85
U.S. OEM PRICE FOR 100 UNITS	\$1000	\$300 (2500)	\$390 (2500)	\$300 (2500)	\$375 (2500)
COMMENTS	Embedded Servo 1.625" High 4.8" Wide			1.625 " High	1.625 " High TM262 is Packaged as 5.25" Half High

MANUFACTURER	TANDON	TANDON	TEAC	TEAC	TEAC
DRIVE					
	TM703	TM755	SD-412	SD-506	SD-510
DISK/TREND GROUP	6	6	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 Plated	40 mm ID Plated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	3370 (Ferrite)	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 36.1	U: 51.04	U: 12.76	U: 6.38	U: 12.76
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,417	U: 10,417	U: 10,416
Data surfaces per spindle	5	5	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	578	981	306	153	306
Track density (TPI)	700	960	345	255	345
Maximum linear density (BPI)	10,000	9528	9074	7690	9074
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	39 (including settling)	35	170 (including settling)	170 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	47.3	43.3	178.3	178.3	93.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	1/83	4/85	3Q82	3Q82	4/84
U.S. OEM PRICE FOR 100 UNITS	\$650 (2500)	\$850 (2500)	--	--	--
COMMENTS		1.625" High	Licensed by Seagate	Licensed by Seagate	1.625" High

MANUFACTURER	TEAC	TECSTOR	TECSTOR	TECSTOR	TECSTOR
DRIVE					
	SD-520	3/315	3/316	3/317	3/318
DISK/TREND GROUP	5	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	14"	14"	14"	14"
Recording medium	40 mm ID Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SMD	SMD	SMD	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.52	U: 315.2	U: 315.2	U: 315.2	U: 315.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,160	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	4	9.5	9.5	9.5	9.5
Heads per data surface	1	2	2	2	2
Tracks per surface	612	1646	1646	1646	1646
Track density (TPI)	690	680	680	680	680
Maximum linear density (BPI)	9074	6450	6450	6450	6450
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	29	29	29	29
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	37.3	37.3	37.3	37.3
Data transfer rate (KBytes/sec)	625	1209	1209	1209	1209
FIRST CUSTOMER SHIPMENT	5/85	12/82	12/82	12/82	12/82
U.S. OEM PRICE FOR 100 UNITS	--	\$5,600	--	--	--
COMMENTS			Compatible with Tandem T16/4104	Compatible with Honeywell BK7A3	Compatible with CDC 9766

MANUFACTURER	TECSTOR	TECSTOR	TECSTOR	TOKICO	TOKICO
DRIVE	3/319	3/320	3/332	DK502-1	DK502-2
DISK/TREND GROUP	8	8	8	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SMD	SMD	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 315.2	U: 315.2	U: 331.8	U: 13.3	U: 20.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 20,160	U: 10,416	U: 10,416
Data surfaces per spindle	9.5	9.5	10	4	6
Heads per data surface	2	2	2	1	1
Tracks per surface	1646	1646	1646	320	320
Track density (TPI)	680	680	680	360	360
Maximum linear density (BPI)	6450	6450	6450	9260	9260
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil 29	Rotary, Voice Coil 29	Rotary, Voice Coil 29	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)
Average positioning time (msec)	8.3	8.3	8.3	8.3	8.3
Average rotational delay (msec)	37.3	37.3	37.3	93.3	93.3
Average access time (msec)	1209	1209	1209	625	625
DATA TRANSFER RATE (KBytes/sec)					
FIRST CUSTOMER SHIPMENT	12/82	12/82	12/82	10/83	10/83
U.S. OEM PRICE FOR 100 UNITS	--	--	\$5,700	--	--
COMMENTS	Compatible with Wang 2265V2	Compatible with Prime 447XF			

MANUFACTURER

DRIVE

DISK/TREND GROUP

MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Technology type

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

TOKICO	TOKICO	TOKICO	TOKICO	TOKYO ELECTRIC COMPANY
DK502-3	DK503-1	DK503-2	DK505-2	TD-5512
5	5	5	5	5
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
ST412	ST412	ST412	ST412	ST412
U: 26.6	U: 6.66	U: 13.33	U: 25.5	U: 12.75
--	--	--	--	--
U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
8	2	4	4	2
1	1	1	1	1
320	320	320	612	612
360	360	360	670	550
9260	9260	9260	9490	10568
3600	3600	3600	3550	3573
Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 85 (including settling)	Band, Stepping Motor 65 (including settling)
8.3	8.6	8.6	8.45	8.4
93.3	93.6	93.6	93.45	73.4
625	625	625	625	625
10/83	10/83	10/83	3/85	3Q85
--	--	--	--	--
	1.625" High	1.625" High	1.625" High	1.625" High

1985 DISK/TREND REPORT

MANUFACTURER	TOKYO ELECTRIC COMPANY	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION
DRIVE					
	TD-5526	MK-800R-32	MK-800R-64	MK-800R-96	MK-50F
DISK/TREND GROUP	5	2	2	2	5
MARKET	OEM	OEM, Captive	OEM, Captive	OEM, Captive	Captive
MEDIA: Generic type	Fixed	CMD	CMD	CMD	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	14"	14"	14"	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	Modified 3350	3330-11	3330-11	3330-11	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SMD	SMD	SMD	ST412, SASI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 25.5	U: 16.289	U: 48.868	U: 80.446	U: 12.75
REMOVABLE	--	U: 16.289	U: 16.289	U: 16.289	--
Capacity per track (Bytes)	U: 10,416	U: 20,160	U: 20,160	U: 20,160	U: 10,416
Data surfaces per spindle	4	1 Fixed 1 Removable	3 Fixed 1 Removable	5 Fixed 1 Removable	4
Heads per data surface	1	2 Fixed 1 Removable	2 Fixed 1 Removable	2 Fixed 1 Removable	1
Tracks per surface	612	823	823	823	306
Track density (TPI)	550	367 Fixed 384 Removable	367 Fixed 384 Removable	367 Fixed 384 Removable	345
Maximum linear density (BPI)	10568	6274 Fixed 6038 Removable	6274 Fixed 6038 Removable	6274 Fixed 6038 Removable	9074
Rotational speed (RPM)	3573	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Fix: Rotary VC Rem: Linear VC	Fix: Rotary VC Rem: Linear VC	Fix: Rotary VC Rem: Linear VC	Band, Stepping Motor
Average positioning time (msec)	65 (including settling)	30	30	30	85 (including settling)
Average rotational delay (msec)	8.4	8.3	8.3	8.3	8.3
Average access time (msec)	73.4	38.3	38.3	38.3	93.3
Data transfer rate (KBytes/sec)	625	1209	1209	1209	625
FIRST CUSTOMER SHIPMENT	3Q85	2Q80	2Q80	2Q80	2Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	1.625" High				2.09" High

MANUFACTURER	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION
DRIVE					
	MK-80F-10	MK-80F-20	MK-53FAB	MK-54FAB	MK-56FAB
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM, Captive	OEM, Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	210 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Technology type	Modified 3350	Modified 3350	3370 (Ferrite)	3370 (Ferrite)	3370 (Ferrite)
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SMD	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 15.3	U: 23.0	U: 43.2	U: 60.5	U: 86.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	2	3	5	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	380	380	830	830	830
Track density (TPI)	450	450	900	900	900
Maximum linear density (BPI)	8824	8824	9383	9383	9383
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	25	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	48.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	1210	1210	625	625	625
FIRST CUSTOMER SHIPMENT	2Q81	2Q81	3/85	3/85	3/85
U.S. OEM PRICE FOR 100 UNITS	--	--	\$1540	\$1605	\$1665
COMMENTS					

MANUFACTURER	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION	TULIN
DRIVE	MK-80F-30	MK-182FA MK-182FB	MK-184FA MK-184FB	MK-186FA MK-186FB	TL226
DISK/TREND GROUP	6	6	7	7	5
MARKET	OEM, Captive	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	210 mm OD	210 mm OD	210 mm OD	130 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Plated
DRIVE: Technology type	Modified 3350	Modified 3350	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SMD	SMD	SMD	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 38.3	U: 83.0	U: 116.1	U: 165.9	U: 26.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 20,160	U: 20,160	U: 10,416
Data surfaces per spindle	5	5	7	10	4
Heads per data surface	1	1	1	1	1
Tracks per surface	380	823	823	823	640
Track density (TPI)	450	900	900	900	656
Maximum linear density (BPI)	8824	6,000 FCI 9,000 BPI	6,000 FCI 9,000 BPI	6,000 FCI 9,000 BPI	10,000
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, band stepping motor
Average positioning time (msec)	40	18	18	18	85 (Including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	26.3	26.3	26.3	93.3
Data transfer rate (KBytes/sec)	1210	1210	1210	1210	625
FIRST CUSTOMER SHIPMENT	2Q81	2Q83	2Q83	4Q83	3/84
U.S. OEM PRICE FOR 100 UNITS	--	\$2345	\$2455	\$2680	\$650
COMMENTS		Average Positioning Time for MK-182FB is 20 ms	Average Positioning Time for MK-184FB is 20 ms	Average Positioning Time for MK-186FB is 20 ms	Embedded servo 1.625" high

MANUFACTURER	TULIN	VERMONT RESEARCH	VICTOR COMPANY OF JAPAN	VICTOR COMPANY OF JAPAN	WESTERN DYNEX
DRIVE	TL240	5017-4	JD-3806M	JD-3812M	WD-505
DISK/TREND GROUP	5	2	5	5	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	5440	Fixed	Fixed	5.25" Cartridge
Nominal disk diameter	130 mm OD 40 mm ID Plated	14"	95 mm OD 25 mm ID Plated	95 mm OD 25 mm ID Plated	130 mm OD 40 mm ID Oxide Coated
Recording medium		Oxide Coated			
DRIVE: Technology type	Modified 3350	3330-11	Modified 3350	Modified 3350	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	VRL, SASI, ANSI X3T9/1226	Modified ST412	Modified ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	U: 40.0	F: 26.2	U: 6.33	U: 12.65	--
REMOVABLE	--	F: 26.2	--	--	F: 6.38
Capacity per track (Bytes)	U: 10,416	F: 12,800	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	6	4	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	640	1024	306	612	306
Track density (TPI)	656	500	566	849	345
Maximum linear density (BPI)	10,000	4000	11439	12808	9022
Rotational speed (RPM)	3600	3165	2322	2322	3600
PERFORMANCE					
Actuator type	Rotary, band, stepping motor	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	45	130 (including settling)	135 (including settling)	45 (including settling)
Average rotational delay (msec)	8.3	9.5	12.9	12.9	8.3
Average access time (msec)	93.3	54.5	142.9	147.9	53.3
Data transfer rate (KBytes/sec)	625	673	400	400	625
FIRST CUSTOMER SHIPMENT	3/84	1975	7/85	9/85	3Q84
U.S. OEM PRICE FOR 100 UNITS	\$850	\$13,065	--	--	--
COMMENTS	Embedded servo 1.625" high	Embedded Servo	Embedded Servo 1.14" high	Embedded Servo 1.14" high	

MANUFACTURER	WESTERN DYNEX	WESTERN DYNEX	WESTERN DYNEX	WESTERN DYNEX	XEBEC
DRIVE	DD-6121	DD-6122	DD-6221	DD-6222	4000 Ow1
DISK/TREND GROUP	1	1	1	2	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	2315/5440	2315/5440	2315/5440	2315/5440	Fixed
Nominal disk diameter	14"	14"	14"	14"	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Technology type	2314	2314	2314	2314	Modified 3350
Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Various Options	Various Options	Various Options	Various Options	SASI
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes) FIXED	--	--	U: 3.13	U: 6.25	F: 10.65
REMOVABLE	U: 3.13	U: 6.25	U: 3.13	U: 6.25	--
Capacity per track (Bytes)	U: 7,812	U: 7,812	U: 7,812	U: 7,812	F: 8,704
Data surfaces per spindle	2	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	203	406	203	406	306
Track density (TPI)	100	200	100	200	367
Maximum linear density (BPI)	2200	2200	2200	2200	8842
Rotational speed (RPM)	1500/2400	1500/2400	1500/2400	1500/2400	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor
Average positioning time (msec)	35	35	35	35	85 (including settling)
Average rotational delay (msec)	20/12.5	20/12.5	20/12.5	20/12.5	8.3
Average access time (msec)	55/47.5	55/47.5	55/47.5	55/47.5	93.3
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	195/312.5	195/312.5	625
FIRST CUSTOMER SHIPMENT	1972	1973	1972	1973	4Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$400
COMMENTS					1.625" High

1985 DISK/TREND REPORT

OPTICAL DISK DRIVE SPECIFICATIONS

Coverage

The following pages list most optical disk drives intended for computer data storage which are now announced or in new production. They are arranged alphabetically by manufacturer.

Recording medium

The composition of the active layer of optical media varies according to manufacturer. The formulation given is the one described by the drive manufacturer. Other formulations of other manufacturers may not operate properly.

Interface

Specific interfaces are listed for most of the drives. As this area is subject to frequent change, consult the manufacturers' most current specifications to insure you have accurate data.

Speed control

Two abbreviations are used here: CAV=constant angular velocity.
CLV=constant linear velocity.

Capacities

Capacities are listed as "U" for unformatted and "F" for formatted. In general, optical drives are preformatted, so the capacity given will be the formatted capacity.

Positioner type

Many optical drives have a multi-stage head positioner. A coarse movement positions the head in the general vicinity of the track to be located. A fine, or vernier, actuator then moves the head to the desired track. Where appropriate, the abbreviation "Crs." is used for "coarse".

OEM prices

The 100 unit price is given for most OEM drives sold in the United States. These prices are often changed by the manufacturers without notice and should be considered as guidelines only. Consult the manufacturer for the current price.

Accuracy

All of the information in this section has been checked for accuracy. However, it is anticipated that some errors may exist due to the rapid state of change within this category and because published specifications do not always cover all of the items listed, requiring verbal inquiries and updates.

1985 DISK/TREND optical disk product groups

While all of the optical drives have been discussed within one portion of the statistical section of this report, three product groups have been defined:

Group 10: Read-only optical disk drives.

Group 11: Read/write disk drives, less than 1 gigabyte.

Group 12: Read/write disk drives, more than 1 gigabyte.

The drives described in this section have been classified in the appropriate group.

MANUFACTURER	ALCATEL THOMSON GIGADISC	FUJITSU, LTD.	HITACHI, LTD.	HITACHI, LTD.	INFORMATION STORAGE INC.
DRIVE	GD1001	F6441B1	CDR 1502S	OD 301-1	525 WC
DISK/TREND GROUP	12	12	10	12	11
MARKET	OEM	Captive	OEM	Captive/OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	4.72"	12"	5.25"
Recording medium	Au-Pt-Polymer	Au-Pt-Polymer	Aluminum	Te-Se-Pb	Te Alloy
Track format	Spiral	Te Alloy	Spiral	Spiral	Concentric
Recording method	Bubble	Pit	Mastering	Pit	Pit
DRIVE: Operating mode	Write Once	Write Once	Read Only	Write Once	Write Once
Interface	SCSI/Prop.	3350-like	PC	SCSI/GPIB/SMD	ESDI/SCSI/PC
Speed control	CAV	CAV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes)	F: 1,000	F: 1,376	F: 552	F: 1,310	F: 100
Capacity per track (Bytes)	F: 25,600	F: 30,720	F: N/A	F: 31,700	F: 8192
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	40,000	44,800	40,640	41,300	40,640
Track density (TPI)	14,432	15,875	15,875	16,000	15,875
Maximum linear density (BPI)	14,500	24,144	27,600	19,500	27,600
Rotational speed (RPM)	1121.5	900	429-200	600	1800
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Solenoid	Crs: Voice Coil Fine: Lens Actuator	Crs: Stepping Motor Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Stepping Motor Fine: Galvonom.
Average positioning time (msec)	200	210.7	400	200	183
Average rotational delay (msec)	27	33.3	600	50	16.7
Average access time (msec)	227	244	1000	250	200
Data transfer rate (KBytes/sec)	479	783	176	440	300
FIRST CUSTOMER SHIPMENT	3Q 1984	3Q 1985	3Q 1985	2Q 1984	3Q 1985
U.S. OEM PRICE FOR 100 UNITS	\$6,933	N/A	\$950	\$12,500	\$800
COMMENTS	Also works with 3M media	Available only in Japan. F6441A1 has SCSI interface.	Has built in ECC. Model CDR 2500 mounts in PC. Price \$900.	Price includes controller	Grooveless Tracking system I.S.I. will certify media.

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o-dd
Nakamura

MANUFACTURER	MATSUSHITA ELECTRIC CO.	MATSUSHITA ELECTRIC CO.	NEC	NIPPON COLUMBIA	OPTICAL STORAGE INTERNATIONAL
DRIVE	SQ-D100	LD-10	N6329-21 N7911	DRD-550	LASERDRIVE 1200
DISK/TREND GROUP	10	11	12	10	12
MARKET	Captive/OEM	Captive/OEM	Captive	OEM	OEM
MEDIA: Nominal disk diameter	4.72"	8"	12"	4.72"	12"
Recording medium	Aluminum	Te-Ox	3M	Aluminum	Te Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
Recording method	Mastering	Phase change	Pit	Mastering	Pit
DRIVE: Operating mode	Read Only	Write Once	Write Once	Read Only	Write Once
Interface	SCSI/PC	SCSI	SASI-like	SASI	SCSI/ISI
Speed control	CLV	CLV	CAV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes)	F: 600	F: 1,200	F: 1,016	F: 553	F: 1,000
Capacity per track (Bytes)	F: N/A	F: N/A	F: 32,768	F: N/A	F: 32,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	41,250	41,250	31,000	40,640	32,000
Track density (TPI)	15,875	23,333	15,900	15,475	15,875
Maximum linear density (BPI)	27,600	15,394	20,000	26,008	14,111
Rotational speed (RPM)	500-250	500-250	900	535-194	480
PERFORMANCE					
Positioner type	Crs: Stepping Motor Fine: Galvonom.	Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	395	200	270	190	150
Average rotational delay (msec)	105	180	33.3	110	62.5
Average access time (msec)	500	380	303.3	300	213
Data transfer rate (KBytes/sec)	153	675	785	159	313
FIRST CUSTOMER SHIPMENT	2Q 1986	4Q 1985	4Q 1983	4Q 1985	3Q, 1983
U.S. OEM PRICE FOR 100 UNITS	--	--	\$14,350	--	\$7,400
COMMENTS	Standalone and slot mount versions avail- able.		Available only in Japan. N7921 is drive library unit. 48 disk capac.	Can operate in vertical position.	Has direct read after write.

MANUFACTURER	OPTIMEM	OPTOTECH	PHILIPS	REFERENCE TECHNOLOGY	SONY
DRIVE	1000	5984	CM100	2000	CDU-1
DISK/TREND GROUP	12	11	10	10	10
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	5.25"	4.72"	12"	4.72"
Recording medium	Au-Pt-Polymer	3M	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral/Concent.	Spiral	Spiral	Spiral
Recording method	Bubble	Pit	Mastering	Mastering	Mastering
DRIVE: Operating mode	Write Once	Write Once	Read Only	Read Only	Read Only
Interface	SCSI/SASI/Prop.	SCSI/PC	Prop.	SCSI	SCSI/PC
Speed control	CAV	CAV	CLV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes)	F: 1,000	F: 200	F: 600	F: 1,000	F: 540
Capacity per track (Bytes)	F: 25,000	F: 11,000	F: N/A	F: 19,600	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	40,000	18,000	41,250	51,000	40,640
Track density (TPI)	14,432	15,000	15,875	14,896	15,875
Maximum linear density (BPI)	15,300	14,000	27,600	24,000	27,600
Rotational speed (RPM)	1121.5	1200	500-200	1800	500-200
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Galvonom.	Crs: Stepping Motor Fine: Galvonom.	Rotary Galvonometer	Crs: Voice coil Fine: Galvonom.	Linear, Voice Coil
Average positioning time (msec)	123	125	890	125	665
Average rotational delay (msec)	27.5	25	110	16.7	86
Average access time (msec)	150	150	1000	151	750
Data transfer rate (KBytes/sec)	475	275	176	1000	176
FIRST CUSTOMER SHIPMENT	2Q, 1984	3Q, 1985	1Q, 1985	4Q, 1984	3Q, 1985
U.S. OEM PRICE FOR 100 UNITS	\$6,900	\$1,500	--	\$8,900	\$575
COMMENTS	Also uses 3M media in pit forming mode.				Price includes SCSI interface.

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delete
1

MANUFACTURER	SONY	SONY	STORAGE TECHNOLOGY CORPORATION	TOSHIBA CORPORATION	TOSHIBA CORPORATION
DRIVE	WDD 2000	WDD 3000	7640	XM-1000	DF-050
DISK/TREND GROUP	11	12	12	10	11
MARKET	OEM/Captive	OEM/Captive	OEM/PCM	OEM	OEM
MEDIA: Nominal disk diameter	8"	12"	14"	4.72"	5.25"
Recording medium	Se-Sb/Bi-Te	Se-Sb/Bi-Te	Te Alloy	Aluminum	Te-C
Track format	Spiral	Spiral	Concentric	Spiral	Spiral
Recording method	Phase change	Phase change	Phase change	Mastering	Pit
DRIVE: Operating mode	Write Once	Write Once	Write Once	Read Only	Write Once
Interface	SCSI/Prop.	SCSI/Prop.	3380/IPI	SCSI	SCSI
Speed control	CLV	CAV/CLV	CAV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes)	F: 500	F:1,100/1,600	F: 4,060	F: 540	F: 250/400
Capacity per track (Bytes)	F: 20,480	F: 25,600	F: 118,600	F: N/A	F: 2000/block
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18,750	43,750	34,224	40,640	18,750
Track density (TPI)	12,700	15,875	15,394	15,875	15,900
Maximum linear density (BPI)	25,391	24,937	20,000	27,600	21,900
Rotational speed (RPM)	900-535	720/720-360	1314	500-200	900
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil		Linear, Voice Coil
Average positioning time (msec)	250	250/620	61.9	195	87
Average rotational delay (msec)	44.7	42/62.5	22.8	85	33
Average access time (msec)	295	292/682.5	84.7	280	120
Data transfer rate (KBytes/sec)	300	300	3000	176	120
FIRST CUSTOMER SHIPMENT	4Q, 1984	2Q, 1985	1986	1Q 1986	3Q 1986
U.S. OEM PRICE FOR 100 UNITS	\$5,300	\$7,200	--	\$450	--
COMMENTS	Controller is \$4000.	Controller is \$4000. 50 disk library unit available.			

MANUFACTURER	TOSHIBA CORPORATION	VAN DER HEEM	VERBATIM	VERBATIM	
DRIVE	DF-0450	DOR-RI	MOD 1	MOD 2	
DISK/TREND GROUP	12	12	11	11	
MARKET	OEM/Captive	OEM	OEM	OEM	
MEDIA: Nominal disk diameter	12"	12"	3.5"	3.5"	
Recording medium	Te-C	Te Alloy	Tb-Fe-Co	Tb-Fe-Co	
Track format	Spiral	Spiral	Concentric	Concentric	
Recording method	Pit	Pit	Magneto-optic	Magneto-optic	
DRIVE: Operating mode	Write Once	Write Once	Erasable	Erasable	
Interface	GPIO	DEC/ISI	SCSI	SCSI	
Speed control	CLV	CAV	CAV	CAV	
CAPACITY/RECORDING DENSITY					
Total capacity (MBytes)	F: 1,860	F: 1,000	F: 40	F: 100	
Capacity per track (Bytes)	F: 4096/block	F: 32,832	F: 10,000	F:	
Data surfaces per spindle	1	1	1	1	
Tracks per surface	45,000	32,188	4,000	10,000	
Track density (TPI)	15,875	15,210	6,350	15,875	
Maximum linear density (BPI)		15,210	15,825	15,825	
Rotational speed (RPM)	460-230	480	600	2000	
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear	Linear	
Average positioning time (msec)	900	65	20	20	
Average rotational delay (msec)	105	62.5	50.5	15	
Average access time (msec)	1000	130	70	35	
Data transfer rate (KBytes/sec)	313	250	125	625	
FIRST CUSTOMER SHIPMENT	4Q84	1983	1987	1987	
U.S. OEM PRICE FOR 100 UNITS	\$12,500	\$120,000(Qty 1)	--	--	
COMMENTS					

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. Also listed are manufacturers of optical disk drives which have announced specific products or are expected to do so soon. The heading "1984 disk sales" refers to the DISK/TREND estimate of moving head rigid disk drive sales only -- no sales of other drive types are included, nor are sales of parts or other disk drive related products such as controllers. "1984 total net sales" covers the fiscal year ending in 1984 for each firm unless noted otherwise, or for the parent company if the disk drive manufacturer is a subsidiary. Northern Telecom is listed with the U.S. firms for convenience.

U.S. Manufacturers

ADVANCED STORAGE TECHNOLOGY, INC.
Subsidiary of Cybernex Corporation
6589 Via Del Oro
San Jose, CA 95119

Cybernex, an ambitious independent manufacturer of thin film heads, established AST in late 1983, to design and manufacture advanced small disk drives using thin film heads. There have been delays in the schedule originally announced, but a product line of half high 5.25" drives with capacities up to 158 megabytes is now promised for first deliveries by the end of 1985.

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 announced several variations of a 14" moving head drive using plated disks. The current version has 160 megabytes capacity and 18 ms average access time, achieved by using 10 heads per data surface.

AMCODYNE, INC.
1301 South Sunset Street
Longmont, CO 80501

1984 disk sales: \$8,200,000

Organized in 1981 by a group of industry veterans with high performance disk drive experience at Storage Technology, Amcodyne started first shipments of its 8" disk cartridge drive (26 MB fixed/26 MB removable) in early 1983. The firm's second product, an 8" fixed disk drive with 224 megabytes capacity, was discontinued in 1985 before deliveries were started, in order to concentrate on the disk cartridge drive market. Although the market for disk cartridge drives is smaller than in previous years, Amcodyne has established a leadership position, with continuing sales to several major system manufacturers.

AMPEX CORPORATION
Subsidiary of Signal Companies, Inc.
401 Broadway
Redwood City, CA 94063

1984 disk sales: \$45,200,000
1984 total net sales: \$5,920,000,000 Net income: \$301,000,000

While most of Ampex' disk drive revenues was previously derived from disk pack drives, the balance has now shifted to 14" and 5.25" Winchester models. A previously announced 8" fixed disk drive was dropped in 1983, victim of an overly lengthy development period. The existing 14" rack mounted OEM Winchester drives were successfully introduced in 1981, before several competitive drives. Ampex took a license from Rodime for 5.25" drives, with production now underway at Hong Kong.

APPLE COMPUTER, INC.
20525 Mariani Avenue
Cupertino, CA 95014

1984 total net sales: \$1,516,000,000 Net income: \$64,100,000

After several on-and-off programs to develop disk drives for internal production, Apple finally started production for 5.25" Winchester drives in mid-1984, for use with the ill-fated Lisa system. Six months later the internal program was dropped, in favor of outside purchase of disk drives.

APPLIED INFORMATION MEMORIES
776 Sycamore Drive
Milpitas, CA 95035

Started in 1982 to develop high capacity 5.25" drives using perpendicular recording, AIM changed direction and developed 5.25" fixed disk drives using longitudinal recording. Delivery of its first drive, with 130 mega-

bytes capacity and 18 millisecond average seek time, started in 1985. But AIM's ambitious manufacturing plans, combined with development delays, consumed all the firm's capital, and venture capitalists weren't interested in venturing further. After failing to find a buyer, the firm entered bankruptcy in September, 1985, and ceased operations.

APPLIED PERIPHERAL SYSTEMS
Subsidiary of Dysan Corporation
555 East Brokaw Road
San Jose, CA 95112

Applied Peripheral Systems was established in 1982, when Dysan split Dastek into two entities: Development and manufacture of thin film heads stayed with Dastek, and the previously announced disk drives became the responsibility of APS. The firm's OEM 14" fixed disk drives offered capacities from 200 to 640 megabytes, using thin film heads with oxide coated Dysan disks. Limited production shipments started in 1982, but never assumed major proportions. The operation was closed down when Dysan was acquired by Xidex.

ATASI CORPORATION
2075 Zanker Road
San Jose, CA 95131

1984 disk sales: \$48,000,000

Atasi is a privately held firm started in 1981 by disk industry veterans to manufacture high capacity 5.25" Winchester fixed drives, and managed to secure an attractive market share by starting production early, in 1982. However, the firm's initial design proved to be a costly design 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, and is operating with a small staff.

BURROUGHS CORPORATION
Burroughs Place
Detroit, MI 48232

After many years of captive disk drive production, Burroughs acquired Memorex in late 1981. All Burroughs disk drive operations have now been consolidated in the firm's Memorex subsidiary and are reviewed under the heading for that organization.

CENTURY DATA SYSTEMS, INC.
Subsidiary of Xerox Corporation
1270 North Kraemer Boulevard
Anaheim, CA 92806

1984 disk sales: \$66,400,000
1984 total net sales: \$8,792,000,000 Net income: \$367,000,000

Century's total sales have been static in the last few years, as newer fixed disk drives gradually replace products in production before the acquisition by Xerox in 1979. Disk cartridge drives, inherited from Xerox' Diablo subsidiary, were phased out in 1981. Century is pinning its future hopes on the higher capacity 14" fixed disk drives introduced during the past three years, plus the 8" fixed and disk cartridge drives announced more recently.

COGITO SYSTEMS CORPORATION
2355 Zanker Road
San Jose, CA 95131

Cogito started operations in 1982, with funding from Chin Fong Investments, Ltd., a Taiwan organization which also owns Magnex, a thin film head manufacturer. Cogito's first products have been half high 5.25" Winchester drives, for which production started in mid-1983, but shipments have remained small.

COMPUTER MEMORIES, INC.
9216 Eton Avenue
Chatsworth, CA 91311

1984 disk sales: \$74,400,000
1984 total net sales: \$47,428,000 Net income: \$1,492,000
(FY ending 3/31/84)

CMI started shipments of 5.25" fixed Winchester drives in 1981, and has announced products with up to 85 megabytes capacity. During 1984 IBM became CMI's largest customer, with major purchases of 20 megabyte drives used in the PC AT. During the firm's most recently reported quarter, IBM purchased 81% of CMI's total shipments. The company has announced that IBM does not intend to continue purchases after December, 1985, and is involved in a desperate scramble to replace the lost business. During September, 1985, Finis Conner, co-founder of Seagate Technology, joined CMI as CEO -- with the mission to quickly find both new customers and new products.

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

1984 disk sales: \$1,314,800,000
1984 total net sales: \$5,027,000,000 Net income: \$32,000,000

Control Data's share of worldwide OEM rigid disk drive revenues fell to 23.7% in 1984, after a continuing decline from 1980's peak of 55%. The firm's area of product weakness has been in fast-growing small fixed drive products and in certain high-end drives impacted by newer Japanese drives. Building on successful product lines in 14" disk cartridges, storage module drives, large disk pack drives, plus mid-range and large fixed disk drives, CDC introduced 9" diameter drives in most of the same product areas. Currently, many of the older OEM drives have peaked in shipments because of competition from newer configurations. However, the 9" CDC drives are now in production and have been supplemented by a 368 megabyte 8" drive announced in mid-1985. Disk drives sold by Control Data are designed and manufactured by Magnetic Peripherals, Inc., a joint venture with ownership now shared by CDC, Honeywell, Sperry and Bull Peripherals. Control Data manages the joint venture and has exclusive responsibility for sales of its products in the OEM market. Drives made by MPI for sale with any of the parent company's systems are considered captive CDC drives for the purposes of DISK/TREND statistics, and captive drives for parent companies are a significant portion of MPI shipments. Control Data has been 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. CDC also is the managing partner in Optical Storage International, an optical disk joint venture with Philips which is covered elsewhere in this section.

DATA GENERAL CORPORATION
4400 Computer Drive
Westboro, MA 01581

1984 disk sales: \$145,900,000
1984 total net sales: \$1,160,815,000 Net income: \$83,256,000

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 of both 14" and 5.25" fixed disk drives to its product line, 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.

DIGITAL EQUIPMENT CORPORATION
 146 Main Street
 Maynard, MA 01754

1984 disk sales: \$633,000,000
 1984 total net sales: \$5.584,000,000 Net income: \$329,000,000

During the many years that DEC has manufactured disk drives, most of the revenues from the program have been derived from disk cartridge drives, notably the high volume RL02. However, in 1981 a new family of 14" Winchester drives appeared. The RA81, a 14" rack mounted Winchester drive with a formatted capacity of 456 megabytes has been the big revenue producer. The other drive in the group is the RA60, a rack mounted disk pack drive with 205 megabytes formatted capacity. These were DEC's first internally designed and produced high end disk drives, and the manufacturing startup for the drives and their controller was painful, but significant to the firm's profitability. DEC's new drives will replace older drives purchased externally on an OEM basis, and are expected to reach large production quantities. In late 1983, DEC started shipping the Aztec, a long-delayed 8" disk cartridge drive, superseding the 14" RL02 -- perhaps too late to maintain the company's disk cartridge drive market at its previous size.

DISC TECH ONE
 849 Ward Drive
 Santa Barbara, CA 93111

1984 disk sales: \$4,100,000

In 1982 Disc Tech One acquired from M/A-Com the Ohio Scientific disk drive operation (previously owned by Okidata). In 1984 the firm merged with Lifetech Industries Corporation, a San Diego hearing aid manufacturer. The intent of the merger was to provide additional financing needed to more fully develop production facilities for the 14" Winchester drives. Disc Tech One started with, later supplemented with 8" Winchesters acquired from 3M and the Disctron 5.25" Winchesters acquired from CCT. In 1985, however, preparations were underway to re-establish Disc Tech One as a separate company.

DISCTRON, INC.
 Subsidiary of Computer & Communications
 Technology Corporation
 1701 McCarthy Boulevard
 Milpitas, CA 95035

1984 disk sales: \$23,200,000
 1984 total net sales: \$120,000,000 Net income: \$11,700,000

CCT established Disctron from the combination of Data Peripherals and Rotating Memory Systems, following the acquisition of RMS in mid-1982. The 8" drives from the Data Peripherals line remain in production, but the

RMS 5.25" Winchester product line was sold in 1984 to Disc Tech One.
CCT's Ultradisc subsidiary produces plated disks for the OEM disk market.

DMA SYSTEMS
601 Pine Avenue
Goleta, CA 93117

1984 disk sales: \$9,300,000

DMA Systems started shipments of its 5.25" 5/5 MB fixed-removable disk cartridge drive in 1982, and established an early leadership position in the 5.25" disk cartridge field, despite relatively high prices compared to fixed disk drives. Later, capacities were doubled on the fixed/removable drives, and an 11 MB half high was put into production. Manufacturing licenses were sold to Memorex, which later discontinued all OEM disk drive operations, and also to Newbury Data and Ricoh, both 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.

EPELO CORPORATION
Subsidiary of Xebec Corporation
2090 Concourse Drive
San Jose, CA 95131

Following Frank Gibeau's departure as founding president of Atasi, he formed Epelo, with Xebec holding a majority interest. Epelo was operated as a separate subsidiary of Xebec until March, 1985, when Xebec closed down the operation. Epelo had planned to introduce a high capacity half high 5.25" Winchester drive.

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

1984 disk sales: \$315,500,000

1984 total net sales: \$6,044,000,000

Net income: \$665,000,000

Hewlett-Packard has an extensive manufacturing operation for captive disk drives at Boise, Idaho, established in 1977 and since expanded, supplemented in mid-1983 with a new \$50 million facility in Bristol, England, and by production of 3.5" Winchester drives at Greeley, Colorado. H-P makes disk cartridge, disk pack, and fixed Winchester disk drives at Boise, which is also the firm's development facility for advanced head and disk technology development. The sputtered disks used in 3.5" drives are produced at Boise. The industry expects H-P to become a major producer of small fixed disk drives using advanced recording technology.

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

1984 disk sales: \$5,200,000

Ibis was one of the most ambitious of the industry's many start up companies from the early 1980's, with a plan to make OEM and PCM versions of a 3380 equivalent drive using composite manganese zinc heads and plated disks. After finding that the technical complexities of such a project are very real, and having learned the extent of the resources needed to launch an adequate sales and service organization, Ibis changed its strategy to concentrate on a parallel track version of the drive. This plan has paid off, and Ibis is now the leader in drives used with supercomputers and certain high end imaging systems -- all of which can make use of the 12 megabyte/second transfer rate which is unique to the Ibis drive.

INFORMATION STORAGE, INC.
 2768 Janitell Road
 Colorado Springs, CO 80906

ISI was started in 1983 by Steve Popovich, formerly the president of Optical Peripherals Laboratory, the Philips and Control Data joint venture for optical drive development which later became part of Optical Storage International. Among the major sources of funds for ISI are CPT and Tallgrass. Sperry also is a significant investor. Tallgrass has announced it will distribute the ISI drive. Sperry has acquired rights to ISI technology, but will make its own drives for military applications. The initial ISI product is a 5.25" write-once drive of 100 megabyte capacity, and is aimed at the personal computer and small system peripherals market. Production is scheduled to begin in the fourth quarter of 1985.

INTERNATIONAL BUSINESS MACHINES CORPORATION
 Route 22
 Armonk, NY 10504

1984 disk sales: \$4,691,300,000
 1984 total net sales: \$45,937,000,000 Net income: \$6,582,000,000

After an embarrassing and expensive period in which IBM had difficulty in establishing quantity production for its new generation of thin film head drives, things are now going much better. The 3370, 3375 and 3380 are being shipped in surprisingly large quantities from plants in the U.S., Europe and Japan. As expected, IBM announced a double capacity version of the 3380 in early 1985, and started shipments in July, 1985. IBM's first significant OEM sales of disk drives were made in early 1984, and involved the 3380 -- both Siemens and Honeywell are buying the drive. For small disk drives sold on a broad basis, it may be very difficult for IBM to set competitive OEM prices, since the company can't afford to undercut the end

user pricing established for the same drives when sold as detachable drives. On the other side of the coin, IBM has become temporarily the world's largest buyer of OEM disk drives, at least on a unit total basis. The firm's disk drive requirements for personal computers and other small systems have driven it to buy OEM drives from at least seven outside manufacturers. But those disk drive manufacturers which have let IBM become a dominant customer have all experienced painful withdrawals when IBM departed.

Internal manufacturing for small diameter disk drives is now going into high gear at IBM: The firm appears to be making all of its own current requirements for 10 megabyte 5.25" drives for the PC XT at its Fujisawa plant, and Rochester and Havant are ramping up production for the 20, 30 and 40 megabyte 5.25" voice coil drives used on various personal computer models. These programs, plus the 3.5" Winchester expected to go into production next year at Fujisawa, will significantly change IBM's role as an OEM disk drive buyer.

INTERNATIONAL MEMORIES, INC.
Subsidiary of Onyx+IMI, Inc.
10381 Bandle Drive
Cupertino, CA 95014

1984 disk sales: \$173,800,000

Despite a major boost in production due to an IBM contract for 5.25" Winchester drives, IMI's parent company decided to close out the disk drive manufacturing operation in early 1985. Although announcing a variety of newer drives, including half high models and high capacity drives, IMI failed to get the new products into production promptly, and was left with a bleak sales outlook after its business with IBM was completed. A large proportion of IMI's non-IBM sales involved shipments (considered as captive business in DISK/TREND statistics) through Onyx and Corvus, a firm sharing many investors with IMI -- and the firm had never been successful in establishing a broader customer base.

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

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

KENNEDY COMPANY

Subsidiary of Magnetics & Electronics, Inc.
a subsidiary of Allegheny International, Inc.
1600 South Shamrock Avenue
Monrovia, CA 91001

1984 disk sales: \$5,700,000
1984 total net sales: \$2,115,000,000 Net income: \$63,600,000

Kennedy entered the OEM 14" Winchester disk drive business in 1978 with unspectacular results, as the company gradually acquired the production expertise needed to make the products it had announced. After indifferent sales experience with a variety of 14" and 8" Winchester disk drives, the firm is now closing out the product line, in favor of concentrating on its tape drive business.

LAPINE TECHNOLOGY CORPORATION

182 Topaz Avenue
Milpitas, CA 95035

LaPine Technology was formed in July, 1983, to develop and manufacture 3.5" Winchester drives. The founders' experience includes several notable disk drive manufacturers. The company is 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). Both 10 and 20 megabyte 3.5" drives will be produced by Kyocera, with the start scheduled for 1985.

MAXTOR CORPORATION

150 River Oaks Parkway
San Jose, CA 95134

1984 disk sales: \$32,800,000
1984 total net sales: \$43,500,000 Net income: \$38,000
(FY ending 3/31/85)

Maxtor was formed in 1982 to develop and manufacture high capacity 5.25" Winchester disk drives for the OEM market, and has become the most controversial new disk drive company in years. Maxtor startled its competitors by announcing late in 1982 a family of 5.25" drives with up to 140 megabyte capacity. These drives, which are now in production, maintain the standard Seagate transfer rate of five megabits per second. Eight disks are used, twice the number any other manufacturer had attempted to place in a 5.25" drive, by positioning the drive motor inside the disk's inner diameter. A 190 megabyte model was added in 1984, then a 380 megabyte version with a 10 megabit/second ESDI interface, still to ship in quantity. Maxtor is now the leader in high end 5.25" Winchesters despite early skepticism by competitors, and even managed a successful public stock offering in a market considered hostile to disk drive companies.

MEGAVAULT

6431 Independence Avenue
Woodland Hills, CA 91367

SLI, a veteran industry supplier of voice coil actuators, changed its name in 1982 to reflect its new emphasis on complete disk drives. Megavault's biggest sale was a kit used by Texas Instruments for a few years in assembling their 8" Winchesters. But that program is completed, and Megavault's own product line of 8" Winchester drives is suffering from a limited customer base.

MEMOREX CORPORATION

Subsidiary of Burroughs Corporation
San Tomas and Central Expressways
Santa Clara, CA 95052

1984 Memorex disk sales:	\$17,800,000	
1984 Burroughs disk sales:	\$249,600,000	
1984 total net sales:	\$4,808,000,000	Net income: \$244,900,000

Memorex was acquired by Burroughs in late 1981, and Burroughs has placed all disk drive development and manufacturing responsibility for the entire company in the Memorex organization. First production deliveries of the firm's 3380 equivalent drive were made in mid-September, 1983, as promised -- and Memorex has been trying to ramp up shipments, but various problems with heads, media and other factors have kept the production level below plan. The Memorex OEM disk drive product line, consisting mostly of 200 megabyte disk pack drives sold to DEC, plus the resale of smaller diameter drives manufactured by others, has been discontinued. One of the first major projects at Memorex under Burroughs management, already satisfactorily completed, was development of controllers to make possible the use of large Memorex disk drives with Burroughs systems -- thus creating another sizeable market for Memorex drives, a captive one.

MICROCOMPUTER MEMORIES, INC.

7444 Valjean Avenue
Van Nuys, CA 91406

1984 total net sales:	\$1,373,000	Net income: (\$5,527,000)
	(FY ending 3/2/85)	

MMI was formed quietly in 1982 to develop a 3.5" Winchester drive, and managed to go public in January, 1984, before the big 1984 decline in technology stocks. The firm started shipping a 10 megabyte drive in 1984 and a 4-platter 20 megabyte version in 1985. The firm is now in quantity production, with most activity in the personal computer add on/add in market.

MICRODATA CORPORATION
Subsidiary of McDonnell Douglas Corporation
17481 Red Hill Avenue
Irvine, CA 92714

1984 disk sales: \$11,900,000

Microdata's disk drive activity became completely a captive operation in support of the firm's computer systems business. The 14" Reflex line of Winchester drives, a pioneer in its day, was eventually converted to the 3350 technology Reflex II version, and in 1985 is being phased out, in favor of disk drives purchased from outside vendors.

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1984 disk sales: \$56,300,000

1984 total net sales: \$60,147,000

Net income: \$819,000

Known as the originator of high capacity 5.25" flexible disk drives, Micropolis entered the 8" Winchester disk drive market in 1979, and became a factor in the marketplace, after the usual Winchester early production problems. The company has embarked on an ambitious development program for small high performance Winchester disk drives, and has become a market leader in high capacity 5.25" drives -- the first firm to establish volume deliveries of 85 megabyte models.

MICROSCIENCE INTERNATIONAL CORPORATION
575 East Middlefield Road
Mountain View, CA 94043

1984 disk sales: \$25,500,000

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, with a 20 megabyte model shipping by mid-1985. Microscience achieved most of its success during 1984 in sales to the personal computer aftermarket, but is emphasizing sales to systems manufacturers in 1985.

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

Micro Storage was formed in 1984 to produce a 5.25" half high disk cartridge drive, with founders from Santa Clara Valley and funding from Omron Tateisi Electronics Company Ltd, Kyoto. First production shipments are

planned for late 1985, with manufacturing by Omron. The firm is involved in a lawsuit by SyQuest Technology, which claims that two ex-employees misappropriated trade secrets.

MILTOPE CORPORATION
1770 Walt Whitman Road
Melville, NY 11747

1984 total net sales: \$43,500,000 Net income: \$4,000,000

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

MINISCRIBE CORPORATION
1871 Lefthand Circle
Longmont, CO 80501

1984 disk sales: \$122,800,000
1984 total net sales: \$123,606,000 Net income: (\$5,744,000)

Production of Miniscribe's 5.25" Winchester drives started in late 1981, stayed at modest levels through most of 1982, then soared starting in late 1982 as IBM started taking 5.25" Winchester deliveries for the personal computer program. Other major OEM customers were subsequently added, and the company has maintained a strong second place position in worldwide shipments of 5.25" Winchester drives below 30 megabytes. It's not been an easy life, however, with drastic changes in IBM's procurements in 1984, coupled with the adverse fortunes of some of Miniscribe's customers which have 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.

NORTHERN TELECOM, INC.

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

1984 disk sales: \$11,000,000

1983 total net sales: \$2,455,000,000 Net income: \$187,000,000
(Basis: C\$ 1.35 = U.S.\$1)

The 8" fixed Winchester drive with 22 megabytes formatted capacity produced at Minneapolis for captive system use has been phased out. Northern Telecom's Memory Systems Division in Ann Arbor, Michigan, is shipping a family of high performance 8" Winchester drives, with capacities up to 378 megabytes. These drives are used for captive applications with Northern Telecom and are supported with an active OEM sales program.

OPTICAL STORAGE INTERNATIONAL

3333 Scott Boulevard
Santa Clara, CA 95052

OSI is a joint venture of Philips and Control Data. While Philips has the majority interest, the organization is managed by Control Data and is headquartered at the Magnetic Peripherals, Inc., facility in Santa Clara, also managed by Control Data. OSI combines two earlier joint ventures, Optical Peripherals Laboratory in Colorado and Optical Media Laboratory in the Netherlands. The entire U.S. operation is scheduled to be consolidated at the Colorado facility sometime in 1986. OSI products currently include a 12" write once drive. Image processing has been the most significant application. The firm is actively pursuing other optical disk products.

OPTIMEM

Subsidiary of Xerox Corporation
435 Oakmead Parkway
Sunnyvale, CA 94086

1984 total net sales: \$8,792,000,000 Net income: \$367,000,000

Currently a subsidiary of Xerox, Optimem began in 1980 as a development program managed by Shugart Associates, at that time the leading manufacturer of small disk drives. Optimem is one of the few U.S. based firms that is shipping a production version of an optical disk drive. 3M and Alcatel-Thomson-Gigadisc are sources for media. The Optimem product is a 12", 1 gigabyte drive with its largest current use in the image processing area.

OPTOTECH, INC.
770 Wooten Road
Colorado Springs, CO 80915

Founded in 1984 by Nelson Yew and Di Chen, Optotech is one of the early suppliers of 5.25 inch write-once drives. Production shipments will begin in late 1985. Initial production will occur in Colorado, but Optotech has stated that its eventual plan is to have its drives manufactured offshore. Small systems suppliers and add-on subsystem suppliers will be Optotech's target market.

PERIPHERAL TECHNOLOGY, INC.
9170 Independence Avenue
Chatsworth, CA 91311

Peripheral Technology was founded in 1985 to develop and market a high capacity 3.5" Winchester drive, with founders who had worked together at Dataproducts, then acquired various disk drive experience. Financing is from Haitai International, a Korean company.

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

The recently announced Plus Hardcard, is an innovative plug-in card for the IBM personal computer aftermarket, which combines a 10 megabyte 3.5" Winchester and all controller electronics on a single add-in card. 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, with introduction in October, 1985.

PER SCI, INC.
Subsidiary of EF Industries
12624 Daphne
Hawthorne, CA 20250

Effective July, 1984, PerSci acquired the 14" disk cartridge drive line from Cipher, which previously had followed an ownership path from Wangco to Perkin Elmer to Cipher. These products have thus joined the PerSci floppy drives and the previously acquired Caelus 14" disk cartridge drives (via EMM), in an organization set up by Ed Farris, an ex-EMM executive, to sell and maintain products nearing the end of their production life. The drives acquired from Cipher are still in production, but at reduced levels.

PRIAM CORPORATION
 20 West Montague Expressway
 San Jose, CA 95134

1984 disk sales: \$81,200,000
 1984 total net sales: \$94,300,000 (FY ending 6/30/84) Net income: \$9,350,000

Priam became a significant supplier of OEM Winchester disk drives in 1981, as volume production was achieved for the firm's original line of mid-range 14" drives and shipments of 8" drives got underway. 8" Winchesters with capacities up to 516 megabytes are offered in competition with Control Data's 9" drives. After abortive efforts to enter the high capacity 5.25", Priam acquired Vertex Peripherals in early 1985, with its successful 5.25" product line of drives up to 85 megabytes. 140 and 190 megabyte 5.25" drives with specifications similar to Maxtor's have been announced for early 1986 delivery.

QUANTUM CORPORATION
 1804 McCarthy Boulevard
 Milpitas, CA 95035

1984 disk sales: \$107,500,000
 1984 total net sales: \$120,349,000 (FY ending 3/31/85) Net income: \$20,973,000

Quantum's original game plan was to provide a low-cost upgrade for the market created by Shugart Associates' SA 1000 8" Winchester drives. The Quantum plan worked very well, and the firm has become the industry's show window example of a profitable, well managed company. 5.25" drives with capacities up to 40 megabytes were added in 1983, and have become the major Quantum product for 1985. But as that product shows signs of reaching maturity, the firm has announced half high OEM 5.25" drives with up to 80 megabytes capacity for delivery before the end of 1985, and has set up Plus Development as a wholly owned subsidiary to pioneer development and marketing of unique 3.5" drives for the personal computer market.

QUME CORPORATION
 Subsidiary of International Telephone & Telegraph Corporation
 2350 Qume Drive
 San Jose, CA 95150

1984 total net sales: \$12,800,000,000 Net income: \$448,000,000

Qume entered the floppy drive business in 1979, hit its production peak in 1984 with orders from IBM, and is phasing out of the disk drive industry, as its floppy business declines to low levels. Plans to manufacture and sell half high 5.25" Winchester drives under license from Tulin have also been abandoned.

REFERENCE TECHNOLOGY, INC
1832 North 55th Street
Boulder, CO 80301

Reference Technology specializes in read-only, high performance drives. Its current product is a 12", read-only unit, but the firm has also begun to remarket the Hitachi CD-ROM. Replication services for media are available through 3M. Reference Technology has entered into marketing agreements with database publishers aimed at providing complete subsystem packages to the ultimate end users. The 12" media used is a video laser-disk which can be used for either data or images.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1984 disk sales: \$302,500,000
1984 total net sales: \$343,903,000 Net income: \$42,019,000

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. In 1982, Seagate's many new competitors nibbled the company's worldwide share of low end 5.25" Winchesters down to 40%, but the firm still held 34% of the worldwide unit shipments in 1984, with 776,000 drives. Seagate has taken the lead in moving production for its high volume drives offshore, to secure lower manufacturing costs. But the world changed for Seagate in mid-1984, with a sharp reduction in sales to its largest customer, IBM -- and an up-and-down buying pattern which continued through 1985. Through tough management, Seagate has stayed profitable, but just barely. The company's hopes in maintaining growth in the future now rest on using its proven production capability to ship the new products it plans to introduce, to the many new and old customers it will have to attract. And, during this period, of course, hoping that IBM will see fit to reward an outstanding vendor with some more business.

SHUGART CORPORATION
Subsidiary of Xerox Corporation
435 Oakmead Parkway
Sunnyvale, CA 94086

1984 disk sales: \$113,200,000
1984 total net sales: \$8,792,000,000 Net income: \$367,000,000

Shugart Associates took advantage of its early leadership in flexible disk drives with its 1979 introduction of an early low-end 14" Winchester drive, the 14" SA 4000, followed by the 8" SA 1000, which was a winner, until 5.25" drives became the low-end standard. Shugart got a late start with 5.25" Winchesters, and as the company fell behind in floppy drives, lost credibility with OEMs. The rigid disk drive programs were phased out this year.

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

1984 disk sales: \$130,100,000
1984 total net sales: \$808,600,000 Net income: (\$505,500,000)

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 was faced with the need to scale back production, well before its next generation of IBM compatible drives was ready for production. 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, 1985, the bankers wouldn't wait, and the company was thrown into Chapter 11. It is no surprise that disk drive order rates have suffered, even though the company was finally ready to increase shipment rates. And now, STC is faced with the task of keeping customers interested, despite the fact that its own answer to IBM's double capacity drive, which has been shipping since July, 1985, won't be ready until mid-1986.

SYQUEST TECHNOLOGY
47923 Warm Springs Boulevard
Fremont, CA 94538

1984 disk sales: \$18,900,000

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, with a production start up scheduled before the end of 1982 and very large quantities planned for 1983. Unfortunately, technical problems with the drive severely compromised the big plans, and the firm didn't get into volume production with a reliable drive until late 1983. During 1984, however, the SyQuest drive sold well in the personal computer add-on market, filling a demand for removable media drives with higher capacity than the floppy drives offered by IBM. A license has been taken by Nippon Systemhouse for sales in Japan, and SyQuest has finally been successful in attracting several system manufacturers who need the firm's combination of capacity and removability.

TANDON CORPORATION
20320 Prairie Street
Chatsworth, CA 91311

1984 disk sales: \$58,700,000
1984 total net sales: \$401,000,000 Net income: \$29,400,000

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. Consistent with the firm's philosophy of maximum practical vertical integration, Tandon internally manufactures a very high proportion of its drives' content, including plated disks. In contrast to its largest 5.25" Winchester competitors, Seagate and Miniscribe, Tandon was not able to sell these products to IBM, and was late in establishing production for half high models. As a result, the company has never been able to advance beyond 3rd or 4th place in low end 5.25" Winchesters, and has begun to focus on higher capacity models.

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

1984 disk sales: \$13,300,000

Tecstor acquired rights in 1981 to a 14" Winchester drive developed by BASF in Europe, but never placed in quantity production. Tecstor's production started at the end of 1981, and the firm now offers a family of high performance 14" fixed disk drives with capacities in the 300 megabyte range. While all of these drives offer interface and file compatibility with several of the Control Data drives in the SMD interface family, several also offer specialized interfaces compatible with specific mini-computer systems.

TEXAS INSTRUMENTS INCORPORATED
Terminals and Peripherals Division
P.O. Box 1444
Houston, TX 77040

1984 disk sales: \$48,000,000
19834 total net sales: \$5,742,000,000 Net income: \$316,000,000

For several years TI assembled 8" Winchesters for captive use with TI computer systems, under a license from Megavault. The company is now phasing out this program, as well as production of 5.25" Winchesters. The 5.25" drives were manufactured for captive use, originally under a Seagate Technology license. TI had planned to use the 5.25" drives as its entry point into the OEM disk drive market, but withdrew that program in 1983 after limited success.

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 initial funding from ITT, the parent of neighboring Qume Corporation, and founders with extensive disk drive industry backgrounds, Tulin's drives range from 13 MB to 40 MB.

VERBATIM CORPORATION
 323 Soquel Way
 Sunnyvale, CA 94086

Verbatim, now a subsidiary of Eastman Kodak, is primarily a media producer and is a major supplier of floppy disks. Its optical disk drive program is based upon work previously done by Philips and has resulted in a demonstration of a working 3.5" erasable media and drive. The design uses the Faraday effect, a form of magneto-optical technology in which the light beam is rotated as it passes through the substrate. Production status is not expected until 1987. Verbatim has discussed two products, one having 40 megabyte capacity and a later product to have 100 megabyte capacity. Because Verbatim is a specialized media producer, the production of the drives will probably be undertaken by Kodak or outside firms. The small physical size of the drive will make it appealing to system manufacturers looking for Winchester backup devices that can be packaged with the system. If achieved in production units, the short average access time will also make this design a candidate for use as the primary system disk.

VERMONT RESEARCH CORPORATION
 Precision Park
 North Springfield, VT 05156

1984 disk sales: \$1,900,000

1984 total net sales: \$9,500,000

Net income: (\$820,000)

VRC has been primarily a manufacturer of head-per-track disk drives and magnetic drum memories, with manufacturing both in Vermont and England. Lower demand for these memory devices has caused flat sales and a shrinkage in the company's staff. A 14" high capacity disk cartridge drive with embedded servo has been produced for several years for militarized computer systems. In 2nd quarter of 1983, VRC started shipping fixed/removable and removable-only disk cartridge drives using the Dysan 8" disk cartridge.

VERTEX PERIPHERALS
 (Acquired by Priam)

1984 disk sales: \$30,000,000

Vertex was started in 1982, with founders primarily from Shugart Associates, to manufacture high capacity 5.25" Winchester disk drives. Drives with up to 85 megabytes capacity were shipped, and a successful, but cash-starved business was established. In early 1985, Vertex was merged into Priam Corporation.

WESTERN DYNEX CORPORATION
3536 West Osborn Road
Phoenix, AZ 85019

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

XEBEC
2221 Old Oakland Road
San Jose, CA 95131

1984 total net sales: \$158,000,000

Net income: \$840,000

Xebec's management has been looking for an entry point into the disk drive manufacturing business for years, as an extension of the firm's success in producing high-volume controllers. In 1984, several programs were launched. In April, Xebec acquired the Datapoint Sunnyvale operations, including production of plated disks and a 5.25" Winchester drive. Also in the Spring, the company funded Frank Gibeau's Epelo start-up for high performance small disk drives. And at the NCC, the Owl, an internally manufactured half high 5.25" drive with built-in SASI was introduced. However, in the past year, Xebec has been short on the cash required to fund disk drive expansion programs, and of the above programs only the Owl remains currently active.

Asian Manufacturers (Exchange basis: 240 Yen = \$1)
(All firms are in Japan unless otherwise noted)

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

1984 total net sales: \$1,230,263,000 Net income \$54,196,000

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. Alps shipments of one sided 5.25" drives have topped all other floppy drive manufacturers worldwide since 1981. Alps began shipping 3.5" floppy drives in 1984. In 1985, Alps began the manufacture of 5.25" half-high and 3.5" rigid disk drives.

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

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also control Japan's Seiko companies, known for watches and electronics. Epson is best known for its dot-matrix printers, but also manufactures a portable computer, displays, line printers, paper tape equipment and floppy disk drives. Floppy drive production began in 1982 with a 5.25" one third high unit. The floppy disk line now includes a variety of 5.25" and 3.5" models, including 3.5" units with very low power requirements. In 1985, Epson introduced a line of half-high 5.25" rigid disks with capacity to 20 megabytes and using sputtered carbon-overcoated plated media. Epson has stated its intentions to ship 3.5" drives plus 40 megabyte and 80 megabyte 5.25" drives in 1986.

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

1984 disk sales: \$879,000,000
1984 total net sales: \$5,041,129,000 Net income: \$277,788,000

Fujitsu is known as the leading manufacturer of computers for the Japanese domestic market and a worldwide factor in computer export markets. But the extent of Fujitsu's disk drive business is less well appreciated. In 1982 the company moved up to third place in worldwide total disk drive revenues. Fujitsu has transitioned from heavy reliance on removable disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters. The company's most impressive captive drives are 10.5" models which provide the Fujitsu answer to IBM's 3370 and 3380 drives. Fujitsu has also offered 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 several fixed disk drives: The high performance 14" 84/168 MB, 8" 48/84/168 MB drives, and the 10.5" 474 MB "Eagle" high performance drive with 1.8 MB/sec transfer rate. Higher capacity versions of several existing OEM drives have been announced. Fujitsu has also developed an optical disk drive in conjunction with Olympus Optical and Asahi Chemical for heads and media, respectively. It is in limited production and available only in Japan.

HITACHI, LTD.
6-2, Otemachi, 2-chome
Chiyoda-ku, Tokyo 100

1984 disk sales: \$501,500,000
1984 total net sales: \$18,196,433,000 Net income: \$696,308,000

While Hitachi is Japan's largest manufacturer of electrical and electronic equipment, it is only the third largest Japanese manufacturer of computer systems. While the firm no longer manufactures removable disk drives, it 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 635 MB and 3380 equivalent drives to National Advanced Systems for distribution with NAS systems in the U.S., and in 1983 started selling 3380 equivalent drives to BASF for distribution in the European PCM market. Hitachi offers a 12" optical disk drive and has begun shipments of CD-ROM units.

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

1984 disk sales: \$7,000,000
1984 total net sales: \$1,211,479,000 Net income: \$53,858,000

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

MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
1006, Kadoma City
Osaka 571

1984 total net sales: \$16,618,829,000 Net income: \$761,450,000

MEI's Panasonic, National, Technics, and Quasar brand names are among the most widely known in the world for appliances, consumer electronics, and communications equipment. The firm, along with Hitachi, promoted the 3.0" microfloppy disk drive and manufactures for a worldwide market. Also in MEI's product portfolio is a CD-ROM, which began shipping in limited quantities in 1985. An 8" optical disk drive is also in limited production with shipments currently limited to use in captive document storage systems.

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

1984 disk sales: \$47,000,000
1984 total net sales: \$7,253,163,000 Net income: \$161,975,000

In addition to being one of Japan's leading electronic and electrical products manufacturers, Mitsubishi Electric is a leader in the domestic small business systems market. The company is phasing out of production of a variety of removable disk types and adding small and mid-range Winchester technology drives. Captive shipments are the major portion of Mitsubishi's disk drive shipments, but the firm has a growing OEM business in 14", 8" and 5.25" Winchester drives.

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

1984 disk sales: \$640,300,000
1984 total net sales: \$7,341,083,000 Net income: \$185,708,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about one fourth of the firm's total revenues. Except for continuing production of large disk pack drives, all current disk drive production involves fixed disk drives, from large to small configurations, for both captive and OEM markets. Fixed disk drives include 14", 8", 5.25" and 3.5" disk diameters, with large scale production for 8" and 5.25" drives. NEC is selling a 1 gigabyte 12" optical disk drive on both a captive and an OEM basis.

NIPPON COLUMBIA CO., LTD.
4-14-14, Akasaka
Minato-ku, Tokyo 107

1984 total net sales: \$326,904,000

Net income: \$9,729,000

Primarily known as a producer of phonograph records, consumer electronics and audio equipment under the Denon brand name, Nippon Columbia is leveraging its CD audio player experience to gain an entry in the CD-ROM market. The firm's product is unusual in that it can operate in a vertical or horizontal position, affording packaging flexibility to manufacturers of small systems. CD-ROM hardware production is scheduled to begin in the fourth quarter of 1985.

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

1984 disk sales: \$12,300,000

1984 total net sales: \$85,829,000

Net income: (\$425,000)

Nippon Electric Industry (NEC owns 34.6% of the firm) is known in Japan by its tradename, Densai. The company produces power supplies for communications and computer equipment, automatic control systems and other electronic equipment. It has manufactured magnetic drum memories for several years. Densai has entered the OEM disk drive market with 5.25" Winchester drives of its own design, and has introduced half high models.

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

1984 disk sales: \$83,100,000

Fujitsu and Hitachi own NPL equally as a joint venture. NPL has the charter to develop advanced disk drives and other magnetic peripherals, and has developed its own versions of most IBM new disk drives introduced since the 3340. Drives developed by NPL may be sold by that firm or the designs may be adapted to the specific requirements of the parent companies and produced by those firms as captive drives. Currently, the major portion of NPL's independent sales are to BASF, which markets PCM drives in Europe, and to Memorex, which markets 3370 equivalent drives in Europe and the U.S. These shipments are treated as PCM shipments by NPL in DISK/TREND statistics to avoid distortion of PCM market totals.

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

Nippon Systemhouse acquired a license in late 1983 to manufacture the SyQuest line of fixed and removable 3.9" disk drives, and to market them in Japan. The firm is a manufacturer of medical systems, and terminals produced for Burroughs in Japan -- and the executive staff includes a number of ex-Burroughs managers. Nippon Systemhouse started disk drive production in 1984 and is concentrating on the OEM market.

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

1984 total net sales: \$1,439,063,000 Net income: 124,129,000

Oki is a diversified manufacturer of electronic communications and data processing equipment, and also has a major role in the Japanese market as a terminal producer. For several years, the firm has made modest quantities of 8" one sided floppy drives for captive use and 5.25" one third high drives for both OEM and captive use. In 1985, Oki obtained rights from Tulin to manufacture and market the Tulin 5.25" half high rigid disk line on a worldwide basis. Production is expected to begin in early 1986.

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

1984 total net sales: \$964,367,000 Net income: \$41,463,000

Omron is best known as a manufacturer of electronic controls and electronic fund transfer systems. The firm is just beginning to make an entry into the data storage products industry through an investment in Micro Storage Corporation, which has designed a 5.25" cartridge disk drive. The drive will be made in volume by Omron.

ORIENTAL PRECISION COMPANY LIMITED
11th Floor, Tae Wha Building
194-27 Insa-dong,
Chongno-gu, Seoul, Korea

OPC, founded in 1953, is one of Korea's pioneering firms in the electronics industry. It is a major supplier of telecommunications equipment, video systems, and a volume producer of CRT terminals. OPC will produce a 3.9" cartridge disk drive under license from Syquest.

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

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

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

1984 total net sales: \$1,964,033,000 Net income: \$63,263,000

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 and 5.25" and 3.5" floppy disk drives used in both captive and OEM applications. In 1985, Ricoh licensed the DMA 5.25" cartridge disk drive design. With the demise of DMA, Ricoh will now be the major source for the product. Production will begin in 1986. Ricoh is also preparing to bring to market an optical disk drive jointly developed with Pioneer.

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

1984 total net sales: \$4,684,071,000 Net income: \$124,129,000

Sony is well recognized as a leader in consumer electronics and has also earned a position as the major supplier of 3.5" floppy disk drives. Sony is fielding a product line of optical disk drives including CD-ROM and write-once types, and is actively engaged in a research program on erasable optical media. The write-once products are available in 8" and 12" diameters. Sony supplies its own optical media. Because of its strong position in the audio CD player market, Sony is expected to be very competitive in the CD-ROM marketplace, with products aimed at the PC and small systems market.

SORD COMPUTER CORPORATION
 20-7, Masago 5-chome
 Chiba-shi, Chiba 260

1984 disk sales: \$16,000,000

Sord was the entrepreneurial wonder of the Japanese computer industry, growing from its founding in the early 1970's to become a major player in the Japanese domestic personal computer industry. The firm offers a wide variety of microcomputer based systems, and has developed its own advanced operating system. Production of 5.25" Winchester disk drives for captive use with Sord systems started in 1983. In recent years, Sord was unable to sustain its market share, and in 1985, the firm was acquired by Toshiba.

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

1984 disk sales: \$4,500,000
 1984 total net sales: \$314,492,000 Net income: 6,808,000

TEAC has taken steps in recent years to expand into computer peripherals, in recognition of slow growth in the worldwide market for quality audio tape decks, its major product area. TEAC has shipped 5.25" flexible disk drives since 1978, with rapid growth. 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. Production started in the second half of 1982, and the firm added a 12 MB half high drive in 1983, for worldwide distribution.

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

1984 disk sales: \$21,200,000
 1984 total net sales: \$376,888,000 Net income: \$6,500,000

Tokico, a member of the Hitachi group, is a manufacturer of automotive equipment, including shock absorbers, brakes and air compressors. The company is manufacturing a 5.25" Winchester fixed disk drive similar to the NPL NP05, with versions of the Tokico drive sold separately by Hitachi and by the Hitachi group trading company, Nissei Sangyo. A half high version went into production in late 1983.

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

1984 total net sales: \$593,271,000 Net income: \$18,063,000

Tokyo Electric is a member of the Toshiba group, and manufactures electronic cash registers, POS systems, lighting fixtures, household appliances and a growing family of data processing products. The firm markets 5.25" floppy drives on a worldwide basis and added 3.5" floppy disk drives in 1984. Also available is a small floppy drive using a spiral track. The first rigid disk products, 5.25" Winchesters, were shipped in 1985.

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

1984 total net sales: \$11,278,792,000 Net income: \$245,850,000

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. Rigid disk drive production is concentrated in captive products, including disk cartridge and disk pack drives, plus newer Winchester technology fixed disk drives in low and mid-range capacities, in both 14" and 8" disk diameters. Selected drives are also sold in the Japanese OEM disk drive market. Toshiba was one of the first firms to offer a commercial 12" optical disk drive, used primarily in Japan's leading document storage system. At the 1985 NCC, Toshiba made a technology announcement of a 5.25" write-once optical drive.

VICTOR COMPANY OF JAPAN, LTD.
4-1 Nihonbashi-Honcho
Chuo-ku, Tokyo 103

1984 total net sales: \$2,721,946,000 Net income \$96,708,000

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 70% of total revenues. JVC is now expanding into computer peripherals, with 5.25" rigid and floppy disk drives among the first products in the field. Half-high 5.25" floppy drives were shipped in mid-1984, and 3.5" rigid and floppy drives will ship in 1985.

European Manufacturers (Exchange basis indicated for each firm)

ALCATEL-THOMSON GIGADISC
 La Boursidiere - R.N. 186
 F-92350 Le Plessis Robinson, France

Beginning as the optical disk operation of Thomson-CSF, ATG was formed when the organization was transferred in 1984 to Alcatel, a maker of image processing systems. ATG was one of the first firms to get into limited production of optical drives, but media shortages have hampered its growth. Optimem and ATG share technology; the two firm's drives can use the same media. The current product line is based upon 12" write-once products using an unusual media developed by ATG. The drive will also operate with 3M media if properly adjusted. Most of the ATG drives have been used in image processing applications.

BASF AG
 D-6700 Ludwigshafen
 West Germany

1984 disk sales: \$29,700,000
 (Basis: DM 2.80 = U.S.\$1)

BASF is one of the world's chemical giants, and a pioneer manufacturer of magnetic recording media. Since the early 1970's, BASF has been a disk drive manufacturer, starting with a license from the old Century Data Systems to make 2314 type drives. The company continues to be a significant factor in the European PCM market. Today, BASF's internally manufactured rigid disk drive products consist only of 5.25" Winchester technology drives made in Germany, which have been enjoying sharp growth during the past year. The firm sold a 14" Winchester product line to Tecstor, and in 1982 sold the product line and facilities for an 8" Winchester drive in Los Gatos, California. BASF resells several Winchester technology drives manufactured in Japan by Nippon Peripherals, Ltd., plus a 3380 equivalent drive made by Hitachi.

BULL PERIPHERALS
 Subsidiary of Compagnie des Machines Bull
 94, Avenue Gambetta
 75960 Paris Cedex 20
 France

1984 disk sales: \$80,800,000
 (Basis: FF 8.40 = U.S.\$1)

In 1982, France's socialist government established control of Cii-HB by taking over Compagnie de Saint-Gobain, which held a majority interest. Honeywell Information Systems' previous 47% share of Cii-HB was reduced to 19.9%, and Compagnie des Machines Bull is now the parent company for several operating units in the Bull Group, including Bull Peripherals.

Bull's production of its unusual 10.5" "Cynthia" rigid disk drives is continuing, but 5.25" fixed and cartridge drives are now being emphasized. Production in France of 5.25" Winchester drives started in 1982, for captive and OEM distribution in Europe. A 5.25" disk cartridge drive was added in 1983. Bull has a cross-licensing arrangement with Vertex (now Priam) under which the organization has been manufacturing high capacity 5.25" drives, and which allows worldwide distribution.

ISOT
51, Chapaev St.
Sofia, Bulgaria

1984 disk sales: \$141,100,000

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 a 14" 80 MB disk pack drive similar to Control Data's storage module drives. ISOT, which operates disk drive factories with perhaps the highest level of vertical integration to be found anywhere in the disk drive industry, is expected to start production of Winchester technology drives this year.

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, which produces rigid and flexible disk drives. 14" disk cartridge and disk pack drives are manufactured in small quantities.

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

1984 disk sales: \$11,200,000
(Basis: Pound = U.S.\$1)

Newbury Data is the new name for the organization known previously as Data Recording Equipment, or DRE. Disk drive products now sold by Newbury Data 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. After the joint venture was dissolved two years ago, DRI regained ownership. Newbury Data is now continuing to sell under license some of the CDC products previously made by the joint venture, but is placing emphasis on newer disk drives, some produced under manufacturing licenses with other U.S. firms. Newbury Data has produced 5.25" disk cartridge drives under a DMA Systems license, and is also in production on Maxtor 140 megabyte 5.25" drives under a license from that firm. New this year is a 3.5" 20 and 40 megabyte drive with 40 ms average access time.

NIXDORF COMPUTER AG
 Furstenallee 7
 4790 Paderborn
 West Germany

1984 disk sales: \$80,000,000
 (Basis: DM 2.80 = U.S.\$1)

Nixdorf has maintained average annual growth of almost 25% for over five years, and the firm has undertaken various programs to control costs through internal manufacturing programs. Nixdorf now manufactures storage module drives in Berlin, West Germany, under a license from Control Data, for captive shipment with Nixdorf systems, and is expected to start production soon for its own internally developed 8" Winchester drives.

OLIVETTI PERIPHERAL EQUIPMENT
 Subsidiary of Ing. C. Olivetti & C., S.p.A.
 via Torina, 603
 10090 S. Bernardo d'Ivrea (Torino)
 Italy

1984 disk sales: \$87,300,000
 (Basis: L 1800 = U.S.\$1)

Under Olivetti's current management, the firm has undertaken numerous changes to modernize the company's product lines and drop out of older lines. The Olivetti Peripheral Equipment organization represented a consolidation of the firm's printer and disk memory activities in 1980. This organization has established production for 5.25" Winchester disk drives at Ivrea, with both captive and OEM markets in mind. The biggest impact on Olivetti's lifestyle during the past few years was purchase of a 25% share in the company by American Telephone and Telegraph, and adoption of an Olivetti-designed personal computer for distribution by AT&T. Production of small disk drives for this program has been underway at Ivrea, resulting in rapid growth in rigid disk drive production.

PERTEC COMPUTER CORPORATION
 Subsidiary of Triumph Werke Nurnberg AG
 9600 Irondale Avenue
 Chatsworth, CA 91311

1984 disk sales: \$3,800,000

Pertec, a pioneer manufacturer of OEM 14" disk cartridge drives, was acquired by Triumph Adler in early 1980. After struggling to bring its disk drive line up to date, the initial 8" Winchester drives announced a few years ago were dropped in favor of a new series of 8" 300 megabyte drives. Meanwhile, the old disk cartridge line, after years of decline, is being phased out.

N.V. PHILIPS
 P.O. Box 218
 5600 MD Eindhoven
 The Netherlands

1984 total net sales: \$17,356,000,000 Net income: \$359,000,000
 (Basis: Fl 3.10 = U.S.\$1)

The Philips organization has been active for many years in the development of optically based information systems. Initial development work was spun off to joint ventures with Control Data. Other Philips subsidiaries, such as Van Der Heem, continue to produce specialized products. Philips' major digital optical product is the CM-100 CD-ROM, which has the distinction of being the first CD-ROM to be accepted by a major system OEM. Digital Equipment Corporation offers it as a peripheral on its Micro-Vax line. Because Philips is a major producer of consumer electronics, the firm is expected to be a major competitor in the CD-ROM market.

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

1984 disk sales: \$74,800,000
 1984 total net sales: \$61,800,000 (FY end 9/84) Net income: \$7,900,000
 (Basis: Pound = \$1.25)

Rodime is a rare European phenomenon: A successful 5.25" OEM disk drive start up company, which proceeded to become the first disk drive manufacturer to achieve large volume production of 3.5" Winchester drives. After being formed in late 1980 by key personnel from the Burroughs facility in Glenrothes, Rodime met its schedule for shipments in 1981, and has continued to achieve a healthy growth rate. Rodime has expanded its product line to include 5.25" models with as much as 53 megabytes capacity.

1985 DISK/TREND REPORT

ROM CONTROL DATA S.R.L.
 Bucharest
 Romania

The Romanian government and Control Data jointly own ROM-CD, with CDC holding 45%. The organization manufactures double density versions of 2314 type drives, using technology provided by CDC. Drives manufactured are marketed in both Eastern Bloc countries and in Western Europe.

SIEMENS AG
 Data and Information Systems Group
 Otto-Hahn-Ring 6
 D-8000 Munchen 83
 West Germany

1984 disk sales: \$36,500,000
 1984 total net sales: \$16,364,776,000 Net income: \$374,562,000
 (Basis: DM 2.80 = U.S.\$1)

After many years of producing rigid disk drives of its own design for captive use with its mainframe systems, Siemens is now closing out its 14" disk drive manufacturing program in Munich. Several disk pack drives and a large fixed disk drive for captive use have been phased out in favor of outside purchases of high performance drives, including IBM's 3380. In the meantime, Siemens has announced a 5.25" Winchester disk drive with capacities up to 300 MB, with initial deliveries promised for fourth quarter, 1985. So far, no plans for captive applications have been announced for this drive; Siemens plans to sell it 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.

VAN DER HEEM ELECTRONICS
 Subsidiary of N. V. Philips
 Regulusweg 15
 2500 AB The Hague
 Netherlands

1984 total net sales: \$17,356,000,000 Net income: \$359,000,000
 (Basis: Fl 3.10 = U.S.\$1)

This firm is a division of Hollandse Signaalapparaten BV, a subsidiary of N.V. Philips. Products include a ruggedized 12" write-once drive used by certain military organizations in Europe and for other applications where a high resistance to stress is needed. The initial MegaDoc optical storage systems provided by Philips also made use of this firm's products. Production volume is nominal.