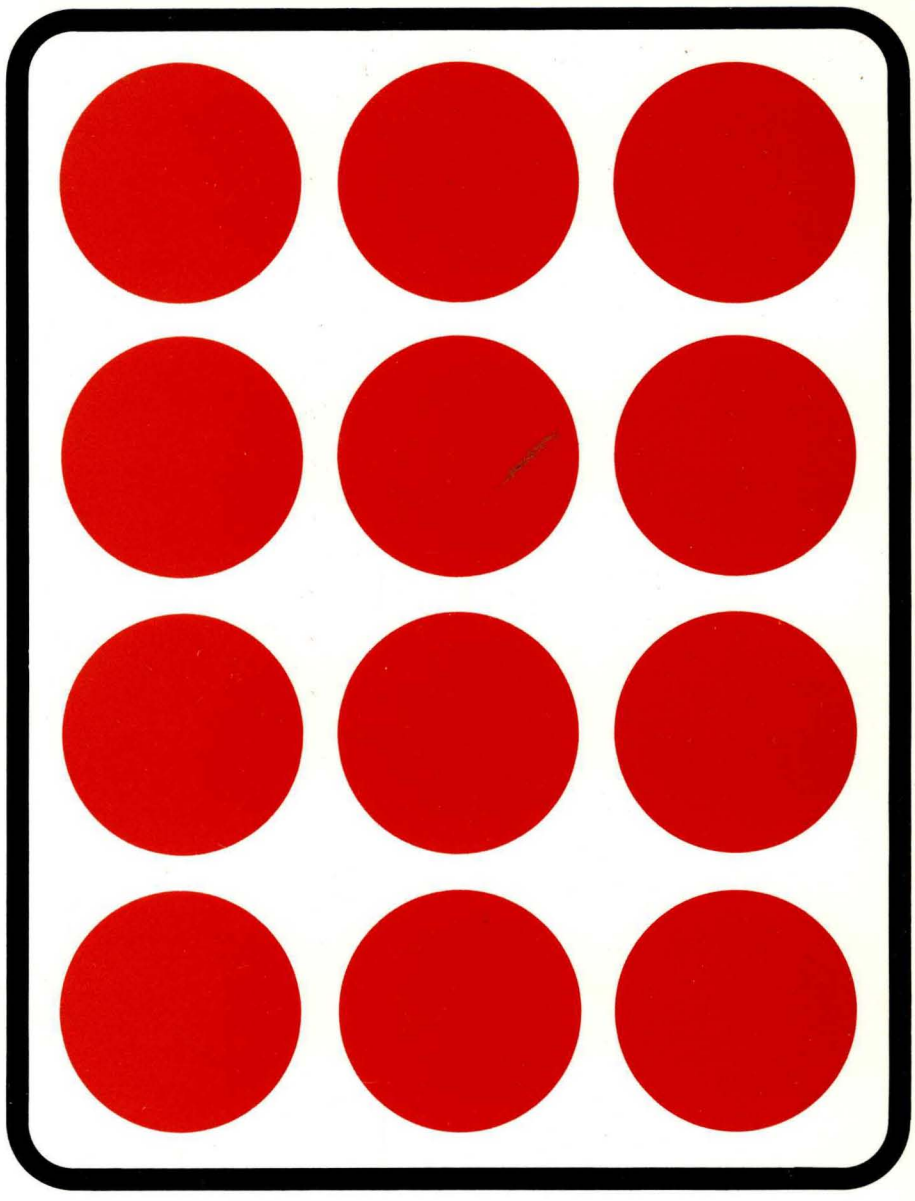

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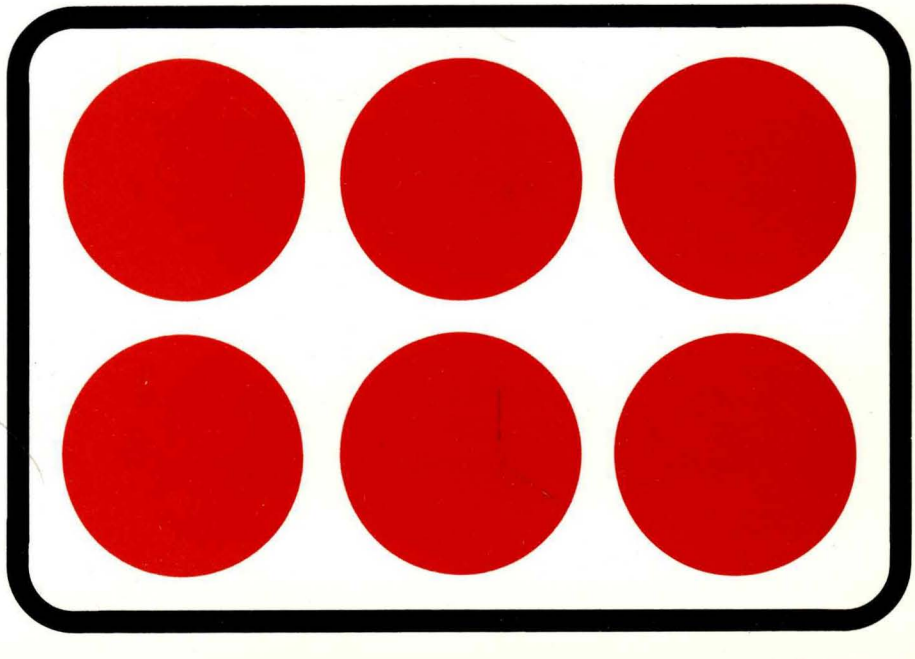

FLEXIBLE DISK DRIVES

1991 DISK/TREND® REPORT

FLEXIBLE DISK DRIVES

November, 1991

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FOREWORD

The rate of change in floppy drive products has become a bit faster. 3.5 inch drives only 12.7 millimeters high are now available, 4 megabyte drives are now in the product lines of most major manufacturers, and the would-be leaders in the future 3.5 inch high capacity floppy drive market are jockeying for position.

The frustrating part of the floppy drive industry is not the excellent record of product innovation, but the apparent inability of the industry to operate at a reasonable profit. It's a problem the managements of the floppy drive manufacturers will have to watch closely -- without profits, the development programs cannot continue.

This is the fifteenth year of the DISK/TREND Report, which is now published in three volumes, including the report on optical disk drives, published in July. A separate report on rigid disk drives was published in October.

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

James N. Porter

Robert H. Katzive

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INTRODUCTION

New and improved tables

Last year we added new tables on Drive Height Analysis and Drive Capacity Analysis to the microfloppy section. Included for the first time in these tables were separate forecasts for drives with heights less than 1 inch and for 4 megabyte drives.

This year we've made improvements in the Current Product Lines table in the summary section of the report (Table 6). Instead of listing products by TPI, a method which has become less useful due to continuing product changes over the years, products are now listed by capacity groups, which should make the table more useful for most readers.

Notes for DISK/TREND ON DISK users

Some users have found it difficult to sort data in the specification tables using spreadsheet programs, in the instances in which not all information is presented in numeric form. This year we have converted the contents of certain fields to purely numeric data as recorded on the diskettes, to make it easier for spreadsheet users to sort and extract data. If you plan to use the specification information in diskette form, please read the DISK/TREND ON DISK section on Special data.

It's becoming more difficult to define drive capacities

We normally identify the capacity of individual disk drives on the basis of unformatted capacities. Until recent years, most OEM drives were specified in unformatted capacities, and our system seemed to be clear to practically everyone. But in the last few years the advent of embedded controllers in rigid disk drives and high capacity floppy drives has meant that many drives are now specified in formatted capacities, and our classification system can be confusing to some. Most users also identify floppy drive capacity by the formatted capacity.

Frankly, we think its probably about time to change our system, so that all drives are classified by their formatted capacities, and we tentatively plan to do just that in next year's DISK/TREND Report. Please let us know if you disagree for any reason.

Summary

Industry size

1990's growth in floppy drive unit shipments was substantially higher than expected, with worldwide shipments of 44.6 million drives, up 16% over the previous year. Unfortunately, the current economic recession has held down the personal computer market, and 1991 shipments are forecasted at only 44.0 million drives, down 1.3%. 1990's strong shipments also generated 3.3% growth in overall floppy drive revenues, but the 1991 revenue total is expected to be down 11.8%.

The industry's revenues are lagging behind shipment levels due to intense competition between the Japanese manufacturers which dominate the industry and the continuing changes in product mix. The rapid shipment growth of microfloppy drives, which now provide almost 70% of the industry's unit shipments, has resulted in major displacement of 5.25 inch drives.

Since the 1991 worldwide average OEM price for 5.25 inch drives is $50, while the average OEM price for microfloppies is only $42, there is a reduction in total revenues of $8 for each 5.25 inch drive displaced. The continuous decline in average OEM prices for microfloppy drives also hurts revenues. The average microfloppy OEM price in 1988 was $59, but is projected at only $37 in 1994.

The average annual unit shipment growth forecasted for all floppy drives during the 1992-94 period is only 2.3%, due to the modest growth rate expected for personal computers, the largest floppy drive market. Total industry revenues are expected to decline 2.6% during the same period, under the pressure of intense competition and dropping prices.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

ALL EXISTING FLEXIBLE DISK DRIVE GROUPS

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1990		Forecast							
	Revenues		1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	4.5	9.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	4.5	9.0	--	--	--	--	--	--	--	--
PCM/Reseller	47.1	66.9	48.4	62.3	66.6	87.8	60.4	81.1	45.0	62.7
OEM/Integrator	5.8	5.8	3.9	3.9	43.5	52.9	59.3	75.5	89.3	117.1
TOTAL U.S. NON-CAPTIVE	52.9	72.7	52.3	66.2	110.1	140.7	119.7	156.6	134.3	179.8
TOTAL U.S. REVENUES	57.4	81.7	52.3	66.2	110.1	140.7	119.7	156.6	134.3	179.8
Non-U.S. Manufacturers										
Captive	20.0	527.2	15.8	380.5	15.4	287.7	20.7	240.6	31.2	225.1
PCM/Reseller	228.8	320.2	192.7	290.5	171.5	268.8	160.1	255.6	143.0	235.8
OEM/Integrator	656.1	1,703.8	611.2	1,583.2	585.9	1,593.1	559.2	1,568.7	546.3	1,498.6
TOTAL NON-U.S. REVENUES	904.9	2,551.2	819.7	2,254.2	772.8	2,149.6	740.0	2,064.9	720.5	1,959.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	962.3	2,632.9	872.0	2,320.4	882.9	2,290.3	859.7	2,221.5	854.8	2,139.3

Marketing channels

After peaking in 1986 at 58 companies, the number of manufacturers participating in the flexible disk drive industry continues downward. There are currently 36 manufacturers of flexible disk drives.

Japanese companies now account for half of the total, with 18 firms still active in the field, although they obviously provide a much higher proportion of the worldwide unit shipments. The total number of floppy drive manufacturers headquartered in Asian countries declined from 32 in 1990 to 25 in 1991, as several companies with low shipment levels dropped out of the business. Other Asian manufacturers are finding it difficult to stay in the floppy drive business, due to the low prices which have resulted from intense competition for market share between the Japanese companies.

The remaining four U.S. manufacturers are all producers of specialized floppy drives, mostly in the high capacity group. The list of European producers is down to one, since the political changes in the previous Eastern Bloc have eliminated the markets for the older drive models in production until last year.

Users of the DISK/TREND Report should note that revenues are reported at the level of each drive's first public sale. The price used for each drive is the estimated value at the first time it is sold to a nonaffiliated buyer, at captive end user, PCM/Reseller or OEM/Integrator levels. An understanding of the relative prices at captive and noncaptive levels 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.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
ALL EXISTING FLEXIBLE DISK DRIVE GROUPS
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1990 Revenues $M	1990 Revenues %	Forecast 1991 $M	Forecast 1991 %	Forecast 1992 $M	Forecast 1992 %	Forecast 1993 $M	Forecast 1993 %	Forecast 1994 $M	Forecast 1994 %
U.S. Manufacturers										
IBM Captive	9.0	.3%	--	--	--	--	--	--	--	--
	-45.5%		--		--		--		--	
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
	--		--		--		--		--	
PCM/Reseller	66.9	2.5%	62.3	2.6%	87.8	3.8%	81.1	3.6%	62.7	2.9%
	-6.7%		-6.9%		+40.9%		-7.6%		-22.7%	
OEM/Integrator	5.8	.2%	3.9	.1%	52.9	2.3%	75.5	3.3%	117.1	5.4%
	-31.0%		-32.8%		--		+42.7%		+55.1%	
Total U.S. Manufacturers	81.7	3.0%	66.2	2.7%	140.7	6.1%	156.6	6.9%	179.8	8.3%
	-18.5%		-19.0%		+112.5%		+11.3%		+14.8%	
Non-U.S. Manufacturers										
Captive	527.2	20.0%	380.5	16.3%	287.7	12.5%	240.6	10.8%	225.1	10.5%
	-1.5%		-27.8%		-24.4%		-16.4%		-6.4%	
PCM/Reseller	320.2	12.1%	290.5	12.5%	268.8	11.7%	255.6	11.5%	235.8	11.0%
	+29.0%		-9.3%		-7.5%		-4.9%		-7.7%	
OEM/Integrator	1,703.8	64.9%	1,583.2	68.5%	1,593.1	69.7%	1,568.7	70.8%	1,498.6	70.2%
	+2.4%		-7.1%		+.6%		-1.5%		-4.5%	
Total Non-U.S. Manufacturers	2,551.2	97.0%	2,254.2	97.3%	2,149.6	93.9%	2,064.9	93.1%	1,959.5	91.7%
	+4.2%		-11.6%		-4.6%		-3.9%		-5.1%	
Worldwide Recap										
Captive	536.2	20.4%	380.5	16.4%	287.7	12.6%	240.6	10.8%	225.1	10.5%
	-3.4%		-29.0%		-24.4%		-16.4%		-6.4%	
PCM/Reseller	387.1	14.7%	352.8	15.2%	356.6	15.6%	336.7	15.2%	298.5	14.0%
	+21.0%		-8.9%		+1.1%		-5.6%		-11.3%	
OEM/Integrator	1,709.6	64.9%	1,587.1	68.4%	1,646.0	71.8%	1,644.2	74.0%	1,615.7	75.5%
	+2.2%		-7.2%		+3.7%		--		-1.7%	
Total All Manufacturers	2,632.9	100.0%	2,320.4	100.0%	2,290.3	100.0%	2,221.5	100.0%	2,139.3	100.0%
	+3.4%		-11.9%		-1.3%		-3.0%		-3.7%	

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

Product mix

1990's surge in microfloppy drive shipments boosted the microfloppy share of all floppy drive unit shipments for that year to 66% of the worldwide total, with 29.4 million drives. Despite the modest growth expected in 1991 for microfloppy drives, the long-term trend is still upward, and the 1994 shipment total is forecasted at 38.9 million drives, 82.4% of the 1994 unit total for all floppy drives. The average annual increase in unit shipments for microfloppy drives during the five year period covered by this report is 11.1%, but falling average unit prices will hold the average annual increase in revenues during the same period to 4.8%.

Although shipments of 5.25 inch floppy drives declined for the first time in 1989, the strong 1990 market generated slight growth for 5.25 inch drives, spearheaded by 1.6 megabyte models. However, the outlook remains bleak for 5.25 inch drives, which will continue to be supplanted by microfloppies in new system models. The forecast is for a decline from 1990's peak of 14.9 million drives to a low of 6.9 million drives in 1994.

Despite current shipments at lower levels than expected, high capacity floppy drives over 5 megabytes are expected to achieve high growth rates as production facilities for new 3.5 inch drives are established. The outlook for 5.25 inch high capacity floppies is continuing decline, after the projected 1992 shipment peak. But the expected demand for the high capacity 3.5 inch drives, especially the new downward compatible one inch high models expected to be in production from several sources in 1992, will probably be sufficient to boost shipments in this product group to new heights, despite manufacturing start-up problems and current lack of an effective media interchange standard.

Figure 1

CHANGING PRODUCT MIX
Worldwide Flexible Disk Drive Revenue

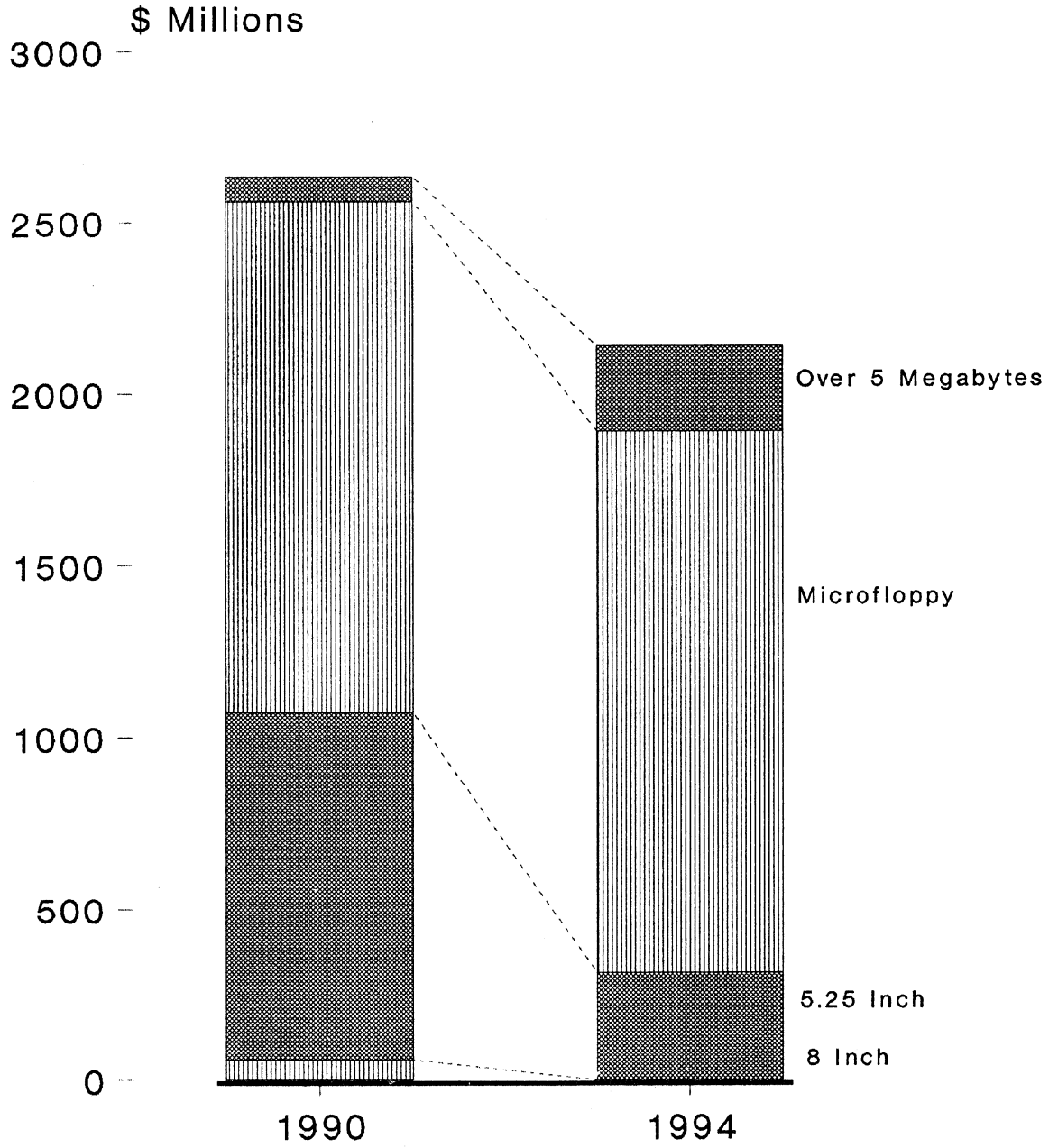

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TABLE 3

WORLDWIDE SHIPMENTS

PRODUCT CATEGORY SUMMARY

ALL MANUFACTURERS

Units: Thousands Dollars: $ Million		1990 Shipments	%	1991 Ship	%	1992 Ship	%	1993 Ship	%	1994 Ship	%
				Forecast							
8 INCH DRIVES											
	Units	141.6	-42.2	86.2	-39.1	48.1	-44.1	15.0	-68.8	--	--
	$M	60.1	-39.9	31.9	-46.9	17.3	-45.7	4.9	-71.6	--	--
5.25 INCH DRIVES											
	Units	14,946.2	+.4	13,136.3	-12.1	11,180.0	-14.8	9,088.0	-18.7	6,945.0	-23.5
	$M	1,012.8	-.8	787.8	-22.2	599.3	-23.9	442.7	-26.1	314.4	-28.9
MICROFLOPPY DRIVES											
	Units	29,445.9	+26.8	30,696.0	+4.2	33,756.0	+9.9	36,552.0	+8.2	38,962.0	+6.5
	$M	1,487.7	+10.4	1,434.0	-3.6	1,521.5	+6.1	1,580.5	+3.8	1,577.7	-.1
DRIVES OVER 5 MEGABYTES											
	Units	81.3	-25.3	90.6	+11.4	420.2	+363.7	793.0	+88.7	1,377.0	+73.6
	$M	72.3	-8.7	66.7	-7.7	152.2	+128.1	193.4	+27.0	247.2	+27.8
TOTAL ALL DRIVES											
	Units	44,615.0	+16.0	44,009.1	-1.3	45,404.3	+3.1	46,448.0	+2.2	47,284.0	+1.7
	$M	2,632.9	+3.3	2,320.4	-11.8	2,290.3	-1.2	2,221.5	-3.0	2,139.3	-3.7

Figure 2

CHANGING PRODUCT MIX

Worldwide Flexible Disk Drive Shipments
All Manufacturers

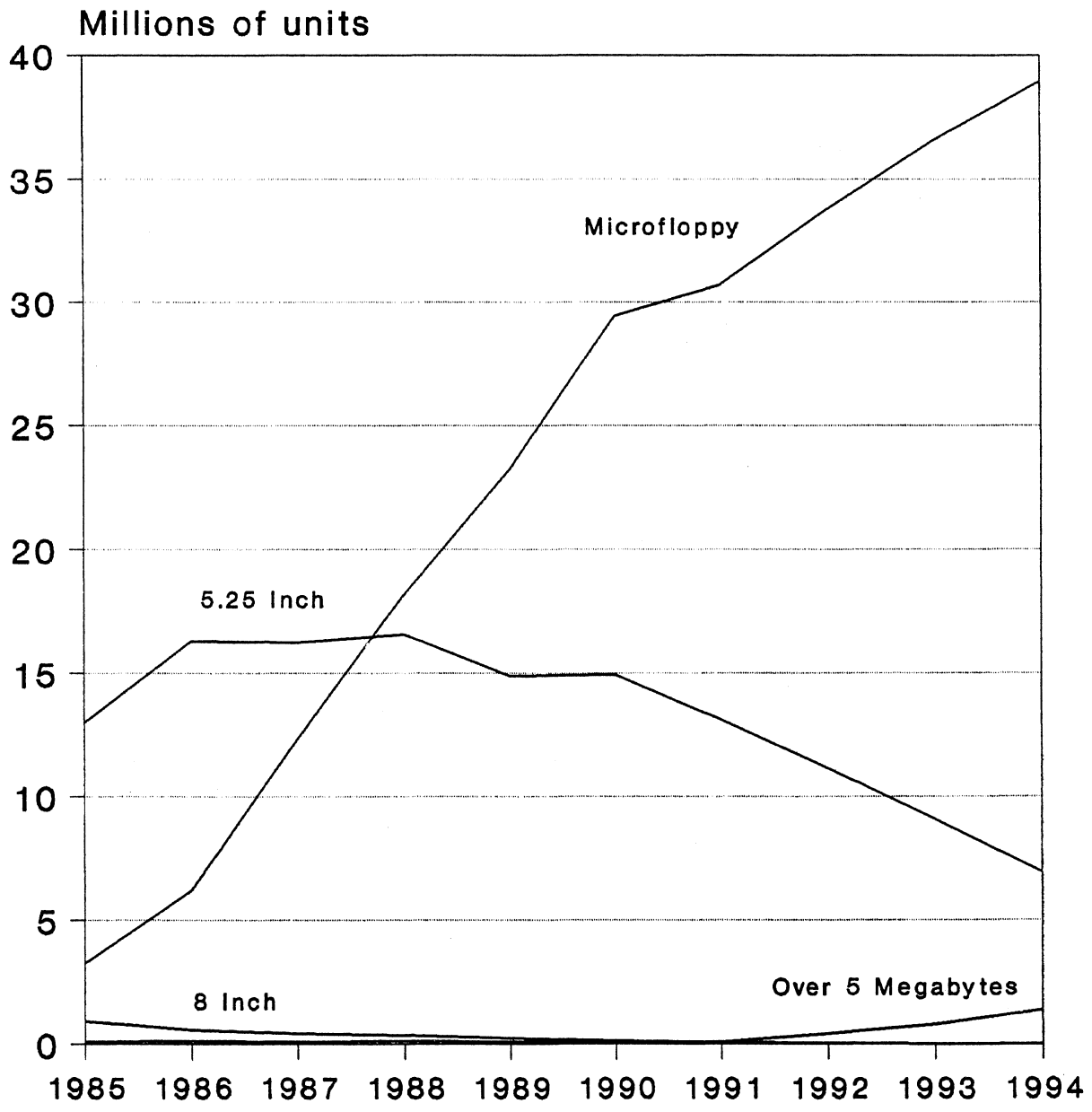

TABLE 4

WORLDWIDE SHIPMENTS

PRODUCT CATEGORY SUMMARY

MANUFACTURERS OF NON-CAPTIVE DRIVES

Units: Thousands Dollars: $ Million		1990 Shipments	%	1991 Ship	%	1992 Ship	%	1993 Ship	%	1994 Ship	%
8 INCH DRIVES											
	Units	69.8	-50.0	45.2	-35.2	26.1	-42.2	9.0	-65.5	--	--
	$M	18.1	-50.1	11.2	-38.1	6.3	-43.7	1.9	-69.8	--	--
5.25 INCH DRIVES											
	Units	13,334.4	-.7	12,180.3	-8.6	10,713.0	-12.0	8,916.0	-16.7	6,905.0	-22.5
	$M	700.4	-4.9	613.3	-12.4	520.4	-15.1	415.9	-20.0	308.3	-25.8
MICROFLOPPY DRIVES											
	Units	28,216.7	+28.4	29,173.0	+3.3	32,078.0	+9.9	34,746.0	+8.3	37,015.0	+6.5
	$M	1,306.2	+14.6	1,249.0	-4.3	1,325.9	+6.1	1,376.6	+3.8	1,370.9	-.4
DRIVES OVER 5 MEGABYTES											
	Units	81.0	-25.3	90.3	+11.4	415.0	+359.5	775.0	+86.7	1,342.0	+73.1
	$M	72.0	-8.7	66.4	-7.7	150.0	+125.9	186.5	+24.3	235.0	+26.0
TOTAL ALL DRIVES											
	Units	41,701.9	+17.0	41,488.8	-.5	43,232.1	+4.2	44,446.0	+2.8	45,262.0	+1.8
	$M	2,096.7	+5.2	1,939.9	-7.4	2,002.6	+3.2	1,980.9	-1.0	1,914.2	-3.3

Figure 3

CHANGING PRODUCT MIX

Non-Captive Flexible Drive Shipments

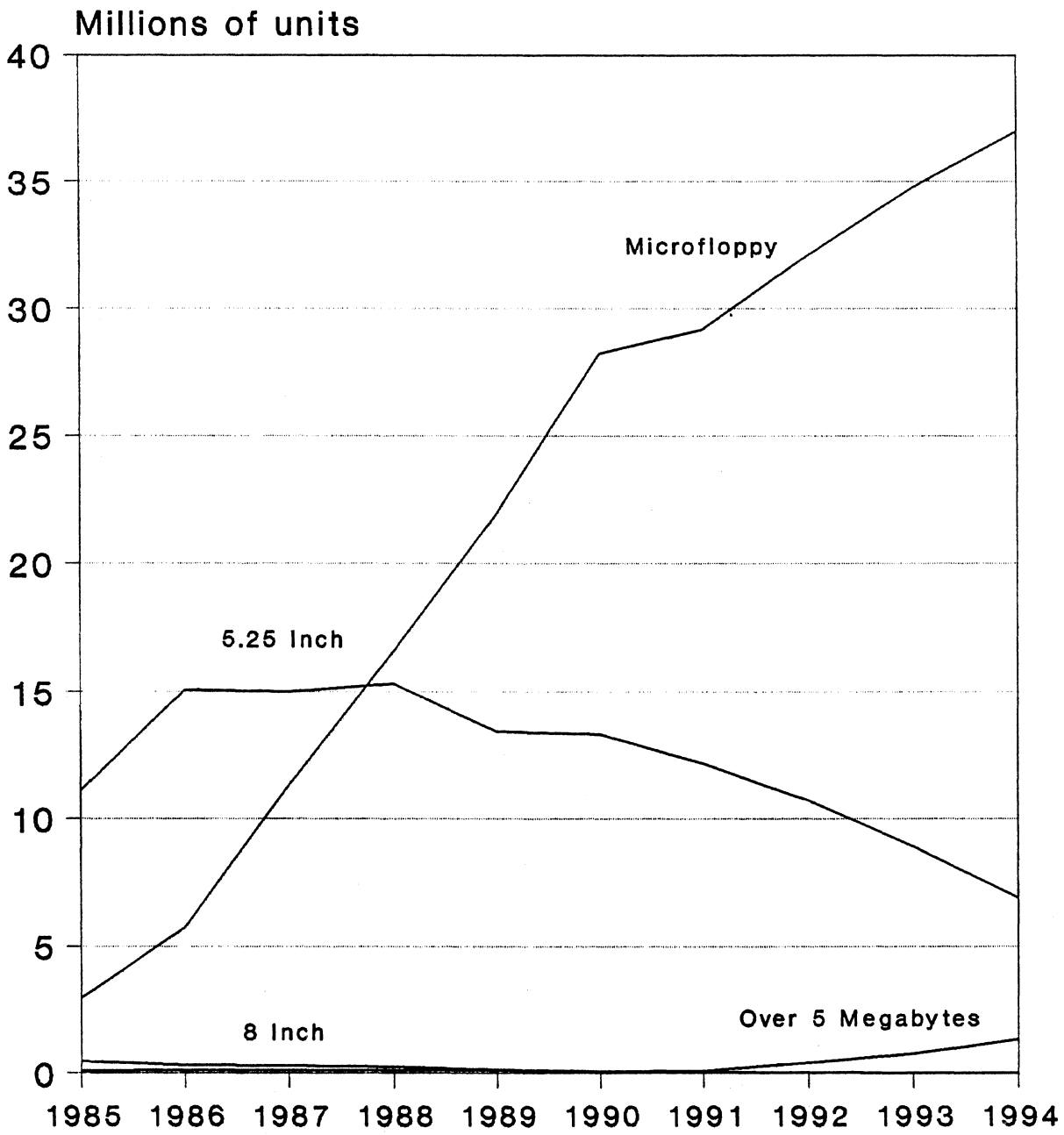

TABLE 5

1990 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL FLEXIBLE MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1990 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Iomega	--	--	64.4	16.6	4.8	.3	69.2	2.6
Other U.S.	9.0	1.7	2.5	.6	1.0	.1	12.5	.5
U.S. Total	9.0	1.7	66.9	17.3	5.8	.3	81.7	3.1
NON-U.S. MANUFACTURERS								
Alps Electric	--	--	--	--	59.2	3.5	59.2	2.2
Canon	5.6	1.0	--	--	35.8	2.1	41.4	1.6
Chinon	--	--	77.1	19.9	98.4	5.8	175.5	6.7
Citizen	--	--	.6	.2	142.0	8.3	142.6	5.4
Matsushita Communication Ind.	--	--	--	--	206.0	12.0	206.0	7.8
Matsushita Electric Industrial	--	--	--	--	64.2	3.8	64.2	2.4
Mitsubishi Electric	17.3	3.2	27.5	7.1	142.2	8.3	187.0	7.1
Mitsumi Electric	--	--	31.2	8.1	65.8	3.8	97.0	3.7
NEC	375.2	70.0	--	--	36.8	2.2	412.0	15.6
Seiko Epson	47.3	8.8	33.2	8.6	71.8	4.2	152.3	5.8
Sony	10.8	2.0	--	--	292.6	17.1	303.4	11.5
Teac	--	--	56.2	14.5	318.0	18.6	374.2	14.2
Toshiba	--	--	31.1	8.0	21.7	1.3	52.8	2.0
Y-E Data	--	--	45.7	11.8	108.9	6.4	154.6	5.9
Other Non-U.S.	71.0	13.2	17.6	4.5	40.4	2.4	129.0	4.9
Non-U.S. Total	527.2	98.3	320.2	82.7	1,703.8	99.7	2,551.2	96.9
WORLDWIDE TOTAL	536.2	100.0	387.1	100.0	1,709.6	100.0	2,632.9	100.0

TABLE 6

Codes: C = Captive
P = PCM
O = OEM

CURRENT PRODUCT LINES
MANUFACTURERS OF FLEXIBLE DISK DRIVES

Codes:

Capacity	8"	5.25"	MICRO
<=.5 MB =		.5	.5
.8 MB =	.8		
1.0 MB =		1	1
1.6 MB =	1.6	1.6	1.6
2.0 MB =			2
3.3 MB =	3	3	
4.0 MB =			4

High Capacity= 8:(MB) 5:(MB) 3:(MB)

Unformatted capacities shown for all drives unless formatted capacity indicated by (F)

DISK/TREND PRODUCT GROUP:		13	14	15	16
U.S. MANUFACTURERS	TYPE	8 INCH	5.25 INCH	MICRO FLOPPIES	HIGH CAPACITY >5 MB
Brier Technology	P,O				3:21/44(F)
Insite Peripherals	O				3:21(F)
Iomega	P,O				5:21/44/90(F)
Miltope	O	.8,1.6			
ASIAN MANUFACTURERS					
Alps Electric	O			1,1.6,2,4	
Asia Commercial	O		.5,1.6		
Brother	C,O			.5	
Canon	O		.5,1.6	1,1.6,2	
Chinon	O		.5,1.6	1,2,4	
Citizen	O			1,1.6,2,4	3:20(F)
Ergo	C,O			2	
Hitachi	C,O	1.6			5:6,8:9
Ho Shin	O		.5,1,1.6		
Mantec Technology	P		.5,1.6		
Matsushita Communication Indust.	O	1.6	.5,1.6	1,1.6,2,4	3:28
Matsushita Electronic Components	O			.5,1,1.6,2	
Mitsubishi Electric	O		.5,1.6	1,1.6,2,4	
Mitsumi Electric	O		.5,1.6	1,1.6,2,4	
NEC	C,O	1.6	1.6	1,1.6,2	3:10(F)
Oriental Precision	C,O		.5,1,1.6		
Roctec	O		.5		
Safronic	O		.5,1.6,2		
Samsung Electronics	C,O		.5,1.6	2,4	
Sankyo Seiki	O			1.6,2	
Seiko Epson	O		.5,1.6	1,1.6,2,4	
Sony	C,O			1,2,4	
Teac	O		.5,1,1.6	1,1.6,2,4	
Toshiba	C,O		.5,1.6	1,2,4	
Y-E Data	O	1.6	.5,1.6,3	1,1.6,2,4	3:26
EUROPEAN MANUFACTURERS					
Elcomatic	O	.8,1.6,3.2			
SOUTH AMERICAN MANUFACTURERS					
Cobra	C	1.6			
Elebra Informatica	O		.5,1.6		
Flexdisc	O		.5,1.6		
Itautec	C		.5,1.6		
Multidigit	P,O		.5,1,1.6		
Prologica	C,O		.5		

Application mix

As personal computers have expanded the range of applications served, new computer markets have been created. Personal computers have taken over a significant share of the functions previously served by dedicated application systems, as well as those of minicomputers and mainframes.

As the role of personal computers has increased, so has that of the floppy drives used with almost all PCs. However, there are now signs that the percentage share of worldwide floppy drive shipments held by business personal computers may be saturating, as the home computer market appears headed for higher growth and as many new notebook portable computers appear without floppy drives.

In 1988 shipments of microfloppy drives overtook 5.25 inch drives for the first time in business personal computer applications. In 1990 the microfloppy share rose to 65.9%, and by 1994 microfloppies are expected to hold 81.7% of the business personal computer market.

Consumer and hobby applications are expected to grow faster than any other application in the next few years. The DISK/TREND forecasts indicate that these applications will consume 10.2% of 1994's overall shipments, up from 1990's 3.3%. As recently as 1988, 5.25 inch drives provided more than half of the floppy drive total for consumer and hobby applications, but microfloppies had risen to 78.2% of the worldwide total in 1990 and are projected to provide 97.4% of the 1994 total.

The proportion of floppy disk drives used in dedicated office systems continues to slide, as personal computers displace many specialized systems in both office and nonoffice environments. In 1994 the share of total floppy drive shipments used with dedicated office systems is expected to be down to 4.2%.

TABLE 7

FLEXIBLE DISK DRIVE APPLICATIONS SUMMARY

CONSOLIDATED WORLDWIDE SHIPMENTS

	1990 Estimate					1994 Projection				
	All FDD	8" All Types	5.25" All Types	Micro Floppy	Over 5 MB	All FDD	8" All Types	5.25" All Types	Micro Floppy	Over 5 MB
MAINFRAME/SUPERMINI General purpose										
Units (000)	61.4	2.5	--	58.9	--	39.0	--	--	39.0	--
Share %	.1%	1.7%	--	.2%	--	.1%	--	--	.1%	--
MINICOMPUTERS AND MULTIPLE USER MICROS Including networks										
Units (000)	826.2	53.2	593.4	179.6	--	500.2	--	277.8	194.8	27.5
Share %	1.9%	37.6%	4.0%	.6%	--	1.1%	--	4.0%	.5%	2.0%
PERSONAL COMPUTERS Single user										
Units (000)	38,372.7	49.4	12,971.9	25,276.4	75.2	38,795.5	--	5,882.3	31,715.1	1,198.0
Share %	86.0%	34.9%	86.8%	85.8%	92.5%	82.0%	--	84.7%	81.4%	87.0%
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application										
Units (000)	2,844.8	19.7	777.2	2,046.5	1.4	2,001.7	--	312.5	1,675.4	13.8
Share %	6.4%	13.9%	5.2%	7.0%	1.7%	4.2%	--	4.5%	4.3%	1.0%
NON-OFFICE SYSTEMS AND WORKSTATIONS Dedicated application										
Units (000)	728.1	13.1	239.1	471.1	4.7	819.5	--	347.3	389.6	82.6
Share %	1.6%	9.2%	1.6%	1.6%	5.8%	1.7%	--	5.0%	1.0%	6.0%
CONSUMER AND HOBBY COMPUTERS										
Units (000)	1,468.2	--	319.8	1,148.4	--	4,800.0	--	69.5	4,675.4	55.1
Share %	3.3%	--	2.1%	3.9%	--	10.2%	--	1.0%	12.0%	4.0%
OTHER APPLICATIONS										
Units (000)	313.6	3.7	44.8	265.0	--	328.3	--	55.6	272.7	--
Share %	.7%	2.7%	.3%	.9%	--	.7%	--	.8%	.7%	--
TOTAL, ALL APPLICATIONS										
Units (000)	44,615.0	141.6	14,946.2	29,445.9	81.3	47,284.0	--	6,945.0	38,962.0	1,377.0
Share %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	--	100.0%	100.0%	100.0%

TECHNICAL REVIEW

Competing technologies

After several years of only incremental improvement in flexible disk drive technology, substantial gains in form factor and capacity for 3.5 inch drives became available in 1991. 12.7 millimeter (half inch) high drives, 4 megabyte drives and 20 megabyte drives are extending the choices available for removable storage and reinforcing the strong position held by floppy disk drives as the low cost removable storage device of choice for most small computing systems. Other technologies attempting to compete with floppy drives are either too slow, too expensive, or are not standardized for universal data interchange. The unique combination of low cost, random access and media removability provided by flexible disk drives is the reason for their success. Any competing technology must offer significant improvements at a competitive price.

Like their rigid disk drive cousins, flexible disk drives are evolving. Smaller form factors, higher capacities, more effective designs and lower cost manufacturing methods sustain floppy drive cost-effectiveness against competitive data storage technologies. Consequently, alternate technologies are finding only limited success in breaking into floppies' established markets, although some displacement of floppy drives is occurring in notebook and hand-held computers where there is insufficient space or power for floppy drives. The high capacity and low profile floppy drive designs now entering the production phase are proof that innovation in floppy disk drives is a continuing process.

A few alternative storage technologies briefly reviewed below have the potential to challenge flexible disk drives in selected markets:

* Small rigid disk drives: Rapid growth of small Winchester drives has displaced large quantities of floppy drives which otherwise would have been sold, but availability of these rigid disk drives has probably also served to increase the size of the total market for small computer systems, and therefore boost the market for floppy drives. For most systems using small fixed disk drives, a companion removable media recording device is necessary to provide for software distribution, save/restore of programs and files, and backup to protect against hardware, software or operator failure. Most of the time, that removable device is a floppy disk drive. With the arrival of 3.5 inch floppy drives in IBM and laptop systems, many organizations have had to increase the total number of floppy drives owned in order to maintain a universal data interchange capability among their PC populations.

  The rigid disk challenge to flexible disk drives is most effectively presented by both disk cartridge drives and small removable fixed disk drives. Small disk cartridge drives, some with capacities as high as 105 megabytes, offer one of the best ways to accomplish fast save/restore of files. They also have access times fast enough to be satisfactory as basic system disks, in lieu of fixed Winchester drives. However, drive and media costs are expensive compared to flexible drives. Furthermore, removable cartridge drives have not been able to compete in form factor with low profile floppy drives, although SyQuest's 2.5 inch, 17 millimeter high, 42 megabyte cartridge drive may prove more of a contender in this respect and its announced OEM drive price also competes well against that of the high capacity floppy drive.

  High cost also makes removable rigid disk drives less attractive as floppy disk replacements because high capacity floppy drives will be able to perform the same function as long as fast performance is not required. Specialized products, such as the Iomega Bernoulli disk drives, now at 90 megabyte capacity, also provide competition for rigid disk drives.

* Semiconductor memory: Semiconductor DRAM memory is still too expensive to compete directly with floppy disk drives. Furthermore, the EEPROM or battery-backed SRAM chips required to preserve data during power off periods cost even more, nor is it certain that they will be available in the high densities anticipated for future DRAMs. Ferroelectric memory shows some promise of being a significant future competitor due to its inherent nonvolatility and a production process similar to that of the well understood CMOS, but is unlikely to be a significant competitor until after 1992.

  However, the price of semiconductor memory is coming down. The chip cost per megabyte is expected to be in the range of one dollar by the late nineties for DRAMs and about two dollars per megabyte for SRAMs and other nonvolatile memory types. By comparison, floppy disk media is expected to cost about fifty cents per megabyte in the same period. However, for semiconductor memory to

continue to advance as expected, difficult problems in manufacturing technology must be overcome -- especially those concerned with producing narrower line widths. The rate of development will slow down as the plant and equipment costs increase and lead times for advanced manufacturing and production equipment become significantly longer.

Small plastic cards containing IC memories ranging from 8 kilobytes to several megabytes in capacity have begun challenging floppy disk drives in selected applications such as games, palmtop computers, medical history storage, programming for electronic musical instruments, and type font storage for printers. Typically the size of a credit card, the cards may contain a PROM, EPROM, or EEPROM depending upon whether the application requires read-only, write-once or rewritable storage. While more expensive than floppy disk media, the cards are less vulnerable, though not immune, to handling damage.

Flash memory, a form of electrically alterable nonvolatile memory, is a possible alternative to floppy disk drives in cases where removable memory with high performance or resistance to shock and vibration is more important than low cost. In 1991, flash memory OEM prices are being quoted in the range of $75 to $100 per megabyte, and are projected by memory manufacturers to decrease to the $10 per megabyte range by mid-decade. These price levels may be acceptable compared to floppy drive prices provided that not more than a few pieces of semiconductor "media" are required during the lifetime of the system.

Flash memory chips can be configured as additional system memory or organized to mimic the file structure of a disk drive. Packaging is typically on a credit card sized plug-in card. Card capacity now ranges from .25 to 10 megabytes, and 20 megabyte cards are anticipated in 1992. Packaging and the system interface for flash memory and other semiconductor memory cards have been standardized through the joint efforts of PCMCIA (Personal Computer Memory Card International Association) and JEIDA (Japan Electronic Industry Development Association). PCMCIA, founded in 1989, claims over 150 members representing semiconductor, connector, component and system manufacturers.

There are a number of different technologies for implementing flash memory, some of which have characteristics that will limit acceptability to system manufacturers, such as 12 volt operation. All flash memory is subject to a lifetime limitation ranging from 10,000 to 100,000 write/erase cycles, depending upon the fabrication technology used. Not all bytes degrade at the same rate, so "bad track" detection methods can be used to extend chip operating life somewhat. For applications where use is read-only or read-mostly, the chips may have acceptable longevity.

While flash memory offers very fast read performance and read data transfer rates, write performance is limited by the need to erase

blocks of bytes before new data can be written. However, because power demand is low and powerup time is fast, flash memories are attractive to manufacturers of notebook and subnotebook systems where battery life is limited and resistance to mechanical shock and vibration is necessary.

Semiconductor memory will compete effectively with floppy drives where the space and power required to support a floppy drive is excessive, mostly in hand-held or some notebook systems, but will not be a near-term significant competitor in general purpose systems because of the relatively high price of the removable semiconductor assembly.

* Magnetic bubbles: Bubble memories continue to succeed in markets requiring specialized packaging or operation under environmental stress. At one time considered a possible challenger to magnetic disk storage, bubble memory suffered a serious loss of credibility after the 1981 departure of National Semiconductor, Texas Instruments and Rockwell International from the field. The highest manufacturing levels are still maintained by Hitachi, with most production used by Nippon Telephone and Telegraph for a variety of telecommunication applications. Hitachi is currently exploring 64 megabit bubble devices.

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

  The nonvolatility of magnetic bubbles and their suitability for capacities too small to be cost-effective for magnetic disk drives has proven to be attractive to system manufacturers for applications such as industrial control systems, robots, point of sale terminals, portable computers, medical instrumentation, avionic systems and militarized systems. Although bubble memory densities have reached 4 megabits per device, they are still not cost competitive with magnetic disk technology. It is improbable that bubbles' prices will approach disks' prices -- and bubbles will now have to defend their specialized markets against encroachments from flash and ferroelectric semiconductor memory.

* Erasable optical disks: The possibility for inroads into the market for flexible high capacity floppy disk drives exists with reversible optical disk systems. Magneto-optical drives were introduced in 1988 and phase change optical recording has now also reached the market. Low-end erasable optical drives offer the

eventual promise of higher capacities and average access times equivalent to those offered by many of today's small magnetic rigid disk drives, but inferior performance and high relative cost will keep them in niche applications until technology improves and increasing volume lowers costs. It also appears that the small erasable optical drive will have capacity substantially above the ranges likely to be reached by flexible disk drives, so there will be little reason for direct competition. Due to optical disk drive complexity and the thickness of the optical cartridge, optical drives will have great difficulty in matching the 3/4 inch high and 1/2 inch high form factors which will be dominant for the 3.5 inch floppy drives used in most applications in the near future.

Drive and media costs for erasable optical storage are far above the costs of conventional floppy technology, and it is unlikely that floppy drives will be impacted soon. However, competition between sub-3.5 inch optical drives and very high-end floppy drives may eventually occur. JVC showed a 40 megabyte 1 inch high 2.5 inch M-O drive prototype at the 1991 COMDEX show, and Sony's audio 2.5 inch M-O drive may also appear in the form of a computer peripheral.

For optical drives offering nominal performance and a limited degree of erasability, prices may someday approach high capacity floppy drive prices, as floppy drive capacity increases above 20 megabytes, although floppy media will remain less expensive than optical media. Both products will compete against tape drives for save/restore applications in small systems and personal computers and will be appropriate for program and data interchange for the more powerful personal computers and network servers.

* Nonreversible optical disks: The first optical disk recording systems to enter the market were "nonreversible" or "write-once" systems. Write-once 5.25 inch and 12 inch drives are being shipped in modest quantities, and CD format writable disk drives in 4.72 inch half high form factor are being shipped in small numbers, but at high cost.

  Because they have track densities approaching 16,000 tracks per inch, write-once drives are capable of higher areal densities than magnetic recording techniques now in use. Capacity of 5.25 inch drives is typically 325 megabytes per disk side, while 12 inch drives offer up to 4.5 gigabytes per side. The drives are being used in optical library based storage systems which access large numbers of optical disks under system control.

  High cost, high capacity, and write-once related system complexities mean that there will be no impact by write-once disks on floppy drives used in their traditional roles. Even the highest capacity floppy drives using conventional technologies will not compete with write-once drives -- the product characteristics and applications are mutually exclusive.

* Read-only optical disks: The read-only optical disk category is dominated by the CD-ROM. Storage capacities of 550 to 600 megabytes are typical of these products. CD-ROM technology borrows heavily from the designs of the 4.72 inch CD audio players now in volume production, resulting in relatively low manufacturing costs. CD-ROM acceptance benefits from industry agreement on the CD standards developed jointly by Sony and Philips and the format standard developed by the High Sierra group. 3.15 inch CD-ROM drives were introduced by Sony in 1990. Most read-only optical drives are essentially part of a data distribution system and will be used with small systems to provide personal access to large amounts of information. They are expected to have no impact on the floppy drive's role in providing backup capabilities for small systems and to have minimal impact on the use of floppy disk drives for distribution of software for personal computers and other small systems. Even where CD-ROM appears as a system peripheral device, floppy disk drives continue to be required, because only selected software will be distributed on CD-ROM for some years to come.

* Tape drives: When disk drive capacities used with small computer systems are above 40 megabytes, the functional requirements for a removable media backup device cannot be met conveniently by today's mainstream flexible disk drives. Floppies' comparatively limited capacity is usually adequate for applications with which the typical file is also small, such as with word processing systems and home computers. But if files are typically large, if a database management system is used, or if it is necessary to back up an entire rigid disk for protection at the end of each day, most of today's floppies are usually not the best answer. However, the new 3.5 inch high capacity floppies being developed by Insite Peripherals, NEC, Citizen, Brier Technology, and others may improve the position of the floppy drive as a backup vehicle.

  Digital cassette and tape cartridge drives were available before most of today's floppy drives, but shipments of these drives have never approached those for floppies. The reasons lie in the inability of tape drives to offer fast direct access to individual data records, generally higher prices for the tape drives and media, and until recently, a lack of industry-wide standards for interfaces and media interchange. Media unit costs are substantially above those for floppy disk media, though lower on a cost per megabyte basis.

  The streaming tape cartridge drives now offered by several manufacturers are frequently used for save-and-restore and backup operations. Streamers have been available from several suppliers during the past few years, but with different interfaces and recording formats from each manufacturer -- a situation which discouraged many system manufacturers from investing in the controller and software development needed to use these drives. However, the advent of high capacity small Winchester drives provided the stimulus for most of the tape cartridge drive manufacturers to quickly agree on common standards for interfaces and recording formats.

Tape standards, plus new tape cartridge drives designed to the same form factor as 3.5 inch and 5.25 inch Winchesters, have resulted in significant penetration by tape cartridge streamers in the backup market for Winchesters in the 40-300 megabyte range. 4 and 8 millimeter helical scan drives provide backup for rigid drives in the half gigabyte and up class, but none of these drives are really competing with floppy drives.

The new generation of high capacity floppy drives will extend the capacity range over which floppies can compete for a role as a backup device to 20-40 megabytes and, eventually, to 80 megabytes. Larger rigid drives will continue to create a demand for tape streamers, helical scan tape drives, or removable rigid disk drives for backup functions. However, floppy drives will undoubtedly continue to be used on many small systems with large capacity Winchester drives. Their role will include software distribution and data interchange, and they will remain a convenient backup method for the small files which usually accompany large files.

* Stretched surface recording: SSR, as this technique is commonly known, was originally devised by the 3M corporation. It employs a disk composed of a thin plastic film with a magnetic coating stretched across concentric cylindrical rings. The chief characteristic of this technology is that it allows a head to fly on an air cushion backed by a deformable surface under the head. This provides close head-media separation needed for high capacity, but also prevents head crashes. Disk drives using this design technique could be produced in either fixed or removable format and could offer the same capacity as a small Winchester drive. The media, however, is expected to have a cost only 1/3 or 1/4 that of the rigid disk media in current or projected future use.

  3M has had various arrangements with other firms interested in developing SSR drives, most of which are now inactive. Reports of joint activity between 3M and Sony have appeared in the trade press in 1989 but there has been little visible activity since. Unless substantial improvements in SSR capacity can be shown, it is possible that the market has passed SSR by.

* Telecommunications: While not strictly a storage technology, telecommunication techniques are being used for data interchange involving notebook and smaller computers where space is insufficient for floppy drives as well as other mandatory functions. The impact of telecommunications is mostly on hand-held or notebook computers and is expected to have a minor negative impact on the demand for floppy drives in future systems.

Flexible disk drive enhancements

Through 1976, IBM led the way in introducing new floppy disk drive technology, but after IBM's 1976 introduction of the two sided 8 inch drive,leadership shifted to Shugart Associates and its successors in the 5.25 inch segment of the market. In 1985, IBM announced that it would phase out production of floppy disk drives, but production continued at a low level until 1990. By the late 1970s, Shugart Associates had shrunk IBM's original technology down to the 5.25 inch format, pulling off one of the most influential repackaging jobs of all time. By 1989, industry shipments of 3.5 inch drives were well ahead of 5.25 inch drive shipments.

The floppy formats which have created the most impact in recent years are the Nippon Telephone & Telegraph 1.6 megabyte version of the 5.25 inch drive, the Sony 3.5 inch, 2 megabyte microfloppy, and, most recently, the 4 megabyte 3.5 inch drive pioneered by Toshiba. Without IBM's leadership, the industry took years to reach a consensus on these formats, while passing others by. And after all the confusion, IBM finally endorsed both the 1.6 megabyte 5.25 inch and the 3.5 inch (including the 2 megabyte version) formats through product introductions. The 4 megabyte version appeared in an IBM system in 1991.

The thrust of floppy drive innovation has currently shifted to two areas: Decreasing height and increasing capacity. The vertical form factor for the newest 3.5 inch drives has decreased to 1/2 inch, spurred by the requirements of notebook system producers, while drives with capacities over 20 megabytes have entered production.

There are many potential technical improvements in flexible disk drive recording technology, each waiting for the backing of an influential firm in the industry. It is expected that by using improved head posi-

tioning systems, multigap heads and high capacity media, manufacturers of flexible disk drives will be able to eventually expand capacity well beyond 40 megabytes while retaining downward compatibility.

Here are some areas where potential advancements in flexible disk drive technology are likely to occur:

* Form factor: The newest 3.5 inch floppy drives now in production require approximately 1/2 inch of vertical front panel space. The smaller volume permits designers of laptop and notebook computers to reduce weight and system package size and to match the heights of new 2.5 inch and 1.8 inch rigid disk drives.

  Drives ranging from 15 to 19 millimeter height are currently being offered as "3/4 inch" drives. Whatever height eventually becomes the industry standard, 3/4 inch high drives are rapidly displacing one inch high floppy disk drives, much as the one inch high units have already largely displaced the 1.625 inch form factor. The 1/2 inch high profile floppy drives will be widely used in notebook computers and are also expected to find early usage in subsystems which combine a 3.5 inch drive with a 5.25 inch drive in a single unit designed to be used in a 1.625 inch slot in desktop systems.

* Media: The polyester substrate used with flexible disks suffers from limitations in its dimensional stability which derive from the manufacturing process used. As a result, today's mainstream floppy drive products using open loop head positioning systems for low cost are limited to 48 TPI with 8 inch drives, 96 TPI with 5.25 inch drives, and 135 TPI with microfloppy drives. The relatively small tonnage of polyester required for diskettes did not inspire plastics manufacturers to invest heavily in research targeted at dimensional stability improvements until the last few years, when the quantities became too large to ignore. However, the magnetic recording industry has been actively developing several methods of increasing track recording density with active servo tracking.

  Some substrate materials do offer high stability and resistance to environmental degradation, but are very expensive relative to polyester films and are unlikely to be widely adopted.

* Longitudinal particulate coatings: Oxide coatings have been the mainstream coating technology for floppy disks. 300 Oersted coatings capable of 5,000 to 6,000 flux changes per inch (FCI) were used on 8 inch and early 5.25 inch diskettes, while 600 Oersted cobalt modified oxide coatings are currently in use on most high density 5.25 inch and microfloppy diskettes. Cobalt modified oxide coatings typically achieve 8,000 to 10,000 FCI for 5.25 inch drives and 17,434 FCI for the 2 megabyte microfloppies in common use.

Oxide coatings are beginning to be displaced by higher performance coatings such as barium ferrite and metal powder coatings. The 4 megabyte 3.5 inch floppy drive introduced by Toshiba and others records at 34,768 FCI and Citizen has demonstrated a 20.6 megabyte drive (formatted) that records at 43,000 FCI on metal powder media. The U.S. producers of very high capacity floppy drives have tended to favor barium ferrite because of its similarities in manufacturing to the familiar oxide coatings and a belief that it can, with further development, be used to reach capacities of 40 to 50 megabytes per diskette. Japanese producers tend to favor metal powder coatings because of its inherently higher performance, previous experience with it in entertainment products, and a strong industry position in metal powder media.

Several Japanese drive and media producers are jointly preparing a proposed standard for 10, 20 and 40 megabyte floppy drives under the auspices of JEIDA (Japan Electronic Industry Development Association). The drives will have downward read/write compatibility with 1 and 2 megabyte drives. This standard, which is planned for release in 1992, is expected to be influential because of its breadth of support.

Manufacturers of flexible media and magnetic particles have promising programs under way to improve the density of longitudinal particulate recording. Based on the information available, it appears that conventional recording methods are being stretched at least to 45,000 FCI now and can be extended further within a few years. Longitudinal particulate recording has many good years left, with the full exploitation of its potential recording density probably to be paced primarily by market forces.

* Isotropic coatings: It is theoretically possible, by reducing the length of magnetic particles, which are normally very long and thin, to resolve magnetic flux changes at much higher densities. It has been demonstrated that such diskettes could be recorded at more than 50,000 BPI. Since diskettes suitable for isotropic recording may be produced in great quantities on coating equipment widely used by media manufacturers today, this technology could be of great interest to the industry if certain thermal instability problems associated with cobalt modification of very small particles can ever be resolved.

* Perpendicular recording: Perpendicular recording offers great potential for increased recording densities on flexible disks. The flying head technology used with rigid disks requires a high revolution rate, which results in very high data transfer rates with perpendicular recording -- faster than most systems and controllers are now ready to handle. However, the contact recording method used with flexible disk drives and the slower rates of revolution encountered, combined with the very high densities of perpendicular recording, could produce transfer rates comparable to the small Winchester disk drives now in wide use.

Several firms have announced tentative specifications for small flexible disk drives using perpendicular recording. Matsushita Electric has claimed the capability to record at 70,000 FCI. Toshiba pioneered development of barium ferrite recording technology for flexible disk drives, and after several years of tentative market exploration introduced a 4 megabyte drive in 1988. Toshiba's design maintains the industry standard open loop 135 TPI density, and the program has been joined by Teac, Sony and other drive and media producers. All of these 4 megabyte drives claim full compatibility with 1 and 2 megabyte media.

Many of the planned flexible disk drives using perpendicular recording would require disks with sputtered chromium-cobalt magnetic surfaces. Sputtering technology is highly developed, but throughput is relatively slow. If the millions of low cost diskettes necessary to support any significant penetration of the flexible disk market by perpendicular recording are to be produced by sputtering, major improvements in production rates are probably necessary.

* Track density: As discussed above, media dimensional stability limitations effectively hold track densities to the ranges now employed, if low cost open loop head positioning systems are to be used. It is possible to increase track densities through the use of prerecorded servo information on disks combined with a closed loop head positioning system, but the industry has been slow to move in that direction because of the general desire to hold costs as low as possible and lack of an industry standard.

Initially, two manufacturers of high capacity 5.25 inch drives attempted to develop the high capacity market using different methods of achieving higher track density. However, Amlyn's late production start spoiled its chance for acceptance of the reference track technology employed in its 3.2 megabyte drive, and the firm closed down operations. Drivetec was more successful in getting started, however, and began shipping its 3.3 megabyte two sided drive in mid-1983. Drivetec used embedded servo information on each diskette to provide tracking information and insure media interchange. Drivetec has since ceased operations, but licensed its technology to Eastman Kodak. Eastman Kodak started production of the 3.3 megabyte drive in 1984, and subsequently produced 6.6, 12 and 24 megabyte drives operating at 384, 333 and 666 TPI, respectively.

Iomega developed a unique design, widely known as the Bernoulli box, that reaches 1,605 tracks per inch in a media cartridge of unconventional design. Initial production began in 1983. The Iomega design uses the hydraulic effects of the rapidly spinning disk to properly position the media relative to the head.

Brier Technology's 3.5 inch drive uses preformatted disks and offers a formatted capacity of 21.4 megabytes and 35 millisecond average head positioning time. A track density of 777 TPI is used.

Insite Peripherals has achieved a track density of 1,245 TPI using optical tracking of a servo pattern imprinted on the disk surface. Brier has announced future availability of a drive with 1,084 TPI and 44.6 megabytes.

* Heads: The new generations of high capacity floppy drives are using multifunction head designs to provide read/write/erase capability at multiple densities. This feature allows downward compatibility in the new generation of 3.5 inch drives with capacities of 4 megabytes and higher now entering the market. All of the high capacity floppy disk drives currently contemplated for production (as well as 4 megabyte floppy drives) will use multigap heads to achieve downward compatibility with 1.0 and 2.0 megabyte 3.5 inch floppy drives.

* Servo technology: The higher track densities being employed in the new generations of flexible disk drives require the use of closed loop head positioning systems. Some, such as Brier's multiple frequency embedded servo and Insite's optical tracking scheme, are innovative and have the potential to set new standards if widely adopted by other companies. Brier writes a servo track on the media at a frequency much lower than the data recording frequency, then uses filtering to separate the readback signal into a data component and a servo tracking component. Insite applies a reflective track pattern to the media surface, and employs simple optics with an inexpensive LED light source to monitor head position.

* Disk diameter: In 1987, smaller diameter flexible disk drives began to receive some notice. 2 inch drives were announced by two firms, but acceptance has been limited. Matsushita Communication Industrial's design approach mapped a standard 3.5 inch 1 megabyte drive format onto 2 inch media and won a major OEM contract for a notebook computer, but the unconventional, noninterchangeable media failed to win broad acceptance.

  Sony has been producing drives and media based upon a video drive used in the Mavica camera. While the Sony specifications are impressive -- 819 kilobyte formatted capacity, 14.3 megabits/second data transfer rate and 3,600 RPM rotation rate -- incompatibility with standard floppy disk drive controllers impedes acceptance. Lack of media interchange capability with the 3.5 inch floppy drives, now the dominant standard for office computers, also restrains the industry's enthusiasm.

  While no 2.5 inch drives have yet appeared, the success of the rigid disk drive 2.5 inch format will create a demand for smaller floppy drives for use in notebook computers. However, the resistance of end users to dealing with yet another floppy drive format may limit the market opportunity to very thin 3.5 inch floppy drive models.

* Encoding and error correction: Effective linear bit density can be improved beyond the raw flux change density by the use of appropri-

ate data encoding schemes which are used with rigid and optical drives. High capacity floppy drives with capacities of 20 megabytes and more are the primary users of sophisticated coding techniques such as 2,7 RLL code (Citizen), 1,7 RLL code (Insite Peripherals) and 1,8 RLL code (Iomega).

Error correction is not yet in use on floppy drives, but will probably be introduced as capacities climb and the effect of media defects becomes more important.

DEFINITIONS

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

MARKET CLASSIFICATION

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

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

Example:

* Drives made by Sony or Samsung and sold with their own computer systems to end users are considered captive, if internally manufactured, or made by a subsidiary.

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

Example:

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

* Shipments by Teac are noncaptive.

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

Examples:

* Disk drives sold by Iomega to end users of IBM or Apple systems.

* Standard drives sold by drive manufacturers to distributors or dealers are considered to be PCM/Reseller drives.

OEM/Integrator: Drives sold by the original producer to system manufacturers which resell them as part of complete computer systems. Also includes sales to system integrators or value-added resellers which combine finished system components and software to provide complete systems for specific applications. Sales by a disk drive manufacturer to a second drive manufacturer for resale are included only in shipment totals for the originating 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.

Example:

* Drives sold by independent drive manufacturers to IBM or other system manufacturers for use with personal computers are considered to be OEM/Integrator drives.

GEOGRAPHIC CLASSIFICATION

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

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

Examples:

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

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

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

Examples:

* Insite Peripherals is considered a U.S. manufacturer, even though most of its disk drives are produced on a contract manufacturing basis in non-U.S. locations.

* Alps Electric is considered a non-U.S. manufacturer, even though some of the firm's floppy drives are manufactured in the U.S.

UNITS OF MEASUREMENT

Spindles: The basic unit in counting disk drives. One spindle consists of the disk drive mechanism required to utilize a single disk. All DISK/TREND unit totals are counted in spindles.

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. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM/Reseller or OEM/Integrator levels. All prices are in 1991 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 nonstandard size disks or new physical configurations may require establishment of new DISK/TREND product groups.

APPLICATION CLASSIFICATION

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

Mainframe/superminicomputer: Disk drives attached to the processor or to a terminal associated with a mainframe or superminicomputer.

Minicomputers/multiple user microcomputers: Drives attached to smaller general-purpose processors typically serving multiple users, including network file servers. Examples: IBM System AS/400, AT&T 3B2, Hewlett-Packard 3000.

Personal computers: Attached to a general purpose microcomputer normally used by a single user, including desktop and portable models. Examples: IBM PS/2, Apple Macintosh, Compaq LTE.

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

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

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

Other applications: Any application not included above.

FLEXIBLE DISK DRIVES, 8 INCH

1991 DISK/TREND REPORT

FLEXIBLE DISK DRIVES, 8 INCH

Coverage

Examples of flexible disk drives in this group include:

One side

Elcomatic	ACP 500
Miltope	DD 400

Two sides

Cobra	MM 500
Elcomatic	ACP 700
Hitachi	FDD-412
Matsushita Communication Ind.	JA-751
Miltope	DD 450, DD 550
NEC	FD 1165
Y-E Data	YD-180

The first flexible disk drives were all 8 inch models, and until the early 1980s this group generated a majority of all floppy drive shipments. However, with the growth of smaller floppy drives and the decline in shipments of 8 inch models, the number of participating manufacturers has shrunk to the short list above.

Most of the flexible disk drives in this group use the recording formats pioneered by IBM for 8 inch flexible disks, "Diskette 2" for two sided standard density or "Diskette 2D" for two sided double density.

Drives using special recording formats to achieve higher capacity than the IBM standard are currently offered by only one manufacturer. Elcomatic's ACP 1500 provides 3.2 megabytes by using 96 TPI and normal recording densities. Burroughs' high capacity floppy drives, which pioneered the use of a reference track for head positioning, are no longer in production.

The "full size" OEM drives in this group were generally designed to the same physical dimensions as the Shugart 801. Almost all of the many OEM 8 inch drives introduced during the 1980's were "half high" models, which now constitute most of the industry's shipments of 8 inch floppy drives.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1990	1991	1992	1993	1994
U.S. manufacturers	10.0	.5	.5	--	--
All manufacturers	60.1	31.9	17.3	4.9	--

The rate of decline in worldwide unit shipments of 8 inch floppy drives accelerated in 1990, with a 42.3% drop. 1990's unit shipments were 141,600 drives, mostly half high models. Worldwide shipments for 8 inch one sided drives peaked in 1981, at 746,600 units, and two sided drives peaked two years later, with 1,275,900 units.

In recent years, the largest factor in maintaining shipments of drives in this product group at a high level has been continuing usage of the two sided 8 inch format in the Japanese domestic market for office computers. But the tide has long since turned, as 8 inch drives were displaced first by the 1.6 megabyte 5.25 inch models, and later by the 3.5 inch drives used in most of the newer systems.

U.S. floppy drive manufacturers shipped only 6,200 8 inch drives in 1990, with shipments in 1991 dropping to almost nothing. The low U.S. total is attributed to the fact that U.S. system manufacturers have long since shifted to smaller diameter floppy drives for personal computers,

specialized workstations and most terminals, leaving systems now approaching the end of their manufacturing cycles as the principal remaining market for 8 inch floppy drives.

Shugart Associates, the early leader in floppy drive shipments, was sold in early 1986, after years of decline under inept Xerox ownership. The Narlinger Group, now operating as Shugart Corporation, acquired the Shugart Associates 8 inch floppy product line, as well as the 8 inch floppy drives purchased from Siemens, Tandon and Control Data. For several years Shugart provided most of the remaining small U.S. OEM shipments, but became inactive in the area as inventories were depleted.

Y-E Data continues to dominate recent non-captive shipments in this group, with 71.6% of 1990 worldwide shipments.

Marketing trends

The drives in this product group are considered obsolete by most system manufacturers, and the current rate of decline in shipments is expected to increase. The last shipments by U.S. manufacturers are expected next year, and the remaining non-U.S. markets will be limited primarily to domestic Japan, with final shipments expected in 1993.

It is believed that this product group's current lack of vigor is traceable to a combination of factors: (1) Rapid development during the 1980s of the 5.25 and 3.5 inch formats, offering capacities equaling those of 8 inch drives at much lower prices, (2) Reliability problems most manufacturers experienced with 8 inch, two sided drives in the late 1970's, which kept many OEMs from committing to the format, and (3) Lack of further development of the 8 inch drive format by IBM, which inhibited manufacturers of OEM drives from investing in higher density versions.

In Japan's domestic market, demand for 8 inch drives continued to grow after the U.S. market started to decline. But despite the popularity of the format in Japan, most manufacturers of small office computer systems felt the pressure to move to desktop versions of their older systems, and the 1.6 megabyte 5.25 inch floppy drive developed under the sponsorship of Nippon Telephone & Telegraph made it possible to do so. More recent availability of 3.5 inch drives in this capacity range have intensified the problem for 8 inch drives.

But the knockout punch for 8 inch drives was delivered by IBM, their originator. IBM used 360 kilobyte 5.25 inch drives in the PC and PC XT, 1.6 megabyte 5.25 inch drives in the PC AT, and eventually 3.5 inch drives in the PS/2. IBM de-emphasized internal production of flexible disk drives, in view of the ready availability of all types of floppy drives at depressed OEM price levels.

Technical trends

With the exception of limited programs by Burroughs, PerSci, and Elcomatic, there have been few serious attempts to introduce higher capacity drives in this group.

The key reason that development of 8 inch drives has been stuck at 1.6 megabytes since 1976 was IBM's lack of innovation in the area. Since the existing 8 inch diskette's physical design and recording format were defined by IBM, and because of IBM's dominant leadership in the applications for 8 inch, two sided floppies, most manufacturers of OEM drives hesitated to attempt the introduction of their own improvements, even though some had undertaken development programs.

Several OEM drive manufacturers were ready to introduce new drives for years, with most planning various track following methods, to make possible increased track density. These plans were generally set back by the reliability problems which were experienced by two sided 8 inch floppy drives until the end of the 1970's, and by the hope of most manufacturers that IBM would take the lead in establishing a new high capacity format, preferably with an improved, higher density media standard.

After all the waiting, the momentum passed to the smaller diameter floppy formats. The high growth of desktop and portable systems is encouraging most manufacturers remaining in the flexible disk drive business to put their development resources into 3.5 inch drives with a new emphasis on reduced packaging size.

Forecasting assumptions

1. IBM will continue the use of 3.5 inch floppy drives for new versions of its personal computer and other small systems, and will not resume internal production of 8 inch drives.

2. Other system manufacturers will continue to move to smaller drives, causing a continuing reduction in worldwide shipments of 8 inch drives, with the last shipments in 1993.

TABLE 8

FLEXIBLE DISK DRIVES, 8 INCH

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1990		Forecast							
	Revenues		1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	4.5	9.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	4.5	9.0	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	1.0	1.0	.5	.5	.5	.5	--	--	--	--
TOTAL U.S. NON-CAPTIVE	1.0	1.0	.5	.5	.5	.5	--	--	--	--
TOTAL U.S. REVENUES	5.5	10.0	.5	.5	.5	.5	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	33.0	--	20.7	--	11.0	--	3.0	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	4.4	17.1	1.2	10.7	.7	5.8	--	1.9	--	--
TOTAL NON-U.S. REVENUES	4.4	50.1	1.2	31.4	.7	16.8	--	4.9	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	9.9	60.1	1.7	31.9	1.2	17.3	--	4.9	--	--
OEM Average Price ($000)	.297	.259	.279	.248	.387	.241	--	.211	--	--

TABLE 9

FLEXIBLE DISK DRIVES, 8 INCH

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1990		Forecast							
	Shipments		1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	3.0	6.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	3.0	6.0	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	.2	.2	.1	.1	.1	.1	--	--	--	--
TOTAL U.S. NON-CAPTIVE	.2	.2	.1	.1	.1	.1	--	--	--	--
TOTAL U.S. SHIPMENTS	3.2	6.2	.1	.1	.1	.1	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	65.8	--	41.0	--	22.0	--	6.0	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	18.0	69.6	6.0	45.1	3.0	26.0	--	9.0	--	--
TOTAL NON-U.S. SHIPMENTS	18.0	135.4	6.0	86.1	3.0	48.0	--	15.0	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	21.2	141.6	6.1	86.2	3.1	48.1	--	15.0	--	--

Cumulative Shipments (Units in thousands)

IBM	1,220.9	1,799.4	1,220.9	1,799.4	1,220.9	1,799.4	1,220.9	1,799.4	1,220.9	1,799.4
Non-IBM	4,116.0	10,283.4	4,122.1	10,369.6	4,125.2	10,417.7	4,125.2	10,432.7	4,125.2	10,432.7
WORLDWIDE TOTAL	5,336.9	12,082.8	5,343.0	12,169.0	5,346.1	12,217.1	5,346.1	12,232.1	5,346.1	12,232.1

TABLE 10
FLEXIBLE DISK DRIVES, 8 INCH
WORLDWIDE SHIPMENTS (000)
DRIVE HEIGHT ANALYSIS

	1990 --Shipments--		Forecast 1991		1992		1993		1994	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	6.0		--		--		--		--	
Full Size	6.0	100.0	--	--	--	--	--	--	--	--
Non-Captive Total	.2		.1		.1		--		--	
Full Size	.2	100.0	.1	100.0	.1	100.0	--	--	--	--
Half High	--	--	--	--	--	--	--	--	--	--
Total U.S.	6.2		.1		.1		--		--	
Full Size	6.2	100.0	.1	100.0	.1	100.0	--	--	--	--
Half High	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS										
Captive Total	65.8		41.0		22.0		6.0		--	
Full Size	.2	.3	.1	.2	--	--	--	--	--	--
Half High	65.6	99.7	40.9	99.8	22.0	100.0	6.0	100.0	--	--
Non-Captive Total	69.6		45.1		26.0		9.0		--	
Full Size	.6	.9	.4	.9	--	--	--	--	--	--
Half High	69.0	99.1	44.7	99.1	26.0	100.0	9.0	100.0	--	--
Total Non-U.S.	135.4		86.1		48.0		15.0		--	
Full Size	.8	.6	.5	.6	--	--	--	--	--	--
Half High	134.6	99.4	85.6	99.4	48.0	100.0	15.0	100.0	--	--
WORLDWIDE RECAP										
Total Worldwide Shipments	141.6		86.2		48.1		15.0		--	
	-42.3%		-39.1%		-44.2%		-68.8%		--	
Full Size	7.0	4.9	.6	.7	.1	.2	--	--	--	--
	-55.4%		-91.4%		-83.3%		--		--	
Half High	134.6	95.1	85.6	99.3	48.0	99.8	15.0	100.0	--	--
	-41.4%		-36.4%		-43.9%		-68.7%		--	

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

TABLE 11

FLEXIBLE DISK DRIVES, 8 INCH

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

	1990 Estimate		1994 Projection	
APPLICATION	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	2.5	1.7	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	53.2	37.6	--	--
PERSONAL COMPUTERS Business and professional, single user	49.4	34.9	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	19.7	13.9	--	--
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	13.1	9.2	--	--
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	3.7	2.7	--	--
Total	141.6	100.0	--	--

TABLE 12

FLEXIBLE DISK DRIVES, 8 INCH

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1990 Net Shipments			
	To United States Destinations		Worldwide	
Drive Manufacturers	Units (000)	%	Units (000)	%
Y-E Data	13.0	71.4	50.0	71.6
Other U.S.	.2	1.1	.2	.3
Other Non-U.S.	5.0	27.5	19.6	28.1
TOTAL	18.2	100.0	69.8	100.0

FLEXIBLE DISK DRIVES, 5.25 INCH

1991 DISK/TREND REPORT

FLEXIBLE DISK DRIVES, 5.25 INCH

Coverage

Examples of flexible disk drives in this group include:

One side: 48 tracks per inch

Asia Commercial	FD-103
Chinon	FZ-501A
Ho Shin	HS-550
Mantec	MTL-FD102E/C
Roctec	RF501A

Two sides: 48 tracks per inch, .5 megabyte

Alps Electric	DFE 222A
Asia Commercial	FD-104
Canon	MD 5201
Chinon	FZ-502
Elebra	9410-B
Flexdisc	FF 650
Ho Shin	HD-551
Itautec	ADF48
Mantec	MTL-FD128
Matsushita Communication Ind.	JA-455
Mitsubishi Electric	MF501C
Mitsumi Electric	D 503V
Multidigit	DF0511
Oriental Precision	OFD 546R
Prologica	D 500SL
Safronic	DS-51A
Samsung Electronics	SFD-500P
Seiko Epson	SD-621L
Teac	FD-55BR
Toshiba	ND-0401
Y-E Data	YD-580

Two sides: 96 tracks per inch, 1.0 megabyte

Ho Shin	HD-552
Multidigit	DF1011
Oriental Precision	OFD 596R
Teac	FD-55FR
Toshiba	ND-06D/DT

Two sides: 96 tracks per inch, 1.6 megabytes

Asia Commercial	FD-106
Canon	MD-5501
Chinon	FZ-506

Two sides: 96 tracks per inch, 1.6 megabytes (continued)

Elebra	9410-D
Flexdisc	FF950
Ho Shin	HD-553
Itautec	ADF96
Mantec	MTL-FD228
Matsushita Communication Ind.	JU-475
Mitsubishi Electric	MF504C, MF504S
Mitsumi Electric	D 509V
Multidigit	DF1622
NEC	FD 1157D, FD 1158C
Safronic	DS-53A
Samsung Electronics	SFD-560D
Seiko Epson	SD-680L
Teac	FD-55GR, FD-55GFR
Toshiba	ND-0801
Y-E Data	YD-380B

Two sides: 96 tracks per inch, 3.3 megabytes

Y-E Data	YE-801

The basic standards for physical size and recording format for this product group were created by the introduction of the Shugart SA 400, the original minifloppy, in 1976. Early growth in small microcomputer systems inspired several innovative one sided 5.25 inch drives, some of which achieved success until the industry's movement to two sided versions. Starting with the 1989 edition of the DISK/TREND Report, all 5.25 inch drives were combined into a single product group, replacing the previous separate groups for one and two sided drives, in view of the continuing decline in shipments for one sided 5.25 inch flexible disk drives.

Because of the continued shrinkage in the physical size of computer systems, reduced drive height became an extremely active area of innovation. Half high drives, pioneered by Tandon and Alps Electric and now offered by most drive manufacturers, have become the dominant physical size standard for 5.25 inch floppy drives.

Two sided 5.25 inch floppy drives became a reality in 1978. The original 48 TPI drives were joined by 96 TPI drives from Tandon, Micro Peripherals and Micropolis in 1980. However, a more influential development occurred in 1982, when 1.6 megabyte 5.25 inch drives were first shipped by Y-E Data, designed to a standard coordinated by Nippon Telephone and Telegraph.

IBM's 1984 introduction of the PC AT, using Y-E Data's 1.6 megabyte drive, stampeded the market into rapid worldwide usage of the 1.6 megabyte 5.25 inch format. The 2.0 megabyte drive using slightly higher linear densities did not provide enough improvement to generate wide interest.

Drivetec's half high drive using an embedded servo technique -- with 192 TPI, and capacity of 3.3 megabytes -- was a technical success and a commercial failure. The company closed down in early 1985, but had licensed Eastman Kodak to make the drive. Eastman Kodak started production of a drive compatible with Drivetec's unit in 1984, later challenged by other 3.3 megabyte formats from Matsushita Communication Industrial and Y-E Data. Usage of 3.3 megabyte drives has been limited, due to lack of industry standards and the movement to 3.5 inch microfloppies.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1990	1991	1992	1993	1994
U.S. manufacturers	--	--	--	--	--
All manufacturers	1,012.8	787.8	599.3	442.7	314.4

5.25 inch floppy drive shipments were surprisingly strong in 1990. After peaking in 1988 with 16.5 million drives, total shipments of 5.25

inch drives were down 10.1% in 1989 -- but the product group had a modest resurgence in growth during 1990. Worldwide total shipments of all 5.25 inch floppy drives were 14.9 million units in 1990, up .4%.

Despite 1990's slight increase in unit shipments, total revenues for the product group continued to decline, depressed by lower average unit prices. The $1,012,800,000 total for the group was down .8%, and a sharper drop of 22.2% is expected for 1991, caused by further reductions in average prices and total shipments, lowering total revenues for the year to $787,800,000.

Total worldwide shipments for 1991 are forecasted at 13.1 million drives, down 12.1%. Surprising strength in demand for 1.6 megabyte drives was responsible for the overall slight growth in 1990 shipments, but even this product configuration is losing momentum. 1.6 megabyte drive shipments are expected to be down 3.1% in 1991. Shipments of .5 megabyte drives are expected to decline 42.9% in 1991, and the smaller shipments of 1 megabyte drives are expected to drop 52.1%.

1.6 megabyte two sided 5.25 inch floppy drives were used predominantly with IBM PC AT personal computers, plus the clones offered by numerous manufacturers. IBM has moved on to the PS/2 personal computer family, using 3.5 inch microfloppies, but the older IBM standards have been tough to kill. Despite abandonment by IBM, the PC AT standard has continued its momentum and has contributed to continuing sales of 1.6 megabyte two sided 5.25 inch drives with numerous AT clones.

Worldwide revenues are another story, however. Despite a modest increase in 1988, the long-term trend for this product group since 1984 has been a continuing decline in revenues, which is expected to continue. The reason is well known: Average unit prices for OEM drives continue to

decline, from $114 in 1984, to $55 in 1989, to $52 in 1990, with a further drop under way in 1991, to $50. Major Japanese floppy drive producers have concentrated on aggressive cost reduction programs, including product redesign and plant relocation, which have resulted in continuing price competition.

Personal computer systems dominate applications for drives in this product group. 86.8% of 1990 worldwide unit shipments were used with personal computers, with minor usage attributed to consumer and hobby computers, office systems and minicomputer applications.

The leading manufacturers of non-captive 5.25 inch drives increased their shipment totals and their market shares in 1990. Teac continued to lead the industry with 3,880,000 drives, for 19.1% of the worldwide total. Matsushita Communication Industrial shipped 2,414,000 drives, for 18.1%, and Chinon shipped 1,749,000 drives, for 13.1%.

Marketing trends

Despite the continuing strength in shipments of 1.6 megabyte drives, even this group is expected to decline at an accelerating rate during the 1992-94 period. Contributing to the configuration's sales weakness will be lower growth for PC AT compatible personal computers, and prices for 3.5 inch floppy drives which are even lower than the prices for 1.6 megabyte 5.25 inch drives. OEM prices for 2.0 megabyte 3.5 inch drives are now $8 - $10 lower than those for 1.6 megabyte 5.25 inch drives, reflecting production volumes more than twice as large.

Overall unit shipments for this product group are expected to decrease at an average annual rate of 19% during the 1992-94 period, and the

1994 unit shipment total is forecasted at only 6,945,000 drives, 96.6% of which are expected to be 1.6 megabyte models.

Total revenue for this product group will decline at a more rapid pace than the shipment decline, averaging -26.3% annually during 1992-94. The revenue loss will be even greater if average unit prices should decline at the same rate experienced in the last few years. However, it is believed that drive manufacturers will be concentrating on 3.5 inch models and little effort will be expended in the future to redesign 5.25 inch drives for lower cost, now that shipments have peaked.

A few years ago it seemed possible that additional development of higher capacity 5.25 inch drives might lead to new major products for the industry, with attention focused on drives with double the capacity of the 1.6 megabyte models then becoming a standard.

However, with the decision by IBM to utilize 3.5 inch drives with personal computers, most of the potential market for a double capacity version of the 1.6 megabyte 5.25 inch drive evaporated. At this time, the principal remaining market opportunity for the currently offered 3.3 megabyte drives appears to be in specialized applications such as Japanese language word processors.

Technical trends

It is considered unlikely that drive manufacturers will devote their resources to further product development for most of the products in this group, considering the outlook for declining production and the obvious need to place development priorities in other product areas.

An interesting improvement in drive packaging is represented by the Teac introduction in 1991 of a 1 inch high 1.6 megabyte 5.25 inch drive.

Three companies had previously introduced "one third high" 5.25 inch drives in the early 1980s, but the demand at that time was limited and all of those models eventually disappeared from the market.

However, the Teac 1 inch high drive may find a more interesting reception, since the firm is offering it in a combination unit with a .5 inch high 3.5 inch drive. Teac's 5.25/3.5 combination can be mounted in a personal computer's half high 5.25 inch slot, providing a significant improvement in interchange flexibility for AT clones.

It now appears that no further effort will be devoted by drive manufacturers to capacity increases for 5.25 inch floppy drives. After several programs during the 1980s using embedded servo techniques, the only remaining 3.3 megabyte 5.25 inch floppy drive still in production is the simpler design by Y-E Data.

Y-E Data's drive employs the standard 96 TPI, with standard track positioning, and doubles the linear density, to maintain full read and write compatibility with both 1.0 and 1.6 megabyte diskettes, even though a special diskette is required for usage at 3.3 megabytes.

Forecasting assumptions

1. The existing momentum of the PC AT format will decline slowly, insuring a residual market for 1.6 megabyte 5.25 inch drives for several years.

2. A positive growth rate for personal computers will be maintained, following flat growth during the 1990/1991 recession.

3. The dollar/yen exchange rate will stay in the current range, and the major Japanese floppy disk drive producers will maintain prices at approximately the current levels or slightly lower.

TABLE 13

FLEXIBLE DISK DRIVES, 5.25 INCH

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1990 Revenues		Forecast 1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. NON-CAPTIVE	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	18.0	312.4	11.6	174.5	7.3	78.9	2.2	26.8	.5	6.1
PCM/Reseller	134.8	197.5	109.4	168.7	84.2	135.2	61.4	101.9	41.6	71.0
OEM/Integrator	164.9	502.9	143.3	444.6	119.4	385.2	94.5	314.0	70.0	237.3
TOTAL NON-U.S. REVENUES	317.7	1,012.8	264.3	787.8	210.9	599.3	158.1	442.7	112.1	314.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	317.7	1,012.8	264.3	787.8	210.9	599.3	158.1	442.7	112.1	314.4
OEM Average Price ($000)	.052	.052	.050	.050	.048	.048	.046	.046	.044	.044

TABLE 14

FLEXIBLE DISK DRIVES, 5.25 INCH

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1990		Forecast							
	Shipments		1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. NON-CAPTIVE	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	103.0	1,611.8	68.0	956.0	45.0	467.0	14.0	172.0	3.0	40.0
PCM/Reseller	2,487.5	3,719.6	2,088.0	3,221.0	1,661.0	2,668.0	1,256.0	2,086.0	887.0	1,513.0
OEM/Integrator	3,164.0	9,614.8	2,883.0	8,959.3	2,494.0	8,045.0	2,057.0	6,830.0	1,590.0	5,392.0
TOTAL NON-U.S. SHIPMENTS	5,754.5	14,946.2	5,039.0	13,136.3	4,200.0	11,180.0	3,327.0	9,088.0	2,480.0	6,945.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	5,754.5	14,946.2	5,039.0	13,136.3	4,200.0	11,180.0	3,327.0	9,088.0	2,480.0	6,945.0
Cumulative Shipments (Units in millions)										
IBM	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
Non-IBM	61.2	124.8	66.3	137.9	70.5	149.1	73.8	158.2	76.3	165.1
WORLDWIDE TOTAL	61.7	125.3	66.7	138.4	70.9	149.6	74.2	158.7	76.7	165.6

TABLE 15
FLEXIBLE DISK DRIVES, 5.25 INCH
WORLDWIDE SHIPMENTS (000)
DRIVE HEIGHT ANALYSIS

	1990 --Shipments--		Forecast 1991		1992		1993		1994	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	--		--		--		--		--	
Non-Captive Total	--		--		--		--		--	
Total U.S.	--		--		--		--		--	
NON-U.S. MANUFACTURERS										
Captive Total	1,611.8		956.0		467.0		172.0		40.0	
Half High	1,611.8	100.0	956.0	100.0	467.0	100.0	172.0	100.0	40.0	100.0
Non-Captive Total	13,334.4		12,180.3		10,713.0		8,916.0		6,905.0	
Full Size	--	--	1.0	--	--	--	--	--	--	--
Half High	13,334.4	100.0	12,179.3	100.0	10,713.0	100.0	8,916.0	100.0	6,905.0	100.0
Total Non-U.S.	14,946.2		13,136.3		11,180.0		9,088.0		6,945.0	
Full Size	--	--	1.0	--	--	--	--	--	--	--
Half High	14,946.2	100.0	13,135.3	100.0	11,180.0	100.0	9,088.0	100.0	6,945.0	100.0
WORLDWIDE RECAP										
Total Worldwide Shipments	14,946.2		13,136.3		11,180.0		9,088.0		6,945.0	
	+.4%		-12.1%		-14.8%		-18.7%		-23.5%	
Full Size	--	--	1.0	--	--	--	--	--	--	--
	--		--		--		--		--	
Half High	14,946.2	100.0	13,135.3	100.0	11,180.0	100.0	9,088.0	100.0	6,945.0	100.0
	+.5%		-12.1%		-14.8%		-18.7%		-23.5%	

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

TABLE 16
FLEXIBLE DISK DRIVES, 5.25 INCH
WORLDWIDE SHIPMENTS (000)
TRACK DENSITY ANALYSIS

	1990 --Shipments--		Forecast 1991		1992		1993		1994	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	--		--		--		--		--	
Non-Captive Total	--		--		--		--		--	
Total U.S.	--		--		--		--		--	
NON-U.S. MANUFACTURERS										
Captive Total	1,611.8		956.0		467.0		172.0		40.0	
48 TPI	91.8	5.7	45.0	4.7	12.0	2.6	--	--	--	--
96 TPI 1.0 MB	10.0	.6	--	--	--	--	--	--	--	--
96 TPI 1.6 MB	1,510.0	93.7	911.0	95.3	455.0	97.4	172.0	100.0	40.0	100.0
Non-Captive Total	13,334.4		12,180.3		10,713.0		8,916.0		6,905.0	
48 TPI	3,059.4	22.9	1,753.3	14.4	951.0	8.9	494.0	5.5	234.0	3.4
96 TPI 1.0 MB	157.0	1.2	80.0	.7	35.0	.3	12.0	.1	--	--
96 TPI 1.6 MB	10,118.0	75.9	10,347.0	84.9	9,727.0	90.8	8,410.0	94.4	6,671.0	96.6
Total Non-U.S.	14,946.2		13,136.3		11,180.0		9,088.0		6,945.0	
48 TPI	3,151.2	21.1	1,798.3	13.7	963.0	8.6	494.0	5.4	234.0	3.4
96 TPI 1.0 MB	167.0	1.1	80.0	.6	35.0	.3	12.0	.1	--	--
96 TPI 1.6 MB	11,628.0	77.8	11,258.0	85.7	10,182.0	91.1	8,582.0	94.5	6,711.0	96.6
WORLDWIDE RECAP										
Total Worldwide Shipments	14,946.2		13,136.3		11,180.0		9,088.0		6,945.0	
	+.4%		-12.1%		-14.8%		-18.7%		-23.5%	
48 TPI	3,151.2	21.1	1,798.3	13.7	963.0	8.6	494.0	5.4	234.0	3.4
	-36.3%		-42.9%		-46.4%		-48.7%		-52.6%	
96 TPI 1.0 MB	167.0	1.1	80.0	.6	35.0	.3	12.0	.1	--	--
	-42.4%		-52.1%		-56.2%		-65.7%		--	
96 TPI 1.6 MB	11,628.0	77.8	11,258.0	85.7	10,182.0	91.1	8,582.0	94.5	6,711.0	96.6
	+20.5%		-3.1%		-9.5%		-15.7%		-21.8%	

Notes: 1. Percentage figures with plus/minus signs refer to year-to-year growth rates.
2: Track densities greater than 96 TPI are grouped with 96 TPI 1.6 MB totals.

TABLE 17

FLEXIBLE DISK DRIVES, 5.25 INCH

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1990 Estimate Units (000)	1990 Estimate %	1994 Projection Units (000)	1994 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	593.4	4.0	277.8	4.0
PERSONAL COMPUTERS Business and professional, single user	12,971.9	86.8	5,882.3	84.7
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	777.2	5.2	312.5	4.5
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	239.1	1.6	347.3	5.0
CONSUMER AND HOBBY COMPUTERS	319.8	2.1	69.5	1.0
OTHER APPLICATIONS	44.8	.3	55.6	.8
Total	14,946.2	100.0	6,945.0	100.0

TABLE 18

FLEXIBLE DISK DRIVES, 5.25 INCH

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1990 Net Shipments			
	To United States Destinations		Worldwide	
Drive Manufacturers	Units (000)	%	Units (000)	%
Teac	1,745.0	30.9	3,880.0	29.1
Matsushita Commun. Ind.	534.0	9.4	2,414.0	18.1
Chinon	885.0	15.7	1,749.0	13.1
Y-E Data	142.0	2.5	1,080.0	8.1
Mitsubishi Electric	462.0	8.2	852.0	6.4
Mitsumi Electric	350.0	6.2	550.0	4.1
Canon	263.0	4.7	543.0	4.1
Seiko Epson	300.0	5.3	480.0	3.6
Toshiba	442.0	7.8	442.0	3.3
Other U.S.	--	--	--	--
Other Non-U.S.	528.5	9.3	1,344.4	10.1
TOTAL	5,651.5	100.0	13,334.4	100.0

FLEXIBLE DISK DRIVES, MICROFLOPPIES

1991 DISK/TREND REPORT

FLEXIBLE DISK DRIVES, MICROFLOPPIES

Coverage

Examples of flexible disk drives in this group include:

3.5" disk diameter, one side, 67.5 TPI

Brother	FB 300

3.5" disk diameter, one side, 135 TPI

Brother	FB 015

3.5" disk diameter, two sides, 135 TPI, 1.0 megabyte

Alps Electric	DFR 423A
Canon	MD 3411
Chinon	F-354
Citizen	OSDC, UODC, V1DC
Matsushita Communication Ind.	JU-253A
Matsushita Electronic Comp.	EME-213
Mitsubishi Electric	MF353C
Mitsumi Electric	D357C
NEC	FD 1037A, FD 1038A
Seiko Epson	SMD-380
Sony	MP-F11W
Teac	FD-235F, FD-335F, FD-05GF
Toshiba	ND-3521
Y-E Data	YD-645C

3.5" disk diameter, two sides, 135 TPI, 1.6 megabytes

Alps Electric	DFP 683A
Canon	MD 3511
Citizen	OUDB
Matsushita Communication Ind.	JU-255
Matsushita Electronic Comp.	EME-262
Mitsubishi Electric	MF354C
Mitsumi Electric	D358T3
NEC	FD 1137C
Sankyo Seiki	FDU-480
Seiko Epson	SMD-1020
Teac	FD-235G, FD-335GF
Y-E Data	YD-686C

3.5" disk diameter, two sides, 135 TPI, 2.0 megabytes

Alps Electric	DFP 723A
Canon	MD 3611
Chinon	FT-357

3.5" disk diameter, two sides, 135 TPI, 2.0 megabytes (continued)

Citizen	OSDA, UODA, V1DE
Ergo	MD-21
Matsushita Communication Ind.	JU-257A
Matsushita Electronic Comp.	EME-263
Mitsubishi Electric	MF355C
Mitsumi Electric	D359C
NEC	FD 1137H, FD 1138H
Safronic	DS-34A
Samsung Electronics	SFD-321D
Sankyo Seiki	FDU-580
Seiko Epson	SMD-340
Sony	MP-F17W
Teac	FD-235HF, FD-335HF, FD-05HF
Toshiba	ND-356S/T
Y-E Data	YD-701B, YD-702F

3.5" disk diameter, two sides, 135 TPI, 4.0 megabytes

Alps Electric	DFR 823
Chinon	FZ-358
Citizen	OSDG
Matsushita Communication Ind.	JU-259A
Mitsubishi Electric	MF 356C
Mitsumi Electric	D352T2, D352C
Seiko Epson	SMD-1060
Sony	MP-F40W
Teac	FD-235J, FD-335J
Toshiba	ND-3571
Y-E Data	YD-742

3.0" disk diameter, one side

Matsushita Electronic Comp.	EME-156

3.0" disk diameter, two sides

Matsushita Electronic Comp.	EME-232

2.0" disk diameter, 254 TPI, 1.0 megabyte

Chinon	FJ-205
Sony	PDD-110

All microfloppy drives with capacities less than 5 megabytes and disk diameters of 3.5 inches or less are included in this product group. The separate types of products include: (1) 3.5 inch drives, both one and two sided versions, which are now manufactured by 18 companies, (2) the 3

inch drive, which is currently offered only by Matsushita Electronic Components, the originator of the format in cooperation with Hitachi, and (3) 2 inch drives, currently offered only by Sony and Chinon.

All 3.5 inch drives are derived from the Sony microfloppy first shipped in 1982, with modifications to achieve logical file organization similar to the larger diskette drives preceding it. Drives with capacities of one megabyte or less use 6,250 bytes per track, the same track capacity as "double density" 5.25 inch diskettes, and also use 40 or 80 tracks per side to maintain file compatibility with 5.25 inch diskettes.

1.6 and 2.0 megabyte 3.5 inch drives were announced in 1985, and are intended for use with the high density media originally proposed by Sony, and operate at up to 17,434 BPI, using the 135 TPI standard of today's production drives. All of the current 1.6 and 2.0 megabyte drives claim "downward compatibility," the ability to read and write on lower capacity diskettes. Since the adoption of 2.0 megabyte drives by IBM in April, 1987, for the PS/2 systems, most major manufacturers of microfloppy drives have announced similar drives.

Most manufacturers of 3.5 inch drives have also made the transition from the earlier 41.3 millimeter high drives ("half high", in 5.25 inch drive terms) to the 25.4 millimeter (one inch) high drives pioneered by Citizen in 1984. Several companies are also shipping drives with heights of 17-19 millimeters (3/4 inch), again prompted by Citizen, which started shipments of 3/4 inch high models in the Spring of 1989. Citizen started shipping 15 millimeter high models in the second quarter of 1991, followed by Teac's introduction of 12.7 millimeter high drives for shipment in the fourth quarter of 1991 and Mitsumi Electric's announcement of similar drives for early 1992 delivery.

While the 3 inch microfloppy format has lost all of its original adherents except Matsushita Electronic Components, the 2 inch drives are still in production, used mostly in Japanese language word processors. Initial shipments of 2 inch drives with "notebook" portable computers have encountered resistance from buyers who did not want to bother with interchange problems, but there may be enough applications in home computers, electronic typewriters and games to keep the 2 inch format alive. However, there are competing interchange standards, and it is not yet clear how many other manufacturers will join the fray.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1990	1991	1992	1993	1994
U.S. manufacturers	--	--	--	--	--
All manufacturers	1,487.7	1,434.0	1,521.5	1,580.5	1,577.7

Shipments of microfloppy drives in 1990 again exceeded expectations, up 26.8% from the previous year, but a modest increase of only 4.2% is forecasted for 1991. Not even a high growth product group such as microfloppy drives is immune to the effects of the current economic recession.

1990's worldwide shipments of 29.4 million drives produced revenues for drive manufacturers totaling $1,487,700,000, an increase of 10.4% over 1989. However, the difficult economic conditions of 1991 are expected to hold shipment growth to only 30.6 million drives, and lower OEM prices will cause total revenues to decline 3.6%, to $1,434,000,000. Less than 5% of worldwide unit shipments of microfloppy drives are captive drives, sold with computer systems made by the drive manufacturer.

Despite the continuous upgrading of the industry's overall product mix to higher capacity drives, average unit prices for this product group continue to decline. The overall average price for microfloppy drives was $59 in 1988, $51 in 1989, $46 in 1990 and an estimated $42 in 1991.

The Drive Capacity Analysis table for microfloppy drives, added to the DISK/TREND Report since last year, indicates that microfloppy drives with capacities of 1 megabyte or less continue to decline and represent less than 18% of 1991's worldwide unit shipments. The 2.0 megabyte models now offered by nearly all major floppy drive manufacturers have become the industry's major products, stimulated by IBM's 1987 adoption of 2.0 megabyte drives for PS/2 personal computers.

The similar 1.6 megabyte drives are used mostly in Japan, primarily by NEC and with computers designed to be compatible with NEC's personal computer product line. 1991 shipments of 1.6/2.0 megabyte drives are expected to provide 81.3% of the total of all microfloppy formats. IBM's long-expected adoption of the 4 megabyte microfloppy format finally occurred in 1991, but initially IBM is using 4 megabyte drives with only one PS/2 model. 4 megabyte 3.5 inch drives are expected to become an important part of the industry in future years, but shipments in 1991 are estimated to total only 371,000 units, as many system manufacturers delay adoption until IBM uses 4 megabyte drives more widely.

The average height of microfloppy drive mechanisms continues to shrink. After years of growth, 1 inch high (25.4 millimeters) drives became the dominant form factor, but the shipment peak for 1 inch high drives was in 1990, with 78.2% of the worldwide microfloppy total. Intense competition has come from drives with smaller heights -- initially 19 millimeters, then 17 millimeters, more recently 15 millimeters, and in

late 1991 12.7 millimeters. Drives with less than 1 inch height are expected to provide 17.4% of total 1991 unit shipments.

Shipments of all drives with disks less than 3.5 inches diameter are grouped together in the disk diameter breakdown tables in this year's DISK/TREND Report. OEM shipments of Matsushita 3 inch drives have declined in the last few years. The major market for these drives has been the European home computer market, but newer systems with other data storage devices have now gained the initiative. 3 inch drives have never significantly penetrated the U.S. market, and after an early lead have been overtaken in the Japan domestic market by 3.5 inch drives.

The subgroup for less than 3.5 inch drives also includes 2 inch drives, now available only in the Sony format. But 2 inch drives obviously cannot provide physical diskette compatibility with 3.5 inch or 5.25 inch drives, and potential users have demonstrated considerable sales resistance for business computer applications, where convenient media interchange is essential. 2 inch drives are likely to remain limited in the near future to typewriter and game applications, for which they are clearly well suited.

Sony, the originator of the 3.5 inch format, continued to lead the industry in non-captive shipments of microfloppy drives in 1990, with 5.7 million drives, 20.5% of the worldwide total. Teac held second place with 13%, and Citizen climbed to third position with 11.8%.

Marketing trends

Total unit shipments for the microfloppy product group are expected to maintain average annual growth of 8.2% in the 1992-94 period. Total

revenues are expected to grow again in 1992, buoyed by high unit shipments, but a continuing decline in average prices will reduce revenues to a no-growth status again in 1994.

Despite the never-ending pressure on average prices, the industry's microfloppy product mix will continue to be upgraded. Shipments of 1.6/2.0 megabyte drives are forecasted to grow from 1991's 24.9 million drives to 33.4 million drives in 1994. But the portion of total shipments held by 1.6/2.0 megabyte drives is expected to peak in 1993, as 4 megabyte drives assume a major part of the industry's shipments.

It remains difficult to forecast the growth rate for 4 megabyte drives, since much of the industry is still waiting for IBM to expand its usage of the format. However, it is expected that during the next year major system manufacturers will start to utilize the new 4 megabyte drives designed for the barium ferrite media originally proposed by Toshiba. Shipments of 880,000 4 megabyte drives are forecasted for 1992, growing to 3.2 million drives in 1994, representing 8.3% of 1994's total shipments of all microfloppy drives.

Shrinking drive heights are expected to continue as a significant trend for microfloppy drives. In the early 1980's there was no standard for the critical height dimension for 3.5 inch drives. Following Sony's original introduction of two inch high drives in 1982, many other manufacturers settled on 1.625 inches (41.3 millimeters -- the same as 5.25 inch half high drives). While 1.625 inches became widely used, many of the same manufacturers also offered drives with 28, 30 or 32 millimeter heights.

Amidst the confusion, Citizen Watch entered the microfloppy business with one inch high drives in 1984, with no immediate impact. However,

during the last five years, all significant producers of 3.5 inch drives added one inch high models, now the dominant physical configuration.

Citizen's 1989 introduction of 3/4 inch drives again exerted a strong influence on the industry. Most of the other Japanese floppy drive manufacturers have also announced 3/4 inch high drives, stimulated by the potential market in very small portable computers. Strictly speaking, 3/4 inches is 19.05 millimeters, but the 3/4 inch microfloppy drives announced to date have been in a range of 17 to 19 millimeters. Citizen's 1990 introduction of 15 millimeter high models also stimulated many competitors to announce microfloppy drives with similar height, but it is now clear that there was more to come.

Both Teac and Mitsumi Electric have announced 12.7 millimeter (exactly one half inch) high drives in 1991, and there is now a widespread belief in the industry that half inch high drives will become a major standard in the industry. Reinforcing this belief is the expected movement to 12.7 millimeter height for the 2.5 inch and smaller hard disk drives used with notebook computers. It is believed that most manufacturers of notebook computers will provide the option of a 3.5 inch floppy drive, assuming that users want a floppy drive with their notebook computers enough to tolerate the slight increase in size and weight. In this market environment, the slight improvement in package size provided by the 12.7 millimeter high drives will be highly valued.

Technical trends

Now that IBM has settled the argument over barium ferrite versus cobalt modified oxide for 4 megabyte drives, the next challenge for most

manufacturers of 3.5 inch drives will be packaging problems in reducing the height of the drive. The only significant problem for the industry in shifting to large scale production of 4 megabyte drives is availability of the new multifunction head required to provide downward compatibility with 1 and 2 megabyte drives, but it appears that there will be adequate production of the new heads in 1992.

It has been very expensive and technically difficult for most manufacturers to match competition with continually smaller drive configurations. But the changes have been achievable, once production of smaller motors and other key components became available.

Many manufacturers have found it convenient to use belt drive arrangements instead of the direct drive motors common with most of today's floppy drives and preferred by the majority of system manufacturers. Several small format drives using direct drive motors have been announced, but considerable effort will probably be expended to explore various mechanical designs before an industry consensus on this point is reached.

Forecasting assumptions

1. 3.5 inch drives with heights less than 1 inch will become the dominant floppy drive configuration by 1993 and 2 megabyte capacities will maintain leadership through 1994.

2. IBM will continue worldwide usage of 3.5 inch floppy drives with all newly introduced personal computers and will expand usage of 4 megabyte 3.5 inch drives on selected systems in 1992.

3. A positive growth rate for personal computers will resume in 1992.

4. The dollar/yen exchange rate will stay in the current range, and prices for non-captive microfloppy drives will continue to decline at the forecasted rate.

TABLE 19

FLEXIBLE DISK DRIVES, MICROFLOPPIES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1990		Forecast							
	Revenues		1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. NON-CAPTIVE	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	2.0	181.5	4.2	185.0	8.1	195.6	17.7	203.9	28.6	206.8
PCM/Reseller	94.0	122.7	83.3	121.8	86.8	132.6	94.9	147.6	95.0	154.4
OEM/Integrator	486.8	1,183.5	466.7	1,127.2	460.8	1,193.3	450.4	1,229.0	451.5	1,216.5
TOTAL NON-U.S. REVENUES	582.8	1,487.7	554.2	1,434.0	555.7	1,521.5	563.0	1,580.5	575.1	1,577.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	582.8	1,487.7	554.2	1,434.0	555.7	1,521.5	563.0	1,580.5	575.1	1,577.7
OEM Average Price ($000)	.048	.046	.044	.042	.042	.041	.040	.039	.037	.037

TABLE 20

FLEXIBLE DISK DRIVES, MICROFLOPPIES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1990 Shipments		Forecast 1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. NON-CAPTIVE	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	17.7	1,229.2	37.0	1,523.0	72.0	1,678.0	156.0	1,806.0	268.0	1,947.0
PCM/Reseller	1,786.0	2,397.0	1,742.0	2,611.0	1,947.0	2,969.0	2,222.0	3,439.0	2,375.0	3,809.0
OEM/Integrator	10,156.0	25,819.7	10,532.0	26,562.0	10,857.0	29,109.0	11,173.0	31,307.0	12,118.0	33,206.0
TOTAL NON-U.S. SHIPMENTS	11,959.7	29,445.9	12,311.0	30,696.0	12,876.0	33,756.0	13,551.0	36,552.0	14,761.0	38,962.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	11,959.7	29,445.9	12,311.0	30,696.0	12,876.0	33,756.0	13,551.0	36,552.0	14,761.0	38,962.0
Cumulative Shipments (Units in millions)										
IBM	--	--	--	--	--	--	--	--	--	--
Non-IBM	40.6	95.0	53.0	125.7	65.8	159.4	79.4	196.0	94.1	234.9
WORLDWIDE TOTAL	40.6	95.0	53.0	125.7	65.8	159.4	79.4	196.0	94.1	234.9

TABLE 21

FLEXIBLE DISK DRIVES, MICROFLOPPIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1990 Revenues			Forecast											
				1991			1992			1993			1994		
	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS
U.S. MANUFACTURERS															
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS															
Captive	7.5	18.2	155.8	6.9	20.1	158.0	5.4	16.4	173.8	2.6	9.9	177.8	.6	5.7	164.3
PCM/Reseller	--	--	122.7	--	--	121.7	--	--	124.4	--	--	127.5	--	--	116.7
OEM/Integrator	12.7	.2	1,170.6	7.9	.1	1,118.5	4.5	.1	1,098.4	1.8	--	1,026.1	--	--	877.0
TOTAL NON-U.S. REVENUES	20.2	18.4	1,449.1	14.8	20.2	1,398.2	9.9	16.5	1,396.6	4.4	9.9	1,331.4	.6	5.7	1,158.0
WORLDWIDE RECAP															
Captive	7.5	18.2	155.8	6.9	20.1	158.0	5.4	16.4	173.8	2.6	9.9	177.8	.6	5.7	164.3
	+4.2%	+38.9%	-16.8%	-8.0%	+10.4%	+1.4%	-21.7%	-18.4%	+10.0%	-51.9%	-39.6%	+2.3%	-76.9%	-42.4%	-7.6%
PCM/Reseller	--	--	122.7	--	--	121.7	--	--	124.4	--	--	127.5	--	--	116.7
	--	--	+37.7%	--	--	-.8%	--	--	+2.2%	--	--	+2.5%	--	--	-8.5%
OEM/Integrator	12.7	.2	1,170.6	7.9	.1	1,118.5	4.5	.1	1,098.4	1.8	--	1,026.1	--	--	877.0
	+39.6%	-94.1%	+12.8%	-37.8%	-50.0%	-4.5%	-43.0%	--	-1.8%	-60.0%	--	-6.6%	--	--	-14.5%
Total Revenues	20.2	18.4	1,449.1	14.8	20.2	1,398.2	9.9	16.5	1,396.6	4.4	9.9	1,331.4	.6	5.7	1,158.0
	+23.9%	+11.5%	+10.2%	-26.7%	+9.8%	-3.5%	-33.1%	-18.3%	--	-55.6%	-40.0%	-4.7%	-86.4%	-42.4%	-13.0%
ANNUAL SHARE, BY DIAMETER	1.4%	1.2%	97.4%	1.0%	1.4%	97.6%	.7%	1.2%	98.1%	.3%	.7%	99.0%	.1%	.5%	99.4%

TABLE 22

FLEXIBLE DISK DRIVES, MICROFLOPPIES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1990 Shipments			Forecast											
	1991			1992			1993			1994		
	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS	<3.5"	3.5" SS	3.5" DS
U.S. MANUFACTURERS															
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS															
Captive	52.0	200.2	977.0	49.0	224.0	1,250.0	40.0	192.0	1,446.0	20.0	125.0	1,557.0	5.0	75.0	1,546.0
PCM/Reseller	--	--	2,397.0	--	--	2,610.0	--	--	2,804.0	--	--	3,004.0	--	--	2,905.0
OEM/Integrator	260.0	4.3	25,555.4	165.0	4.0	26,379.0	95.0	2.0	26,992.0	40.0	--	26,227.0	--	--	23,798.0
TOTAL NON-U.S. SHIPMENTS	312.0	204.5	28,929.4	214.0	228.0	30,239.0	135.0	194.0	31,242.0	60.0	125.0	30,788.0	5.0	75.0	28,249.0
WORLDWIDE RECAP															
Captive	52.0	200.2	977.0	49.0	224.0	1,250.0	40.0	192.0	1,446.0	20.0	125.0	1,557.0	5.0	75.0	1,546.0
	+8.3%	+40.0%	-8.3%	-5.8%	+11.9%	+27.9%	-18.4%	-14.3%	+15.7%	-50.0%	-34.9%	+7.7%	-75.0%	-40.0%	-.7%
PCM/Reseller	--	--	2,397.0	--	--	2,610.0	--	--	2,804.0	--	--	3,004.0	--	--	2,905.0
	--	--	+53.2%	--	--	+8.9%	--	--	+7.4%	--	--	+7.1%	--	--	-3.3%
OEM/Integrator	260.0	4.3	25,555.4	165.0	4.0	26,379.0	95.0	2.0	26,992.0	40.0	--	26,227.0	--	--	23,798.0
	+48.6%	-94.9%	+26.9%	-36.5%	-7.0%	+3.2%	-42.4%	-50.0%	+2.3%	-57.9%	--	-2.8%	--	--	-9.3%
Total Shipments	312.0	204.5	28,929.4	214.0	228.0	30,239.0	135.0	194.0	31,242.0	60.0	125.0	30,788.0	5.0	75.0	28,249.0
	+39.9%	-10.3%	+27.1%	-31.4%	+11.5%	+4.5%	-36.9%	-14.9%	+3.3%	-55.6%	-35.6%	-1.5%	-91.7%	-40.0%	-8.2%
ANNUAL SHARE, BY DIAMETER	1.1%	.7%	98.2%	.7%	.7%	98.6%	.4%	.6%	99.0%	.2%	.4%	99.4%	--	.3%	99.7%

TABLE 23
FLEXIBLE DISK DRIVES, MICROFLOPPIES
WORLDWIDE SHIPMENTS (000)
DRIVE HEIGHT ANALYSIS

	1990 --Shipments--		Forecast 1991		1992		1993		1994	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	--		--		--		--		--	
Non-Captive Total	--		--		--		--		--	
Total U.S.	--		--		--		--		--	
NON-U.S. MANUFACTURERS										
Captive Total	1,229.2		1,523.0		1,678.0		1,806.0		1,947.0	
Less than 1 inch	325.0	26.4	645.0	42.5	948.0	56.6	1,285.0	71.3	1,677.0	86.2
1 inch	559.0	45.6	565.0	37.1	475.0	28.3	366.0	20.3	190.0	9.8
More than 1 inch	345.2	28.0	313.0	20.4	255.0	15.1	155.0	8.4	80.0	4.0
Non-Captive Total	28,216.7		29,173.0		32,078.0		34,746.0		37,015.0	
Less than 1 inch	2,199.0	7.8	4,702.0	16.1	9,776.0	30.5	19,044.0	54.9	28,626.0	77.4
1 inch	22,436.4	79.6	21,747.0	74.6	20,155.0	62.9	14,052.0	40.4	7,179.0	19.4
More than 1 inch	3,581.3	12.6	2,724.0	9.3	2,147.0	6.6	1,650.0	4.7	1,210.0	3.2
Total Non-U.S.	29,445.9		30,696.0		33,756.0		36,552.0		38,962.0	
Less than 1 inch	2,524.0	8.6	5,347.0	17.4	10,724.0	31.8	20,329.0	55.7	30,303.0	77.9
1 inch	22,995.4	78.2	22,312.0	72.8	20,630.0	61.2	14,418.0	39.4	7,369.0	18.9
More than 1 inch	3,926.5	13.2	3,037.0	9.8	2,402.0	7.0	1,805.0	4.9	1,290.0	3.2
WORLDWIDE RECAP										
Total Worldwide Shipments	29,445.9		30,696.0		33,756.0		36,552.0		38,962.0	
	+26.8%		+4.2%		+9.9%		+8.2%		+6.5%	
Less than 1 inch	2,524.0	8.6	5,347.0	17.4	10,724.0	31.8	20,329.0	55.7	30,303.0	77.9
	+801.1%		+111.8%		+100.5%		+89.5%		+49.0%	
1 inch	22,995.4	78.2	22,312.0	72.8	20,630.0	61.2	14,418.0	39.4	7,369.0	18.9
	+24.7%		-2.9%		-7.5%		-30.1%		-48.8%	
More than 1 inch	3,926.5	13.2	3,037.0	9.8	2,402.0	7.0	1,805.0	4.9	1,290.0	3.2
	-12.6%		-22.6%		-20.9%		-24.8%		-28.5%	

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

TABLE 24
FLEXIBLE DISK DRIVES, MICROFLOPPIES
WORLDWIDE SHIPMENTS (000)
DRIVE CAPACITY ANALYSIS

	1990 --Shipments--		Forecast 1991		1992		1993		1994	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	--		--		--		--		--	
Non-Captive Total	--		--		--		--		--	
Total U.S.	--		--		--		--		--	
NON-U.S. MANUFACTURERS										
Captive Total	1,229.2		1,523.0		1,678.0		1,806.0		1,947.0	
1 Megabyte or Less	259.2	21.1	279.0	18.3	236.0	14.1	145.0	8.0	80.0	4.1
1.6/2.0 Megabytes	970.0	78.9	1,244.0	81.7	1,427.0	85.1	1,605.0	89.0	1,735.0	89.2
4.0 Megabytes	--	--	--	--	15.0	.8	56.0	3.0	132.0	6.7
Non-Captive Total	28,216.7		29,173.0		32,078.0		34,746.0		37,015.0	
1 Megabyte or Less	6,395.3	22.7	5,117.0	17.5	4,094.0	12.8	3,190.0	9.2	2,230.0	6.0
1.6/2.0 Megabytes	21,780.4	77.3	23,685.0	81.3	27,119.0	84.6	29,792.0	85.8	31,667.0	85.7
4.0 Megabytes	41.0	--	371.0	1.2	865.0	2.6	1,764.0	5.0	3,118.0	8.3
Total Non-U.S.	29,445.9		30,696.0		33,756.0		36,552.0		38,962.0	
1 Megabyte or Less	6,654.5	22.6	5,396.0	17.6	4,330.0	12.8	3,335.0	9.1	2,310.0	5.9
1.6/2.0 Megabytes	22,750.4	77.4	24,929.0	81.3	28,546.0	84.7	31,397.0	86.0	33,402.0	85.8
4.0 Megabytes	41.0	--	371.0	1.1	880.0	2.5	1,820.0	4.9	3,250.0	8.3
WORLDWIDE RECAP										
Total Worldwide Shipments	29,445.9		30,696.0		33,756.0		36,552.0		38,962.0	
	+26.8%		+4.2%		+9.9%		+8.2%		+6.5%	
1 Megabyte or Less	6,654.5	22.6	5,396.0	17.6	4,330.0	12.8	3,335.0	9.1	2,310.0	5.9
	-19.5%		-18.9%		-19.7%		-22.9%		-30.7%	
1.6/2.0 Megabytes	22,750.4	77.4	24,929.0	81.3	28,546.0	84.7	31,397.0	86.0	33,402.0	85.8
	+52.2%		+9.5%		+14.5%		+9.9%		+6.3%	
4.0 Megabytes	41.0	--	371.0	1.1	880.0	2.5	1,820.0	4.9	3,250.0	8.3
	--		+804.8%		+137.2%		+106.8%		+78.5%	

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

TABLE 25

FLEXIBLE DISK DRIVES, MICROFLOPPIES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1990 Estimate Units (000)	1990 Estimate %	1994 Projection Units (000)	1994 Projection %
MAINFRAME/SUPERMINI General purpose	58.9	.2	39.0	.1
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	179.6	.6	194.8	.5
PERSONAL COMPUTERS Business and professional, single user	25,276.4	85.8	31,715.1	81.4
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	2,046.5	7.0	1,675.4	4.3
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	471.1	1.6	389.6	1.0
CONSUMER AND HOBBY COMPUTERS	1,148.4	3.9	4,675.4	12.0
OTHER APPLICATIONS	265.0	.9	272.7	.7
Total	29,445.9	100.0	38,962.0	100.0

TABLE 26

FLEXIBLE DISK DRIVES, MICROFLOPPIES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1990 Net Shipments			
	To United States Destinations		Worldwide	
Drive Manufacturers	Units (000)	%	Units (000)	%
Sony	3,314.0	27.8	5,784.0	20.5
Teac	1,237.0	10.4	3,670.0	13.0
Citizen	1,384.0	11.6	3,334.0	11.8
Y-E Data	723.0	6.1	2,264.0	8.0
Mitsubishi Electric	1,781.0	14.9	2,238.0	7.9
Matsushita Commun. Ind.	280.0	2.3	2,105.0	7.5
Chinon	988.0	8.3	1,746.0	6.2
Seiko Epson	725.0	6.1	1,700.0	6.0
Matsushita Elec. Ind.	--	--	1,655.0	5.9
Mitsumi Electric	285.0	2.4	1,250.0	4.4
Alps Electric	500.0	4.2	975.0	3.5
Toshiba	562.0	4.7	562.0	2.0
NEC	2.0	--	444.0	1.6
Other U.S.	--	--	--	--
Other Non-U.S.	161.0	1.2	489.7	1.7
TOTAL	11,942.0	100.0	28,216.7	100.0

FLEXIBLE DISK DRIVES, OVER 5 MEGABYTES

1991 DISK/TREND REPORT

FLEXIBLE DISK DRIVES, CAPACITY OVER 5 MEGABYTES

Coverage

Examples of flexible disk drives included in this group are:

5.25" Bernoulli principle drives

Iomega	B144, Bernoulli 90

8" flexible disk drives

Hitachi	FDD 441

5.25" flexible disk drives

Hitachi	FDD 541

3.5" flexible disk drives

Brier Technology	BR 3225, BR 3250
Citizen	IFDD-20
Insite Peripherals	I325VM
Matsushita Communication Ind.	JU-2521
NEC	FD 1335C, FD 1335H
Y-E Data	YD-750

All types of floppy drives with capacities over 5 megabytes have been consolidated into this section. The functional and physical characteristics of these products are varied, and are individually discussed below. Unfortunately, there has been no industry agreement on media interchange standards, and most of the high capacity floppy drives announced to date are incapable of interchanging diskettes with drives of other manufacturers, except for the downward compatibility with lower capacity standard floppy drives claimed by manufacturers of some 3.5 inch drives.

Iomega's Bernoulli principle drives: Iomega's drives use the Bernoulli effect to control head/disk spacing. These are high performance drives, using flexible disks in a removable rigid cartridge, and a sophisticated

internal air flow system to maintain the proper position of the disk relative to the recording head. A voice coil rotary head positioning system, in conjunction with an embedded servo, provides average seek times equivalent to many rigid disk drives.

Iomega started deliveries of the original 8 inch 10 megabyte Alpha-10 in September, 1982, replaced by a half high model in 1984, and supplemented by a 21 megabyte version in 1985. A 5 megabyte full size 5.25 inch drive was introduced in 1983, followed by a 21 megabyte half high model in 1986, a 44 megabyte version in 1989, and the current 90 megabyte model in July, 1991.

Other flexible disk drives: For several years the technology required for production of higher capacity floppy drives using conventional recording techniques has been available, and several approaches have been offered. Hitachi was the first to offer drives in this group, starting with a 9.6 megabyte 8 inch drive in 1984, followed in 1985 by a 6.5 megabyte 5.25 inch drive. Both of these drives have been used only in limited applications, and only in Japan.

Building on the technology used in its earlier 3.3 megabyte 5.25 inch drive licensed from Drivetec, Eastman Kodak started shipments of a 6.6 megabyte 5.25 inch drive in 1986, followed by a more advanced 12 megabyte embedded servo drive in 1987, with marketing responsibility subsequently transferred to Verbatim, then a Kodak subsidiary. Primary responsibility for manufacturing was turned over to Data Technology, a firm in which Eastman Kodak had an investment, and which has since been merged into Qume. Qume added a 24 megabyte version in 1988, but production of the entire drive series was recently discontinued, due to declining sales.

The newest developments in high capacity floppies involve 3.5 inch drives announced by Brier Technology and Insite Peripherals, plus several drives by Japanese companies. Because 3.5 inch microfloppies have become the standard floppy format for most personal computer systems, it is expected that new activity in the high capacity floppy drive marketplace will involve 3.5 inch drives.

NEC delivered its 9.4 megabyte (formatted) drive in August, 1988, with NEC systems in the domestic Japanese market, and in 1990 superseded it with a 10.18 megabyte model which incorporates read and write compatibility with 1 and 2 megabyte diskettes. Both drives employ embedded servos, and use metal powder media.

Brier Technology has announced 21 megabyte (formatted) 3.5 inch drives using a unique "dual level" or "buried" recording system in which embedded servo information occupies the same position as data tracks without reducing track capacity. The first version of the 21 megabyte Brier drive was delivered in early 1990, and a new drive with downward read/write compatibility to 1 and 2 diskettes appeared in early 1991.

Insite Peripherals has achieved quick fame in the industry by announcing its trademarked "floptical" technology, a combination of optical tracking methods with conventional magnetic recording. Insite uses a reflective servo pattern applied to the surface of standard 3.5 inch diskettes to achieve high track density (1,245 TPI), resulting in a capacity of 21 megabytes (formatted).

Insite is currently delivering a new version of the drive which provides downward read/write compatibility with 1 and 2 megabyte 3.5 inch drives, and which is manufactured for Insite on a contract basis by Matsushita Kotobuki Electronics. Insite also has licensed the floptical tech-

nology to Iomega, which plans to enter the market with drives compatible with Insite's in mid-1992, using Chinon as a contract manufacturing source.

Several Japanese manufacturers have announced (and de-announced) various high capacity 3.5 inch floppy drives, including Matsushita Communication Industrial, Citizen, Y-E Data and others. It is not clear that any of the currently announced drives will be produced in quantity, since Japan Electronic Industry Development Association (JEIDA) has organized a standards committee to attempt to achieve common standards for 20 and 40 megabyte drives to be produced by Japanese floppy drive manufacturers.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1990	1991	1992	1993	1994
U.S. manufacturers	71.7	65.7	140.2	156.6	179.8
All manufacturers	72.3	66.7	152.2	193.4	247.2

Unit shipments and revenues for this product group in 1990-91 are below previous expectations, due to limited availability of high capacity 3.5 inch drives and the recession's impact on shipments of Bernoulli 5.25 inch drives. Worldwide shipments for all drives in the product group were only 81,300 in 1990 and an estimated 90,600 in 1991, the lowest level in recent years.

Iomega's Bernoulli principle drives: Iomega's Bernoulli drives compete primarily with small Winchester disks and removable rigid disk cartridge drives, rather than with most of the flexible disk drives available in the

past, due to their capacity, performance, and pricing.

Because of the unique characteristics of its drives and lack of effective second sources, Iomega has achieved most of its sales successes through its program to sell Bernoulli Box subsystems in the personal computer add-on market with distribution through dealers. During 1983-85, an 8 inch subsystem sold through dealers to IBM PC users was the key to the firm's growth to over $100 million in annual sales.

In 1986, however, sales grew only modestly and profits went into a slide, due to competition from small hard disks and industry-wide decline of the 8 inch form factor. Success of a 21 megabyte half high 5.25 inch drive introduced in 1986 was delayed by technical problems, but the product started to take off in 1987. Although the company followed a policy of emphasizing sales of the 5.25 inch drive in the OEM market in an attempt to diversify its distribution channels, most current shipments are still sold in the PCM/reseller distribution channel.

For years, Iomega's main difficulty in selling to major system manufacturers on an OEM basis has been lack of credible alternate sources for the company's drives. The products are unique, and system manufacturers, as always, are reluctant to take a chance on a sole-source product. Attempts to establish token alternate sources in Japan and the U.S. have been abortive.

The market for 8 inch Bernoulli drives is now gone, and Iomega's drive shipments are currently all 5.25 inch models, totaling 74,400 drives in 1990. While the firm's 1991 disk drive shipments are still predominantly 44 megabyte drives, the 90 megabyte model introduced in mid-1991 with a newly aggressive pricing policy is expected to grow rapidly.

Other flexible disk drives: Most of the non-Bernoulli high capacity drives produced to date have been 5.25 inch drives previously introduced by Konica, Eastman Kodak (later sold by Verbatim), and Data Technology (now Qume). While Qume's 10 megabyte drives built most of the group's shipment momentum, they were quickly replaced by the 20 megabyte models sold by both Qume and Verbatim. But time has passed by this group of 5.25 inch drives, and only Hitachi is still producing some older 5.25 inch and 8 inch models, at low production levels.

3.5 inch high capacity floppy drives continue to offer the promise of significant shipment levels, but delays in initiating manufacturing arrangements have prevented the shipment growth previously expected for 1990 and 1991. Shipments of only 15,000 3.5 inch drives are now expected in 1991.

Both Insite Peripherals and Brier Technology have made arrangements for contract manufacturing of downward compatible drives by Japanese manufacturers, but large production quantities are only now starting to be available, in late 1991. Insite has also licensed Iomega to make drives consistent with its "floptical" standard, and Iomega has arranged for contract manufacturing by Chinon, but first shipments are not expected until mid-1992. Potential first shipments of floppy drives under the proposed JEIDA 20 megabyte standard by Japanese drive manufacturers cooperating with the program are not expected until 1992.

The future of most high capacity flexible disk drives will probably be found as backup devices used with Winchester disk drives and in applications such as data logging, in which access time is not a factor. Cartridge tape drives are the established competitor in these applications, and the new floppy drives could have a friendly reception as a tape

drive replacement by end users and system OEMs, both of whom usually respond favorably to faster performance and easier system integration.

Marketing trends

Because of the large latent demand believed to exist for improved system backup devices, rapid growth is expected for this product group, once high capacity 3.5 inch drives are in production from multiple vendors.

Volume production capability for 3.5 inch drives finally seems assured for next year, at least for the Insite "floptical" drives, and potentially for the Brier design and the JEIDA standard. DISK/TREND forecasts now project worldwide shipments of 320,000 3.5 inch drives in 1992, growing to 1.3 million drives in 1994. During the same period, 5.25 inch drives, mostly the Bernoulli type, are expected to peak in 1992 at 100,000 units, then decline to 57,000 drives in 1994.

Although 3.5 inch drives are expected to prevail in the high capacity floppy drive market, there will be many challenges along the way. The most important of these is the lack of a consensus in the industry on just what formats should be used. As a result, the high capacity 3.5 inch drives active in the market during the next few years will include several models with various embedded servo head positioning techniques and at least one with optical tracking methods.

As usual, the customers will be put off by all of the ensuing bickering over standards and will find it easy to delay purchases. For these reasons, current DISK/TREND forecasts could be conservative if any of the competing 3.5 inch products quickly becomes a mainstream de facto standard

-- but the industry's history argues against the probability of a quick consensus, unless IBM makes an early choice among the contenders.

Technology trends

The major product development challenges in this product group during the remainder of the 1990's will be to increase capacity and lower product cost. If high capacity floppy drives are to achieve prominence in data storage markets, they must offer sufficient capacity to be attractive for most small system backup requirements and they must provide aggressive price competition to tape cartridge drives, removable hard disk drives and erasable optical disk drives.

Since the 3.5 inch form factor for data storage products in this class is clearly destined to prevail, the development task will be to increase capacities beyond the 20 megabytes now available and to achieve the design simplification required for low manufacturing cost.

Brier Technology, the first company to announce a specific high capacity 3.5 inch floppy drive, uses a "dual servo" technique, in order to avoid wasting valuable capacity in each data track for servo information. The Japanese floppy drive manufacturers cooperating with the JEIDA standardization program are using conventional embedded (interspersed) servo technology, and some plan to offer floppy drives capable of letting the individual user write the embedded servo data as part of the diskette initialization.

Insite Peripherals' optical tracking method is perhaps the most innovative approach, with obvious potential for greater capacity and low manufacturing costs. Insite's reflective servo pattern is imprinted on the diskette as part of the media manufacturing process, and potentially

will increase the media manufacturing cost only slightly when high shipment levels are achieved.

None of the above product designs provide for media interchange except among drives of the same type, plus lower capacity 3.5 inch drives. All serious contenders have announced downward read/write compatibility with 1 and 2 megabyte formats, but the likelihood that 4 megabyte floppy drives will also become an industry standard poses an additional compatibility requirement.

Of course, none of the interesting technical developments in this field will see wide application unless producible at low cost. This is not going to be easy, since these drives will require sophisticated head positioning systems, multifunction heads, high density encoding schemes, error correction capability, high reliability and embedded controllers. Furthermore, the media must be priced low enough to avoid buyer resistance, while still offering long life, adequate durability and easy handling. It's definitely a difficult development task, but without low cost these drives will enjoy only a small niche.

Forecasting assumptions

1. Volume production of 3.5 inch high capacity drives from multiple vendors will be available in 1992.
2. No major system OEM, such as IBM or Apple Computer, will adopt a product in this group for system usage through 1992.
3. Shipments of 5.25 inch Bernoulli drives will peak in 1992.

TABLE 27

FLEXIBLE DISK DRIVES, OVER 5 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1990		Forecast							
	Revenues		1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	47.1	66.9	48.4	62.3	66.6	87.8	60.4	81.1	45.0	62.7
OEM/Integrator	4.8	4.8	3.4	3.4	43.0	52.4	59.3	75.5	89.3	117.1
TOTAL U.S. NON-CAPTIVE	51.9	71.7	51.8	65.7	109.6	140.2	119.7	156.6	134.3	179.8
TOTAL U.S. REVENUES	51.9	71.7	51.8	65.7	109.6	140.2	119.7	156.6	134.3	179.8
Non-U.S. Manufacturers										
Captive	--	.3	--	.3	--	2.2	.8	6.9	2.1	12.2
PCM/Reseller	--	--	--	--	.5	1.0	3.8	6.1	6.4	10.4
OEM/Integrator	--	.3	--	.7	5.0	8.8	14.3	23.8	24.8	44.8
TOTAL NON-U.S. REVENUES	--	.6	--	1.0	5.5	12.0	18.9	36.8	33.3	67.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	51.9	72.3	51.8	66.7	115.1	152.2	138.6	193.4	167.6	247.2
OEM Average Price ($000)	.623	.573	.576	.466	.251	.250	.185	.185	.152	.153

TABLE 28

FLEXIBLE DISK DRIVES, OVER 5 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1990 Shipments		Forecast 1991		1992		1993		1994	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	50.7	72.1	65.0	81.5	133.0	166.0	162.0	205.0	166.0	217.0
OEM/Integrator	7.7	7.7	5.9	5.9	171.0	210.0	323.0	413.0	595.0	780.0
TOTAL U.S. NON-CAPTIVE	58.4	79.8	70.9	87.4	304.0	376.0	485.0	618.0	761.0	997.0
TOTAL U.S. SHIPMENTS	58.4	79.8	70.9	87.4	304.0	376.0	485.0	618.0	761.0	997.0
Non-U.S. Manufacturers										
Captive	--	.3	--	.3	--	5.2	2.0	18.0	6.0	35.0
PCM/Reseller	--	--	--	--	2.0	4.0	20.0	32.0	40.0	65.0
OEM/Integrator	--	1.2	--	2.9	20.0	35.0	75.0	125.0	155.0	280.0
TOTAL NON-U.S. SHIPMENTS	--	1.5	--	3.2	22.0	44.2	97.0	175.0	201.0	380.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	58.4	81.3	70.9	90.6	326.0	420.2	582.0	793.0	962.0	1,377.0
Cumulative Shipments (Units in thousands)										
IBM	--	--	--	--	--	--	--	--	--	--
Non-IBM	557.6	688.5	628.5	779.1	954.5	1,199.3	1,536.5	1,992.3	2,498.5	3,369.3
WORLDWIDE TOTAL	557.6	688.5	628.5	779.1	954.5	1,199.3	1,536.5	1,992.3	2,498.5	3,369.3

TABLE 29

FLEXIBLE DISK DRIVES, OVER 5 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1990 Revenues			Forecast									
				1991			1992			1993		1994	
	3.5"	5.25"	8"	3.5"	5.25"	8"	3.5"	5.25"	8"	3.5"	5.25"	3.5"	5.25"
U.S. MANUFACTURERS													
PCM/Reseller	.3	62.6	4.0	3.6	58.7	--	17.3	70.5	--	21.6	59.5	24.0	38.7
OEM/Integrator	--	4.0	.8	--	3.4	--	49.0	3.4	--	73.8	1.7	117.1	--
TOTAL U.S. REVENUES	.3	66.6	4.8	3.6	62.1	--	66.3	73.9	--	95.4	61.2	141.1	38.7
NON-U.S. MANUFACTURERS													
Captive	--	--	.3	--	--	.3	2.0	--	.2	6.9	--	12.2	--
PCM/Reseller	--	--	--	--	--	--	1.0	--	--	6.1	--	10.4	--
OEM/Integrator	--	.2	.1	.4	.2	.1	8.8	--	--	23.8	--	44.8	--
TOTAL NON-U.S. REVENUES	--	.2	.4	.4	.2	.4	11.8	--	.2	36.8	--	67.4	--
WORLDWIDE RECAP													
Captive	--	--	.3	--	--	.3	2.0	--	.2	6.9	--	12.2	--
	--	--	--	--	--	--	--	--	-33.3%	+245.0%	--	+76.8%	--
PCM/Reseller	.3	62.6	4.0	3.6	58.7	--	18.3	70.5	--	27.7	59.5	34.4	38.7
	--	+7.9%	-73.5%	--	-6.2%	--	+408.3%	+20.1%	--	+51.4%	-15.6%	+24.2%	-35.0%
OEM/Integrator	--	4.2	.9	.4	3.6	.1	57.8	3.4	--	97.6	1.7	161.9	--
	--	+7.7%	-40.0%	--	-14.3%	-88.9%	--	-5.6%	--	+68.9%	-50.0%	+65.9%	--
Total Revenues	.3	66.8	5.2	4.0	62.3	.4	78.1	73.9	.2	132.2	61.2	208.5	38.7
	-25.0%	+7.9%	-69.2%	--	-6.7%	-92.3%	--	+18.6%	-50.0%	+69.3%	-17.2%	+57.7%	-36.8%
ANNUAL SHARE, BY DIAMETER	.4%	92.5%	7.1%	6.0%	93.5%	.5%	51.4%	48.6%	--	68.5%	31.5%	84.4%	15.6%

TABLE 30

FLEXIBLE DISK DRIVES, OVER 5 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1990 Shipments			Forecast									
				1991			1992			1993		1994	
	3.5"	5.25"	8"	3.5"	5.25"	8"	3.5"	5.25"	8"	3.5"	5.25"	3.5"	5.25"
U.S. MANUFACTURERS													
PCM/Reseller	.8	68.2	3.1	13.0	68.5	--	72.0	94.0	--	120.0	85.0	160.0	57.0
OEM/Integrator	--	6.7	1.0	--	5.9	--	204.0	6.0	--	410.0	3.0	780.0	--
TOTAL U.S. SHIPMENTS	.8	74.9	4.1	13.0	74.4	--	276.0	100.0	--	530.0	88.0	940.0	57.0
NON-U.S. MANUFACTURERS													
Captive	--	--	.3	--	--	.3	5.0	--	.2	18.0	--	35.0	--
PCM/Reseller	--	--	--	--	--	--	4.0	--	--	32.0	--	65.0	--
OEM/Integrator	.1	.8	.3	2.0	.7	.2	35.0	--	--	125.0	--	280.0	--
TOTAL NON-U.S. SHIPMENTS	.1	.8	.6	2.0	.7	.5	44.0	--	.2	175.0	--	380.0	--
WORLDWIDE RECAP													
Captive	--	--	.3	--	--	.3	5.0	--	.2	18.0	--	35.0	--
	--	--	--	--	--	--	--	--	-33.3%	+260.0%	--	+94.4%	--
PCM/Reseller	.8	68.2	3.1	13.0	68.5	--	76.0	94.0	--	152.0	85.0	225.0	57.0
	--	-12.1%	-84.2%	--	+.4%	--	+484.6%	+37.2%	--	+100.0%	-9.6%	+48.0%	-32.9%
OEM/Integrator	.1	7.5	1.3	2.0	6.6	.2	239.0	6.0	--	535.0	3.0	1,060.0	--
	-95.0%	+5.6%	-40.9%	--	-12.0%	-84.6%	--	-9.1%	--	+123.8%	-50.0%	+98.1%	--
Total Shipments	.9	75.7	4.7	15.0	75.1	.5	320.0	100.0	.2	705.0	88.0	1,320.0	57.0
	-57.1%	-10.6%	-78.7%	--	-.8%	-89.4%	--	+33.2%	-60.0%	+120.3%	-12.0%	+87.2%	-35.2%
ANNUAL SHARE, BY DIAMETER	1.1%	93.2%	5.7%	16.6%	83.0%	.4%	76.3%	23.7%	--	89.0%	11.0%	96.0%	4.0%

TABLE 31

FLEXIBLE DISK DRIVES, OVER 5 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1990 Estimate Units (000)	1990 Estimate %	1994 Projection Units (000)	1994 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTIUSER MICROS Business and professional, including networks	--	--	27.5	2.0
PERSONAL COMPUTERS Business and professional, single user	75.2	92.5	1,198.0	87.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	1.4	1.7	13.8	1.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	4.7	5.8	82.6	6.0
CONSUMER AND HOBBY COMPUTERS	--	--	55.1	4.0
OTHER APPLICATIONS	--	--	--	--
Total	81.3	100.0	1,377.0	100.0

TABLE 32

FLEXIBLE DISK DRIVES, OVER 5 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1990 Net Shipments			
	To United States Destinations		Worldwide	
Drive Manufacturers	Units (000)	%	Units (000)	%
Iomega	54.7	93.7	74.4	91.9
Other U.S.	3.7	6.3	5.4	6.7
Other Non-U.S.	--	--	1.2	1.4
TOTAL	58.4	100.0	81.0	100.0

FLEXIBLE DISK DRIVE SPECIFICATIONS

FLEXIBLE DISK DRIVE SPECIFICATIONS

Coverage

The product specification section of this report includes most flexible disk drives intended for computer data storage which are now in production or announced, arranged alphabetically by manufacturer.

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

Capacities

Capacities are listed as "U" for unformatted or "F" for formatted. All capacities are per spindle. For DISK/TREND purposes, one spindle consists of the disk drive mechanism required to utilize a single flexible disk. In general, unformatted capacities are shown for most drives without embedded controllers, and formatted capacities are given for drives with embedded controllers, such as SCSI.

When more than one figure is given in the specifications for "Total capacity", the highest number is usually the maximum capacity at which the drive is designed to operate. The lower capacity levels also shown indicate the additional densities at which the drive is designed to operate, which in some cases require setting switches on the drive.

Accuracy

All information 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 were necessary. Your corrections will be most welcome and will be included in the next edition.

OEM prices

Previous editions of the DISK/TREND Report included information in the specifications section on the OEM/Integrator price for drives sold in the United States at the 500 unit level, or for larger quantities in some cases. Starting with last year's edition of the report, price information for individual products is no longer included, because of the rapid changes involved and the lack of actual selling activity at the low quantity level for which prices were provided.

DISK/TREND product groups

In most cases the product groups used for individual drives are clear, but a few arbitrary decisions have been made. Please note that all drives with capacities over 5 megabytes have been placed in the high capacity group, regardless of disk diameter.

1991 DISK/TREND product groups for flexible disk drives

Group number	Drives included
13.	Flexible disk drives, 8 inch
14.	Flexible disk drives, 5.25 inch
15.	Flexible disk drives, microfloppies
16.	Flexible disk drives, over 5 megabytes

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	DF 312D	DF 313H	DF 314H	DF 314N	DFR 423F
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/1.6/2.0	U: 1.0
Capacity per track (Bytes)	U: 6,250	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717	8717/14184	8714/17434	8714/14184/ 17434	8717
Rotational speed (RPM)	300	360	300	300/360/300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	83.3	100	100/83.3/100	100
Data transfer rate (KBytes/sec)	31.25	62.5/37.5	62.5/31.25	62.5/62.5/31.25	31.25
SIZE (Inches: H x W x D)	.65 x 3.8 x 5.0	.65 x 3.8 x 5.0	.65 x 3.8 x 5.0	.65 x 3.8 x 5.0	1.0 x 4.0 x 5.7
FIRST CUSTOMER SHIPMENT	4/91	4/91	4/91	4/91	5/90
COMMENTS	Direct drive	Direct drive	Direct drive	Direct drive	

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ASIA COMMERCIAL
DRIVE	DFR 683F	DFR 723F	DFR 783F	DFR 823F	FD-103
DISK/TREND GROUP	15	15	15	15	14
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/1.6/2.0	U: 1.0/2.0/4.0	U: .125/.250
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/25,000	U: 3,125/6,250
Data surfaces per spindle	2	2	2	2	1
Tracks per surface	80/77	80	80/77	80	40
Track density (TPI)	135	135	135	135	48
Maximum linear density (BPI)	8717/14518	8717/17434	8717/17434	8717/34868	2768/5536
Rotational speed (RPM)	300/360	300	300/360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Band, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	6
Settling time (msec)	15	15	15	15	20
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100/83.3	100	100/83.3	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5/125	15.63/31.25
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.7	1.0 x 4.0 x 5.7	1.0 x 4.0 x 5.7	1.0 x 4.0 x 5.7	1.625 x 5.75 x 8.25
FIRST CUSTOMER SHIPMENT	5/90	5/90	5/90	8/90	2Q85
COMMENTS					For Apple IIC and Apple IIE

MANUFACTURER	ASIA COMMERCIAL	ASIA COMMERCIAL	ASIA COMMERCIAL	ASIA COMMERCIAL	ASIA COMMERCIAL
DRIVE	FD-104	FD-106	FD-148	FD-200	FD-201
DISK/TREND GROUP	14	14	14	14	14
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	5.25"	5.25"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .250/.5	U: .8/1.6	U: .125/.250	U: .5	U: 1.6
Capacity per track (Bytes)	U: 3,125/6,250	U: 5,208/10,416	U: 3,125/6,250	U: 6,250	U: 10,416
Data surfaces per spindle	2	2	1	2	2
Tracks per surface	40	80	40	80	160
Track density (TPI)	48	96	48	48	96
Maximum linear density (BPI)	2938/5876	4823/9646	2768/5536	5536	9646
Rotational speed (RPM)	300	360	300	300	360
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	6	3	6	6	3
Settling time (msec)	15	18	20	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	83.3	100	100	83.3
Data transfer rate (KBytes/sec)	15.63/31.25	31.25/62.5	15.63/31.25	31.25	62.5
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.25	1.625 x 5.75 x 8.25	1.625 x 5.88 x 8.0	1.81 x 6.0 x 9.0	1.81 x 6.0 x 9.0
FIRST CUSTOMER SHIPMENT	1Q86	3Q87	4Q85		
COMMENTS	For IBM PC XT	For IBM AT	For Commodore C64		

MANUFACTURER	BRIER TECHNOLOGY	BRIER TECHNOLOGY	BRIER TECHNOLOGY	BROTHER	BROTHER
DRIVE	BR 3020	BR 3225	BR 3250	FB 015 FB 400	FB 100
DISK/TREND GROUP	16	16	16	15	15
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	Captive
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	Barium Ferrite	Barium Ferrite	Barium Ferrite	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 21.4	F: 21.4	F: 44.6	U: .320	F: .1024
Capacity per track (Bytes)	**	**	**	U: 4,102	F: 2,560
Data surfaces per spindle	2	2	2	1	1
Tracks per surface	516	516	683	78	40
Track density (TPI)	777	777	1084	135	67.5
Maximum linear density (BPI)	26000*	26000*	30000*	5180	4064
Rotational speed (RPM)	720	720	720	300	300
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Lead Screw, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	15	15	15	20	60
Settling time (msec)	--	--	--	10	20
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	41.6	41.6	41.6	100	100
Data transfer rate (KBytes/sec)	1250	1250	1250	19.50	15.63
SIZE (Inches: H x W x D)	1.625 x 4.0 x 5.75	1.0 x 4.0 x 5.75	1.0 x 4.0 x 5.75	1.0 x 4.06 x 6.69	2.16 x 5.1 x 6.5
FIRST CUSTOMER SHIPMENT	1Q90	1Q91	1Q92	10/87	1984
COMMENTS	Dual level embedded servo 35 msec average head positioning *RLL Code **Varies by zone	Dual level embedded servo. 35 msec average head position. *RLL Code. **Varies by zone. Downward comp. with 1 & 2 MB (Read & Write)	Dual level embedded servo. 29 msec average head position. *RLL Code. **Varies by zone. Downward comp. with 1 & 2 MB (Read & Write)	FB 400 is kit for typewriter GCR encoded	Used in knitting machines

MANUFACTURER	BROTHER	CANON	CANON	CANON	CANON
DRIVE	FB 300	MD 5201	MD 5501	MD 3411 MD 3421	MD 3441
DISK/TREND GROUP	15	14	14	15	15
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	5.25"	5.25"	3.5"	3.5"
Recording medium	Oxide Coated	Oxide Coated	High Density Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .250	U: .250/.5	U: 1.0/1.6	U: 1.0	U: 1.0
Capacity per track (Bytes)	U: 6,250	U: 3,125/6,250	U: 6,250/10,416	U: 6,250	U: 6,250
Data surfaces per spindle	1	2	2	2	2
Tracks per surface	40	40	80/77	80	80
Track density (TPI)	67.5	48	96	135	135
Maximum linear density (BPI)	8128	2938/5876	5922/9646	8717	8717
Rotational speed (RPM)	300	300	360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	24	6	3	3	3
Settling time (msec)	24	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	83.3	100	100
Data transfer rate (KBytes/sec)	31.25	15.63/31.25	31.25/62.5	250	31.25
SIZE (Inches: H x W x D)	2.51 x 5.19 x 8.03	1.06 x 5.75 x 7.8	1.06 x 5.75 x 7.8	1.0 x 4.0 x 5.89	.77 x 4.0 x 5.1
FIRST CUSTOMER SHIPMENT	1985	7/86	7/86	4Q88	1990
COMMENTS	Used with typewriters				Direct drive motor

MANUFACTURER	CANON	CANON	CANON	CANON	CHINON
DRIVE	MD 3511 MD 3521	MD 3541	MD 3611 MD 3621	MD 3641	FR-506
DISK/TREND GROUP	15	15	15	15	14
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/2.0	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250/10,420	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	96
Maximum linear density (BPI)	8717/14527	8717/14527	8717/17434	8717/17434	5922/9870
Rotational speed (RPM)	300/360	360	300	300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100/83.3	83.3	100	100	100/83.3
Data transfer rate (KBytes/sec)	250/500	37.5/62.5	250/500	31.25/62.5	37.5/62.5
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.89	.77 x 4.0 x 5.1	1.0 x 4.0 x 5.89	.77 x 4.0 x 5.1	1.625 x 5.75 x 7.6
FIRST CUSTOMER SHIPMENT	4/88	4/90	4/88	4/90	1Q91
COMMENTS		Direct drive motor		Direct drive motor	

MANUFACTURER	CHINON	CHINON	CHINON	CHINON	CHINON
DRIVE	FZ-501A	FZ-502	FZ-506	FB-354 FB-354I	FB-357 FB-357I
DISK/TREND GROUP	14	14	14	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	3.5"	3.5"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .125/.250	U: .250/.5	U: 1.0/1.6	U: .5/1.0	U: 1.0/2.0
Capacity per track (Bytes)	U: 3,125/6,250	U: 3,125/6,250	U: 6,250/10,416	U: 3,125/6,250	U: 6,250/12,500
Data surfaces per spindle	1	2	2	2	2
Tracks per surface	40	40	80	80	80
Track density (TPI)	48	48	96	135	135
Maximum linear density (BPI)	2768/5536	2938/5876	5922/9870	4359/8717	8717/17434
Rotational speed (RPM)	300	300	300/360	300	300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	6	5	3	3	3
Settling time (msec)	20	20	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100/83.3	100	100
Data transfer rate (KBytes/sec)	15.63/31.25	15.63/31.25	37.5/62.5	15.63/31.25	31.25/62.5
SIZE (Inches: H x W x D)	1.625 x 5.75 x 7.6	1.625 x 5.75 x 7.6	1.625 x 5.75 x 7.6	1.26 x 4.0 x 5.9	1.26 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	8/83	3/87	4/87	11/84	7/86
COMMENTS				FB-354I in 5.25" frame	FB-357I in 5.25" frame

MANUFACTURER	CHINON	CHINON	CHINON	CHINON	CHINON
DRIVE	FJ-205	FT-354	FT-357	FZ-354 FZ-354I FZ-354IS	FZ-357 FZ-357I FZ-357IS
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	2.0"	3.5"	3.5"	3.5"	3.5"
Recording medium	Metal Powder	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.194	U: .5/1.0	U: 1.0/2.0	U: .5/1.0	U: 1.0/2.0
Capacity per track (Bytes)	U: 23,888	U: 3,125/6,250	U: 6,250/12,500	U: 3,125/6,250	U: 6,250/12,500
Data surfaces per spindle	1	2	2	2	2
Tracks per surface	50	80	80	80	80
Track density (TPI)	254	135	135	135	135
Maximum linear density (BPI)	51200	4359/8717	8717/17434	4359/8717	8717/17434
Rotational speed (RPM)	3600	300	300	300	300
PERFORMANCE					
Actuator type	Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	4	3	3	3	3
Settling time (msec)	--	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	8.3	100	100	100	100
Data transfer rate (KBytes/sec)	1787.5	15.63/31.25	31.25/62.5	15.65/31.25	31.25/62.5
SIZE (Inches: H x W x D)	.79 x 2.5 x 3.4	.67 x 4.0 x 5.1	.67 x 4.0 x 5.1	1.0 x 4.0 x 5.11	1.0 x 4.0 x 5.11
FIRST CUSTOMER SHIPMENT	1Q92	2Q91	2Q91	1Q90	1Q90
COMMENTS	Compatible with Sony 2.0" FDD			FZ-354I and FZ-354IS in 5.25" frame	FZ-357I and FZ-357IS in 5.25" frame

MANUFACTURER	CHINON	CITIZEN	CITIZEN	CITIZEN	CITIZEN
DRIVE	FZ-358	OSDA	OSDB	OSDC	OSDD
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	Barium Ferrite	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0/4.0	U: 1.0/2.0	U: 1.0/1.6	U: 1.0	U: 1.0
Capacity per track (Bytes)	U: 6,250/12,500 25,000	U: 6,250/12,500	U: 6,250/10,416	U: 6,250	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80/77	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/17434/ 34868	8717/17434	8717/14184	8717	8717
Rotational speed (RPM)	300	300	300/360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	6
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100/83.3	100	100
Data transfer rate (KBytes/sec)	31.25/62.5/125	31.25/62.5	31.25/62.5	31.25	31.25
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	2Q91	4Q87	4Q87	4Q87	4Q87
COMMENTS					

MANUFACTURER	CITIZEN	CITIZEN	CITIZEN	CITIZEN	CITIZEN
DRIVE	OSDE	OSDF	OSDG	U0DA U1DA	U0DB U1DB
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	Barium Ferrite	Barium Ferrite	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6/2.0	U: 1.0/2.0/4.0	U: 1.0/1.6/4.0	U: 1.0/2.0	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250/12,500	U: 6,250/25,000	U: 6,250/25,000	U: 6,250/12,500	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80	80/77	80	80/77
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/17434	8717/17434/ 34868	8717/14184/ 34868	8717/17434	8717/14184
Rotational speed (RPM)	300	300	300/360	300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100/83.3	100	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5/125	31.25/62.5/125	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	.77 x 4.0 x 5.1	.77 x 4.0 x 5.1
FIRST CUSTOMER SHIPMENT	4Q89	4Q90	4Q90	3Q89	2Q90
COMMENTS					

MANUFACTURER	CITIZEN	CITIZEN	CITIZEN	CITIZEN	CITIZEN
DRIVE	U0DC U1DC	U0DD U1DD	V1DA V2DA	V1DB V2DB	V1DC V2DC
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0	U: 1.0	U: 1.0/2.0	U: 1.0/1.6	U: 1.0
Capacity per track (Bytes)	U: 6,250	U: 6,250	U: 6,250/12,500	U: 6,250/10,416	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717	8717	8717/17434	8717/14184	8717
Rotational speed (RPM)	300	300	300	300/360	300
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	6	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	100/83.3	100
Data transfer rate (KBytes/sec)	31.25	31.25	31.25/62.5	31.25/62.5	31.25
SIZE (Inches: H x W x D)	.77 x 4.0 x 5.1	.77 x 4.0 x 5.1	.59 x 3.8 x 5.1	.59 x 3.8 x 5.1	.59 x 3.8 x 5.1
FIRST CUSTOMER SHIPMENT	2Q89	2Q89	2Q91	2Q91	2Q91
COMMENTS					

MANUFACTURER	CITIZEN	CITIZEN	COBRA	ELCOMATIC	ELCOMATIC
DRIVE	V1DE V2DE	IFDD-20	MM 500	ACP 500 ACP 550	ACP 700 ACP 750
DISK/TREND GROUP	15	16	13	13	13
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	8"	8"	8"
Recording medium	High Density Oxide Coated	Metal Powder	Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6/2.0	F: 20.6	U: .802/1.6	U: .401/.802	U: .8/1.6
Capacity per track (Bytes)	U: 6,250/12,500	F: 32,000	U: 10,416	U: 5,208/10,416	U: 5,208/10,416
Data surfaces per spindle	2	2	2	1	2
Tracks per surface	80/77/80	320	77	77	77
Track density (TPI)	135	542	48	48	48
Maximum linear density (BPI)	8717/17434	64500 BPI* 43000 FCI	3268/6536	3268/6536	3408/6816
Rotational speed (RPM)	300/360	600	360	360	360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Linear, Voice Coil	Lead Screw, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING: Track to track (msec)	3	3	6	3	3
Settling time (msec)	15	--	10	15	15
Head load time (msec)	Continuous Contact	Continuous Contact	30	35	35
Average rotational delay (msec)	100/83.3	50	83.3	83.3	83.3
Data transfer rate (KBytes/sec)	31.25	437.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	.59 x 3.8 x 5.1	1.0 x 4.0 x 6.2**	4.9 x 8.4 x 15.0	4.35 x 8.55 x 12.0	4.35 x 8.55 x 12.0
FIRST CUSTOMER SHIPMENT	2Q91	4Q91	1979	4Q81	4Q81
COMMENTS		*2,7 RLL Code 50 msec average head position. SCSI interface. Downward comp. with 1 & 2 MB (Read & Write) **Without SCSI interface board		ACP 500: AC ACP 550: DC	ACP 700: AC ACP 750: DC

MANUFACTURER	ELCOMATIC	ELEBRA INFORMATICA	ELEBRA INFORMATICA	ERGO	FLEXDISC
DRIVE	ACP 1500	9410-B	9410-D	MD-21 MD-22	FF650
DISK/TREND GROUP	13	14	14	15	14
MARKET	OEM	OEM	OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	8"	5.25"	5.25"	3.5"	5.25"
Recording medium	Oxide Coated	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.6/3.2	U: .5	U: 1.6	U: 1.0/2.0	U: .250/.5
Capacity per track (Bytes)	U: 10,416	U: 6,250	U: 10,416	U: 6,250/12,500	U: 3,125/6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	154	40	80	80	40
Track density (TPI)	96	48	96	135	48
Maximum linear density (BPI)	3408/6816	5877	14528	8717/17434	2938/5876
Rotational speed (RPM)	360	300	300/360	300	300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Lead Screw, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	1.5	6	3	3	6
Settling time (msec)	32	15	15	15	15
Head load time(msec)	35	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	83.3	100	83.3	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25	62.5	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	4.35 x 8.55 x 12.0	1.67 x 5.88 x 8.0	1.67 x 5.88 x 8.0	1.0 x 4.0 x 5.9	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	1983	2Q85	1Q86	1Q90	1986
COMMENTS				MD-22 is tested to tighter specifications	

MANUFACTURER	FLEXDISC	HITACHI	HITACHI	HITACHI	HO SHIN
DRIVE	FF950	FDD 412 FDD 413B	FDD 441	FDD 541	HS-550
DISK/TREND GROUP	14	13	16	16	14
MARKET	OEM	Captive, OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	8"	8"	5.25"	5.25"
Recording medium	High Density Oxide Coated	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .8/1.6	U: .8/1.6	U: 9.6	U: 6.5	U: .250
Capacity per track (Bytes)	U: 5,208/10,416	U: 5,208/10,416	U: 31,250	U: 31,250	U: 6,250
Data surfaces per spindle	2	2	2	2	1
Tracks per surface	77	77	154	104	40
Track density (TPI)	96	48	96	125	48
Maximum linear density (BPI)	4823/9646	3408/6816	20560*	29560	5536
Rotational speed (RPM)	360	360	360	720	300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	3	3	2	2	6
Settling time (msec)	15	35	15	37	15
Head load time(msec)	Continuous Contact	50	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	83.3	83.3	83.3	41.7	100
Data transfer rate (KBytes/sec)	62.5/125	31.25/62.5	187.5	375	31.25
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	2.24 x 8.54 x 13.0	2.24 x 8.54 x 12.9	1.625 x 5.75 x 8.6	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	1990	2/82	2/84	1Q85	12/87
COMMENTS			*2,7 RLL Code		For use with Apple II

MANUFACTURER	HO SHIN	HO SHIN	HO SHIN	INSITE PERIPHERALS	IOMEGA
DRIVE	HS-551	HS-552	HS-553	I325VM	B120/B220 Bernoulli Box II
DISK/TREND GROUP	14	14	14	16	16
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	3.5"	5.25"
Recording medium	Oxide Coated	Oxide Coated	High Density Oxide Coated	Barium Ferrite	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .5	U: 1.0	U: 1.6	F: 21	F: 21.4
Capacity per track (Bytes)	U: 6,250	U: 6,250	U: 10,416	F: 13,824	F: 16,128
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	40	80	77	753	677
Track density (TPI)	48	96	96	1245	570
Maximum linear density (BPI)	5876	5922	9646	23980 BPI* 17985 FCI	23511 BPI* 17633 FCI
Rotational speed (RPM)	300	300	360	720	1845.7
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Crs:Step. Motor Fine:Voice Coil	Linear, Voice Coil
POSITIONING:Track to track(msec)	6	3	3	1	6.2 (including settling)
Settling time (msec)	15	15	15	15	--
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	41.6	16.25
Data transfer rate (KBytes/sec)	31.25	31.25	31.25	200	666
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.0 x 4.0 x 5.9	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	3/88	3Q88	3Q88	4/91	9/87
COMMENTS	For use with IBM PC XT	For use with IBM PC XT	For use with IBM PC AT	*1,7 RLL Code 80 msec average position. time Optical servo track system. SCSI interface Downward comp. with 1 & 2 MB (Read & Write)	*1,8 RLL Code 40 msec average positioning time

MANUFACTURER	IOMEGA	IOMEGA	IOMEGA	ITAUTEC	ITAUTEC
DRIVE	B144/B244 Bernoulli Box II/44	Bernoulli 90	Beta-20	ADF48	ADF96
DISK/TREND GROUP	16	16	16	14	14
MARKET	PCM	OEM, PCM	OEM	Captive	Captive
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	5.25"	5.25"
Recording medium	Barium Ferrite	Metal Powder	High Density Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 44.5	F: 90	F: 21.4	U: .5	U: 1.6
Capacity per track (Bytes)	F: 20,480	F:	F: 16,128	U: 6,250	U: 10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	1088	1516	677	40	80
Track density (TPI)	1095	1605	570	48	96
Maximum linear density (BPI)	28541 BPI* 21405 FCI	37961 BPI* 28470 FCI	23511 BPI* 17633 FCI	5876	9646
Rotational speed (RPM)	2027	2368	1845.7	300	360
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
POSITIONING:Track to track(msec)	3.7		6.2 (including settling)	6	3
Settling time (msec)	--	--	--	15	18
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	14.8	12.7	16.25	80	83
Data transfer rate (KBytes/sec)	692.5	1173.7	666	31.25	62.5
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.67 x 5.87 x 8.19	1.67 x 5.87 x 8.19
FIRST CUSTOMER SHIPMENT	2/89	7/91	3Q86	1/86	1/87
COMMENTS	*1,8 RLL Code 32 msec average positioning time	*1,7 RLL Code 27 msec average positioning time	*1,8 RLL Code 38 msec average positioning time SCSI interface		

MANUFACTURER	MANTEC TECHNOLOGY	MANTEC TECHNOLOGY	MANTEC TECHNOLOGY	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	MTL-FD102E/C	MTL-FD128	MTL-FD228	JA-751	JU-455 JA-551*
DISK/TREND GROUP	14	14	14	13	14
MARKET	PCM	PCM	PCM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	8"	5.25"
Recording medium	Oxide Coated	Oxide Coated	High Density Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .125/.250	U: .5	U: 1.6	U: .8/1.6	U: .5
Capacity per track (Bytes)	U: 3,125/6,250	U: 6,250	U: 10,416	U: 5,208/10,416	U: 6,250
Data surfaces per spindle	1	2	2	2	2
Tracks per surface	40	40	77	77	40
Track density (TPI)	48	48	96	48	48
Maximum linear density (BPI)	2768/5536	5876	9646	3408/6816	5876
Rotational speed (RPM)	300	300	360	360	300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	4
Settling time (msec)	16	16	16	25	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	50	Continuous Contact
Average rotational delay (msec)	100	100	83.3	83.3	100
Data transfer rate (KBytes/sec)	15.63/31.25	31.25	31.25	31.25/62.5	31.25
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	2.2 x 8.6 x 12.1	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	1987	1987	6/88	1987	1982
COMMENTS	For use with Apple IIC and Apple IIE			Sold only in Japan	*Sold only in Japan

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	JU-475 JU-595*	JU-236A	JU-237A	JU-239A	JU-253
DISK/TREND GROUP	14	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .5/1.0 or U: .8/1.6	U: 1.0/1.6/2.0	U: 1.0/2.0	U: 1.0/2.0/4.0	U: 1.0
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/12,500 25,000	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	77/80	80	80	80	80
Track density (TPI)	96	135	135	135	135
Maximum linear density (BPI)	5922/9646	8717/14184/ 17434	8717/17434	8717/34868	8717
Rotational speed (RPM)	300/360	300/360	300	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100/83.3	100/83.3	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5/125	31.25
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	.67 x 4.0 x 5.2	.67 x 4.0 x 5.2	.67 x 4.0 x 5.2	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	1983	3Q91	3Q90	1Q91	1987
COMMENTS	*Sold only in Japan	Direct drive motor 96 mm width available	Direct drive motor 96 mm width available	Direct drive motor 96 mm width available	

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	JU-253A	JU-255	JU-255A	JU-257	JU-257A
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/2.0
Capacity per track (Bytes)	U: 6,250	U: 6,250/10,416	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80/77	80/77	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717	8717/14184	8717/14184	8717/17434	8717/17434
Rotational speed (RPM)	300	300/360	300/360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	6	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100/83.3	100/83.3	100	100
Data transfer rate (KBytes/sec)	31.25	31.25/37.5/62.5	31.25/37.5/62.5	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	1986	1987	1987	1987	1987
COMMENTS	Sold only in Japan	Sold only in Japan	Sold only in Japan	Sold only in Japan	5V (single)

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS
DRIVE	JU-259A	JU-2521	EME-156	EME-232	EME-213 EME-214
DISK/TREND GROUP	15	16	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3"	3"	3.5"
Recording medium	Barium Ferrite	Metal Powder	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0/4.0	U: 1.0/2.0/28 F: 21.4	U: .250	U: 1.0	U: 1.0
Capacity per track (Bytes)	U: 6,250/12,500 25,000	*	U: 6,250	U: 6,250	U: 6,250
Data surfaces per spindle	2	2	1	2	2
Tracks per surface	80	80/325	40	80	80
Track density (TPI)	135	135/542	100	200	135
Maximum linear density (BPI)	8717/34868	52620 BPI 35080 FCI	8946	9891	8717
Rotational speed (RPM)	300	600	300	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Linear, Voice Coil	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	10	12	12	3/6
Settling time (msec)	15	--	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	50	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5/125	1500 (SCSI)	31.25	31.25	31.25
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.5 x 3.5 x 5.9	1.5 x 3.5 x 5.9	1.0 x 4.0 x 5.75
FIRST CUSTOMER SHIPMENT	4Q90	4Q92	1987	1987	1989
COMMENTS	SCSI interface option	50 msec. average positioning time *Varies by zone Downward comp. with 1,2 & 4 MB (Read & Write)	Replaces EME-155	Replaces EME-231	

MANUFACTURER	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MILTOPE
DRIVE	EME-262	EME-263	EME-264	EME-273	DD 400
DISK/TREND GROUP	15	15	15	15	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	8"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.6	U: 2.0	U: 1.0	U: 1.0/2.0	U: .401/.802
Capacity per track (Bytes)	U: 10,416	U: 12,500	U: 6,250	U: 6,250	U: 5,208/10,416
Data surfaces per spindle	2	2	2	2	1
Tracks per surface	80	80	80	80	77
Track density (TPI)	135	135	135	135	48
Maximum linear density (BPI)	14528	17434	8717	8717/17434	3268/6536
Rotational speed (RPM)	300	300	300	300	360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	6
Settling time (msec)	15	15	15	15	10
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	16
Average rotational delay (msec)	100	100	100	100	83.3
Data transfer rate (KBytes/sec)	31.25	62.5	31.25	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	.67 x 3.8 x 5.3	.67 x 3.8 x 5.3	.67 x 3.8 x 5.3	.59 x 3.8 x 5.1	5.44 x 8.44 x 18.0
FIRST CUSTOMER SHIPMENT	1989	1989	1989	4/91	1977
COMMENTS					Sold as militarized subsystem

MANUFACTURER	MILTOPE	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	DD 450	MF 501C	MF 504C	MF 504S	MF 353C
DISK/TREND GROUP	13	14	14	14	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	8"	5.25"	5.25"	5.25"	3.5"
Recording medium	Oxide Coated	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .8/1.6	U: .5	U: 1.0/1.6	U: 1.0/1.6	U: 1.0
Capacity per track (Bytes)	U: 5,208/10,416	U: 6,250	U: 6,250/10,416	U: 6,250/10,416	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	77	40	80/77	80/77	80
Track density (TPI)	48	48	96	96	135
Maximum linear density (BPI)	3408/6816	5877	5922/9870	5922/9870	8717
Rotational speed (RPM)	360	300	300/360	300/360	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Spindle Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	5	6	3	3	3
Settling time (msec)	10	15	15	15	15
Head load time(msec)	16	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	83.3	100	100/83.3	100/83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25	31.25/62.5	31.25/62.5	31.25
SIZE (Inches: H x W x D)	5.44 x 8.44 x 18.0	1.625 x 5.75 x 7.7	1.625 x 5.75 x 7.7	1.12 x 5.75 x 7.5	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	1980	2Q88	2Q88	3Q89	2Q87
COMMENTS	Sold as militarized subsystem				

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MF 354C	MF 355C	MF 355E	MF 355S	MF 356C
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/1.6/2.0	U: 1.0/1.6/2.0	U: 1.0/2.0/4.0
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/25,000
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184	8717/17434	8717/17434	8717/17434	8717/34868
Rotational speed (RPM)	300/360	300	300/360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100/83.3	100	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5/125
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	.58 x 3.8 x 5.0	.67 x 4.0 x 5.1	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	2Q87	2Q87	2Q91	4Q90	2Q91
COMMENTS					

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
DRIVE	MF 356E	D 503V	D 509V	D 509V2	D 352C
DISK/TREND GROUP	15	14	14	14	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	5.25"	5.25"	5.25"	3.5"
Recording medium	Barium Ferrite	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0/4.0	U: .500	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/2.0/4.0
Capacity per track (Bytes)	U: 6,250/25,000	U: 6,250	U: 6,250/10,416	U: 6,250/10,416	U: 6,250/25,000
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	40	80	80	80
Track density (TPI)	135	48	96	96	135
Maximum linear density (BPI)	8717/34868	5876	5922/9646	5922/9646	8717/34768
Rotational speed (RPM)	300	300	360	360	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	6	3/5	3/5	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	83.3	83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5/125	31.25	37.5/62.5	37.5/62.5	31.25/62.5/125
SIZE (Inches: H x W x D)	.58 x 4.0 x 5.9	1.625 x 5.75 x 7.4	1.625 x 5.75 x 7.4	1.625 x 5.75 x 7.4	.67 x 4.0 x 6.1
FIRST CUSTOMER SHIPMENT	1992	3/85	1987	4Q88	1Q92
COMMENTS					

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
DRIVE	D 352T2	D 357B	D 357C	D 357P2 D 357T2 D 357T3	D 358T3
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	Barium Ferrite	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0/4.0	U: 1.0	U: 1.0	U: 1.0	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250/25,000	U: 6,250	U: 6,250	U: 6,250	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/34768	8717	8717	8717	8718/14184
Rotational speed (RPM)	300	300	300	300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	6	6	3/6	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	100	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5/125	31.25	31.25	31.25/62.5	31.25
SIZE (Inches: H x W x D)	1.0 x 4.0 x 6.1	1.0 x 4.0 x 6.1	.67 x 4.0 x 6.1	1.0 x 4.0 x 6.1	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	2Q90	4/87	1Q90	4Q88	3Q91
COMMENTS				D 357P2 is in 5.25" form factor	

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MULTIDIGIT
DRIVE	D 359C	D 359F	D 359P2 D 359T2 D 359T3	D 281 D 284 D 286	DF0511
DISK/TREND GROUP	15	15	15		14
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	72 mm	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0	U: 1.0/1.6/2.0	U: 1.0/2.0	U: .064	U: .5
Capacity per track (Bytes)	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/12,500	U: 64,000	U: 6,250
Data surfaces per spindle	2	2	2	1	2
Tracks per surface	80	80	80	1	40
Track density (TPI)	135	135	135	59	48
Maximum linear density (BPI)	8717/17434	8717/17434	8717/17434	4410	5877
Rotational speed (RPM)	300	300	300	423	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	N/A	Band, Stepping Motor
POSITIONING:Track to track(msec)	6	3	3/6	N/A	6
Settling time (msec)	15	15	15	N/A	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	N/A	Continuous Contact
Average rotational delay (msec)	100	100	100	N/A	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	12.63	31.25
SIZE (Inches: H x W x D)	.67 x 4.0 x 6.1	.5 x 3.7 x 5.1	1.0 x 4.0 x 6.1	1.73 x 4.6 x 4.1	1.625 x 5.75 x 8.06
FIRST CUSTOMER SHIPMENT	1Q90	1Q92	4Q88	2/86	1985
COMMENTS				64,000 bytes in single spiral track Front loading QDM-02 is MSX subsystem	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	FD 1158C	FD 1158D	FD 1037A	FD 1038A	FD 1039A
DISK/TREND GROUP	14	14	15	15	15
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/1.6	U: .5/1.0	U: 1.0	U: 1.0
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/10,416	U: 3,125/6,250	U: 6,250	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	96	96	135	135	135
Maximum linear density (BPI)	5922/9870	5922/9870	4359/8717	8717	8717
Rotational speed (RPM)	360	360	300	300	300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Linear, Stepping Motor	Linear, Pulse Motor	Linear, Pulse Motor
POSITIONING:Track to track(msec)	3	3	3	2	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	83.3	83.3	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	15.63/31.25	31.25	31.25
SIZE (Inches: H x W x D)	1.0 x 5.75 x 7.5	1.0 x 5.75 x 7.5	1.0 x 4.0 x 5.1	.75 x 4.0 x 5.12	.59 x 4.0 x 4.0
FIRST CUSTOMER SHIPMENT	2Q90	3Q90	1987	1Q90	2/91
COMMENTS		With VFO			

MANUFACTURER	MULTIDIGIT	MULTIDIGIT	NEC	NEC	NEC
DRIVE	DF1011	DF1622	FD 1165	FD 1157C	FD 1157D
DISK/TREND GROUP	14	14	13	14	14
MARKET	OEM, PCM	OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	8"	5.25"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0	U: 1.6	U: .8/1.6	U: 1.0/1.6	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250	U: 10,416	U: 5,208/10,416	U: 6,250/10,416	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	77	80	80
Track density (TPI)	96	96	48	96	96
Maximum linear density (BPI)	5922	9646	3408/6816	5922/9870	5922/9870
Rotational speed (RPM)	300	360	360	360	360
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	50	35	35
Average rotational delay (msec)	100	83.3	83.3	83.3	83.3
Data transfer rate (KBytes/sec)	31.25	62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.06	1.625 x 5.75 x 8.06	2.28 x 8.54 x 12.7	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	1986	1986	4Q81	1987	1987
COMMENTS					With VFO

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	FD 1137C	FD 1137D	FD 1137H	FD 1138C	FD 1138D
DISK/TREND GROUP	15	15	15	15	15
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/1.6	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/10,416	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14528	8717/14528	8717/17434	8717/14528	8717/14528
Rotational speed (RPM)	300/360	300/360	300	300/360	300/360
PERFORMANCE					
Actuator type	Linear, Stepping Motor	Linear, Stepping Motor	Linear, Stepping Motor	Linear, Pulse Motor	Linear, Pulse Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100/83.3	100/83.3	100	100/83.3	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.1	1.0 x 4.0 x 5.1	1.0 x 4.0 x 5.1	.75 x 4.0 x 5.0	.75 x 4.0 x 5.0
FIRST CUSTOMER SHIPMENT	1987	1987	1987	1Q90	2Q90
COMMENTS		With VFO			With VFO

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	FD 1138H	FD 1139C	FD 1139D	FD 1139H	FD 1335C
DISK/TREND GROUP	15	15	15	15	16
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Metal Powder
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/2.0	F: .7/1.2/10.18
Capacity per track (Bytes)	U: 6,250/12,500	U: 6,250/10,416	U: 6,250/10,416	U: 6,250/12,500	F: 19,968
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	255
Track density (TPI)	135	135	135	135	431
Maximum linear density (BPI)	8717/17434	8717/14528	8717/14528	8717/17434	8717/36595
Rotational speed (RPM)	300	300/360	300/360	300	360
PERFORMANCE					
Actuator type	Linear, Pulse Motor	Linear, Pulse Motor	Linear, Pulse Motor	Linear, Pulse Motor	Linear, Pulse Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100/83.3	100/83.3	100	83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/1250
SIZE (Inches: H x W x D)	.75 x 4.0 x 5.0	.59 x 4.0 x 4.0	.59 x 4.0 x 4.0	.59 x 4.0 x 4.0	1.0 x 4.0 x 5.12
FIRST CUSTOMER SHIPMENT	1Q90	2/91	7/91	2/91	1/90
COMMENTS			With VFO		Downward comp. with 1 & 1.6 MB (Read & Write)

MANUFACTURER	NEC	ORIENTAL PRECISION	ORIENTAL PRECISION	ORIENTAL PRECISION	ORIENTAL PRECISION
DRIVE	FD 1335H	OFD-506R	OFD-516R	OFD-546R	OFD-596R
DISK/TREND GROUP	16	14	14	14	14
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	5.25"	5.25"	5.25"	5.25"
Recording medium	Metal Powder	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F:.7/1.47/10.18	U: 1.0/1.6	U: 1.6	U: .250/.5	U: .5/1.0
Capacity per track (Bytes)	F: 19,968	U: 6,250/10,416	U: 10,416	U: 3,125/6,250	U: 3,125/6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	255	77/80	77	40	80
Track density (TPI)	431	96	96	48	96
Maximum linear density (BPI)	8717/36595	5922/9870	9646	2938/5876	2961/5922
Rotational speed (RPM)	360	300/360	360	300	300
PERFORMANCE					
Actuator type	Linear, Pulse Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	83.3	100/83.3	83.3	100	100
Data transfer rate (KBytes/sec)	31.25/1250	62.5/37.5	62.5	15.63/31.25	15.63/31.25
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.12	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	1/90	6/89	6/89	1983	1983
COMMENTS	Downward comp. with 1 & 2 MB (Read & Write)			Licensed by TEAC	Licensed by TEAC

MANUFACTURER	PROLOGICA (MICRO-PERIFERICOS)	ROCTEC	ROCTEC	SAFRONIC	SAFRONIC
DRIVE	D 500SL	RF501A	RF501R	DS-51A	DS-53A
DISK/TREND GROUP	14	14	14	14	14
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	5.25"	5.25"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .250/.5	U: .250	U: .250	U: .5	U: .5/1.6
Capacity per track (Bytes)	U: 3,125/6,250	U: 6,250	U: 6,250	U: 6,250	U: 6,250/10,416
Data surfaces per spindle	2	1	1	2	2
Tracks per surface	40	40	40	40	80
Track density (TPI)	48	48	48	48	96
Maximum linear density (BPI)	2936/5876	5576	5576	5876	5876/9870
Rotational speed (RPM)	300	300	300	300	300
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING: Track to track (msec)	6	6	6	4	3
Settling time (msec)	20	20	20	15	15
Head load time (msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	100	100
Data transfer rate (KBytes/sec)	15.63/31.25	31.25	31.25	31.25	31.25/62.5
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.5	2.67 x 5.8 x 10.0	1.625 x 5.75 x 7.6	1.625 x 5.75 x 7.6
FIRST CUSTOMER SHIPMENT	9/85	4Q87	3Q87	1989	1989
COMMENTS		For Apple II	External drive for Atari systems		

MANUFACTURER	SAFRONIC	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	DS-34A	SFD-500P	SFD-560D	SFD-321D	SFD-342K
DISK/TREND GROUP	15	14	14	15	15
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	5.25"	5.25"	3.5"	3.5"
Recording medium	High Density Oxide Coated	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .1.0/2.0	U: .5	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/2.0/4.0
Capacity per track (Bytes)	U: 6,250/12,500	U: 6,250	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/25,000
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	40	80/77	80	80
Track density (TPI)	135	48	96	135	135
Maximum linear density (BPI)	8717/17434	5876	5922/9646	8717/17434	8717/34868
Rotational speed (RPM)	300	300	300/360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	6	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	83.3	100	83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25	31.25/62.5	31.25/62.5	31.25/62.5/125
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	1989	3Q88	4Q87	2Q89	1Q92
COMMENTS					

MANUFACTURER	SANKYO SEIKI	SANKYO SEIKI	SANKYO SEIKI	SEIKO EPSON	SEIKO EPSON
DRIVE	FDU-480	FDU-580	FDU-583	SD-621L	SD-680L
DISK/TREND GROUP	15	15	15	14	14
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	5.25"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/2.0	U: 2.0	U: .5	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/12,500	U: 12,500	U: 6,250	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80	80	40	80
Track density (TPI)	135	135	135	48	96
Maximum linear density (BPI)	8717/14184	8717/17434	17434	5876	5922/9870
Rotational speed (RPM)	300/360	300	300	300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	4	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	35
Average rotational delay (msec)	100/83.3	100	100	100	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	62.5	31.25	37.5/62.5
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.1	1.0 x 4.0 x 5.1	1.0 x 4.0 x 5.1	1.625 x 5.75 x 7.7	1.625 x 5.75 x 7.7
FIRST CUSTOMER SHIPMENT	2Q87	2Q87	3Q87	2Q86	3Q86
COMMENTS					

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON
DRIVE	SMD-1020	SMD-1040	SMD-1060	SMD-340	SMD-380
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/2.0/4.0	U: 1.0/2.0	U: 1.0
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/25,000	U: 6,250/12,500	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14528	1817/17434	8717/34868	8717/17434	8717
Rotational speed (RPM)	300/360	300	300	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	100	100
Data transfer rate (KBytes/sec)	37.5/62.5	31.25/62.5	31.25/62.5/125	31.25/62.5	31.25
SIZE (Inches: H x W x D)	.71 x 4.0 x 5.1	.71 x 4.0 x 5.1	.71 x 4.0 x 5.1	1.0 x 4.0 x 5.75	1.0 x 4.0 x 5.75
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	1Q91	1/89	1/89
COMMENTS	Direct drive motor	Direct drive motor	Direct drive motor		

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	MP-F11W	MP-F120	MP-F17W	MP-F40W	MP-F52W
DISK/TREND GROUP	15	15	15	15	15
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0	U: 1.0/2.0	U: 1.0/2.0	U: 1.0/2.0/4.0	U: .5/1.0
Capacity per track (Bytes)	U: 6,250	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/25,000	U: 3,125/6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717	8717/17434	8717/17434	8717/34868	4359/8717
Rotational speed (RPM)	300	300	300	300	600
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	6
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	100	50
Data transfer rate (KBytes/sec)	31.25	31.25/62.5	31.25/62.5	31.25/62.5/125	31.25/62.5
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	1.18 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	2Q87	4Q90	2Q87	1Q91	2Q85
COMMENTS					

MANUFACTURER	SONY	SONY	SONY	SONY	TEAC
DRIVE	MP-F53W MP-F53W-00D	MP-F63W-00D MP-F63W-01D	MP-F73W-00D MP-F73W-01D	PDD-110	FD-155GF
DISK/TREND GROUP	15	15	15	15	14
MARKET	Captive, OEM	OEM	OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	2.0"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Metal Powder	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .5/1.0	U: 1.0	U: 1.0/2.0	U: 1.0	U: 1.0/1.6
Capacity per track (Bytes)	U: 3,125/6,250	U: 6,250	U: 6,250/12,500	U: 20,000	U: 6,250/10,416
Data surfaces per spindle	2	2	2	1	2
Tracks per surface	80	80	80	50	80/77
Track density (TPI)	135	135	135	254	96
Maximum linear density (BPI)	4359/8717	8717	8717/17434	51200	5922/9646
Rotational speed (RPM)	300	300	300	3600	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	6	3	3	4	3
Settling time (msec)	15	15	15	--	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	8.3	83.3/100
Data transfer rate (KBytes/sec)	15.63/31.25	31.25	31.25/62.5	1787.5	31.25/62.5
SIZE (Inches: H x W x D)	1.18 x 4.0 x 5.9	1.18 x 4.0 x 5.9	1.18 x 4.0 x 5.9	.79 x 2.5 x 3.5	1.0 x 5.75 x 7.52
FIRST CUSTOMER SHIPMENT	3Q85	1Q86	1Q86	3Q88	8/91
COMMENTS				Data version of 2" still video disk	Dual speed

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	FD-55BR	FD-55FR	FD-55GFR	FD-55GR	FD-55GS
DISK/TREND GROUP	14	14	14	14	14
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	5.25"	5.25"
Recording medium	Oxide Coated	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .5	U: 1.0	U: 1.0/1.6	U: 1.6	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250	U: 6,250	U: 6,250/10,416	U: 10,416	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	40	80	80/77	77	80/77
Track density (TPI)	48	96	96	96	96
Maximum linear density (BPI)	5876	5922	5922/9646	9646	5922/9646
Rotational speed (RPM)	300	300	300/360	360	300/360
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	4/6	3	3	3	3
Settling time (msec)	10/15	15	15	15	15
Head load time(msec)	50	50	50	50	Continuous Contact
Average rotational delay (msec)	100	100	100/83.3	83.3	100/83.3
Data transfer rate (KBytes/sec)	31.25	31.25	31.25/62.5	62.5	31.25/62.5
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.7 x 5.7 x 8.0
FIRST CUSTOMER SHIPMENT	1987	1987	1987	1987	1990
COMMENTS			Dual speed		SCSI interface

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	FD-05GF	FD-05HF	FD-05HG	FD-235F	FD-235G
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/1.6/2.0	U: 1.0	U: 1.6
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250	U: 10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184	8717/17434	8717/17434	8717	14528
Rotational speed (RPM)	300/360	300	300/360	300	360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100/83.3	100	100/83.3	100	83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25	62.5
SIZE (Inches: H x W x D)	.5 x 4.0 x 5.1	.5 x 4.0 x 5.1	.5 x 4.0 x 5.1	1.0 x 4.0 x 5.71	1.0 x 4.0 x 5.71
FIRST CUSTOMER SHIPMENT	10/91	10/91	10/91	2Q88	2Q88
COMMENTS	Direct drive motor	Direct drive motor	Direct drive motor		

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	FD-235GF	FD-235HF	FD-235HS	FD-235J	FD-235JS
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite	Barium Ferrite
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/2.0	U: 1.0/2.0/4.0	U: 1.0/2.0/4.0
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/25,000	U: 6,250/25,000
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14528	8717/17434	8717/17434	8717/34868	8717/34868
Rotational speed (RPM)	300/360	300	300	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100/83.3	100	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5/125	31.25/62.5/125
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.71	1.0 x 4.0 x 5.71	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.71	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	1990	1Q89	1990
COMMENTS			SCSI interface		SCSI interface

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	FD-335F	FD-335GF	FD-335HF	FD-335HG	FD-335HS
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/1.6/2.0	U: 1.0/2.0
Capacity per track (Bytes)	U: 6,250	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500	U: 6,250/12,500
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717	8717/14528	8717/17434	8717/17434	8717/17434
Rotational speed (RPM)	300	300/360	300	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	100/83.3	100	100	100
Data transfer rate (KBytes/sec)	31.25	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (Inches: H x W x D)	.75 x 4.0 x 5.3	.75 x 4.0 x 5.3	.75 x 4.0 x 5.3	.75 x 4.0 x 5.3	.75 x 4.0 x 5.3
FIRST CUSTOMER SHIPMENT	9/90	9/90	9/90	9/90	--
COMMENTS	Direct drive motor	Direct drive motor	Direct drive motor	Direct drive motor	Direct drive motor SCSI interface

MANUFACTURER	TEAC	TEAC	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	FD-335J	FD-335JS	ND-0401 ND-04DT-A	ND-0801 ND-08DE-A	ND-3521 ND-352SH/TH-A
DISK/TREND GROUP	15	15	14	14	15
MARKET	OEM	OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	5.25"	5.25"	3.5"
Recording medium	Barium Ferrite	Barium Ferrite	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0/4.0	U: 1.0/2.0/4.0	U: .5	U: 1.0/1.6	U: .5/1.0
Capacity per track (Bytes)	U: 6,250/12,500 25,000	U: 6,250/12,500 25,000	U: 6,250	U: 6,250/10,416	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	40	80/77	80
Track density (TPI)	135	135	48	96	135
Maximum linear density (BPI)	8717/34868	8717/34868	5876	5922/9646	8717
Rotational speed (RPM)	300	300	300	360	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	6	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continous Contact	Continous Contact	Continuous Contact
Average rotational delay (msec)	100	100	100	100/83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5/125	31.25/62.5/125	31.25	31.25/62.5	31.25
SIZE (Inches: H x W x D)	.75 x 4.0 x 5.3	.75 x 4.0 x 5.3	1.6 x 5.7 x 8.2	1.6 x 5.7 x 8.2	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	9/90	--	1Q88	1Q88	1Q88
COMMENTS	Direct drive motor	Direct drive motor SCSI interface			

MANUFACTURER	TOSHIBA	TOSHIBA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	ND-3561 ND-356S/T-A	ND-3571	YD-180	YD-380B-1710B	YD-380B-1711B
DISK/TREND GROUP	15	15	13	14	14
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	8"	5.25"	5.25"
Recording medium	High Density Oxide Coated	Barium Ferrite	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/2.0	U: 1.0/2.0/4.0	U: .8/1.6	U: 1.6	U: 1.0/1.6
Capacity per track (Bytes)	U: 6,250/12,500	U: 6,250/25,000	U: 5,208/10,416	U: 10,416	U: 6,250/10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	77	77	80
Track density (TPI)	135	135	48	96	96
Maximum linear density (BPI)	8717/17434	8717/34768	3408/6816	9646	5922/9870
Rotational speed (RPM)	300	300	360	360	360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	50	50	50
Average rotational delay (msec)	100	100	83.3	83.3	83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5/125	31.25/62.5	62.5	37.5/62.5
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	1.0 x 4.0 x 5.9	2.25 x 8.55 x 12.6	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	1Q88	1/92	9/81	4/86	4/86
COMMENTS					

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	YD-380B-1714B	YD-380B-1734H	YD-380B-1734S	YD-380B-1736B	YD-580B-1354B YD-580B-1355B
DISK/TREND GROUP	14	14	14	14	14
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	5.25"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/1.6	U: .5
Capacity per track (Bytes)	U: 6,250/10,416	U: 6,250/10,416	U: 6,250/10,416	U: 6,250/10,416	U: 6,250
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80	80/77	80	40
Track density (TPI)	96	96	96	96	48
Maximum linear density (BPI)	5922/9646	5922/9870	5922/9870	5922/9870	5876
Rotational speed (RPM)	300/360	600/720	600/720	360	300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	5
Settling time (msec)	15	15	15	15	15
Head load time(msec)	50	Continuous Contact	Continuous Contact	Continuous Contact	50
Average rotational delay (msec)	100/83.3	50/41.6	50/41.6	83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5	75/125	75/125	37.5/62.5	31.25
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0
FIRST CUSTOMER SHIPMENT	4/86	6/90	6/91	2Q87	4/86
COMMENTS		Double speed drive sold for duplicator	Double speed, simultaneous R/W drive sold for duplicator	Also sold as YD-380B-PC	

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	YD-580B-1376B	YD-801 YD-802	YD-645C YD-646C	YD-646F	YD-665C
DISK/TREND GROUP	14	14	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	3.5"	3.5"	3.5"
Recording medium	Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: .5	U: 3.333	U: 1.0	U: 1.0	U: 1.6
Capacity per track (Bytes)	U: 6,250	U: 20,832	U: 6,250	U: 6,250	U: 10,416
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	40	80	80	80	77
Track density (TPI)	48	96	135	135	135
Maximum linear density (BPI)	5876	19740	8717	4358/8717	14184
Rotational speed (RPM)	300	180	300	300	360
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	5	3	6	6	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	50	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	100	166.7	100	100	83.3
Data transfer rate (KBytes/sec)	31.25	62.5	31.25	15.63/31.25	62.5
SIZE (Inches: H x W x D)	1.625 x 5.75 x 8.0	1.625 x 5.75 x 8.0	1.0 x 4.0 x 5.9	.68 x 3.78 x 5.9	1.0 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	2Q87	1Q87	1986	12/89	1986
COMMENTS	Also sold as YD-580B-PC	Compatible with 1.0 and 1.6 MB formats			

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	YD-685C-1505H	YD-686C	YD-686F	YD-701B YD-702B	YD-701B-6031H
DISK/TREND GROUP	15	15	15	15	15
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/1.6	U: 1.0/2.0	U: 1.0/2.0
Capacity per track (Bytes)	U: 6,250/10,390	U: 6,250/10,416	U: 6,250/10,416	U: 6,250/12,500	U: 6,250/12,500
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80/77	80/77	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184	8717/14184	8717/14184	8717/17434	8717/17434
Rotational speed (RPM)	600/720	300/360	300/360	300	600
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	50/41.6	100/83.3	100/83.3	100	50
Data transfer rate (KBytes/sec)	62.5/125	31.25/62.5	31.25/62.5	31.25/62.5	62.5/125
SIZE (Inches: H x W x D)	.68 x 4.0 x 5.9	1.0 x 4.0 x 5.9	.68 x 3.78 x 5.9	1.0 x 4.0 x 5.9	.68 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	6/90	1Q87	1/90	1Q87	6/90
COMMENTS	Double speed drive sold for duplicator				Double speed drive sold for duplicator

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	YD-701B-6030S	YD-702F	YD-702G	YD-742	YD-750
DISK/TREND GROUP	15	15	15	15	16
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Barium Ferrite	Metal Powder
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	U: 1.0/1.6/2.0	U: 1.0/2.0	U: 1.0/1.6/2.0	U: 1.0/2.0/4.0	U: 26.4 F: 20.8
Capacity per track (Bytes)	U:6,250/10,390/12,500	U: 6,250/12,500	U:6,250/10,390/12,500	U: 6,250/25,000	U:
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77/80	80	80/77/80	80	380
Track density (TPI)	135	135	135	135	677
Maximum linear density (BPI)	8717/14184/17434	8717/17434	8717/14184/17434	8717/34868	45800
Rotational speed (RPM)	600/720/600	300	300/360/300	300	1080
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING:Track to track(msec)	3	3	3	3	20
Settling time (msec)	15	15	15	15	--
Head load time(msec)	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact	Continuous Contact
Average rotational delay (msec)	50/41.6/50	100	100/83/100	100	27.8
Data transfer rate (KBytes/sec)	62.5/125/125	31.25/62.5	31.25/62.5/62.5	31.25/62.5/125	625
SIZE (Inches: H x W x D)	1.0 x 4.0 x 5.9	.68 x 3.78 x 5.9	.59 x 3.78 x 5.1	1.0 x 4.0 x 5.9	1.625 x 4.0 x 5.9
FIRST CUSTOMER SHIPMENT	6/91	1/90	7/91	1990	4/92
COMMENTS	Double speed, simultaneous R/W drive sold for duplicator		Direct drive motor		50 msec average positioning time Read compatible with 1.0 and 2.0 MB

MANUFACTURER PROFILES

1991 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing flexible magnetic disk drives, or which have indicated specific plans to enter the market, are listed in this section. The heading "1990 FDD sales" refers to the DISK/TREND estimate of flexible 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. "1990 total net sales" covers the fiscal year ending in 1990 for each firm unless noted otherwise, or for the parent company if the disk drive manufacturer is a subsidiary. The fiscal years of listed firms end on December 31, 1990, unless otherwise noted.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars is given below. The average exchange rate for 1990 is used, as reported by the U.S. Federal Reserve Bulletin and rounded to three significant figures, except that the exchange rate for the Brazilian Cruzeiro, which fluctuates widely, has been averaged from several sources.

Country	Currency	Currency units per U.S. dollar
Brazil	Cruzeiro	90.0
Hong Kong	Dollar	7.79
Japan	Yen	145
South Korea	Won	710
Taiwan	Dollar	26.9

U.S Manufacturers

BRIER TECHNOLOGY, INC.
25 Meca Drive
Norcross, GA 30093

Incorporated in April, 1986, Brier was founded by managers from Data Technology and other data storage firms to develop high capacity 3.5 inch floppy disk drives. The initial product was a 21.4 megabyte drive originally scheduled for 1989 shipment. The drive has a "buried" embedded servo, using preformatted diskettes with barium ferrite media. In the Spring of 1988, an interest in Brier was purchased by Intelligent Systems, which also owns Peachtree Software, Princeton Graphics Systems, Quadram, and other PC oriented peripherals companies. Limited shipments of the 21.4 megabyte drive began in late 1989, later replaced by a 1 inch high version of the drive with full read/write downward compatibility with 1 and 2 megabyte drives. Brier licensed Irwin Magnetics, since purchased by Cipher, as a second manufacturing source, but this arrangement has not produced results. Brier has pursued primarily the aftermarket, with most of the drives distributed through Quadram subsystem sales. In late 1989, Brier announced a manufacturing and investment agreement with National Computer Ltd. of Japan, whereby NCL would manufacture Brier products under license and act as Brier's exclusive distributor in Asia. In return, Brier received an equity investment from NCL.

DATA TECHNOLOGY CORPORATION (See Qume Corporation)

EASTMAN KODAK COMPANY
343 State Street
Rochester, NY 14650

1990 total net sales: $18,908,000,000 Net income: $703,000,000

Although the Spin Physics operation of Eastman Kodak had previously introduced flexible disk media using isotropic particulate coatings, Kodak's action in licensing the Drivetec embedded servo 5.25 inch drive was the firm's first step into flexible disk drive hardware. Production started in 1984 at Rochester, New York. Later models with capacities up to 24 megabytes were manufactured by Data Technology Corporation (now Qume), a Santa Clara controller manufacturer in which Kodak had an investment, with marketing responsibility turned over to Kodak's Verbatim subsidiary, which distributed the Eastman Kodak high capacity drives under its own brand name. The program has been phased out as shipments declined during the last few years.

GENISCO TECHNOLOGY CORPORATION
14930 Alondra Boulevard
La Mirada, CA 90638

Genisco produces ruggedized and militarized peripherals. The firm purchased rights to the Shugart Associates 3.5 inch microfloppy program, which was aborted when Xerox lost interest in the disk drive business. Limited quantities of a 1 megabyte microfloppy were used in a militarized subsystem starting in 1987, since replaced with commercially available drives, modified as necessary.

INSITE PERIPHERALS, INC.
4433 Fortran Drive
San Jose, CA 95134-2302

Insite's announcement of a 20 megabyte 3.5 inch microfloppy, combining an optical head positioning scheme with magnetic recording, has aroused widespread interest in the industry. Trademarked as the "floptical", the drive uses an LED on the head assembly to follow optically reflective servo tracks on the surface of 3.5 inch barium ferrite media. A 1 inch high version that is downward compatible with standard 3.5 inch 1 and 2 megabyte drives in both read and write modes became available in late 1991, the result of Insite's contract manufacturing arrangement with Matsushita Kotobuki Electronics. Insite is attempting to achieve mainstream status for the "floptical" through licensing of established drive and media manufacturers, with Iomega as the first announced licensee, and is aggressively seeking additional strategic relationships. 3M and Hitachi Maxell have been granted licenses as media producers and have made equity investments in Insite.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1990 total net sales: $69,018,000,000 Net income: $6,020,000,000

IBM introduced the original one and two sided 8 inch flexible disk drives, and has used them on a wide variety of business systems, word processing systems, terminals and specialized equipment. After years of neglecting the minifloppy product area, IBM emerged as the world's largest buyer of OEM floppy drives, when it used two sided 48 TPI 5.25 inch drives for the successful PC program. This choice established the two sided 48 TPI format as a mainstream minifloppy configuration. Later, the IBM blessing was given to 1.6 megabyte 5.25 inch drives and to 3.5 inch microfloppies, and these configurations are now industry standards. The 1987 introduction of the PS/2 series of personal computers using both 1 and 2 megabyte microfloppies reinforced the 3.5 inch trend and gave the 2 megabyte format a major boost. In 1991, IBM finally announced 4 megabyte barium ferrite 3.5 inch drives on one PS/2 system model. IBM's preparations for this move

were widely followed and prompted many Japanese floppy drive manufacturers to prepare for production of 4 megabyte barium ferrite drives, but IBM's limited endorsement has prompted most other system OEMs to be cautious in making commitments to use 4 megabyte drives until IBM's intentions become clearer.

IBM made extensive preparations to design and manufacture its own 5.25 inch and microfloppy drives, but abruptly cancelled the program in mid-1985 -- choosing to rely on the low cost floppy drives available from numerous suitable vendors. Internal production of 8 inch floppy drives continued until recently to support older system families.

IOMEGA CORPORATION
1821 West 4000 South
Roy, UT 84067

1990 FDD sales: $69,200,000
1990 total net sales: $120,442,000 Net income: $13,958,000

Iomega, founded in 1980 by former IBM managers, was successful in establishing production capability for its unique 8 inch drive, which maintained control of head/disk contact with the Bernoulli effect, and a 5.25 inch version was added in mid-1983. The products were originally intended as OEM drives, but Iomega had much better luck with subsystems sold in the personal computer add-on market. The original 8 inch subsystem for the IBM PC market provided most of the company's early revenue growth until surpassed by the 20 megabyte half high 8 inch drives introduced in 1985. However, half high 5.25 inch models in production since 1987 have largely displaced 8 inch drives, and Iomega announced that it would discontinue new production of 8 inch drives in December, 1991. The 5.25 inch product line includes drives offering 21.4 megabytes capacity, a 44.5 megabyte model, and a 90 megabyte model added in 1991. These are also marketed in subsystems. Iomega has licensed the Insite Peripherals 'Floptical' drive, and has selected Chinon as a manufacturing partner for the drive. An mid-1992 production startup is expected.

MILTOPE CORPORATION
1770 Walt Whitman Road
Melville, NY 11747

1990 total net sales: $110,773,000 Net income: $2,644,000

8 inch flexible disk drives are manufactured internally by Miltope for use in its line of militarized peripherals, which include disk, tape and bubble memory subsystems. Both one and two sided 8 inch drives are produced. Miltope also produces small quantities of militarized rigid disk drives.

QUME CORPORATION
500 Yosemite Drive
Milpitas, CA 95035

1990 total net sales: $217,520,000 (FY ending 2/28/91) Net income: ($19,617,000)

Qume is a manufacturer of storage controllers, storage controller chip sets, flexible disk drives, printers and video displays. Floppy disk drives represented 2% of fiscal 1990 revenues.

Qume's floppy drive operations started in 1979, with a manufacturing license from Y-E Data. Except for some confusion when the firm reorganized its marketing and manufacturing programs in 1981, Qume maintained continuous growth in the OEM market -- and received a big boost in 1983 by being selected as a vendor for half high 5.25 inch floppy drives to IBM for the PC Junior. However, Qume's management didn't care for today's floppy drive prices, and after licensing production in China, closed down floppy drive manufacturing. A significant number of already completed drives were sold in 1986, and a small remainder was sold in 1987. In June, 1988, Qume's parent sold the operation to Data Technology Corporation (DTC), which adopted the Qume name for the combined operation, and which now makes printers, terminals and data storage products. DTC now operates as a manufacturing subsidiary, along with Qume Taiwan.

DTC, founded in 1979, operated for several years as a controller manufacturer and subsystem vendor, with founders originally from Xebec. Eastman Kodak had a minority investment in the firm, and arrangements were made to manufacture and market the 12 megabyte 5.25 inch floppy drive developed by Kodak, which was also being marketed by that firm's Verbatim subsidiary. A 24 megabyte version began shipping in mid-1988. The 24 megabyte drives were manufactured in Taiwan by DTC Technology, a subsidiary firm in which Qume has a 24.05% interest, until declining volume led to termination of production in 1991.

Asian Manufacturers

(All fiscal years for Japanese companies end in March, 1990, unless otherwise noted.)

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

1990 FDD sales: $59,200,000
1990 total net sales: $2,777,841,000 Net income: $4,903,000

Alps Electric is a diversified manufacturer of electronic components and subassemblies for television, audio, instruments and computer applications. Printers, keyboards, mice and disk drives together account for approximately 14% of Alps revenues. Production of captive 5.25 inch floppy drives for use with Alps systems started several years ago, but has not been emphasized. The firm's big increase in floppy drive shipments came in 1981, with a rapid buildup of shipments to Apple Computer. Alps began shipping 3.5 inch microfloppy drives in mid-1984, and enjoyed a major increase in shipments in 1987 as a vendor to IBM for the PS/2 personal computer family. Alps also offers a product line of rigid disk drives.

In the spring of 1987, Alps became the first Japanese company to manufacture floppy drives in the U.S., with 5.25 inch drives made in Garden Grove, California. Alps also manufactures floppy drives in Ireland. In 1989, Alps announced a 2 inch floppy drive for use with video camera systems, but has not announced a similar product for use as a computer peripheral. A 4 megabyte 3.5 inch drive began shipping in mid-1990. A prototype 2.5 inch non-removable floppy disk drive with a 10 megabyte capacity and average seek time of 50 milliseconds was shown to prospective customers in 1991 but has not been formally announced.

ASIA COMMERCIAL CO., LTD.
444-452 Des Voeux Road West
Hong Kong

Asia Commercial, founded in 1968 as a watch manufacturer, has been an aftermarket supplier of floppy drives for IBM, Apple, MSX and other microcomputers since 1985. The firm also manufactures a variety of other computer related products. Shipments of 5.25 inch one sided drives began in 1985, and two sided drives were added in 1986. A 3.5 inch drive was added in 1987. Manufacturing is in Dongguan, People's Republic of China, managed by Manhattan Electronics, a closely associated firm headquartered in Hong Kong at the same location as Asia Commercial.

BROTHER INDUSTRIES
9-35, Horita-dori
Mizuhoku, Nagoya 467
Japan

1990 total net sales: $1,647,531,000 (FY ending 11/30/90) Net income: $2,207,000

Brother is Japan's largest manufacturer of sewing machines, knitting machines and typewriters, with rapid growth in recent years in printers and other office equipment. Brother began shipping a 100 kilobyte 3.5 inch microfloppy drive in 1984 and added one inch high 1, 1.6, and 2 megabyte versions in 1986. The firm was unable to achieve a high enough production volume to remain competitive in the OEM market, and Brother's floppy disk drive production is now dedicated to use in Brother products.

CANON ELECTRONICS CO., INC.
Subsidiary of Canon, Inc.
1248, Shimokagemori, Chichibu-city
Saitama, 369-18
Japan

1990 FDD sales: $41,400,000
1990 total net sales: $11,916,883,000 (FY ending 12/31/90) Net income: $423,503,000

Canon Electronics produces electronic subassemblies for Canon cameras, as well as other electronic components, including magnetic heads, and systems. Floppy disk drives represent 10% of Canon Electronics revenues, down from 27% in 1987. One and two sided 5.25 inch floppy drives have been in production since 1979, originally under a BASF license for one third high drives. Canon also developed its own unique microfloppy using a 97 mm disk, but these drives were dropped, and the firm began shipments of 3.5 inch microfloppies in late 1984. Floppy drives are produced for both captive applications and for sale to the OEM market, both domestic and export. One inch high 3.5 inch drives began production in mid-1986, and in 1988 Canon commenced production of 2 megabyte 3.5 inch drives. 19.5 millimeter high 3.5 inch drives were introduced in late 1989.

CHINON INDUSTRIES, INC.
21-17 Takashima 1-chome
Suwa-City, Nagano 392
Japan

1990 FDD sales: $175,500,000
1990 total net sales: $334,766,000 Net income: ($386,000)

Chinon, founded in 1948, is a manufacturer of electronics, cameras and photographic equipment, with worldwide distribution. Eastman Kodak is a

minority shareholder in the firm, holding 12.3% ownership. The company produces scanners, CD-ROM drives and printers as well as floppy disk drives, many of which are made on a contract manufacturing basis for other firms. In 1984, data products accounted for less than 10% of company revenues, but grew to 52% in 1990, with a major proportion contributed by floppy drive shipments. The firm introduced its flexible disk drive product line in 1984, currently consisting of half high 5.25 inch drives and 3.5 inch microfloppies. Chinon announced a Sony-type 2 inch 3,600 RPM floppy disk drive in 1991. A 4 megabyte 3.5 inch drive was introduced in 1990. Chinon and Iomega have an agreement for Chinon to produce the 'Floptical' disk drive that Iomega licensed from Insite Peripherals. Production is expected to start in mid-1992.

CITIZEN WATCH CO., LTD.
2-1-1, Nishi-Shinjuku
Shinjuku-ku, Tokyo 160
Japan

1990 FDD sales: $142,600,000
1990 total net sales: $2,306,297,000 Net income: $66,786,000

Citizen is steadily expanding its diversification into additional products, from its basic position of strength as Japan's second largest watch manufacturer. Watches are now down to 50% of sales, machine tools hold 13% and electronic equipment the balance. In addition to printers, displays, and small computers, Citizen introduced 3.5 inch microfloppies in 1984, offering the first one inch floppy drive, and began an aggressive sales program in the U.S. and Europe, aimed at the OEM market.

In 1989, Citizen again led the industry in drive packaging, this time with the first introduction of 19 millimeter high 3.5 inch floppy disk drives, followed in 1990 with drives only 15 millimeters high. A 20.6 megabyte (formatted) floppy drive using metal powder media was announced in late 1989, with specification changes considered likely to conform to the JEIDA specification for high capacity floppy drives now under preparation.

COPAL CO., LTD.
2-16-20, Shimura
Itabashi-ku, Tokyo 174
Japan

1990 total net sales: $433,890,000 Net income: ($3,028,000)

Starting with camera shutters, Copal has diversified into a wide range of electronic components, photographic equipment, clocks, machine tools and printers. Electronic information systems products accounted for about 36% of revenues in 1990. After experience in contract manufacturing for floppy drives, Copal introduced its own 5.25 inch floppy drives in 1985, later adding 3.5 inch models. Fujitsu, Ltd. has a 13% ownership position

in Copal and has supplied key personnel to assist in joint product development efforts. Until recently, Copal manufactured the floppy drives sold by Fujitsu in the U.S. and Europe. However, the firm closed down its floppy drive manufacturing operation, due to the small market share held by its own label and the low profitability experienced in contract manufacturing.

EASTERN PERIPHERALS PVT. LTD.
72, S. D. F. III
Seepz, Andheri (E)
Bombay, 400 096
India

Eastern Peripherals was originally established to make 5.25 inch floppy disk drives and components for Tandon Corporation, and is owned by members of the Tandon family. With Tandon Corporation's departure from the disk drive business in 1987, Eastern Peripherals continued as an OEM floppy drive manufacturer, using models developed by Tandon, and also produces heads, stepping motors, and other electronic products.

ERGO ELECTRONICS CO., LTD.
388 Castle Peak Road
Tsuen Wan, New Territories
Hong Kong

Ergo was founded in 1978 as the Evergo Corporation and changed its name in 1985 to reflect new management. The firm assembles personal computers and also manufactures 5.25 inch floppy disk drives for the Apple compatible market, with drives for the IBM personal computer market added in 1986. 3.5 inch drives were announced in late 1989, with the mechanisms assembled under contract in the People's Republic of China.

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

1990 total net sales: $17,584,641,000 Net income: $598,331,000

Despite its role as Japan's leading computer manufacturer and a major participant in the worldwide market for OEM rigid disk drives, Fujitsu was not a participant in the flexible disk drive industry until 1984, except as a buyer of OEM drives for use with its systems. Fujitsu's 3.5 inch microfloppy manufacturing program, which was discontinued in the mid-1980s, was later sold to Hyundai. At the same time an investment was made in Copal, which until recently produced floppy drives sold under the Fujitsu label in the U.S. and in Europe.

GOLDSTAR TELECOMMUNICATION CO., LTD.
20, Yoido-dong
Youngdungpo-gu, Seoul 150
South Korea

1990 total net sales: $244,395,000 Net income: ($39,867,000)

A member of the Lucky-GoldStar Group, one of Korea's major industrial families, GoldStar Telecommunication is a diversified manufacturer of telecommunication equipment, automation systems and computer peripherals. Computer peripherals account for about 14.2% of sales. A 20% ownership is held by Siemens, the largest shareholder. In an effort to expand beyond existing terminal and printer products, the company marketed half high 5.25 inch floppy drives starting in the mid-1980's with distribution limited to Korea. Sales in the U.S. were delayed due to a lawsuit by Tandon Corporation, since settled, claiming improper use of Tandon product designs by ex-employees.

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

1990 total net sales: $48,812,793,000 Net income: $1,454,917,000

Hitachi is Japan's largest electric and electronics manufacturer, with about 46% of its total sales generated by the computer and communications industry. Hitachi has been making 8 inch floppy drives since 1976 for both captive and OEM applications. In 1982, the firm entered the 5.25 inch market, and also joined in the 3 inch microfloppy standard with Matsushita Electric Industrial, but has since dropped production of 3 inch floppy drives. In early 1986, the firm began shipping a 1.6 megabyte 3.5 inch drive, but manufacturing ceased in 1987. Hitachi took a leadership role in introducing high capacity flexible disk drives designed to use high density particulate media developed by Maxell, including a 9.6 megabyte 8 inch drive and a 6.5 megabyte 5.25 inch drive, but production remained small. The firm has also made technology announcements concerning vertical recording. However, in recent years floppy drive activity has dwindled and production is now mostly directed at filling internal needs.

HO SHIN SUB-SYSTEM CO., LTD.
3-5 Lane 145
Hsien Sheng S. Road, Section 1
Taipei 106
Taiwan

Founded in 1983, Ho Shin originally produced 8 inch drives, but later switched to production of 5.25 inch drives. Current products include half

high drives for IBM and Apple systems. Ho Shin has moved its production facilities to the People's Republic of China. Current production is largely consumed in the PRC.

HYUNDAI ELECTRONICS INDUSTRIES CO., LTD.
San 136-1, Ami-ri, Bubal-myun
Ichon-kun, Kyoungki-do
South Korea

Hyundai's first attempt to enter the disk drive business was a disastrous joint venture with Tandon, which was abandoned in early 1987 after serious friction between the joint venturers. Hyundai later concluded an agreement with Fujitsu to take over the 3.5 inch microfloppy program which Fujitsu was preparing for market introduction at the time it acquired control of Copal, which then was chosen as the Fujitsu floppy drive manufacturing arm. Using the Fujitsu products as a starting point, Hyundai established its own microfloppy drive manufacturing program at the large electronics complex at Ichon, but production levels have been low, for captive use only.

JAPAN PERIPHERAL NETWORK CORPORATION. (See Safronic Corporation)

JIN TECH ELECTRONICS CORP.
40-42 Lane 166, Li-San Street
Nei Hu, Taipei
Taiwan

Jin Tech was founded as Oceanic Electronics. The firm began to ship one sided 5.25 inch floppy drives in 1985. The product line now includes one and two sided drives for Apple, Commodore and IBM compatible personal computers. In late 1989, Oceanic was split into two organizations, Jin Tech, which is responsible for marketing, and Oceanic, which retains manufacturing responsibility. In 1990, floppy disk drive production was halted, but floppy drives are purchased for use in subsystems.

MANTEC TECHNOLOGY, LTD.
Flat A, 18/F., Chai Wan Industrial Center
20 Lee Chung Street
Chai Wan
Hong Kong

Mantec was founded in 1985 as a producer of floppy disk drives and modems. The drives produced are two sided 5.25 inch 360 kilobyte models and a one sided drive which is Apple compatible. The company is a spinoff from Manhattan Electronics, which is associated with Asia Commercial, another Hong Kong producer of floppy disk drives.

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

1990 FDD sales: $206,000,000
1990 total net sales: $2,697,366,000 Net income: $78,979,000

Matsushita Communication Industrial is a member of the Matsushita Electric Industrial group, a worldwide giant in appliances and electronics. During the early growth of the floppy drive industry, MCI manufactured most of the Shugart floppy drive line under license for the Japanese OEM market. MCI later added floppy drives of its own design, including half high 5.25 inch and 3.5 inch microfloppy drives. The firm made half high 5.25 inch drives on a contract manufacturing basis for Shugart and in 1985 acquired marketing rights in the United States, which has resulted in significant sales by the firm's U.S. Panasonic subsidiary. MCI has a joint venture with a manufacturer in the Philippines, Precision Electronics Corporation, to manufacture floppy disk drives and other computer components.

The firm introduced a 1 megabyte 2 inch floppy drive that was adopted by Zenith in 1989 for use in a notebook computer but was otherwise shunned by the computer industry. In 1987, MCI became one of several firms that licensed the barium ferrite technology used in the Toshiba 4 megabyte 3.5 inch floppy drive. MCI has also announced high capacity 3.5 inch drives and 17 millimeter high 3.5 inch drives with 1,2, and 4 megabyte capacities. A 28 megabyte 3.5 inch drive, downward compatible with the 1 and 2 megabyte formats, was introduced in 1991 for production in late 1992, and will probably evolve to be compatible with the expected JEIDA specifications.

MATSUSHITA ELECTRONIC COMPONENTS CO., LTD.
Subsidiary of Matsushita Electric Industrial Co., Ltd.
1006, Kadoma, Kadoma City
Osaka 571
Japan

1990 FDD sales: $64,200,000
1990 total net sales: $2,387,200,000 Net income: $2,331,000

Matsushita's Panasonic, National, Technics and Quasar brand names are among the most widely known in the world for appliances, consumer electronics and communications equipment. Matsushita Electronic Components Co. (MACO) joined with Hitachi in attempting to establish a 3 inch microfloppy standard, and is now the sole manufacturer of 3 inch microfloppy drives, which have widest acceptance in the European market. Production of one inch high 3.5 inch microfloppies began in 1987 and a 15 millimeter high version was added in 1991.

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

1990 FDD sales: $187,000,000
1990 total net sales: $20,527,034,000 Net income: $529,628,000

Mitsubishi Electric is a leader in the Japanese domestic small business systems market, and one of the country's leading electronic and electrical products manufacturers. Captive 8 inch drives have been used with the firm's Melcom systems for several years, and the company also participates in the domestic OEM market. A family of half high two sided 5.25 inch floppy drives was introduced in 1982, with capacities up to 2 megabytes. Mitsubishi also started shipping a 3.5 inch microfloppy drive in 1983 and introduced a 2 megabyte version as early as 1985.

After production of flexible disk drives was moved to expanded facilities at Mitsubishi's Koriyama Works, a joint venture for the manufacture of floppy disk drives was also established in Thailand with Kang Yong Electric Manufacturing Co., a firm 80% owned by Mitsubishi. Production of one inch high 3.5 inch drives at Koriyama began in 1987, and Mitsubishi has become a major supplier of flexible disk drives to IBM. In 1991, the firm introduced a 4 megabyte 3.5 inch drive and a 14.8 millimeter high 3.5 inch 2 megabyte drive.

MITSUMI ELECTRIC CO., LTD.
8-8-2, Kokuryo-cho
Chofu-City, Tokyo 182
Japan

1990 FDD sales: $97,000,000
1990 total net sales: $1,093,848,000 (FY ending 1/31/90) Net income: $10,559,000

Mitsumi is a leading manufacturer of electronic subassemblies and components, including magnetic heads. Floppy disk drives represent about 8% of sales. The firm established a joint venture facility with Commodore, named Newtronics, to produce 5.25 inch and 3.5 inch floppy drives, and acquired complete ownership of Newtronics in 1986.

In 1984, Mitsumi introduced a very low cost 2.8 inch drive using a special Maxell disk under the name "Quick Disk", which uses a single spiral track with 64,000 kilobytes capacity. It is used primarily in low-end home systems, including games. One inch high 3.5 inch drives went into production in 1987, followed by 3/4 inch high drives in 1989. A 12.7 millimeter high 2 megabyte 3.5 inch drive was announced in late 1991. Mitsumi has established a manufacturing facility in Malaysia for floppy disk drives and will begin manufacturing in the Philippines in early 1992.

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

1990 FDD sales: $412,000,000
1990 total net sales: $23,752,945,000 Net income: $587,717,000

About 47% of NEC's revenues are generated by computer mainframes, small business systems, minicomputers and desktop systems -- and the firm remains the clear leader in the growing Japan domestic personal computer market. Since 1978 the company has manufactured two sided 8 inch floppy drives, and was one of the earliest firms to offer half high 8 inch drives, with shipments starting in late 1981. 3.5 inch microfloppy drives and half high 5.25 inch drives were introduced in 1984. The majority of NEC's floppy drive shipments have been for captive applications, making the company the world leader in total DISK/TREND revenues for flexible disk drives.

NEC moved into the high capacity floppy drive market with the 1988 introduction of a 3.5 inch 9.4 megabyte (formatted) drive for sale with its microcomputer systems. A 10 megabyte version with downward compatibility to 1 and 2 megabyte drives was introduced in 1990. NEC is very active on the JEIDA committee working to standardize high capacity 3.5 inch floppy disk drives. In 1989, NEC announced that it was establishing a subsidiary in Hong Kong to oversee procurement and manufacturing in southeast Asia, including production of floppy disk drives in the Philippines.

ORIENTAL PRECISION COMPANY, LTD.
Tae Wha Building, 11th Floor
194-27 Insa-dong, Chongno-gu
Seoul
South Korea

1990 total net sales: $167,629,000 (FY ending 12/31/90) Net income: ($5,596,000)

OPC, established in 1953, is a diversified producer of electronic products and systems including terminals, telecommunication products, small computers and radio products. Computer equipment accounts for about one fifth of annual sales. The firm manufactures a line of 5.25 inch floppy drives under license from Teac, and also does contract manufacturing of small rigid disk drives. In 1991, OPC was purchased by Jade Insurance, part of the Korea Chemical Group. The company's future as a drive manufacturer under the new ownership is unclear.

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

1990 total net sales: $5,761,821,000 Net income: $109,455,000

Copiers, sensitized papers and photographic equipment provide the major part of Ricoh's revenues, but the firm has been investing in the growing line of data processing equipment which now accounts for about 30% of Ricoh sales. Starting in 1979, Ricoh made 8 inch floppy drives, in both one and two sided versions, originally under a Calcomp manufacturing license. The firm later introduced half high 5.25 inch drives intended for both captive and OEM applications. Recent production rates were very low and production ceased in 1990.

ROCTEC ELECTRONICS LTD.
Subsidiary of Roctec Enterprises
Union Industrial Building
18 Lee Chung Street
Chai Wan
Hong Kong

Roctec Electronics was established in 1986 when a group of engineers approached the parent organization and proposed establishing floppy drive manufacturing. Shipments of 5.25 inch drives, mostly two sided, began in 1987. Recent production has declined. Roctec has its assembly facilities in Hong Kong, and also makes use of manufacturing facilities in the People's Republic of China, working with an organization which provides manufacturing on a contract basis. Roctec is emphasizing externally mounted diskette add-on products for various personal computers including Apple, Commodore, Compaq, IBM, and Toshiba.

SAFRONIC CORPORATION
7-5-17 Nakazato
Tendo-shi, Yamagata 994

Safronic, founded in October, 1988, originally was called Digital Systems, Inc., and later adopted the name of its major distributor, Japan Peripherals Network (JPN). In 1991, the firm adopted its present name, with JPN remaining a separate organization distributing peripherals, mostly floppy disk drives made by Safronic. Safronic now manufactures half high 5.25 inch drives and 2 megabyte 3.5 inch drives. Production facilities are currently located in Hanamaki.

SAMSUNG ELECTRONICS CO., LTD.
Subsidiary of the Samsung Group
Taipyung-ro, Chung-ku
Seoul
South Korea

1990 total net sales: $6,348,810,000 Net income: $102,751,000

Samsung Electronics is the leading manufacturer of consumer electronics and appliances in Korea. About 21% of sales are computer or communications products. In 1988, the firm merged with Samsung Semiconductor and Telecommunications, with Samsung Electronics the surviving organization. Samsung got started in floppy drive production in 1983 when Shugart granted a license to manufacture and market the Shugart 5.25 inch floppy drives in South Korea, but consumer electronics and appliances are the firm's major sources of income. Samsung is currently making half high 5.25 inch drives with capacities up to 1.6 megabytes, and production of 3.5 inch 2 megabyte one inch high drives began in 1989.

SANKYO SEIKI MFG. CO., LTD.
17-2, 1-chome, Shinbashi
Minato-ku, Tokyo 105
Japan

1990 total net sales: $868,400,000 Net income: $9,303,000

Sankyo Seiki is a leading manufacturer of musical movements, industrial robots and a wide variety of small electromechanical components used in cameras, video recorders, timers and other products. The firm received a major investment in 1988 from Nippon Steel as part of that firm's diversification program into technology industries. In 1981, the firm began shipping a spiral track flexible disk drive for word processing, program loading and special industrial applications, and in mid-1984 added 3.5 inch microfloppies. The current 3.5 inch line consists only of 1 inch high models. Production of spiral track drives ended in 1987.

SEIKO EPSON CORPORATION
3-5, Owa 3-chome, Suwa-shi
Nagano, 392
Japan

1990 FDD sales: $152,300,000

Seiko Epson is owned by the privately held Suwa Seikosha/Epson group held by members of the Hattori family, who also control Japan's Seiko companies active in watches and electronics. Epson is best known for matrix printers, now used worldwide with personal computers. Epson also manufactures line printers, LCDs, paper tape equipment, watch components, and its own portable computer.

The first Epson floppy drive was a captive 5.25 inch one third high unit first shipped in 1982 and used with the Epson portable computer. Starting in October, 1983, Epson added an OEM floppy drive product line of 5.25 and 3.5 inch models, including 3.5 inch drives with very low power requirements. At the 1985 Fall Comdex, Seiko Epson showed a 2.5 inch floppy disk drive prototype for which no manufacturing program has ever been announced. As of 1991, the product line included half high 5.25 inch drives and 25.4 millimeter and 18 millimeter high 3.5 inch drives.

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

1990 FDD sales: $303,400,000
1990 total net sales: $20,312,014,000 Net income: $709,021,000

Sony, founded in 1946, is best known as a consumer electronics producer, but in recent years has made it clear that expansion in communications and computer products markets is a major company objective. About 19% of sales are now in nonconsumer products. Included are word processing and personal computer equipment -- both of which use the Sony 3.5 inch microfloppy which has been shipping since late 1981.

After initially taking a somewhat stiff posture on granting licenses, Sony demonstrated flexibility in working with the U.S. manufacturers concerned with establishing common standards. The result was agreement on the 3.5 inch media standard by Sony and several U.S. drive and media manufacturers -- and a growing number of Japanese firms rushing to make 3.5 inch microfloppy drives. After a big early boost when Hewlett-Packard selected Sony's drive for a variety of personal computers, there was a two year period of attack from contentious sponsors of rival standards, but the industry consensus on the Sony 3.5 inch drive has been in place for several years. Sony's microfloppy drive and media shipments grew strongly after Apple chose the drive for its Macintosh system and other systems manufacturers signed on.

Sony proposed to the industry a 2 megabyte, 3.5 inch media standard in 1985, which has become a de facto industry standard, with a little help from IBM. In 1987, Sony responded to the growing industry support for one inch high 3.5 inch drives by introducing its own model. A 4 megabyte 3.5 inch floppy disk drive was introduced in 1991. The firm has been pioneering the submicrofloppy field with a very high bandwidth 1 megabyte, 2 inch floppy based upon a design used in the Mavica video camera storage device. Sony is also an active producer of CD-ROM, erasable and write-once optical disk drives, and has also entered the 3.5 inch rigid disk drive market as a supplier to Apple.

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

1990 FDD sales: $374,200,000
1990 total net sales: $762,131,000 Net income: $27,497,000

Teac is a leading manufacturer of consumer and professional audio recorders, but digital recording equipment is a major portion of the firm's product mix, now accounting for about 69% of total revenues. Shipments of 5.25 inch floppies for the OEM market started in 1978, and rapid growth made Teac the leader in worldwide OEM floppy drive revenues during the last few years. Major products today are half high 5.25 inch drives and microfloppy drives. In 1985, Teac announced its line of 3.5 inch drives, including a 2.0 megabyte model and subsequently added one inch high models. The firm joined Toshiba in 1987 in announcing 4 megabyte 3.5 inch floppy drives using barium ferrite media. 19 millimeter high 3.5 inch drives were introduced in 1989, and a 4 megabyte model was introduced in 1990. In 1991, Teac introduced the industry's first 12.7 millimeter high 3.5 inch floppy disk drive, moving to the front in the race to downsize floppy disk drive form factors. Teac has made manufacturing and licensing arrangements with a number of other firms in Japan, Korea, and other countries.

TECMATE ELECTRONIC INC.
30 Section 3, Chung-Shan N. Road
Taipei
Taiwan

Tecmate, also known under its NPH brand name, was founded in 1982 and for a while become one of Taiwan's largest floppy disk drive producers. The firm produced 5.25 and 3.5 inch floppy disk drives and other electronic products for small computers. By 1990, production had declined to low levels and the firm sold its remaining inventory and some production equipment to Vitoria Tecnologia, a Brazilian firm.

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

1990 FDD sales: $52,800,000
1990 total net sales: $29,323,814,000 Net income: $909,214,000

Toshiba is one of Japan's major diversified electric and electronics manufacturers, with products ranging from heavy electric machinery to home appliances and communications equipment. Toshiba has a major share of the Japanese minicomputer and small business system markets. 8 inch floppy

drives for both captive and OEM markets were produced starting in 1977. Half high two sided 5.25 inch drives were added in 1982, with the more recent addition of microfloppy drives. Although now de-emphasizing internal production of standard floppy drives, Toshiba has actively promoted advanced technology, including optical drives. High capacity barium ferrite media has been developed by the firm for 4 megabyte 3.5 inch floppies, with initial production of drives and media starting in 1988. Several other firms have licensed the drive and media. Toshiba is also working on 3.5 inch drives with 15-20 megabyte capacity, and displayed a 16 megabyte 3.5 inch drive using barium ferrite media at the Japan Business Show in May, 1989.

Y-E DATA, INC.
60, 1-1, Higashi-Ikebukuro 3-chome
Toshima-ku, Tokyo 170
Japan

1990 FDD sales: $154,600,000
1990 total net sales: $220,393,000 Net income: $152,000

Y-E Data is a spin-off of Yaskawa Electric, a diversified manufacturer of heavy electric, factory automation and data processing equipment. Data processing products are the responsibility of Y-E Data, which first manufactured 8 inch one sided floppy drives in 1974 under an Orbis license. Disk drives represent about two thirds of current sales. Y-E Data became an early leader in the Japanese OEM markets for both 8 and 5.25 inch two sided drives. Y-E Data also cooperated with NTT on the standard for 1.6 megabyte 5.25 inch drives and has been shipping its version since early 1982. Microfloppy drives were added in 1984. Y-E Data's biggest sale of all came in 1984, with IBM's selection of the firm's 1.6 megabyte 5.25 inch drive for use with the PC AT. In 1986, one inch high 3.5 inch drives were added to the product line. In addition to its drive manufacturing activities, Y-E Data is supplying drive kits to manufacturers in India and mainland China. A 4 megabyte 3.5 inch microfloppy drive using cobalt modified oxide media was introduced in 1988 in an unsuccessful attempt to develop an industry standard, and a preliminary announcement of a 27.8 megabyte drive using metal particle media was made in 1989, with specifications revised in 1991. 17 millimeter high 1 and 2 megabyte 3.5 inch drives were announced in 1990, and a 15 millimeter high version was introduced in 1991.

European Manufacturers

DZU
6000 Stara Zagora
Bulgaria

DZU is the current name for the Bulgarian organization known for many years as ISOT, following a series of reorganizations in 1989 of the governmental structure which manages Bulgarian technology industries. DZU produces flexible and rigid disk drives, as well as most of the components needed for disk drive fabrication, plus many other electrical and electronic devices. Isotimpex is the foreign trade organization for Bulgarian computer equipment and other electronic products. Disk drives manufactured by DZU are exported to Eastern Bloc countries, with some magnetic media products also exported to Western countries. Rigid disk drives, in several older IBM configurations, have been produced since the 1960s, later joined by 8 inch and 5.25 inch floppy drives. As a result of the economic upheaval in the former Eastern Bloc countries, DZU production has been greatly reduced and is now confined to half high 5.25 inch models.

ELCOMATIC LTD.
Subsidiary of British & Commonwealth Shipping Co., Ltd.
Kirktonfield Road
Nielston, Glasgow
Scotland

In July, 1981, Elcomatic acquired the 8 inch flexible disk product line of MFE. These drives had been manufactured mostly in a two sided version at plants in Salem, Massachusetts, and in Livingston, Scotland. Elcomatic moved manufacturing to a Glasgow plant and is continuing to produce 8 inch two sided floppy drives for the European market. 1988 production was impacted by a shortage of suitable heads, but product redesign enabled Elcomatic to resume production, although at low levels, due to declining markets for 8 inch floppy drives.

ISOT (See DZU)

MAGYAR OPTIKAI MUVEK
XII, Csorsz u.35
H-1525 Budapest
Hungary

Usually known by the abbreviation of its Hungarian name, MOM, or the "Hungarian Optical Works", this organization has produced 8 inch one sided floppy drives for several years, including various subsystems. A full size 5.25 inch one sided drive was added in 1980, replaced by half high

one and two sided drives in 1987. MOM reorganized itself in 1989 as a holding company with five manufacturing subsidiaries and handles export trade for all of them. The dropping of trade barriers in the former Eastern Bloc countries made production costs uncompetitive with drives produced in Asia, and MOM stopped production of floppy disk drives in 1991.

PERIPHERAL DATA SYSTEMS
Asenovgradsko Shose
Plovdiv
Bulgaria

Peripheral Data Systems (formerly known as Instrumentation and Automation) had the charter from the Bulgarian government for product development and to establish high volume manufacturing facilities for peripherals used in personal computers, in order to facilitate usage of personal computers throughout the country. With assistance from ISOT, plus acquisition of tooling from outside countries, the organization started production of 5.25 inch flexible disk drives in 1985. However, with the extensive political and economic changes which have occurred in all former Eastern Bloc countries, floppy drive production by this organization has dropped to a low level.

ROBOTRON
VEB Robotron-Buchungsmaschinenwerk Karl-Marx-Stadt
Annabergerstrasse 93
DDR-9010 Karl-Marx-Stadt
Germany

The Robotron group, founded in 1969, was the East German organization responsible for manufacture of computing and office equipment, communication equipment, electronic instruments and consumer electronic devices. The Robotron facility for peripheral equipment initiated manufacture of a unique 5.25 inch one sided floppy drive during 1984, after several years of buying similar drives from outside sources for Robotron equipment, and later started production of standard 5.25 inch floppy drives under a Teac license. With the integration of East and West Germany now in effect, Robotron has been broken up, and the production of floppy disk drives phased out in the face of Asian competition.

South American Manufacturers

COBRA COMPUTADORES E SISTEMAS BRASILEIROS S.A.
Avenida Commandante Guaranys, 447
Jacarepagua
22700 Rio de Janeiro/RJ
Brazil

Cobra, founded in 1974, is Brazil's largest computer company. Its products include minicomputers, microcomputers, terminals and other computer peripherals. The company has made a variety of floppy and rigid disk drives, usually under license from U.S. manufacturers. Cobra's floppy disk manufacturing is currently limited to an 8 inch one sided drive originally designed by Caldisk. Production levels are modest, and the drives are used in Cobra's own system products.

ELEBRA INFORMATICA S.A.
Rua Maestro Joaquim Capocchi, 165
Jurubatuba
04696 Sao Paulo/SP
Brazil

Elebra was founded in 1979, and is believed to be the most significant specialized manufacturer of computer peripherals in South America. Its product lines include floppy disk drives, rigid disk drives, printers and tape drives. Floppy disk production includes one and two sided 5.25 inch drives, both 48 and 96 TPI versions.

FLEXDISC TECNOLOGIA S.A.
Rua Francisco Tramontano, 100
05686 Sao Paulo/SP
Brazil

Originally known as Electrodigi S.A. Electronica Digital, Flexdisc has had several name changes. Its present name was adopted in mid-1986. Floppy disk drives have been produced by Flexdisc since 1979, originally under a Shugart Associates license. Current products also include rigid disk drives, controllers, and other peripheral products. The floppy disk product line began with 8 inch drives, but now includes one and two sided 5.25 inch floppy drives.

ITAUTEC INFORMATICA S.A.
Rua Odorico Mendes, 540
03106 Mooca
Sao Paulo SP
Brazil

Itautec is part of the Itau group, Brazil's second largest bank. Itautec was formed in 1979 to automate the banking systems of its parent organiza-

tion and went into the computer systems business in 1984. The firm began production of floppy disk drives in 1986 and rigid disk drives, made under license from BASF, in 1988. The current floppy disk drive line consists of 360 KB and 1.2 MB half high models.

MULTIDIGIT TECNOLOGIA S.A.
BR 290, Km 75
Distrito Industrial de Gravatai
94000 Gravatai/RS
Brazil

Multidigit was founded in 1979 with a cadre of Brazilian university students, and so qualifies as a genuinely homegrown company. Products include floppy and rigid drives, controllers, and tape drives. The floppy drives are half high 5.25 inch models using both 48 and 96 TPI and have been produced since 1985 and 1986, respectively.

PROLOGICA INDUSTRIA E COMERCIO DE MICROCOMPUTADORES LTDA.
Rua Fidencio Ramos, 302
04551 Villa Olimpia
Sao Paulo SP
Brazil

Prologica began as a retail store for electronic components, but soon moved into sales of kits for radios and, eventually, sales of microcomputer kits. The company decided to produce floppy drives in 1982 and actually started production of an IBM compatible 500 kilobyte drive in 1983. This was superseded in 1985 by a half high version. In 1984, the firm established a related company, Microperifericos, to manufacture drives for OEM customers and to do contract manufacturing.

VITORIA TECNOLOGIA S/A
Rua Joao Batista Parra, 100
Vitoria/Centro Industrial da Grande Vitoria
CIVIT II Serra Espirito Santo
BRAZIL

Vitoria Technologia has purchased the inventory and much of the production equipment of Tecmate, a Taiwan company that formerly produced floppy disk drives. The floppy disk drive product line, consisting of 5.25" drives compatible with Apple, IBM and MSX type systems, was announced in 1990.

1991 DISK/TREND REPORT

DISK/TREND ON DISK

INTRODUCTION

DISK/TREND ON DISK is a set of floppy disks containing the statistical tables and specification tables from the annual DISK/TREND Reports. The disk files have been prepared in a format usable on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. A system with a hard disk is highly recommended, but a system with two floppy disks can be used if necessary. All DISK/TREND ON DISK files contain data only -- manipulation of data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended.

A file translation program, AutoImport, is available from DISK/TREND to assist in converting the data supplied to the formats of several popular spreadsheet programs.

Two types of diskette files are supplied for each DISK/TREND disk drive report. The first type contains the statistical tables in ASCII format. File names are keyed to the table numbers in the report for easy identification. The second type contains the specification section in a Lotus 1-2-3 data base format. Multiple disks of each type are provided where the files are too numerous or too large to fit on a single floppy disk. The color used on the label of each floppy disk is similar to the color used on the cover of the corresponding report for ease in identification.

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

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

One copy of AutoImport is provided automatically at no extra charge to DISK/TREND subscribers who have purchased an original copy of DISK/TREND ON DISK but is provided only in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any time. If you have not purchased DISK/TREND ON DISK, but would find AutoImport useful with other file translation tasks, it may be purchased independently from DISK/TREND or White Crane Systems, Inc.

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

DISK/TREND ON DISK
Information License

DISK/TREND supplies diskettes containing selected information from the 1991 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1991 DISK/TREND Report volume.

YOU MAY:

1. Install and use the information on a single computer system, provided that you or the organization by which you are employed has purchased at least one copy of the DISK/TREND report volume associated with the information.

2. Make backup copies of the information for your own use. Such backup copies may be used only on the computer on which the information is installed. You must reproduce the copyright notice on any copies.

3. Reproduce the information, but not the associated programs or documentation, contained in the Product for use within internal documents distributed within the organization by which you are employed.

YOU MAY NOT:

1. Install, or allow the use of, the information on more than a single computer system.

2. Transfer the information through or within a computer network.

3. Distribute the information or any portion thereof in any form outside the organization by which you are employed or modify the information for purposes of distribution.

4. Transfer this license to another party.

AUTOIMPORT

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

Trademarks

IBM is a trademark of International Business Machines Corporation.

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

MS-DOS is a trademark of Microsoft Corporation.

AutoImport is a trademark of White Crane Systems, Inc.

Getting started

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

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

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

STATISTICAL TABLES

Loading and Installation

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

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

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

   TYPE A:READ.ME>PRN

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

   COPY A:?T*.*

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

   COPY A:*.PRN

   The utility file names are of the form FORMLIN?.PRN. The files are specific to use with Lotus 1-2-3 data parsing if you prefer not to use AutoImport for file translation.

   Installing AutoImport: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place Auto-Import disk 1 in drive A and type: A:INSTALL C:\AIMP and then ENTER. Follow any instructions appearing on the screen until installation is complete. To make AutoImport accessible from any directory, place C:\AIMP in your AUTOEXEC.BAT file's 'PATH' statement. See your MS-DOS instruction manual for information about this step.

   If you are using a floppy-only system, copy the Auto-Import disks and use only the copies in following steps. In a floppy-only system, AutoImport disk 1 should be in drive A when AutoImport is in use for file translation.

3. If you are using AutoImport (highly recommended) for translation of files to spreadsheet format, do the translation at this point. See the following section on using AutoImport for details.

4. Now you are ready to start your spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the spreadsheet

system disk in drive A. If you are using a rigid disk system, place a copy of the spreadsheet system disk in floppy drive A if required by the security provisions of your spreadsheet program. Now start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the appropriate file retrieval command to select a file. An example of a Lotus 1-2-3 command is:

/FR<filename>

The file names are in the format XTYY.WK1, where:

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

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

ZZ= Year of Report.

Examples:
File RT10.WK1 is Rigid Disk Drive Report Table 10
File FT2.WK1 is Flexible Disk Drive Report Table 2
File OT1.WK1 is Optical Disk Drive Report Table 1

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

If you don't use AutoImport

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

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

- FORMLINA.PRN — Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.

- o FORMLINB.PRN — Used with Table 2.
- o FORMLINF.PRN — Used with Tables 3 and 4.
- o FORMLIND.PRN — Used with Application tables.
- o FORMLINE.PRN — Used with Drive Height, Drive Capacity, and Track Density tables in Flexible Disk Drive Report.

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

After you have used spreadsheet tools to translate a file, you will understand why we recommend AutoImport for this function.

Using AutoImport:

Using AutoImport is a two-step process. Step one is creation of a translation mask for each format used in files to be converted. The typical DISK/TREND Report uses 5 to 7 standard mask designs (which have been precomputed and included on your Statistical Tables disk) plus additional masks that are dependent upon table content, as some table types have variable numbers of columns. You will have to create your own masks for such tables, but this can be done easily as shown below.

Step two is the translation process. Once the mask has been created, it can be used with any table matching the mask format. See the table below which relates table types to specific masks.

MASK TABLE

Mask File Name	Rigid Report	Flexible Report	Optical Report
MASKA	<-------- Table 1--------->		Tables 1,2
	<------------ Product Group Revenue ---------------->		
	<------------ Product Group Shipment ---------------->		
MASKB	<-------- Table 2 -------->		Tables 3,4
MASKC	Tables 3 to 8	Tables 3,4	Tables 5 to 12
MASKD	<----- All Product Group Application Tables ------->		
MASKE	N/A	Drive Height, Track Density, Drive Capacity	Write-Once/ Erasable Analysis
MASKF	Applications Summary		
MASKG	N/A*	Product Group Market Share	N/A*

* Variable format depending upon number of disk diameters in the product group.

TABLE NUMBER TO MASK CROSS-REFERENCE

Table Number	1991 Rigid Report	1991 Flexible Report	1991 Optical Report
1	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA
3	MASKC	MASKC	MASKB
4	MASKC	MASKC	MASKB
5	MASKC	--	MASKC
6	MASKC	--	MASKC
7	MASKC	MASKF	MASKC
8	MASKC	MASKA	MASKC
9	MASKC	MASKA	MASKC
10	--	MASKE	MASKC
11	--	MASKD	MASKC
12	MASKA	MASKG	MASKC
13	MASKA	MASKA	--
14	--	MASKA	--
15	--	MASKE	--
16	MASKD	MASKE	--
17	--	MASKD	MASKA
18	MASKA	MASKG	MASKA
19	MASKA	MASKA	--
20	--	MASKA	--
21	--	--	MASKD
22	MASKD	--	--
23	--	MASKE	MASKA
24	MASKA	MASKE	MASKA
25	MASKA	MASKD	--
26	--	MASKG	--
27	--	MASKA	MASKE
28	MASKD	MASKA	MASKD
29	--	--	--
30	MASKA	--	MASKA
31	MASKA	MASKD	MASKA
32	--	MASKG	MASKD
33	--		MASKA
34	MASKD		MASKA
35	--		MASKA
36	MASKA		MASKA
37	MASKA		--
38	--		--
39	--		MASKE
40	MASKD		MASKA
41	--		MASKA
42	MASKA		--
43	MASKA		--
44	--		MASKE
45	--		MASKA
46	MASKD		MASKA
47	--		--

Cross-reference (continued)

Mask File Name	1991 Rigid Report	1991 Flexible Report	1991 Optical Report
48	MASKA		--
49	MASKA		MASKE
50	--		
51	--		
52	MASKD		
53	--		
54	MASKA		
55	MASKA		
56	--		
57	--		
58	MASKD		
59	--		
60	MASKA		
61	MASKA		
62	--		
63	--		
64	--		
65	MASKD		
66	--		

-- indicates that the format of this table is variable or nonstandard. Create a mask using AutoImport if a spreadsheet is needed.

Translation using precomputed masks

1. First, copy the files you wish to translate to the AIMP directory from DISK/TREND ON DISK floppy disk. Go to the AIMP directory, insert the floppy disk in drive A and type the following commands:

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

   These commands copy the data files and mask files you need.

   If you are using a two floppy disk system, copy the files you want to translate to a second floppy disk along with the mask files. Make sure that no more than half of the floppy disk is filled, because you will need space for the converted files.

2. Now start AutoImport. When the opening screen appears, select the 'TRANSLATE' menu item using the arrow keys or just type 'T'. (The AutoImport menu system works just like the menus in Lotus 1-2-3.)

3. When the next screen appears, enter the name of the mask to use on the top line where the highlighted space is. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. Press 'ENTER'.

4. Select the output file name. Type OFT (Output:File:Type-in)

   Enter the name of the file. The file name form recommended is ?Tnn, where ? is the type of report (R, F, or O), T is just that, and nn is the DISK/TREND Report table number matching the file being translated. You should not enter the file name extension as the system adds it automatically for you. Press 'ENTER'.

   Examples: RT4 FT12 OT14

5. Enter the input file name using the same file naming convention as above. Type IT (Input:Type-in)

   Enter the name of the file, <u>including the extension</u>, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.91R FT12.91F OT14.910

6. The default spreadsheet type to which the translation is made is Lotus 1-2-3 version 2.x. If you wish to translate to a different spreadsheet format you may choose it by typing /TS and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Type 'G' for 'GO' or select 'GO' using the arrow keys. You will see the file being translated scroll by as the translation proceeds.

8. If you want to do more translations, repeat from step 3.

9. When you are done translating, leave AutoImport by typing /Q (Quit) to return to the AutoImport main menu and then /E (Exit) to leave AutoImport and return to DOS. It will save you some keystrokes if you copy your new spreadsheet files to your spreadsheet directory. If you are using a two floppy system, just remove the AutoImport disk from drive A and substitute your spreadsheet disk.

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select 'Mask' using the arrow keys or type 'M'.

2. Name the file you will use as the template to create the mask. The file name will be of the form ?Tnn.yy?, where ? is the type of report (R, F, or O), nn is the table number and yy is the report year.

   Example: FT20.91F

   To name the file, type /FIT (File:Input:Type-in). When the highlighted blank space appears, fill it in with the file name and press 'Enter'. The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the left top of the report table. Now type /LH (Line:Header). Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press 'Enter'. If there are any footnotes at the bottom, the lines in which they appear can be treated the same way by locating the header at the left margin of the first footnote line, typing /LH, extending the highlight area over the note and pressing 'Enter'.

4. Next, locate the longest left margin label (excluding the header lines) in the table. Position the cursor so that it is at the left margin of the line containing the longest label. Type /AY (Auto:Yes). This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

   In a few cases, the automatic feature may be confused by a table layout and all values will not be picked for conversion. In these unusual cases, you may be be able to get the overlooked values included by repeating this step on another line.

   Another unusual case can occur in which the right-hand part of a label is somehow included in a value occurring in the next column to the right. Deal with this rare case as follows:

   - o Place cursor in left margin of offending line. Type /CW to adjust width and then use arrow keys to move right column margin clear of the column of values.

   - o Set cursor on last position of column to the right of the left margin labels. Type /DCO to delete this one column from the mask.

   - o Now place cursor in first space to the right of the left margin label column. Type /C and then adjust the column width to encompass all places in the values column you have been working with. This will restore the mask column, also.

5. Save the mask in a mask file. Type /FMS (File:Mask:Save). Fill in the name of the mask file.

   Example: FT20MSK

6. Save the output file. Type /FOT (File:Output:Type-in). Now enter the file name.

   Example: FT20. You don't need to enter the file extension.

7. To make more masks, repeat from step 2. To quit the mask function, type /Q (quit). This returns you to the AutoImport main menu. To leave AutoImport, type /E.

Other AutoImport Functions

AutoImport can do much more than the functions described above, which are those concerned with a basic understanding of how to create spreadsheets from DISK/TREND ON DISK files. See the separate AutoImport manual provided for details of these other functions.

SPECIFICATION TABLES

Loading

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

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

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

   TYPE A:READ.ME>PRN

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

   COPY A:?S*.*

3. Now you are ready to start Lotus 1-2-3 or other spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus spreadsheet system disk in drive A. If you are using a rigid disk system, place the spreadsheet system disk in floppy drive A. If your spreadsheet is not Lotus 1-2-3, you will have to translate the data from Lotus 1-2-3 to your format. Almost all spreadsheet packages of recent vintage are able to do this translation. After translation, if needed, start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the spreadsheet File Retrieve command to select a file. The equivalent Lotus 1-2-3 command is:

   /FR<filename>

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

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

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

ZZ= Year of report.

Example: FS191 Flexible disk specification table

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

Using the specification data base

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

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

The data base has been set up for data extraction using Lotus 1-2-3 commands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the data base is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

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

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

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

Saving time

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

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

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

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

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

In order to make it easier to do sorting or extraction analysis on the data, the contents of certain fields have been modified and are not exactly the same as in the printed report tables. The affected fields have

been converted to purely numeric fields as described below. Where multiple values existed, the value representing the highest level of performance or capability has been retained.

Comments and asterisks in the affected fields have been eliminated. A '0' means that no data was available. Asterisks are retained in the comment field so that you will have an indication that one or more characteristics of the drive was referenced to a comment. Check the printed report table for details.

The affected fields are:

Group:	Numeric conversion: Now you can extract a range of groups.
TPI	Will be a single numeric value, 0 if data not available. If a drive model has several configurations, the highest TPI is used.
RPM	Numeric conversion: You can now extract a range of values.
Track to track positioning time	Will be a single numeric value, 0 if data not available. If a drive model is specified as having more than one positioning time, the shortest will be used. Settling time is always included.

A country code field has been added in the last column of the data base. The code explanation is:

1 = U.S. manufacturer
2 = Asian manufacturer
3 = European manufacturer
4 = South American or other manufacturer

Codes are based upon the location of the manufacturer's headquarters.

First ship date has been modified so that the last two characters will always represent the year of shipment. An entry of ??89 in the criterion field for the First Ship Date column will cause all drives first shipped in 1989 to be extracted.

Apple Macintosh compatibility: While DISK/TREND on DISK has been prepared for use on IBM PC compatible computers, users have reported that they are able to translate files into Macintosh format using Apple Computer software. The specific software reported used is Apple File Exchange.

Technical support

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

Call us at: 415-961-6209 (Or FAX: 415-969-2560)

Ask for Technical Support

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

1. Tell us what is on the diskette label.

2. Have your computer up and displaying the data or operation that is the subject of your call.

3. Have this manual and the Lotus 1-2-3 reference manual handy.

If you have questions about AutoImport as it is used with DISK/TREND ON DISK, contact DISK/TREND at the number above. Questions about other functions of AutoImport should be referred to White Crane Systems.