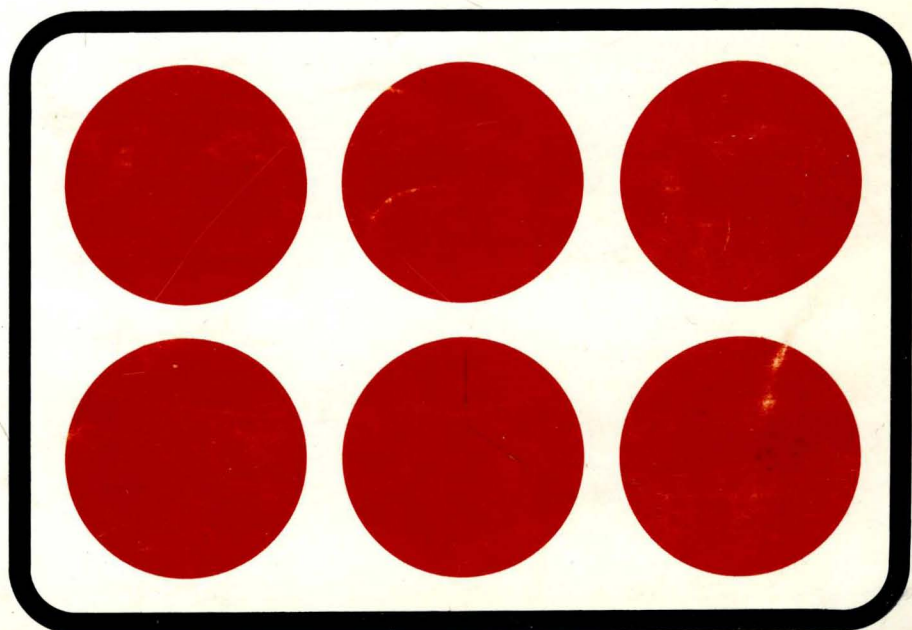


1978 DISK/TREND REPORT

FLEXIBLE
DISK
DRIVES



1978 DISK/TREND REPORT

FLEXIBLE DISK DRIVES

September, 1978

James N. Porter
1224 Arbor Court
Mountain View, California 94040
415/961-6209

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FOREWORD

Welcome to the second year of the DISK/TREND Report!

The format established for last year's edition is being repeated again this year: The 1978 DISK/TREND Report is being published in two sections. This volume covers flexible disk drives, and a separate report published in June covered moving head rigid disk drives.

Many subscribers to last year's report have contacted me for additional information or discussion on various aspects of the disk drive business. Your inquiries are most welcome, and I will be happy to provide any non-proprietary information from my files which can be extracted without extensive research. Projects requiring more elaborate research and analysis can be addressed on a normal consulting basis if desired.

I hope that you will give me your comments on the DISK/TREND Report, with any suggestions for improvement you may have. The report will continue to be published on an annual basis, and the usefulness of future editions will be increased through your ideas for improved content and format.

James N. Porter

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INTRODUCTION

How to use this DISK/TREND Report

The 1978 DISK/TREND Report follows the same organization as last year's original edition: Data is grouped primarily by products, and other variables such as distribution channels, companies and applications, are analysed within each product group. Here are some suggestions:

- * Look for information on specific segments of the industry in the appropriate product sections first.
- * Look for industry-wide data and consolidated statistics in the summary section.
- * Look for data on individual disk drives in the specification section, printed on yellow paper.
- * Look for background on disk drive manufacturers in the manufacturer profile section at the end of the volume.

Please note these key points

- * All DISK/TREND projections are based on current or announced products, plus the effect of evolutionary improvements -- without attempting to predict the introduction of completely new configurations or the invention of new technologies.
- * Specific definitions for several terms which could have varying meanings to DISK/TREND users have been prepared for use in this report. The definitions section, although boring, can save you time!
- * The value of leased disk drives is given on an "if sold" basis for all revenue estimates.
- * All unit totals are given in spindles. A disk drive containing two spindles, therefore, is counted as two spindles.

SUMMARY

Industry size

Flexible disk drive manufacturers generated an estimated \$289,600,000 in worldwide sales of drives in 1977, with sales by U.S. manufacturers totaling \$219,700,000, or 76% of the worldwide total.

Continued spectacular sales growth is in store for most manufacturers of floppy drives. The 1977 worldwide sales total represented a 74% increase over the previous year, and DISK/TREND forecasts through 1981 indicate an average annual growth rate in revenues of 32%. However, major shifts in product mix are underway, with the original floppy format -- 8 inch, one sided -- destined to peak in 1979. Newer formats are rising fast, and will provide floppies' future growth.

The share of worldwide sales held by U.S. manufacturers was down to 76% in 1977, but it is expected to stabilize at about 75-76% through 1981. There is continuous growth in non-U.S. manufacturing programs in both captive and OEM product areas, but the United States market, which is served almost entirely by U.S. manufacturers, is growing just as fast. Indeed, the U.S. remains far ahead of the rest of the world in developing internal markets for both new floppy drive formats and new application areas.

Since the sale of all data processing equipment is sensitive to economic factors, these forecasts assume a reasonably healthy world economy, with the U.S. GNP maintaining 3-5% annual growth.

TABLE 1
 CONSOLIDATED WORLDWIDE SHIPMENTS
 ALL EXISTING FLEXIBLE DISK DRIVE GROUPS
 REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)									
	1977 Shipments		Forecast							
			1978		1979		1980		1981	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM	70.8	96.2	75.4	112.9	92.9	145.8	122.1	190.9	145.1	230.3
Other U.S. Captive	37.6	52.4	65.0	91.2	107.6	126.7	134.7	175.9	164.7	206.4
TOTAL U.S. CAPTIVE	108.4	148.6	140.4	204.1	200.5	272.5	256.8	366.8	309.8	436.7
PCM	--	--	--	--	7.7	11.6	20.0	32.6	23.4	40.1
OEM	55.7	71.1	100.4	123.7	126.7	156.0	132.9	162.9	146.2	180.7
TOTAL U.S. NON-CAPTIVE	55.7	71.1	100.4	123.7	134.3	167.6	152.9	195.5	169.6	220.8
TOTAL U.S. PRODUCTION	164.1	219.7	240.8	327.8	334.9	440.1	409.7	562.3	479.4	657.5
<u>Non-U.S. Manufacturers</u>										
Captive	3.5	54.1	4.8	80.4	7.1	114.5	12.0	135.7	18.2	169.5
OEM	--	15.8	4.0	27.8	5.4	33.6	6.1	38.6	8.7	47.9
TOTAL NON-U.S. PRODUCTION	3.5	69.9	8.8	108.2	12.5	148.1	18.1	174.3	26.9	217.4
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE PRODUCTION		289.6		436.0		588.2		736.6		874.9
TOTAL WORLDWIDE CAPTIVE		202.7		284.5		387.0		502.5		606.2
TOTAL WORLDWIDE NON-CAPTIVE		86.9		151.5		201.2		234.1		268.7

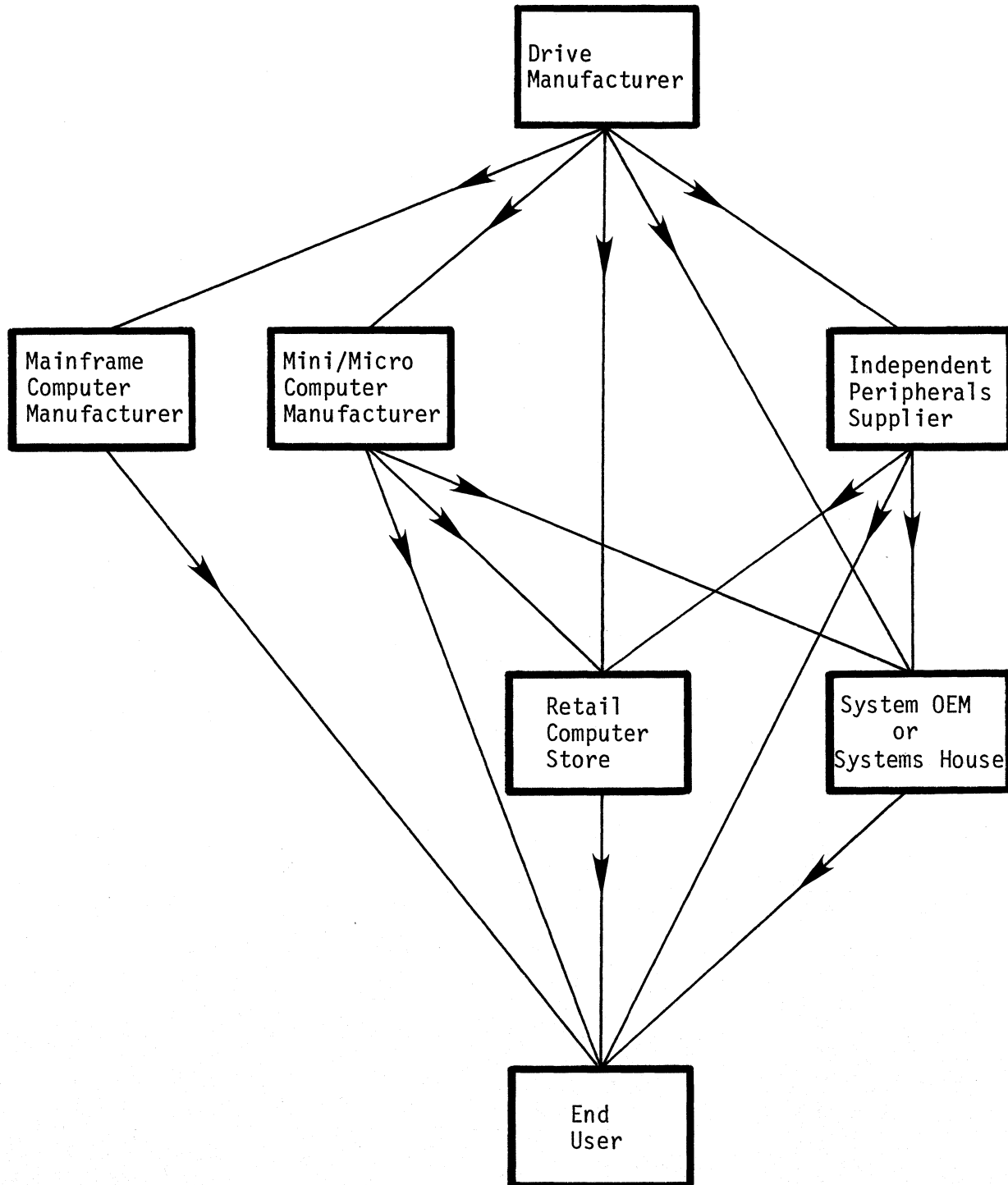
Marketing channels

The classic distribution pattern for OEM flexible disk drives is illustrated in Figure 1. The majority of OEM drives are sold to a computer manufacturer, system OEM or independent peripherals supplier -- which adds a power supply, controller, interface electronics and enclosure. The drive is then marketed to an end user or systems house as a subsystem or as part of a complete system. Some OEM drives are sold without basic drive electronics to major OEMs with the internal capability to complete the manufacturing job.

Flexible disk subsystems ready to attach to widely used mini-computers (such as those of DEC, Data General and Hewlett Packard) and microcomputers (via the popular S-100 bus) are available directly from many drive manufacturers. The market for subsystems is concentrated primarily with system houses, smaller system OEMs and computer stores selling to end users.

The emergence of the retail computer store was originally sparked by the activities of individual retail entrepreneurs throughout the United States, and a few drive manufacturers have found it profitable to develop and sell subsystems directly to dealers, as a specialized marketing program. In the last year, large quantities of drives have also started to move into this market segment through chain electronics stores (Tandy's Radio Shack) and catalog merchandising (Heathkit). A significant portion of the flexible disk drives moving through these channels are actually not being purchased for hobbyist use, but are installed with microcomputer-based small business systems.

Figure 1
NON-CAPTIVE MARKETING STRUCTURE
FLEXIBLE DISK DRIVES



Industry structure

Flexible disk drives are now produced by 19 United States manufacturers and 13 manufacturers in Europe and Japan. Flexible disk drive manufacturing operations in several Eastern European countries are not included in the totals, since they are not participants to date in free world markets.

Total captive production by IBM continues to grow. IBM's share of the worldwide total has been declining in recent years, however, due to the growth of all other market classes. It is believed that IBM's share of worldwide revenues will stabilize at about 25-26% during 1978-1981. Other U.S. captive manufacturers, which generated 18% of worldwide revenues in 1977, are expected to grow steadily, with revenues approaching 24% in 1981.

Non-captive manufacturers' share of total revenues are projected to decline only slightly through 1981. The revenues for OEM drives will have increased slightly in 1978 with U.S. manufacturers generating 28% of worldwide revenues, and non-U.S. manufacturers, 6%. However, the loss of sales volume to captive programs is inevitable in the OEM drive business, and through 1981, U.S. manufacturers will probably drop by about 7% points of market share, and the non-U.S. manufacturers, about 1%. Offsetting this loss in volume is the expected emergence of a growing plug compatible market based on systems installed by IBM and other major system manufacturers. The PCM market should approach 5% of the worldwide total by 1981.

Among non-U.S. drive manufacturers, the split between captive and OEM drive production is expected to remain about the same through 1981. Production of captive drives by computer manufacturers will grow rapidly, but so will the shipments of OEM drives to independent system OEMs.

TABLE 2
 CONSOLIDATED WORLDWIDE SHIPMENTS
 ALL FLEXIBLE DISK DRIVE GROUPS
 MARKET CLASS SUMMARY

Worldwide Revenues By Manufacturer Type	1977 Shipments		FORECAST							
			1978		1979		1980		1981	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
<u>U.S. Manufacturers</u>										
IBM	96.2	33.2	112.9	25.9	145.8	24.8	190.9	25.9	230.3	26.3
Other U.S. Captive	52.4	18.1	91.2	20.9	126.7	21.5	175.9	23.9	206.4	23.6
PCM	--	--	--	--	11.6	2.0	32.6	4.4	40.1	4.6
OEM	71.1	24.6	123.7	28.4	156.0	26.5	162.9	22.1	180.7	20.7
Total U.S. Mfgr's	219.7	75.9	327.8	75.2	440.1	74.8	562.3	76.3	657.5	75.2
<u>Non-U.S. Manufacturers</u>										
Captive	54.1	18.7	80.4	18.4	114.5	19.5	135.7	18.4	169.5	19.3
OEM	15.8	5.4	27.8	6.4	33.6	5.7	38.6	5.3	47.9	5.5
Total Non-U.S. Mfgr's	69.9	24.1	108.2	24.8	148.1	25.2	174.3	23.7	217.4	24.8
<u>Worldwide</u>	289.6	100.0	436.0	100.0	588.2	100.0	736.6	100.0	874.9	100.0

Product mix

8 inch, one sided flexible disk drives increased 76% in unit worldwide shipments in 1977, and are forecasted to rise another 46% in 1978. DISK/TREND projections, however, indicate that 1979 will be the production peak for drives in this group, with declines in subsequent years. Total industry production of all floppy formats will continue to register healthy increases through 1981, but those increases will all be attributable to newer formats.

8 inch, two sided drives have had a slower build-up in shipment rates during 1977 and 1978 than expected, due to difficult technical problems. Most manufacturers now appear to be ready for volume production in 1979, and the anticipated heavy demand for additional capacity should make two sided drives the dominant 8 inch format by 1981.

5.25 inch drives continue to grow at a rate which has surprised the industry. 146,000 spindles are forecast for 1978 worldwide shipments of one sided drives, a 234% increase over 1977. Large volume shipments of two sided versions should start in 1979, with rapid increases thereafter. DISK/TREND forecasts indicate an average annual growth rate for all 5.25 inch drives of 64% for the years from 1979 to 1981.

OEM market

Trends in product mix for OEM drives parallel total worldwide shipments for the complete industry, except that OEM product trends occur first. Noteworthy in 1979 is an expected decline in 8 inch, one sided drive shipments, due to displacement by two sided drives -- a decline which leads total industry shipments by a year.

Figure 2
CHANGING PRODUCT MIX
WORLDWIDE FLEXIBLE DISK DRIVE SHIPMENTS
CONSOLIDATED REVENUE

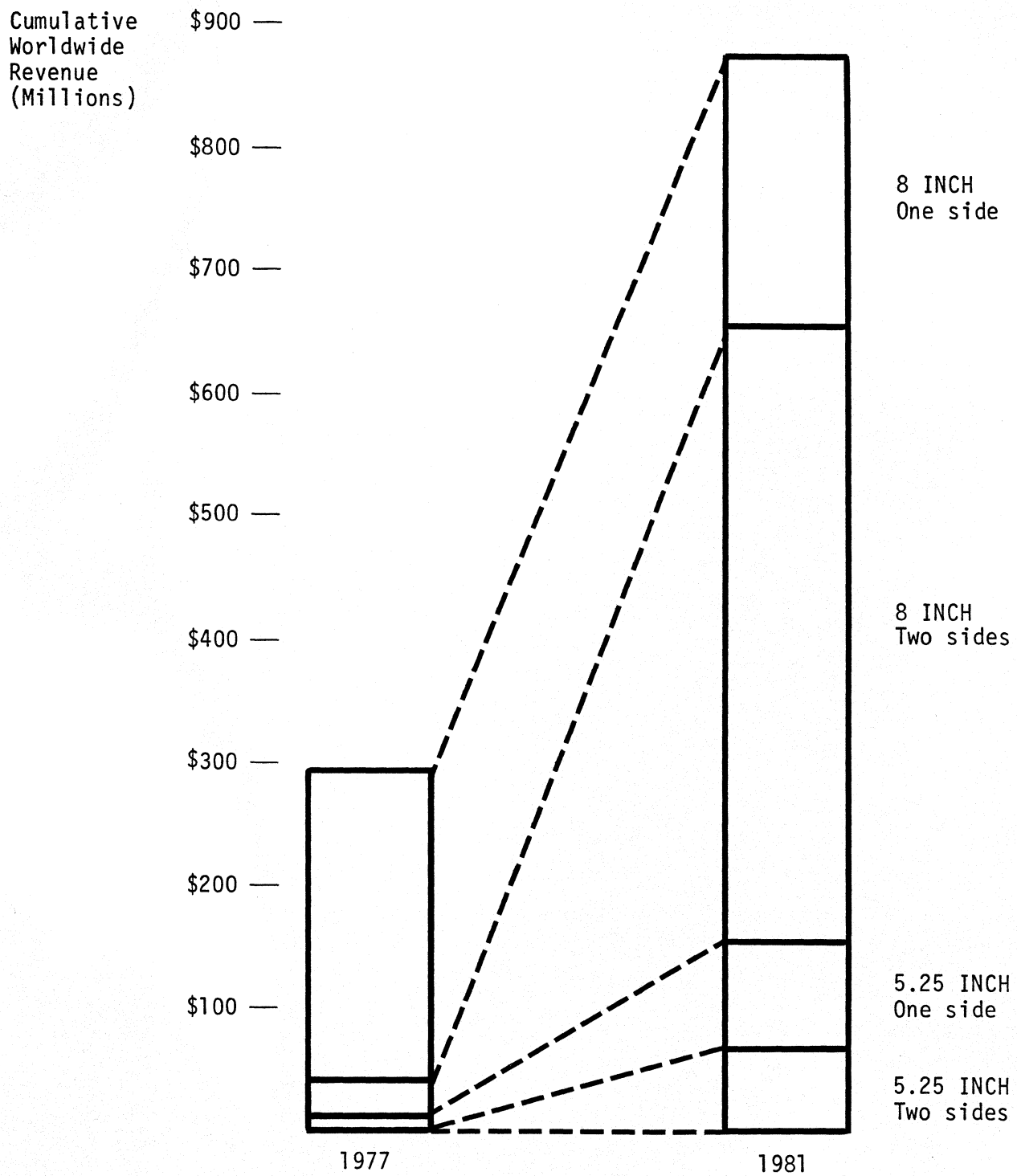


TABLE 3
WORLDWIDE SHIPMENTS
PRODUCT CATEGORY SUMMARY
ALL MANUFACTURERS

Units: Thousands Dollars: \$ Million		FORECAST									
		1977 Shipments		1978		1979		1980		1981	
		Ship	Δ%	Ship	Δ%	Ship	Δ%	Ship	Δ%	Ship	Δ%
8 Inch One side	Units	349.0	+ 76.0	510.0	+ 46.1	544.0	+ 6.7	407.0	- 25.2	298.0	- 26.8
	\$M	254.6	+ 53.7	340.4	+ 33.7	359.4	+ 5.6	292.4	- 18.6	218.8	- 25.2
8 Inch Two Sides	Units	14.7	--	57.9	+293.9	185.0	+219.5	330.0	+ 78.4	504.0	+ 52.7
	\$M	25.6	--	66.0	+157.8	167.4	+153.6	338.4	+102.2	500.7	+ 48.0
8 Inch Total	Units	363.7	+ 83.3	567.9	+ 56.2	729.0	+ 28.4	737.0	+ 1.1	802.0	+ 8.8
	\$M	280.2	+ 69.0	406.4	+ 45.0	526.8	+ 29.6	630.8	+ 19.7	719.5	+ 14.1
5.25 Inch One Side	Units	43.7	--	146.0	+234.1	226.0	+ 54.8	288.0	+ 27.4	347.0	+ 20.5
	\$M	9.4	--	29.2	+210.6	49.9	+ 70.9	65.4	+ 31.1	86.8	+ 32.7
5.25 Inch Two Sides	Units	--	--	1.5	--	52.0	--	158.0	+203.9	287.0	+ 81.7
	\$M	--	--	.4	--	11.5	--	40.4	+251.3	68.6	+ 69.8
5.25 Inch TOTAL	Units	43.7	--	147.5	+237.5	278.0	+ 88.5	446.0	+ 60.4	634.0	+ 42.2
	\$M	9.4	--	29.6	+214.9	61.4	+107.4	105.8	+ 72.3	155.4	+ 46.9
TOTAL ALL DRIVES	Units	407.4	+104.3	715.4	+ 75.6	1007.0	+ 40.8	1183.0	+ 17.5	1436.0	+ 21.4
	\$M	289.6	+ 74.4	436.0	+ 50.6	588.2	+ 34.9	736.6	+ 25.2	874.9	+ 18.8

Figure 3
CHANGING PRODUCT MIX
WORLDWIDE FLEXIBLE DISK DRIVE SHIPMENTS
ALL MANUFACTURERS

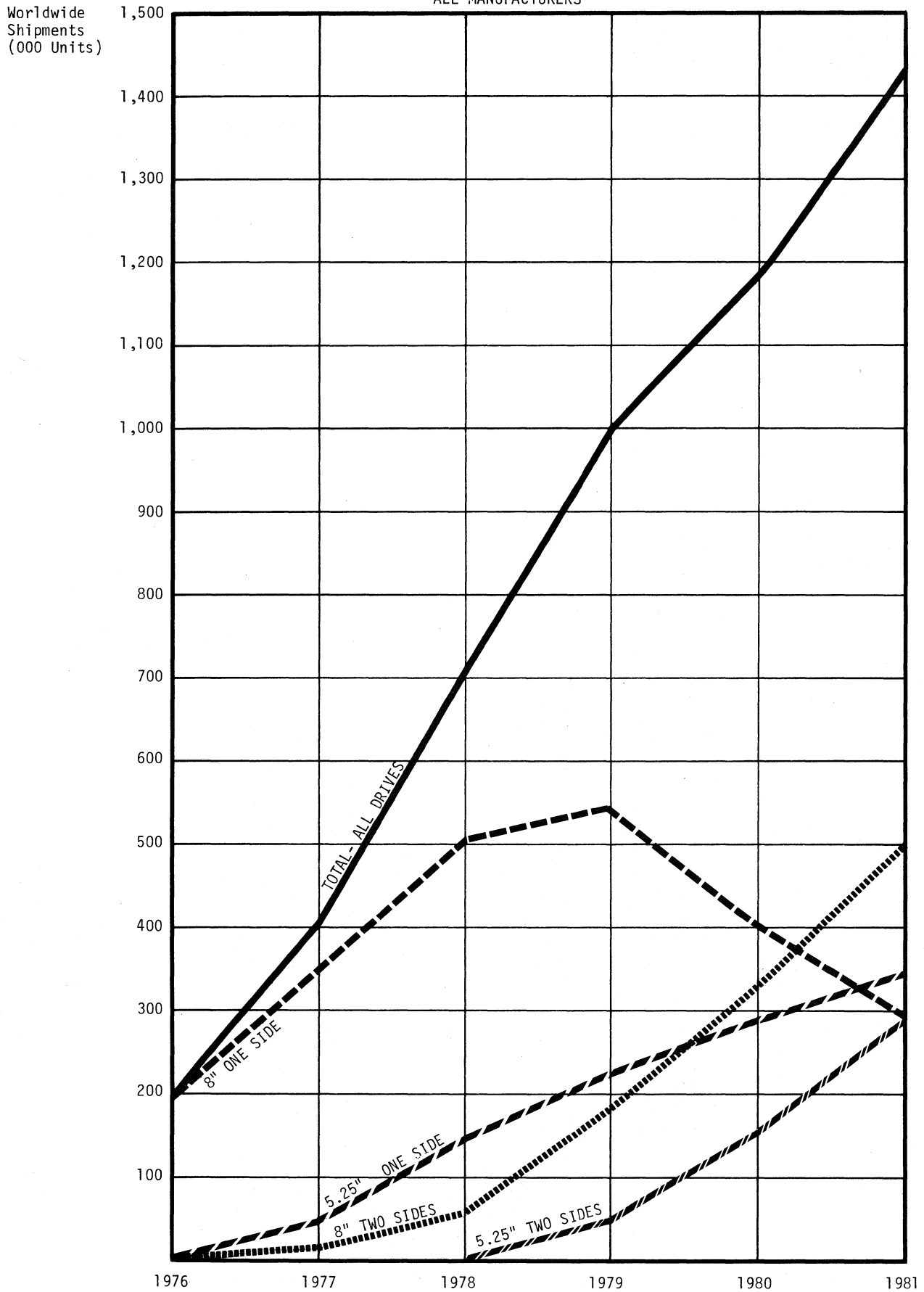


TABLE 4
WORLDWIDE SHIPMENTS
PRODUCT CATEGORY SUMMARY
MANUFACTURERS OF OEM DRIVES

Units: Thousands Dollars: \$ Million		FORECAST									
		1977 Shipments		1978		1979		1980		1981	
		Ship	Δ%	Ship	Δ%	Ship	Δ%	Ship	Δ%	Ship	Δ%
8 Inch One Side	Units	222.5	+ 69.7	334.0	+ 50.1	319.0	- 4.5	209.8	- 34.2	130.4	- 37.9
	\$M	76.9	+ 65.0	110.5	+ 43.7	100.2	- 9.3	63.7	- 36.4	38.5	- 39.6
8 Inch Two Sides	Units	1.4	--	30.9	--	105.8	+242.4	177.0	+ 67.3	260.0	+ 46.9
	\$M	.6	--	12.8	--	40.6	+217.2	64.6	+ 59.1	90.9	+ 40.7
8 Inch Total	Units	223.9	+ 70.8	364.9	+ 63.0	424.8	+ 16.4	386.8	- 9.0	390.4	+ 0.9
	\$M	77.5	+ 66.3	123.3	+ 59.1	140.8	+ 14.2	128.3	- 8.9	129.4	+ 0.9
5.25 Inch One Side	Units	43.7	--	144.0	+229.5	208.0	+ 44.4	251.0	+ 20.7	280.0	+ 11.6
	\$M	9.4	--	27.8	+195.7	37.3	+ 34.2	43.2	+ 15.8	46.6	+ 7.9
5.25 Inch Two Sides	Units	--	--	1.5	--	52.0	--	145.0	+178.9	267.0	+ 84.1
	\$M	--	--	.4	--	11.5	--	30.0	+160.9	52.6	+ 75.3
5.25 Inch Total	Units	43.7	--	145.5	+233.0	260.0	+ 78.7	396.0	+ 52.3	547.0	+ 38.1
	\$M	9.4	--	28.2	+200.0	48.8	+ 73.1	73.2	+ 50.0	99.2	+ 35.5
TOTAL ALL DRIVES	Units	267.6	+102.6	510.4	+ 90.7	684.8	+ 34.2	782.8	+ 14.3	937.4	+ 19.8
	\$M	86.9	+ 85.3	151.5	+ 74.3	189.6	+ 25.2	201.5	+ 6.3	228.6	+ 13.5

Figure 4
 CHANGING PRODUCT MIX
 WORLDWIDE FLEXIBLE DISK DRIVE SHIPMENTS
 MANUFACTURERS OF OEM DRIVES

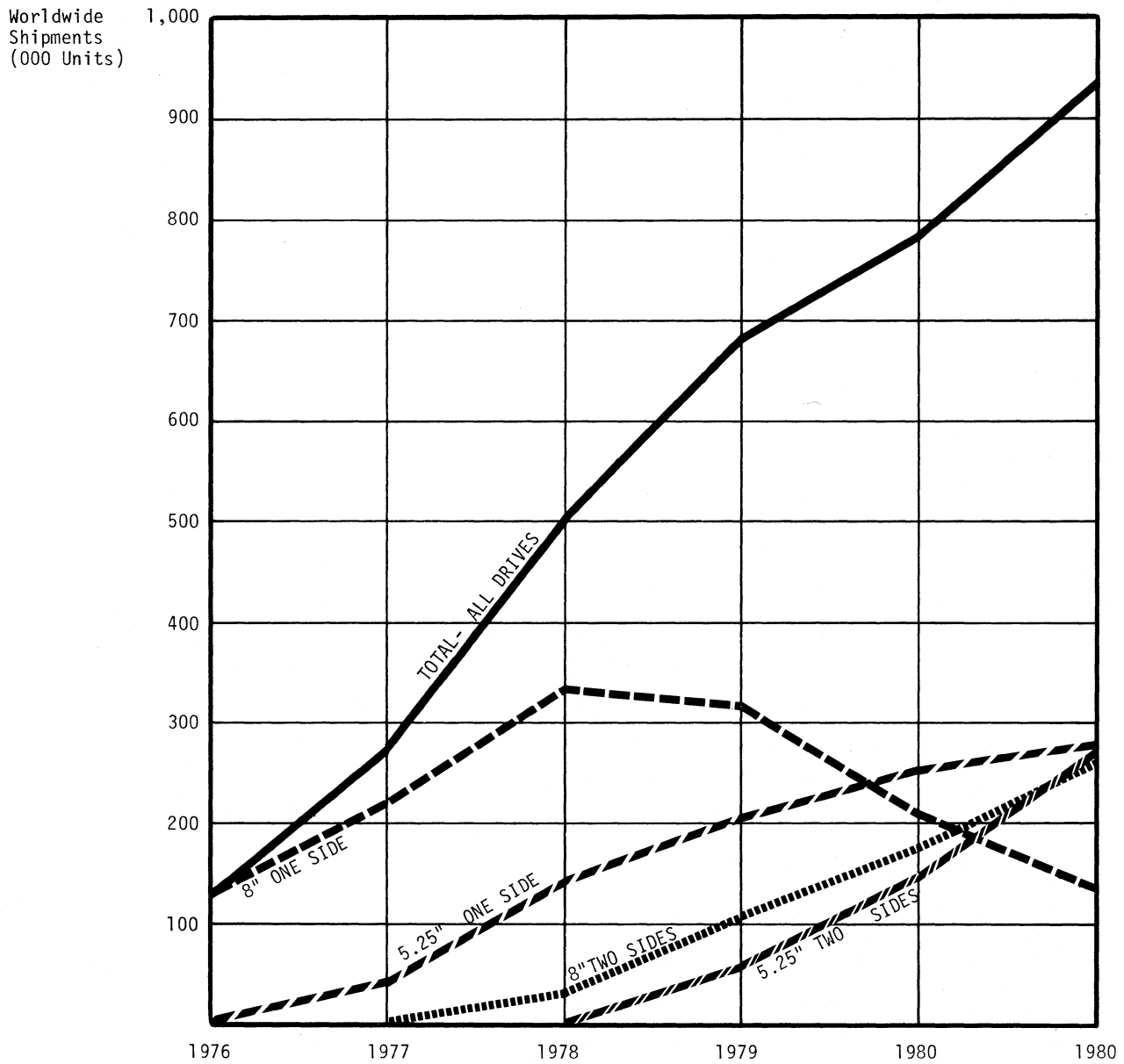


TABLE 5

1977 MARKET SHARES

U.S. FLEXIBLE DISK DRIVE MANUFACTURERS

Based on revenue generated by worldwide shipments
of flexible disk drives by U.S. manufacturers

	Captive		OEM		Total Industry	
	\$M	%	\$M	%	\$M	%
BURROUGHS	14.4	9.7	-	-	14.4	6.6
CALCOMP	-	-	4.7	6.6	4.7	2.1
CONTROL DATA	8.8	5.9	9.2	12.9	18.0	8.2
DATAPOINT	4.4	3.0	-	-	4.4	2.0
DIGITAL EQUIPMENT	11.0	7.4	-	-	11.0	5.0
GSI (Now Siemens)	-	-	2.3	3.2	2.3	1.0
IBM	96.2	64.7	-	-	96.2	43.8
INNOVEX (Now Innotronics)	-	-	1.0	1.4	1.0	.5
MEMOREX	.6	.4	4.7	6.6	5.3	2.4
MICROPOLIS	-	-	1.2	1.7	1.2	.6
PER SCI	-	-	2.3	3.2	2.3	1.0
PERTEC	7.7	5.2	2.0	2.8	9.7	4.4
REMEX	-	-	.3	.4	.3	.1
SHUGART	-	-	40.1	56.4	40.1	18.3
SYCOR	4.9	3.3	.2	.3	5.1	2.3
SYKES DATATRONICS	-	-	1.1	1.6	1.1	.5
WANGCO	.6	.4	1.9	2.7	2.5	1.1
TOTAL	148.6		71.1*		219.7*	

* Includes minimal shipments by companies not listed above which were starting production in 1977.

TABLE 6
CURRENT PRODUCT LINES
MANUFACTURERS OF FLEXIBLE DISK DRIVES

DISK/TREND CATEGORY:		10	11	12	13
		8 INCH ONE SIDE	8 INCH TWO SIDES	5.25 INCH ONE SIDE	5.25 INCH TWO SIDES
<u>U.S. Manufacturers</u>	<u>Type</u>				
Burroughs	C		X		
Calcomp	C,0	X	X		
Control Data	C,P,0	X	X		
Datapoint	C	X			
Digital Equipment	C	X			
IBM	C	X	X		
Innotronics	0	X			
Memorex	C,0	X	X		
MFE	0	X	X		
Micro Peripherals	0		X	X	X
Micropolis	0			X	X
PerSci	0	X	X		
Pertec	C,0	X	X	X	X
QYX	C			X	
Remex	0	X			
Shugart Associates	C,0	X	X	X	X
Sycor	C,0	X			
Sykes Datatronics	0	X			
Wangco	C,0	X	X	X	X
<u>Japanese Manufacturers</u>					
Hitachi	C,0	X	X		
Matsushita	0	X	X		
Mitsubishi	C	X	X		
Ok Electric	C	X			
Toshiba	C,0	X	X		
Yaskawa Electric	0	X	X		X
<u>Western European Manufacturers</u>					
BASF	0	X	X	X	X
Daisy Holland	C	X			
Data Recording Instruments	0	X	X		
Logabax	C	X			
Olivetti	C	X			
Sagem	0	X			
Siemens	C,0	X	X		

Code: C = Captive
P = PCM
0 = OEM

Application mix

Small business systems lead in usage of flexible disk drives today, with 31% of all units shipped worldwide, and are expected to still be the largest application area for floppy drives in 1981. However, there will be changes in product mix within the application area: 8 inch, one sided drives were the dominant choice in 1977, but two sided 8 inch drives are forecasted to account for over half of the floppy drives used on small business systems in 1981, with most of the balance split between 8 inch, one sided drives and 5.25 inch, two sided drives.

Terminals of all kinds were second in total floppy drive usage in 1977, but will drop to fifth place among application areas in 1981. IBM interchange requirements will keep 8 inch drives, both one sided and two sided, in a dominant position, but many specialized systems will also be using 5.25 inch drives.

The largest percentage increases in floppy usage will be in connection with word processing and the hobby/personal computer area. Although word processing will be using all floppy formats in 1981, 5.25 inch drives will predominate, with one sided versions the most popular, boosted by captive manufacturing programs for drives included in smart typewriter systems. The hobby/personal computer market will also find various uses for all available floppy formats, but the lowest price drive, assumed to still be the 5.25 inch, one sided drive in 1981, will be the volume winner.

Miscellaneous mini/micro computer systems used for other applications will also grow rapidly in floppy usage, in all formats, but 8 inch, two sided drives will be largest in 1981, due to storage size.

TABLE 7
FLEXIBLE DISK DRIVE APPLICATION PROJECTION
CONSOLIDATED WORLDWIDE SHIPMENTS

	1977 Estimate					1981 Projection				
	ALL FDD	8" ONE SIDE	8" TWO SIDE	5.25" ONE SIDE	5.25" TWO SIDE	ALL FDD	8" ONE SIDE	8" TWO SIDE	5.25" ONE SIDE	5.25" TWO SIDE
<u>SMALL BUSINESS SYSTEMS</u>										
Units (000)	127.6	112.1	9.4	6.1	--	395.8	90.4	215.2	6.9	83.3
Share %	31%	32%	64%	14%	--	28%	30%	43%	2%	29%
<u>MINI/MICRO COMPUTER SYSTEMS</u>										
Units (000)	73.9	67.4	3.0	3.5	--	235.7	52.9	105.7	31.2	45.9
Share %	18%	19%	20%	8%	--	16%	18%	21%	9%	16%
<u>TERMINALS</u>										
Units (000)	99.6	95.1	2.3	2.2	--	184.1	53.7	75.0	38.2	17.2
Share %	24%	27%	16%	5%	--	13%	18%	15%	11%	6%
<u>WORD PROCESSING</u>										
Units (000)	63.0	49.9	--	13.1	--	330.5	55.9	69.2	142.3	63.1
Share %	16%	14%	--	30%	--	23%	19%	14%	41%	22%
<u>HOBBY/PERSONAL COMPUTERS</u>										
Units (000)	26.7	9.2	--	17.5	--	234.5	31.8	21.6	118.0	63.1
Share %	7%	3%	--	40%	--	16%	11%	4%	34%	22%
<u>OTHER APPLICATIONS</u>										
Units (000)	16.6	15.3	--	1.3	--	55.4	13.3	17.3	10.4	14.4
Share %	4%	5%	--	3%	--	4%	4%	3%	3%	5%
<u>TOTAL, ALL APPLICATIONS</u>										
Units (000)	407.4	349.0	14.7	43.7	--	1,436.0	298.0	504.0	347.0	287.0
Share %	100%	100%	100%	100%	--	100%	100%	100%	100%	100%

TECHNICAL REVIEW

Competing technologies

Flexible disk drives have achieved phenomenal growth because they offer an attractive combination of low cost, random access and media removability. This combination of features has been in demand by the information processing industry in the 1970's, triggered by the continuing distribution of computing power to individual workstations. Floppy drives remain the most suitable auxiliary storage method for innumerable applications because no alternative device with an equal combination of capabilities is available.

At this time, it does not appear that serious challenges to the existing floppy formats are to be expected from electromechanical devices such as optical disks or other magnetic media systems. Optical disks are still limited to one-shot recording, due to lack of a reversible medium, and the hardware may be too expensive, in any event. Magnetic recording on tape, in cassette or cartridge form, can provide cheaper hardware, but is limited to applications without editing requirements, due to serial recording methods. The only conceivable magnetic recording challenge to today's floppy formats is from new floppy hardware using smaller disks.

The more serious challenges to future growth of floppy drive markets are presented by non-mechanical technologies such as CCD's and magnetic bubbles. Here is the current status of these alternative technologies:

- * Charge coupled devices: Although frequently discussed as a flexible disk competitor, CCDs will probably not be used as a replacement for floppies, but in applications which complement them. CCD's volatility precludes usage analogous to most floppy

applications, but their fast access and non-mechanical reliability are well suited for certain other requirements. Head-per-track swapping disks are a well mapped target for CCDs, and they are destined also for use as cache memories, between processors and disk drives, to increase system throughput. As the capacity of flexible disk drive systems increase, and their usage patterns approach those of rigid disk drives, it is possible that both CCDs and floppies may be used in common subsystems. Many CCD manufacturers have found it difficult to develop the market for previously announced 64 K-bit devices, in view of the emergence of 64 K-bit MOS rams at competitive prices. It is possible that widespread CCD usage may have to wait for 256 K-bit chips.

- * Magnetic bubbles: It is to be expected that magnetic bubbles will be used in the future for many jobs for which flexible disk drives would have been marginally suitable. Bubbles will probably be the more appropriate choice for system designers when reliability, ability to withstand severe environments, and small system size are the paramount requirements. But floppies will still be the choice of most designers well past 1981 for almost all of the current floppy applications, because they offer off-line storage of inactive files. If cost effective removability is ever offered by magnetic bubbles, it will be well into the future, and would involve units of capacity quite small compared to flexible disk media.

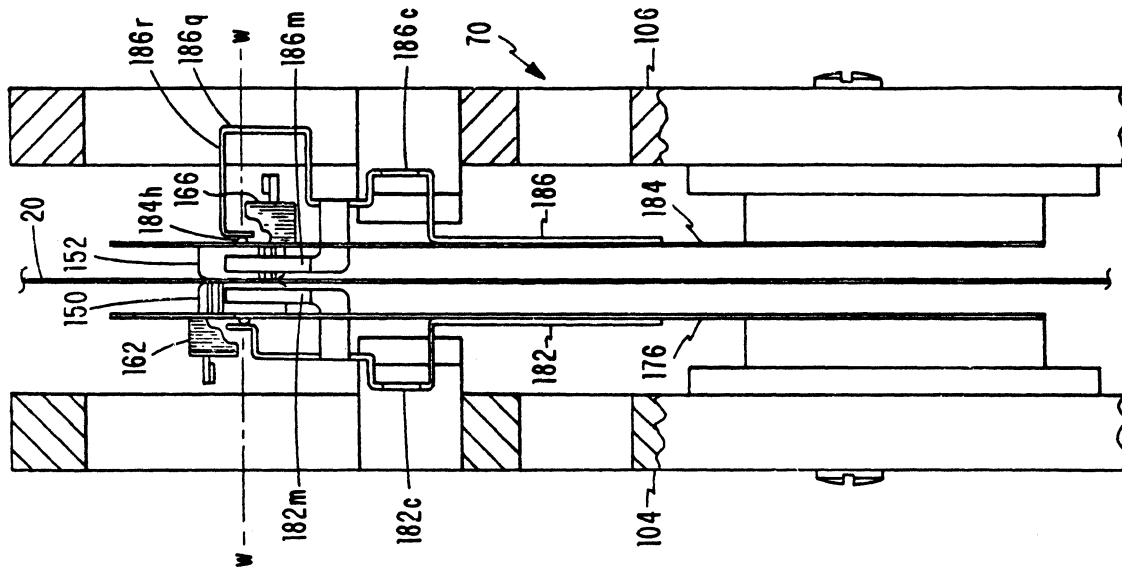
In the meantime, 92 K-bit magnetic bubble chips are available from Texas Instruments after a difficult production start-up, 256 K-bit chips are being announced by TI and others, and 1 M-bit chips are coming in a year or two. With the availability of 250 K-bit bubble chips from multiple vendors, combined with peripheral and controller circuits on integrated circuit chips, designers for independent system OEMs will finally have a chance to use bubbles where they make sense. Of course, major firms with in-house bubble programs have the same opportunity. Through 1981, bubbles won't be a match for floppies on cost per megabyte stored, but it is safe to expect product introductions to be commonplace. Small bubble memories will be paired with microcomputers in a myriad of applications, including high-end calculators, smart typewriters, personal computers, home appliance controllers, portable terminals and automobiles, to name some of the obvious uses. Rather than cause any significant negative impact on flexible disk drive shipments, magnetic bubbles will probably have the effect of creating entirely new markets for floppy drives -- wherever a low cost, random access, removable storage device is needed.

Floppy drive enhancements:

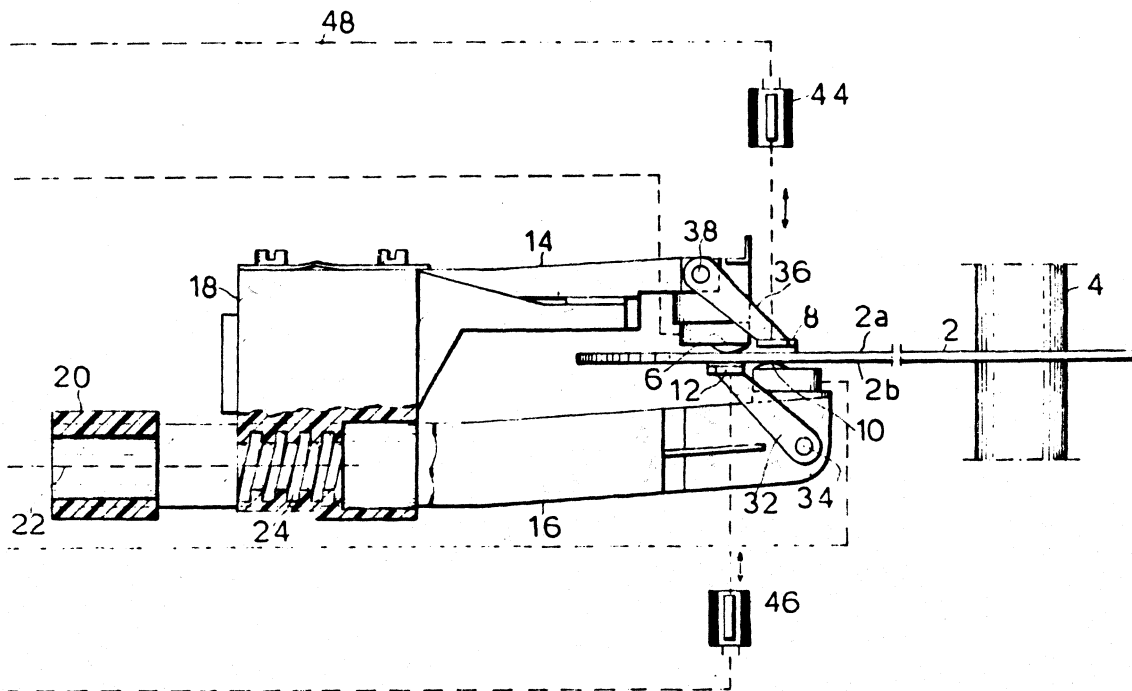
The technology of flexible disk drives has been evolving, and it will surely continue to do so. Here are the key areas to watch:

- * Double bit density: With the introduction of IBM's chosen double density format in December, 1977, on System/34, the industry's uncertainty over which double density recording system to use has been eliminated. Single chip controllers are now becoming available at low prices, and major system OEMs are designing many of their own in the IBM format. It is safe to assume a strong tendency in 1979 to introduction of systems operating at double density, and more of the same later.
- * Double track density: Micropolis remains the only flexible disk drive manufacturer to offer drives operating at more than the industry standard of 48 TPI -- the Micropolis drives use 100 TPI to provide 77 tracks on 5.25 inch media. Double track density with 8 inch diskettes is apparently not possible with existing media, because the thermal and hygroscopic extremes to which floppies are exposed cause uneven distortion of the plastic substrate. 48 TPI is practical under these environmental conditions, but track registration at double density can be problematical. More stable media does not appear to be available soon, so the answer to double track density for 8 inch drives must come from either isolating the media in a stable environment or providing a head positioning system capable of following eccentric tracks. Either solution could raise costs greatly, thus removing one of the key reasons for using floppies in the first place. Burroughs is known to have offered a new drive to selected customers, using 150 TPI in a drive with 5 MB formatted capacity per spindle, but the price level and introduction date has not been announced.
- * Two sided drives: The industry has experienced a painful start-up in providing independent two sided drives similar to IBM's, in which the heads on each side of the media are directly opposite each other, eliminating the pressure pad used on one sided drives. As noted in the patent illustrations in Figure 5, the Burroughs approach uses a pressure pad opposite each head. Although it apparently eliminates the media wear problem experienced with the IBM approach, the Burroughs technique could cause a problem with pressure pad wear in long term usage. It now appears that the rest of the industry, which is using IBM-style heads, and a variation by Tandon Magnetics, is finally prepared for large-scale production. The key problems involved results of "tap" tests performed in OEM evaluations, in which heads are loaded repeatedly at the same point -- and which produced excessive media wear by most early OEM drives. Changes in head contours, carriages, timing of the loading cycle and media have all contributed to improved performance, and drive production is now steadily increasing.
- * Access time: PerSci remains alone as the only drive manufacturer offering a linear motor actuator, with much faster access times

ILLUSTRATIONS FROM SELECTED PATENTS
MAGNETIC HEADS FOR FLEXIBLE DISK DRIVES



Enlarged side view of heads in IBM design for two sided drive
U.S. PATENT 4,089,029 May 9, 1978



Reduced side view of heads in Burroughs design for two sided drive
U.S. PATENT 4,085,428 April 18, 1978

than the rest of the industry. In view of Per Sci's outstanding growth in sales, it's hard to understand why this capability has not been more widely offered. So far, the rest of the industry has found the 3 millisecond track to track access time offered by the new band actuators to be all the improvement required.

- * Revolutionary improvements: It remains possible that elements of existing floppy technology may be reconfigured into new storage systems of various types. Some of the leading possibilities are systems which would use smaller disks, larger disks, or multiple disk stacks. The smaller flexible disk drive continually receives attention on the industry rumor circuit, probably because it would seem to be naturally suited for use with smart typewriters, personal computers and some types of terminals, and would presumably lower the cost threshold for floppy drives even further. Shugart and/or IBM are usually mentioned in the rumors. However, Shugart could dampen growth of its large market for 5.25 inch drives with a new small floppy, and is probably not ready to make such a move soon. IBM could make good use of such a drive in the typewriter/word processing area, but there are no clear hints of any such intention. Larger disks are also sheer speculation -- with the potential advantage being larger capacity.

In the last year additional patents have been issued to both IBM and Burroughs for various features of multiple disk stacks using flexible disks. Burroughs has been developing an 80 MB system using 4 two sided flexible disks in a stack which rotates at high speed. IBM's work is believed to involve a larger number of disks. Either system could have an attractive future as low cost auxiliary storage for small business systems requiring large quantities of data available on-line, but not needing the high performance of more expensive rigid disk drives. In any event, if a flexible disk stack drive is eventually introduced, it will probably be by a major system manufacturer.

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. All terms defined below are used throughout the DISK/TREND Report with the meanings given.

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

Captive: Disk drives manufactured internally or by a subsidiary of a computer manufacturer or system OEM, and sold 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 the OEM market class are classified accordingly. Most DISK/TREND statistics separate data between IBM and "other captive", but the term still pertains to the disk drives involved, not the manufacturer. Examples:

- * Drives sold by DEC, Burroughs or Olivetti are considered captive, if internally manufactured.
- * In the case of a joint venture disk drive manufacturer such as Magnetic Peripherals, Inc., a joint venture of Control Data and Honeywell, MPI drives sold by Honeywell are included in captive, and MPI drives sold by CDC are included in captive, PCM or OEM groups, as appropriate.

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

- * Shipments by Pertec or Wangco are non-captive, except for drives sold with systems by parent companies or subsidiaries.
- * CDC drive sales to NCR are non-captive, in that NCR does not share in ownership of MPI, and are included in OEM totals.

PCM: Disk drives sold or leased by "plug compatible manufacturers" directly to end users; to be included in this category, drives must be supplied in plug compatible configurations for installation with systems sold by other manufacturers. Although the PCM category currently consists primarily of drives intended for use with IBM systems, such as

Series/1, it may include any drives which are suitably equipped to be connected without additional hardware to systems to all types, including minicomputers and small business systems.

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

Independent: Any disk drive manufacturer other than IBM.

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

- * An OEM shipment by a U.S. drive manufacturer to a European system manufacturer is included in worldwide totals.
- * An OEM shipment by a Japanese drive manufacturer to a U.S. system manufacturer is included in U.S. totals.
- * A Burroughs shipment of a drive manufactured in Europe to a European end user is included in worldwide totals.

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

- * IBM, Memorex and Burroughs are considered U.S. manufacturers, even though each firm manufactures some of its disk drives in non-U.S. locations.
- * Siemens, which manufactures flexible disk drives in Mexico, is considered a non-U.S. manufacturer despite the fact that these products are managed by the firm's OEM peripherals operation in California. Siemens acquired General Systems International's flexible disk product line in early 1978; shipments of the same products through the end of 1977, before the Siemens acquisition, are classified as originating from a U.S. manufacturer.
- * BASF is considered a non-U.S. manufacturer, although the firm is initiating manufacture of flexible disk drives in the U.S.

Revenue: Based on sale of disk drives alone, as normally sold by individual manufacturers, without auxiliary hardware or spare parts. When sold as an integral part of a system or subsystem, the value of the disk drive alone has been estimated for DISK/TREND purposes. Sale prices are actual public sale transaction prices, whether at captive end user, PCM, or OEM levels. All projected prices are in 1978 constant dollars.

Spindles: The basic unit used in counting disk drives. One spindle consists of the disk drive mechanism required to utilize a single disk or stack of disks operated as a unit, whether disks are fixed, completely removable, or a combination of fixed and removable. All DISK/TREND unit totals are counted in spindles, even though some drive configurations include more than one spindle. On an arbitrary basis, the PerSci drives which utilize a single actuator mechanism to control head movement on two separate flexible disks are counted as two spindles each.

Forecasts: Expected performance of 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 two sided recording, disks in non-standard sizes, or new physical configurations would probably require establishment of new DISK/TREND product categories.

Distribution channels: Shipments of non-captive drives are analyzed by each of the following distribution channels:

Mainframe computer manufacturers: The major manufacturers of medium and large scale computers. In the U.S. this group consists of IBM, Sperry Univac, Honeywell, Burroughs, Control Data and NCR.

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

System OEMs/system houses: (1) OEMs which manufacture a system requiring floppy drives, such as Incoterm, Vydec or Tektronix. (2) Systems houses, of any size, which combine finished components and custom software to offer users complete systems.

Independent peripherals suppliers: Specialized manufacturers which buy drives, add controllers, interfaces, power supplies and other equipment or software, and offer complete subsystems to end users, system OEMs and system houses. Examples are Data Systems Design, Advanced Electronic Design and North Star.

Retail computer stores: Outlets performing the function of local trading area dealers, usually with a store suitable for walk-in trade, offering low cost computer systems, peripherals, other components and advice to individual buyers. Includes chain stores and direct mail marketing companies -- however, firms which take system responsibility for stock computer products, such as Tandy's Radio Shacks and the Heathkit organization, are considered system OEMs.

FLEXIBLE DISK DRIVES, 8 INCH, ONE SIDE

Coverage

Examples of flexible disk drives in this group include:

IBM	3740, System/32
BASF	6101, 6102
Calcomp	142M
Control Data	9400, 9404
Datapoint	9381 series
Digital Equipment	RX01, RX02
Innotronics	410, 420
Logabox	LX 45D
Memorex	651, 550
MFE	500
Olivetti	FDU 2010
PerSci	70, 277
Pertec	410, 500 series
Remex	RFD 1000
Sagem	DS3
Shugart	SA 900/901, SA 800/801
Siemens	100-8
Sycor	FD 145
Sykes Datatronics	7150, 9150
Toshiba	ND-10
Wangco	76
YE Data	YD-74C

This category includes all drives designed to use single sided flexible disks of nominal 8 inch diameter, including both "soft sector" and "hard sector" drives. Most soft sector drives are designed to use IBM compatible media, with a single index hole. Hard sector drives use additional holes in the disks to identify sectors and include both the Memorex 651 format and the more widely used Shugart format.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
U.S. manufacturers	184.8	241.7	255.0	205.4	154.6
All manufacturers	254.6	340.4	359.4	292.4	218.7

The dynamic growth of this product group continued in 1977, with a 76% increase in worldwide unit shipments. 1978 worldwide shipments will be considerably greater than previously expected, rising to an estimated 510,000 units, a 46% increase over 1977. Among major manufacturers of one sided 8 inch drives, only IBM's shipments appear to have already peaked -- due to the maturity of the 3740 series of data entry terminals and IBM's preference for two sided drives on recently introduced equipment using floppies. Significant IBM shipments of one sided drives continue, however, on System/32 and other applications.

Underlying the high growth rate in non-IBM shipments of 8 inch one sided drives has been the continued good economic climate, plus heavy usage of floppy drives in rapidly expanding segments of the information processing industries, such as small business systems and terminals. And, during late 1977 and more than half of 1978, technical problems associated with two sided drives have slowed their introduction and subsequent displacement of major portions of the market share held by one sided drives. Many system OEMs have temporarily continued large volume purchases of one sided drives, despite a desire to utilize the higher capacities of two sided drives, to provide time to insure that the new drives will not cause field problems.

The OEM market continues to generate about 65% of worldwide unit shipments, with a total of 334,000 drives projected for 1978. OEM shipments

for the same period will generate only 32.5% of worldwide revenues, however, because of the prices at which drives are sold to system OEMs, computer manufacturers, systems houses and other buyers. DISK/TREND estimates of average OEM prices have been revised downward for 1977 and 1978, based on actual sales experience of the manufacturers. Average OEM price per spindle is now estimated at \$324 for 1978 shipments to U.S. destinations, and \$331 worldwide.

Among U.S. manufacturers, Shugart Associates increased its market share of unit shipments to worldwide destinations from 32.9% in 1976, to 54.3% in 1977. Control Data is now solidly in second place, with 15.1% in 1977. PerSci was the only other U.S. manufacturer to increase market share in 1977; the firm increased its shipments more than four times over the previous year, achieving a 3.1% market share. All other U.S. manufacturers lost market share in 1977, led by Calcomp, due to its loss of the DEC business to an internal manufacturing program. Memorex, GSI (now Siemens), Pertec and Wangco all dropped 1-2% in market share points.

Due to changes in ownership of two U.S. manufacturers, certain changes are being made in DISK/TREND forecasts which include their shipments. General Systems, Inc., sold its flexible disk drive product line to Siemens, and shipments will now be considered as originating from a non-U.S. manufacturer for 1978 and later years. Siemen's shipments are classified as partly OEM and partly captive, as appropriate. Shugart Associates was acquired by Xerox at the end of 1977, and starting in 1978 a portion of Shugart's shipments are considered captive, reflecting usage of Shugart drives in Xerox products.

Production of captive drives also grew substantially, following a production curve which lags a few years behind that for OEM drives. In 1978

worldwide shipments of captive drives by U.S. manufacturers is projected at 66,200 spindles, with shipments of non-U.S. manufacturers at 69,500 spindles. The largest individual manufacturing programs are those of DEC and Olivetti.

Marketing trends

Ironically, the rapid growth of shipments for 8 inch one sided drives is expected to be matched by a rapid decline, as system designers turn to two sided drives for most applications requiring additional capacity. The more volatile OEM drive market is expected to lead the decline, as noted in this comparison of projected annual worldwide unit shipments:

	<u>All drives</u>	<u>OEM drives</u>
1977	+76.0%	+69.7%
1978	+46.1%	+50.1%
1979	+ 6.7%	- 4.5%
1980	-25.2%	-34.2%
1981	-26.8%	-37.9%

DISK/TREND forecasts for this group are based partially on the assumption that the functional problems which disrupted introduction of two sided drives are now manageable, and that large-scale production of two sided drives will be available from most manufacturers of OEM drives in 1979. In this event, large chunks of OEM drive business will be diverted from one sided drives in several application areas, most notably in small business systems.

IBM's production of one sided drives is expected to decline, but at an average annual rate of only 6% -- due to continued usage on System/32

and several terminals, plus the fact that IBM's original one sided diskette format is a basic media interchange standard. Other captive production programs will probably not peak until 1979, since most of the parent system manufacturers are taking a more leisurely approach to initiation of production for two sided drives.

Average OEM price levels are destined to decline further. Learning curve improvements in manufacturing costs will reflect the lessons learned and volume levels achieved for all types of floppy drives, not just the 8 inch one sided kind. And most manufacturers will allow individual OEMs to amalgamate purchases of all types of floppy drives for the purpose of calculating quantity discounts -- thus significantly tending to reduce average unit prices, as shipping volumes of floppy drives grow on an overall basis. DISK/TREND forecasts of OEM prices indicate an 8% reduction in average unit prices with each doubling of total 8 inch one sided units shipped worldwide through 1981.

There is no doubt that Shugart Associates will retain leadership among manufacturers of OEM drives through 1981, but it may be difficult during this period for Shugart to capture additional market share. Several other competitors are recovering from shaky periods with new products now in production, with manufacturing lines designed for efficient, volume production, and with new managements in place.

Technical trends

It is not anticipated that future advances in floppy disk drive technology will be introduced first in the 8 inch one sided format, but it is probable that this format will benefit from advances pioneered in other floppy disk formats.

For example, most of the OEM 8 inch one sided drives shipped in recent times have been capable of double density (double bit density) operation, but have actually been used as standard density drives, because of OEM concern over lack of standardization in double density recording formats. However, IBM has now contributed another de facto standard to the industry -- the double density standard first shipped on two sided drives with System/34 in December, 1977 -- and a rapid build-up of double density usage is now expected. The trend will be helped greatly by current introductions of low cost single chip controllers, using the IBM double density recording format. Other potential improvements originated for other formats may include double track density, improved media and faster actuator mechanisms.

Forecasting assumptions

1. 8 inch two sided drives will be favored for most capacity sensitive applications designed for introduction in 1979 or later.
2. 8 inch one sided drives will retain wide usage through 1981 for several application areas, including data entry and some other devices requiring media interchange in the IBM format.
3. Existing applications for 8 inch, one sided drives in word processing systems will be almost entirely replaced by 5.25 inch drives within the next few years.
4. The trend to internal production of floppy drives by mainframe and major minicomputer manufacturers will continue.

TABLE 8
FLEXIBLE DISK DRIVES, 8 INCH, ONE SIDE
REVENUE SUMMARY

DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)

	1977 Shipments		Forecast							
			1978		1979		1980		1981	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM	64.2	85.6	56.4	80.6	46.9	72.2	43.1	67.5	37.8	59.9
Other U.S. Captive	29.0	38.0	53.4	72.8	73.9	99.5	59.8	81.5	42.7	59.5
TOTAL U.S. CAPTIVE	93.2	123.6	109.8	153.4	120.8	171.7	102.9	149.0	80.5	119.4
PCM	--	--	--	--	1.8	2.6	3.2	4.6	2.6	3.7
OEM	46.2	61.2	67.6	88.3	62.0	80.7	40.0	51.8	24.2	31.5
TOTAL U.S. NON-CAPTIVE	46.2	61.2	67.6	88.3	63.8	83.3	43.2	56.4	26.8	35.2
TOTAL U.S. PRODUCTION	139.4	184.8	177.4	241.7	184.6	255.0	146.1	205.4	107.3	154.6
<u>Non-U.S. Manufacturers</u>										
Captive	3.5	54.1	4.8	76.5	5.2	84.9	5.1	75.1	3.9	57.2
OEM	--	15.7	2.4	22.2	2.7	19.5	1.5	11.9	.8	7.0
TOTAL NON-U.S. PRODUCTION	3.5	69.8	7.2	98.7	7.9	104.4	6.6	87.0	4.7	64.2
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE PRODUCTION		254.6		340.4		359.4		292.4		218.8
TOTAL WORLDWIDE CAPTIVE		177.7		229.9		256.6		224.1		176.6
TOTAL WORLDWIDE NON-CAPTIVE		76.9		110.5		102.8		68.3		42.2

TABLE 9

FLEXIBLE DISK DRIVES, 8 INCH, ONE SIDE

UNIT SHIPMENT SUMMARY (000 UNITS)

Net Shipments to U.S. Destinations	Installed YE 1976	1977 Shipments				Installed YE 1977	FORECAST							
		Captive	Non- Captive	Total	1978		1979		1980		1981			
					Ship		Inst	Ship	Inst	Ship	Inst	Ship	Inst	
IBM	92.8	32.1	--	32.1	124.9	28.2	153.1	24.7	177.8	22.7	200.5	21.0	221.5	
Non-IBM	161.7	29.6	136.8	166.4	328.1	268.9	597.0	291.1	888.1	207.6	1095.7	141.0	1236.7	
TOTAL	254.5	61.7	136.8	198.5	453.0	297.1	750.1	315.8	1065.9	230.3	1296.2	162.0	1458.2	
Worldwide Net Shipments														
IBM	116.0	42.8	--	42.8	158.8	40.3	199.1	38.0	237.1	35.5	272.6	33.3	305.9	
Non-IBM	240.8	83.7	222.5	306.2	547.0	469.7	1016.7	506.0	1022.3	371.5	1393.8	164.7	1658.5	
TOTAL	356.8	126.5	222.5	349.0	705.8	510.0	1215.8	544.0	1759.8	407.0	2166.8	298.0	2464.8	

TABLE 10

FLEXIBLE DISK DRIVES, 8 INCH, ONE SIDE

SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	FORECAST									
	1977 Net Shipments		1978		1979		1980		1981	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>Non-Captive Shipments</u>										
OEM -- Units (000)	136.8	222.5	216.0	334.0	210.2	319.0	139.1	209.8	86.1	130.4
PCM -- Units (000)	--	--	--	--	1.8	2.6	3.6	5.1	3.2	4.6
<u>Average Unit Price</u>										
To OEMs (\$)	338	346	324	331	308	314	298	304	290	295
To End Users (\$)	--	--	--	--	975	990	900	885	830	845
<u>Value of Shipments</u>										
To OEMs (\$M)	46.2	76.9	70.0	110.5	64.7	100.2	41.5	63.7	25.0	38.5
To End Users (\$M)	--	--	--	--	1.8	2.6	3.2	4.5	2.7	3.9

TABLE 11

FLEXIBLE DISK DRIVES, 8 INCH, ONE SIDE
DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

<u>Distribution Channel</u>	<u>1977 U.S. Net Shipments</u>		<u>FORECAST</u>			
	<u>Units (000)</u>	<u>%</u>	<u>1978 %</u>	<u>1979 %</u>	<u>1980 %</u>	<u>1981 %</u>
Mainframe computer manufacturers	13.8	10.1	9.6	9.1	8.7	8.3
Mini/micro computer manufacturers	24.7	18.1	17.7	17.4	17.2	17.0
System OEMs/systems houses	78.7	57.5	58.6	59.4	60.0	60.6
Independent peripherals suppliers	16.9	12.4	12.9	13.2	13.4	13.6
Direct to end user/retail dealers	<u>2.7</u>	<u>1.9</u>	<u>1.2</u>	<u>.9</u>	<u>.7</u>	<u>.5</u>
TOTAL	136.8					

TABLE 12

FLEXIBLE DISK DRIVES, 8 INCH, ONE SIDE
MARKET SHARE SUMMARY
Non-Captive Disk Drives

<u>U.S. Drive Manufacturers</u>	<u>1977 Net Shipments</u>			
	<u>To United States Destinations</u>		<u>Worldwide</u>	
	<u>Units (000)</u>	<u>%</u>	<u>Units (000)</u>	<u>%</u>
Shugart Associates	77.6	56.7	97.0	54.3
Control Data	15.0	11.0	27.0	15.1
Calcomp	8.4	6.1	14.0	7.9
Memorex	8.5	6.2	11.6	6.5
GSI (Now Siemens)	7.0	5.1	7.0	3.9
Per Sci	5.2	3.8	5.5	3.1
Pertec	4.8	3.5	5.4	3.0
Wangco	3.5	2.6	3.5	2.0
Others	<u>6.8</u>	<u>5.0</u>	<u>7.5</u>	<u>4.2</u>
	136.8	100.0	178.5	100.0

FLEXIBLE DISK DRIVES, 8 INCH, TWO SIDES

Coverage

Examples of flexible disk drives in this group include:

IBM	3600 series, System/34, 4964, 4966, 5114
BASF	6104
Burroughs	9489-11, 12
Calcomp	143M, 144
Control Data	9406, 210-10
Data Recording	7200
Hitachi	201, 401
Memorex	552
MFE	700
Micro Peripherals	B82
PerSci	299
Pertec	650
Shugart	SA 850/851
Siemens	200-8
Toshiba	ND-20, ND-20D
Wangco	276
YE Data	YD-174

The Burroughs drive in this group is unique in its specifications and is offered only with Burroughs systems. All other drives listed are designed to match IBM's recording formats for two sided drives -- the Diskette 2 format for "single" density recording, and the Diskette 2D format for double density recording.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
U.S. manufacturers	25.5	57.5	128.4	264.1	373.3
All manufacturers	25.6	66.0	167.4	338.4	500.7

Through the first half of 1978, most of the 8 inch, two sided drives actually installed were made by IBM and Burroughs. Although numerous OEM drives had been announced in 1977 by U.S. and non-U.S. manufacturers, quantities delivered through mid-1978 were small, due to the technical problems which delayed acceptance of the new drives by system OEMs.

The problems with two sided drives centered on the head/disk interface, and were manifested by excessive media wear under certain operating conditions. The chief difficulty involved potential loss of data when a single track was accessed repeatedly -- a rare problem in actual operation of most systems, but a red-flag in OEM engineering evaluations of new drives. As the result of intensive development activities by manufacturers of drives, heads and media, greatly improved performance is now available with drives from many manufacturers. Production capability is still limited, however, paced by availability of critical components such as heads.

The DISK/TREND forecast for worldwide unit shipments of 8 inch, two sided OEM drives in 1978 is now 30,900 spindles, down sharply from the forecast made a year ago, a revision due entirely to the problems discussed above. U.S. manufacturers are expected to ship about two thirds of this total, with the balance from Matsushita, Toshiba, YE Data, BASF, DRI and Siemens.

Limited captive shipments by some Japanese manufacturers are expected in 1978, but no new U.S. captive production is expected to be added to the established IBM and Burroughs programs this year.

Marketing trends

It is believed that manufacturers of OEM drives have been successful in improving product quality to the extent that the majority of system OEMs

will now be willing to activate numerous deferred plans for introducing two sided drives with new systems and adding them as options on older systems.

The well-known delays in introduction of two sided drives are a major complicating factor in estimating the growth rate of this product group during the next few years. The data processing industry's demand for floppies with greater capacity must be counter-balanced with the predictable conservatism of system designers reluctant to use a device which some fear might cause field usage problems. On balance, it is believed that demand for this product is sufficient to overcome initial skepticism, assuming reasonable evaluation results by most OEMs.

The DISK/TREND forecast for 1979 worldwide shipments of OEM drives is 105,800 spindles, of which 82,000 will be shipped by U.S. manufacturers. 1979 worldwide shipment of all two sided drives is forecast at 185,000 spindles, reflecting substantial shipment increases by IBM, Burroughs and non-U.S. captive manufacturers. It is also possible that other U.S. captive manufacturing programs could be initiated in 1979.

Price levels for OEM drives are expected to decline following a pattern similar to that of 8 inch, one side drives, with two sided drives declining from a 25% premium over one side drives in 1977 to an 18% differential in 1981.

Technical trends

The most significant potential improvements in 8 inch, two sided drives involve attempts to increase capacity. The trend from "single" bit density (3,268 BPI maximum) to "double" bit density (6,536 BPI maximum)

has been slowly underway for several years. But widespread usage of double density is now expected to grow rapidly, in many cases introduced on new systems simultaneously with two sided drives. Also facilitating this movement will be the general availability of single chip controllers, now being introduced at low prices. These controllers will make broadly available the GCR recording system now established as the IBM standard -- and generally considered to be the future de facto standard for the industry.

Much industry speculation has centered on the feasibility of double track density. 100 TPI is already a standard production feature with one manufacturer of 5.25" drives, but double track density with 8 inch drives presents greater problems because of the uneven dimensional changes which occur in diskette polyester substrates when subjected to changes in temperature and humidity. The solution apparently must be found in more stable media, isolating the diskette's environment, or in using more sophisticated head positioning systems, which would be capable of following eccentric track movement. So far, such media improvement doesn't appear imminent, and the necessary drive modifications would be expensive, probably ruling them out for most OEM applications. Such a drive could be feasible for a captive manufacturer to use with a proprietary system, however, and Burroughs has indicated to key potential customers that it will introduce a two sided drive using 150 TPI, and providing 5 MB formatted capacity per spindle.

IBM has taken another approach to adding capacity -- the new magazine drive to be delivered on System/34 in January, 1979, and on Series/1 in February. This drive uses up to two magazines holding 10 diskettes each,

plus three individual diskettes, all of which may be used sequentially under system control. This appears to be IBM's answer, perhaps an interim one, to the need for backing up fixed rigid disks, and loading programs and user data. It could, of course, inspire independent versions, opening up a whole new area of floppy hardware development. One unanswered question remains after IBM's announcement: the transfer rate was given at 125 KB/sec, twice the normal for drives using Diskette 2 media. Whether IBM has changed the rotational speed, doubled the bit density (not likely), reads/writes both sides of the diskette in parallel, or whatever, will have to be answered in January.

Forecasting assumptions

1. Technical problems which delayed early shipments of 8 inch, two sided drives will have been adequately solved by head, drive and media improvements currently being implemented to allow most OEM drive manufacturers to ship drives in production quantities during the last half of 1978.
2. Two sided drives will be generally accepted by the end of 1978 by system OEMs as offering adequate reliability and data integrity.
3. Additional captive two side drives will be introduced by major U.S. and non-U.S. manufacturers by the end of 1979.

TABLE 13

FLEXIBLE DISK DRIVES, 8 INCH, TWO SIDES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)									
	1977 Shipments		Forecast							
			1978		1979		1980		1981	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM	6.6	10.6	19.0	32.3	46.0	73.6	79.0	123.4	107.3	170.4
Other U.S. Captive	8.6	14.4	10.2	17.0	21.1	14.6	45.6	65.1	75.2	100.1
TOTAL U.S. CAPTIVE	15.2	25.0	29.2	49.3	67.1	88.2	124.6	188.5	182.5	270.5
PCM	--	--	--	--	5.9	9.0	16.8	28.0	20.8	36.4
OEM	.5	.5	6.9	8.2	24.2	31.2	37.4	47.6	52.3	66.4
TOTAL U.S. NON-CAPTIVE	.5	.5	6.9	8.2	30.1	40.2	54.2	75.6	73.1	102.8
TOTAL U.S. PRODUCTION	15.7	25.5	36.1	57.5	97.2	128.4	178.8	264.1	255.6	373.3
<u>Non-U.S. Manufacturers</u>										
Captive	--	--	--	3.9	1.9	29.6	6.9	57.3	12.2	102.9
OEM	--	.1	1.6	4.6	2.2	9.4	2.2	17.0	3.7	24.5
TOTAL NON-U.S. PRODUCTION	--	.1	1.6	8.5	4.1	39.0	9.1	74.3	15.9	127.4
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE PRODUCTION		25.6		66.0		167.4		338.4		500.7
TOTAL WORLDWIDE CAPTIVE		25.0		53.2		117.8		245.8		373.4
TOTAL WORLDWIDE NON-CAPTIVE		.6		12.8		49.6		92.6		127.3

TABLE 14
FLEXIBLE DISK DRIVES, 8 INCH, TWO SIDES
UNIT SHIPMENT SUMMARY (000 UNITS)

	Installed YE 1976	1977 Shipments			Installed YE 1977	FORECAST							
		Captive	Non- Captive	Total		1978		1979		1980		1981	
						Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
<u>Net Shipments to U.S. Destinations</u>													
IBM	.6	3.3	--	3.3	3.9	9.5	13.4	20.0	33.4	32.9	66.3	44.7	111.0
Non-IBM	--	4.8	1.2	6.0	6.0	26.9	32.9	88.9	121.8	158.0	279.8	242.0	521.8
TOTAL	.6	8.1	1.2	9.3	9.9	36.4	46.3	108.9	155.2	190.9	346.1	286.7	632.8
<u>Worldwide Net Shipments</u>													
IBM	.7	5.3	--	5.3	6.0	14.7	20.7	32.0	52.7	51.4	104.1	71.0	175.1
Non-IBM	--	8.0	1.4	9.4	9.4	43.2	52.6	153.0	205.6	278.6	484.2	433.0	917.2
TOTAL	.7	13.3	1.4	14.7	15.4	57.9	73.9	185.0	258.3	330.0	588.3	504.0	1092.3

TABLE 15

FLEXIBLE DISK DRIVES, 8 INCH, TWO SIDES

SHIPMENT AND PRICE SUMMARY

Non-Captive Disk Drives

	FORECAST									
	1977 Net Shipments		1978		1979		1980		1981	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>Non-Captive Shipments</u>										
OEM -- Units (000)	1.2	1.4	20.9	30.9	70.3	105.8	111.0	177.0	163.6	260.0
PCM -- Units (000)	--	--	--	--	4.2	6.4	12.0	20.0	16.0	28.0
<u>Average Unit Price</u>										
To OEMs (\$)	410	414	405	413	376	384	357	365	342	350
To End Users (\$)	--	--	--	--	1400	1425	1400	1425	1300	1325
<u>Value of Shipments</u>										
To OEMs (\$M)	.5	.6	8.5	12.8	26.4	40.6	39.6	64.6	56.0	90.0
To End Users (\$M)	--	--	--	--	5.9	9.1	16.8	28.5	20.8	37.1

TABLE 16

FLEXIBLE DISK DRIVES, 8 INCH, TWO SIDES

DISTRIBUTION CHANNEL SUMMARY

U.S. Non-Captive Disk Drives

<u>Distribution Channel</u>	FORECAST			
	<u>1978</u> <u>%</u>	<u>1979</u> <u>%</u>	<u>1980</u> <u>%</u>	<u>1981</u> <u>%</u>
Mainframe computer manufacturers	3.9	5.7	7.5	8.2
Mini/micro computer manufacturers	18.2	20.1	21.4	22.5
System OEMs/systems houses	66.4	62.3	58.9	56.7
Independent peripherals suppliers	10.5	11.1	11.6	12.1
Direct to end user/retail dealers	1.0	.8	.6	.5

FLEXIBLE DISK DRIVES, 5.25 INCH, ONE SIDE

Coverage

Examples of flexible disk drives in this group include:

BASF	6106
Micro Peripherals	B51
Micropolis	1015-II, 1043-II
Pertec	200
Shugart	SA 400
Wangco	82

When Shugart Associates introduced the SA 400 in 1976, a media and recording standard was established for 5.25 inch drives. Each of the manufacturers listed above offers drives with nominal media interchangeability using Shugart's 35 track recording standard. Several also offer 40 track versions with higher capacities, and Micropolis has several models which operate at 100 TPI, using 77 tracks per surface. Two sided 5.25 inch drives are covered in a separate category, newly established this year.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
U.S. manufacturers	9.4	28.2	47.2	56.2	70.4
All manufacturers	9.4	29.2	49.9	65.4	86.8

1978 was expected to be a good year for 5.25 inch, one sided drives, but the extent of the demand has been startling to everyone involved. The DISK/TREND projection for 1978 worldwide unit shipments is 146,000 spindles, mostly OEM drives -- up 234.1% from 43,700 in 1977.

5.25 inch drives are now used in a wide diversity of applications, but the most significant current areas are word processing and the hobby computer market, including the large segment which is really oriented to small business applications utilizing microcomputers. Also, an extensive list of firms now offer subsystem versions of 5.25 inch OEM drives, interfaced to a variety of microcomputers, with several companies in the field enjoying attractive sales volume.

Shugart's role as innovator of this format, combined with a leadership position in 8 inch drives, was translated into an 87% worldwide market share of 5.25 inch drive spindles shipped in 1977. Wangco and Micropolis were the only other manufacturers of 5.25 inch drives which achieved normal production deliveries in 1977, with others shipping only nominal quantities.

In 1978, the U.S. manufacturers of OEM 5.25 inch drives were joined by BASF, which initiated manufacture in Germany, with a U.S. start-up also planned for late 1978. Another 1978 development was the appearance of captive 5.25 manufacturing programs for the first time, with some usage in systems offered by corporate relatives of existing OEM manufacturers -- plus the initiation of captive manufacture by QYX, the Exxon Enterprises organization now offering a smart typewriter in selected markets.

Marketing trends

This product group will continue to be dominated by OEM drives through 1981. A high proportion of OEM shipments are purchased by system OEMs too small to undertake internal disk drive manufacturing programs, especially in view of the price pressure to be expected from rapid learning curve cost

reductions attributable to the current fast build-up in shipment rates. On the other hand, it is reasonable to expect additional 5.25 inch OEM drives from U.S. and non-U.S. floppy disk drive manufacturers which have not yet entered the format, but which already have extensive manufacturing know-how with 8 inch drives. Tandon Magnetics is now offering to supply either complete or partial 5.25 inch drive assemblies to its customers for floppy heads, and it is possible that this action will add to the number of drive manufacturers participating in the 5.25 inch market.

Due to additional competition from current and future competitors in the OEM 5.25 inch drive market, Shugart's market share may be expected to decline from the high introductory-phase level of 1977. However, it would not be a surprise if Shugart retained a share of at least 50% after all the dust settles. Average worldwide OEM prices are estimated at \$193 for 1978. A decline of 5% is projected with each doubling of cumulative industry shipments, with the average worldwide OEM price reaching \$166 in 1981.

The major limiting factor in the future growth of one sided 5.25 inch drives will be two sided versions. Shipments of two sided drives have been slow to start, due to an understandable industry emphasis in solving production start-up problems on two sided 8 inch drives first. But 5.25 inch two sided drives should be generally available in 1979, and they may be expected to be more attractive to many system OEMs than single sided drives for applications such as small business systems, and many others. The net effect on 5.25 inch, one sided drives will be to hold the average annual growth rate from 1979 to 1981 at 34.2% -- a low rate of increase in the floppy drive business.

More extensive captive production by existing major floppy drive manufacturers is also a good bet. The 5.25 inch, one sided drive (plus its two sided cousin) will offer a lower cost disk system to the majors, just as it does today to the many adventurous new companies developing a myriad of microcomputer applications. The one sided 5.25 inch drive will be favored wherever cost is the most sensitive design parameter, and where IBM interchange standards can be ignored.

Technical trends

The biggest factor behind the high growth achieved by one sided 5.25 inch drives has been that they offer the lowest cost of any type of floppy drive. As a result, they possess an inherent vulnerability to any new floppy format offering significant further cost advantages. Of course, the format envisioned by many observers would use a smaller disk, in the range of three to four inches in diameter.

Among the independent manufacturers, only Shugart seems adequately positioned to carry off such an introduction. But, despite rumors, it would be an unlikely near-term move, because of an obvious negative effect on Shugart's substantial 5.25 inch drive sales. A more likely approach for Shugart would be a stripped-down 5.25 inch drive, designed for minimum performance at the lowest possible price; such a drive would retain substantial parts commonality with Shugart's standard 5.25 inch drives for manufacturing efficiency. The "Eurodisk," a small drive proposed by Standard Elektrik Lorenz, a German ITT affiliate, has so far attracted no following. IBM, of course, would create an instant industry standard if it should introduce a small floppy format, for use, perhaps, with smart typewriters and desk-top computers. Such a possibility doesn't constitute a trend, however, unless IBM actually does it.

In the meantime, look for 5.25 inch drives to become more cost-effective devices through capacity improvements. The Micropolis approach of using 100 TPI to provide 77 tracks on one surface does work, and could prove to be an example for others to follow. Micropolis has also demonstrated that 1 MB capacity is also feasible on a two sided, 77 track, 5.25 inch drive operated at 6380 BPI with a GCR encoding system. Even without such heroics, general availability of the single chip controllers designed primarily to operate 8 inch drives in the IBM double density format will have the effect of facilitating widespread use of double density recording on 5.25 inch drives.

Forecasting assumptions

1. Introduction of a smaller floppy format by either IBM or Shugart will not occur before 1980.
2. 5.25 inch, one sided drives will continue to be the dominant choice for floppy applications sensitive to cost and physical size requirements, but will be displaced in most applications also requiring larger capacity by two sided 5.25 inch drives.
3. Additional OEM and captive manufacturers will produce 5.25 inch drives in 1979.

TABLE 17

FLEXIBLE DISK DRIVES, 5.25 INCH, ONE SIDE

REVENUE SUMMARY

DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)

	Forecast									
	1977 Shipments		1978		1979		1980		1981	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	1.4	1.4	12.6	12.6	18.9	18.9	32.4	32.4
TOTAL U.S. CAPTIVE	--	--	1.4	1.4	12.6	12.6	18.9	18.9	32.4	32.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	9.0	9.4	25.5	26.8	31.8	34.6	32.6	37.3	32.0	38.0
TOTAL U.S. NON-CAPTIVE	9.0	9.4	25.5	26.8	31.8	34.6	32.6	37.3	32.0	38.0
TOTAL U.S. PRODUCTION	9.0	9.4	26.9	28.2	44.4	47.2	51.5	56.2	64.4	70.4
<u>Non-U.S. Manufacturers</u>										
Captive	--	--	--	--	--	--	--	3.3	2.1	7.8
OEM	--	--	--	1.0	.3	2.7	1.5	5.9	2.5	8.6
TOTAL NON-U.S. PRODUCTION	--	--	--	1.0	.3	2.7	1.5	9.2	4.6	16.4
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE PRODUCTION		9.4		29.2		49.9		65.4		86.8
TOTAL WORLDWIDE CAPTIVE		--		1.4		12.6		22.2		40.2
TOTAL WORLDWIDE NON-CAPTIVE		9.4		27.8		37.3		43.2		46.6

TABLE 18
FLEXIBLE DISK DRIVES, 5.25 INCH, ONE SIDE
UNIT SHIPMENT SUMMARY (000 UNITS)

	Installed YE 1976	1977 Shipments			Installed YE 1977	FORECAST							
		Captive	Non- Captive	Total		1978		1979		1980		1981	
						Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
<u>Net Shipments to U.S. Destinations</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	.9	--	41.8	41.8	42.7	134.9	177.6	198.5	376.1	232.3	608.4	268.0	876.4
TOTAL	.9	--	41.8	41.8	42.7	134.9	177.6	198.5	376.1	232.3	608.4	268.0	876.4
<u>Worldwide Net Shipments</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	1.0	--	43.7	43.7	44.7	146.0	190.7	226.0	416.7	288.0	704.7	347.0	1051.7
TOTAL	1.0	--	43.7	43.7	44.7	146.0	190.7	226.0	416.7	288.0	704.7	347.0	1051.7

TABLE 19

FLEXIBLE DISK DRIVES, 5.25 INCH, ONE SIDE

SHIPMENT AND PRICE SUMMARY

Non-Captive Disk Drives

	FORECAST									
	1977 Net Shipments		1978		1979		1980		1981	
	<u>U.S.</u>	<u>Worldwide</u>	<u>U.S.</u>	<u>WW</u>	<u>U.S.</u>	<u>WW</u>	<u>U.S.</u>	<u>WW</u>	<u>U.S.</u>	<u>WW</u>
<u>Non-Captive Shipments</u>										
OEM -- Units (000)	41.8	43.7	132.9	144.0	180.5	208.0	200.8	251.0	210.5	280.0
<u>Average Unit Price</u>										
To OEMs (\$)	215	216	192	193	178	179	170	172	164	166
<u>Value of Shipments</u>										
To OEMs (\$M)	9.0	9.4	25.5	27.8	32.1	37.3	34.1	43.2	34.5	46.6

TABLE 20
 FLEXIBLE DISK DRIVES, 5.25 INCH, ONE SIDE
 DISTRIBUTION CHANNEL SUMMARY
 U.S. Non-Captive Disk Drives

<u>Distribution Channel</u>	<u>1977 U.S. Net Shipments</u>		<u>FORECAST</u>			
	<u>Units (000)</u>	<u>%</u>	<u>1978 %</u>	<u>1979 %</u>	<u>1980 %</u>	<u>1981 %</u>
Mainframe computer manufacturers	--	--	--	2.1	3.0	3.8
Mini/micro computer manufacturers	5.0	12.0	12.2	12.5	12.7	12.9
System OEMs/systems houses	30.0	71.8	73.2	71.7	71.3	70.8
Independent peripherals suppliers	5.2	12.4	10.9	10.2	9.8	9.5
Direct to end user/retail dealers	<u>1.6</u>	3.8	3.7	3.5	3.2	3.0
TOTAL	41.8					

TABLE 21
 FLEXIBLE DISK DRIVES, 5.25 INCH, ONE SIDE
 MARKET SHARE SUMMARY
 Non-Captive Disk Drives

<u>U.S. Drive Manufacturers</u>	<u>1977 Net Shipments</u>			
	<u>To United States Destinations</u>		<u>Worldwide</u>	
	<u>Units (000)</u>	<u>%</u>	<u>Units (000)</u>	<u>%</u>
Shugart Associates	36.1	86.3	38.0	87.0
Wangco	3.0	7.2	3.0	6.8
Micropolis	2.5	6.0	2.5	5.7
Others	<u>.2</u>	<u>.5</u>	<u>.2</u>	<u>.5</u>
	41.8	100.0	43.7	100.0

FLEXIBLE DISK DRIVES, 5.25 INCH, TWO SIDES

Coverage

Examples of flexible disk drives in this group include:

BASF	6108
Micro Peripherals	B52
Micropolis	1015-IV, 1055-IV
Pertec	250
Shugart	SA 450
Wangco	282
YE Data	YD-274

This is a new DISK/TREND category, intended to encompass the two sided versions of previously introduced 5.25 inch, one sided drives. Following Shugart Associates' announcement of the SA 450 in October, 1977, all other drive manufacturers also active in the 5.25 inch format subsequently announced two sided drives -- followed by the first Japanese manufacturer to offer 5.25 inch drives, YE Data (Yaskawa Electric).

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
U.S. manufacturers	--	.4	9.5	36.6	59.2
All manufacturers	--	.4	11.5	40.4	68.6

Two sided 5.25 inch flexible disk drives suffer from the same set of head/media technical problems which plagued two sided 8 inch drives during start-up of manufacturing operations. And the same improvements in heads, carriages, head load timing and media are now making it possible for shipments to commence.

Based on its position as industry leader in other floppy drive formats, Shugart is expected to jump quickly to a leading position in shipments in this product category, also. However, Shugart did not start shipping these drives until well into the second half of 1978, and total 1978 shipments by Shugart, plus other manufacturers, are expected to be small. The DISK/TREND estimate of 1978 total worldwide shipments is 1,500 spindles.

Market trends

The market available to 5.25 inch, two sided drives is expected to grow rapidly in the future. Extensive early usage is inevitable in word processing and in segments of the "computer hobbyist" market. A major portion of that market is really built around microcomputer-based small business systems, almost all of which use floppies. The inexpensive addition of large hunks of additional disk capacity will be irresistible to many OEMs making small business systems in this class.

Within a few years, widespread usage of 5.25 inch, two sided drives in all floppy drive applications is predictable, but the heaviest usage should occur in the two areas mentioned above, plus conventional minicomputer-based small business systems.

In addition to their ability to compress additional capacity into the same small physical size as one sided drives, 5.25 inch, two sided drives offer a significant step-up in cost effectiveness. The capacity range of drives in this group overlaps the capacities of 8 inch, one sided drives, but a comparison of DISK/TREND average unit prices for OEM drives in the two groups shows that 5.25 inch, two sided drives average less than 60% of

the price for 8 inch, one sided drives. With this kind of price advantage, it is inevitable that 5.25, two sided drives will be the choice for applications over a wide spectrum. It is assumed that no major manufacturer will introduce a smaller flexible disk format, including two sided versions, at least through 1980 -- which would lower the threshold price for floppy drives even further.

In view of the apparent demand for 5.25 inch, two sided drives, the DISK/TREND projection for 1979 indicates worldwide OEM shipments of 52,000 spindles, growing to 267,000 spindles in 1981. OEM prices for this group are expected to follow a similar, but somewhat steeper, declining trend than that for one sided 5.25 inch drives, so that in 1981 average prices for two sided 5.25 inch drives will be about 18% higher than for one sided 5.25 inch drives. Drives from other OEM manufacturers should be available in 1979.

IBM is not expected to be active in 5.25 inch drives, but other captive manufacturers could find the format attractive, especially in word processing and small business system applications. DISK/TREND forecasts envision the start of captive production in 1980.

The tendency for both OEM and captive floppy drive manufacturers which have so far deferred development of 5.25 inch drives to enter the field could be accelerated by the new availability of a "trade" source for drive assemblies. Tandon Magnetics' offer to supply 5.25 inch drive assemblies in either complete or partial form to its magnetic head customers could prompt introductions sooner than might otherwise be expected. An analogous development is the expected market entry of Qume Corporation, under a license agreement from YE Data.

Technical trends

Two sided drives were created to provide twice as much capacity at a relatively small increase in price. The capacity of two sided drives can be doubled again by operating them at double bit density, and it is believed that operation in this mode will be widely accepted by OEMs for two sided 5.25 inch drives, starting in 1979. Establishment of IBM's double bit density recording method as a de facto industry standard will pave the way for double density recording in two sided 5.25 inch drives, just as it will for two sided, 8 inch drives. And the low cost single chip controllers now starting to be available for this standard will be especially helpful in promoting use of double density among the OEMs using 5.25 drives, many of which are too small to justify diversion of resources to internal development of a suitable controller.

The other remaining method of increasing capacity, of course, is the 100 TPI recording system used to date only by Micropolis. This firm offers 5.25 inch, two sided drives with an unformatted capacity of up to 1.17 MB when operated in Micropolis' GCR recording method. With that kind of capacity in a 5.25" drive, can imitators ignore it forever?

Forecasting assumptions

1. Introduction of a smaller floppy format by either IBM or Shugart will not occur before 1980.
2. 5.25 inch, two sided drives will tend to be favored by system designers for applications sensitive to cost considerations, but for which more than minimum capacity levels are required.
3. Additional 5.25 inch, two sided drives will be introduced by manufacturers of OEM drives in 1979 and by captive manufacturers by 1980.

TABLE 22

FLEXIBLE DISK DRIVES, 5.25 INCH, TWO SIDES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)									
	1977 Shipments		Forecast							
			1978		1979		1980		1981	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	10.4	10.4	14.4	14.4
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	10.4	10.4	14.4	14.4
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	.4	.4	8.7	9.5	22.9	26.2	37.7	44.8
TOTAL U.S. NON-CAPTIVE	--	--	.4	.4	8.7	9.5	22.9	26.2	37.7	44.8
TOTAL U.S. PRODUCTION	--	--	.4	.4	8.7	9.5	33.3	36.2	52.1	59.2
<u>Non-U.S. Manufacturers</u>										
Captive	--	--	--	--	--	--	--	--	--	1.6
OEM	--	--	--	--	.2	2.0	.9	3.8	1.7	7.8
TOTAL NON-U.S. PRODUCTION	--	--	--	--	.2	2.0	.9	3.8	1.7	9.4
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE PRODUCTION	--	--	.4	--	11.5	--	40.4	--	68.6	--
TOTAL WORLDWIDE CAPTIVE	--	--	--	--	--	--	10.4	--	16.0	--
TOTAL WORLDWIDE NON-CAPTIVE	--	--	.4	--	11.5	--	30.0	--	52.6	--

TABLE 23

FLEXIBLE DISK DRIVES, 5.25 INCH, TWO SIDES

UNIT SHIPMENT SUMMARY (000 UNITS)

	Installed YE 1976	1977 Shipments			Installed YE 1977	FORECAST							
		Captive	Non-	Total		1978		1979		1980		1981	
			Captive			Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
<u>Net Shipments to U.S. Destinations</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	--	--	--	--	--	1.5	1.5	41.0	42.5	129.7	172.2	221.2	393.4
TOTAL	--	--	--	--	--	1.5	1.5	41.0	42.5	129.7	172.2	221.2	393.4
<u>Worldwide Net Shipments</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	--	--	--	--	--	1.5	1.5	52.0	53.5	158.0	211.5	287.0	498.5
TOTAL	--	--	--	--	--	1.5	1.5	52.0	53.5	158.0	211.5	287.0	498.5

TABLE 24

FLEXIBLE DISK DRIVES, 5.25 INCH, TWO SIDES

SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	FORECAST									
	1977 Net Shipments		1978		1979		1980		1981	
	<u>U.S.</u>	<u>Worldwide</u>	<u>U.S.</u>	<u>WW</u>	<u>U.S.</u>	<u>WW</u>	<u>U.S.</u>	<u>WW</u>	<u>U.S.</u>	<u>WW</u>
<u>Non-Captive Shipments</u>										
OEM -- Units (000)	--	--	1.5	1.5	41.0	52.0	116.7	145.0	203.2	267.0
<u>Average Unit Price</u>										
To OEMs (\$)	--	--	240	240	218	221	204	207	194	197
<u>Value of Shipments</u>										
To OEMs (\$M)	--	--	.4	.4	8.9	11.5	23.8	30.0	39.4	52.6

TABLE 25
 FLEXIBLE DISK DRIVES, 5.25 INCH, TWO SIDES
 DISTRIBUTION CHANNEL SUMMARY
 U.S. Non-Captive Disk Drives

<u>Distribution Channel</u>	FORECAST			
	1978 %	1979 %	1980 %	1981 %
Mainframe computer manufacturers	--	3.2	4.8	6.0
Mini/micro computer manufacturers	15.5	17.1	18.6	19.7
System OEMs/systems houses	79.7	69.7	64.1	60.6
Independent peripherals suppliers	1.8	6.8	9.7	11.2
Direct to end user/retail dealers	3.0	3.2	2.8	2.5

DISK DRIVE SPECIFICATIONS

Coverage

This listing includes most U.S. and many non-U.S. disk drives now in new production or announced. Also included for reference are several IBM systems in which flexible disk drives are used, even though the drives are not sold as separate products.

Generally, no attempt has been made to include drives sold by computer system manufacturers but purchased on an OEM basis from others. Also not listed in most cases are captive drives which are similar to OEM models made by the same manufacturer. Listings for most manufacturers are confined to OEM drive models, but subsystems complete with power supply, controller and interface are listed for some manufacturers, for clarity.

DISK/TREND CATEGORIES

In most cases category assignments noted for individual drives are clear, but a few arbitrary decisions have been made. The category for 8 inch, one sided drives includes not only the drives nominally compatible with IBM media, but also a variety of "hard sector" drives, including the unique Memorex 651. The newly announced IBM magazine drive has been included in the 8 inch, two sided category, based on information so far released by IBM. The magazine mechanism appears to feed diskettes to a single drive.

Generic type

In most cases IBM drive and media model numbers are used to describe the general physical form of drives and media, since IBM's designations are well known throughout the industry. However, usage of an IBM model number is not meant to imply interchangeability. Individual drives may require media with a variety of special characteristics, such as non-standard recording disks, sectors, initialization, etc.

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 disk or stack of disks operated as a unit.

Accuracy

This information has been made as accurate as possible through extensive cross-checking. However, it is anticipated that some errors may be included, due primarily to the problem that many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries were necessary. Please point out any errors -- or omissions -- you may notice; your corrections will be most welcome and will be included in the next edition.

DISK/TREND DISK DRIVE GROUPS

Flexible disk drives

10. 8 inch, one side
11. 8 inch, two sides
12. 5.25 inch, one side
13. 5.25 inch, two sides

MANUFACTURER PROFILES

Every known manufacturer of flexible disk drives headquartered in the United States is listed in this section, with a brief description of the firm's role in the industry. The heading "FDD sales" refers to the DISK/TREND estimate of self-manufactured flexible disk drives sold only -- no sales of other drive types are included, nor are sales of parts or other related products. "Total net sales" are for each parent company's 1977 fiscal year.

BURROUGHS CORPORATION
Burroughs Place
Detroit, MI 48232

313/972-7000

1977 FDD sales: \$14,400,000

1977 total net sales: \$1,180,834,874

Net income: \$215,179,580

Burroughs has been manufacturing a unique one megabyte, two sided drive since 1976 at Glenrothes, Scotland, with a later start-up at Guadalajara, Mexico. This drive is used with Burroughs small business systems and intelligent terminals, and an industry compatible one sided drive purchased from Control Data is also available with Burroughs systems. Current Burroughs floppy drive development programs include a two sided 8 inch drive with 5 MB formatted capacity per spindle and an 80 MB drive using a stack of four floppy disks on a single spindle. The firm may also find it necessary to either make or buy industry standard 5.25 inch drives to support the Redactron line of word processing equipment.

CALIFORNIA COMPUTER PRODUCTS, INC.
3320 East La Palma
Anaheim, CA 92806

714/632-0400

1977 FDD sales: \$4,700,000

1977 total net sales: \$118,224,000

Net income: (\$1,692,000)

Calcomp seems to be turning around, after years of disastrous financial results. The firm may end 1978 in the black, reflecting actions taken

to rebuild product lines and streamline the organization. Calcomp's floppy disk product line also seems to be positioned for a comeback, following the loss of a major part of its sales when DEC stopped buying drives from Calcomp in favor of an internal manufacturing program. Floppy drive manufacturing is now in a newly designed facility, with up-to-date products, and a dedicated management group. Calcomp's joint program with Tandon Magnetics to develop improved heads for two sided recording may also pay dividends in providing an ability to ship two sided 8 inch drives in quantity earlier than some competitors.

CONTROL DATA CORPORATION

8100 34th Avenue South
Minneapolis, MN 55440

612/853-8100

1977 FDD sales: \$18,000,000

1977 total net sales: \$1,512,875,000

Net income: \$62,995,000

CDC is now in second place in OEM floppy drives, and is also a major manufacturer of captive drives. Floppy drives sold by CDC are manufactured by Magnetic Peripherals, Inc., a firm jointly owned by CDC and Honeywell, with management responsibility vested in CDC. Floppy drive development and manufacturing operations are located at the MPI Oklahoma City plant, having been moved from Hawthorne, California, early in 1976.

DATAPOINT CORPORATION

9725 Datapoint Drive
San Antonio, TX 78285

512/699-7000

1977 FDD sales: \$4,400,000

1977 total net sales: \$103,000,000

Net income: \$8,400,000

Datapoint's floppy drives are manufactured under a license from Shugart Associates. It is strictly a captive manufacturing operation, with drives produced for use with the firm's intelligent terminals and other products.

DIGITAL EQUIPMENT CORPORATION

146 Main Street
Maynard, MA 01754

617/897-5111

1977 FDD sales: \$11,000,000

1977 total net sales: \$1,058,614,000

Net income: \$108,500,000

DEC set up its floppy drive manufacturing operation in 1976, and has been completely self-sufficient in floppy drive production since mid-1977. The original drive was manufactured under license from Calcomp, the outside

supplier displaced by DEC's captive program. The firm announced its first drive with double bit density in 3rd quarter, 1978. It wouldn't be a surprise to see an 8 inch, two sided drive from DEC before the end of 1979, and eventual introduction of a 5.25 inch drive is also plausible.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

914/765-1900

1977 FDD sales: \$96,200,000

1977 total net sales: \$18,133,184,000

Net income: \$2,719,414,000

Although manufacturers of OEM floppy drives produce many times the number of drives IBM does each year, IBM still sets the standards for industry interchange -- including both physical characteristics of 8 inch diskettes and recording methods. IBM's standards were established to facilitate interchange between the dozens of individual devices now using floppies on IBM systems, of course, but the corollary benefits to makers of OEM drives included simplification of the product design problem and creation of user confidence in stability of the formats. IBM's latest contribution to floppy standards were the two sided 8 inch drive in 1976 and the recording scheme for double bit density recording in late 1977. IBM has presumably passed up the 5.25 inch format introduced by Shugart Associates, and the question is: What's the next floppy drive from IBM? Could it be a smaller drive, in the 3 inch range? Could it be a mass memory using a stack of floppies? We'll all just have to keep watching.

INNOTRONICS
Brooks Road
Lincoln, MA 01773

617/259-0600

1977 FDD sales: None

Innotronics is a privately held company attempting to rise from the ashes of Innovex, one of the pioneer manufacturers of floppy drives, which closed its doors in late 1977. The Innovex assets were sold at auction by an unsympathetic bank that held an overdue loan. The rights to the product line, plus most of the inventory and equipment, were bought at auction by key Innovex employees, who promptly launched Innotronics. Freed from debt, these stubborn entrepreneurs will now have another chance to find a favorable niche in the market.

MEMOREX CORPORATION

San Tomas and Central Expressways
Santa Clara, CA 95052

408/987-1000

1977 FDD sales: \$5,300,000

1977 total net sales: \$450,112,000

Net income: \$56,325,000

Memorex was the earliest pioneer in the OEM floppy drive market, with the 1972 introduction of the 651. Despite some OEM adoptions for the 651 in its early life, Memorex failed to support the floppy program with a competitive drive compatible with IBM's 3740, in the critical year or two after it was introduced. So Shugart Associates, with its IBM compatible drive, rode the crest of the market's mainstream -- and Memorex eventually introduced a competitive IBM compatible version a few years later. The 651 has now peaked, and is on the way down. Memorex' 8 inch, one sided and two sided IBM compatible drives are now in production, with shipment volume starting to build. Memorex' chance for a future role in the OEM floppy drive market will probably depend on whether the company's management is willing to provide a dedicated OEM development and sales organization -- then have the patience to wait for the slow maturation period required by OEM marketing programs.

MFE CORPORATION

Keewaydin Drive
Salem, NH 03079

603/893-1921

1977 FDD sales: Minimal

MFE is a privately held company which achieved a major position as a manufacturer of OEM digital cassette drives. MFE announced in mid-1977 a two sided 8 inch floppy drive, with deliveries planned for 3rd quarter, 1977. Unfortunately, the firm suffered from the same start-up problems with two sided drives as the rest of the industry, and volume deliveries were deferred until well into 1978. MFE is an established marketer of small OEM peripherals, and the firm has the chance with floppies to add substantially to its sales volume.

MICRO PERIPHERALS, INC.

21201 Oxnard Street
Woodland Hills, CA 91367

213-999-2870

1977 FDD sales: Minimal

Started in 1977, Micro Peripherals is a privately held company formed by key personnel from Orbis (now part of the Perkin-Elmer Wangco operations). Production is underway for a 5.25 inch, one sided drive, and a two sided version is planned for late in the year. The Micro Peripherals strategy is to produce an OEM drive designed for efficient production in large quantities, and marketing activities have been designed accordingly -- with early sales to manufacturers of microcomputer-based small business and hobby computer systems.

MICROPOLIS CORPORATION
7959 Deering Avenue
Canoga Park, CA 91304

213/703-1121

1977 FDD sales: \$1,200,000

Micropolis is a privately held company founded in 1977 by two ex-founders of Pertec. It successfully introduced the only floppy drive to operate at 100 TPI -- a 5.25 inch drive originally sold primarily as a subsystem to computer stores. Micropolis has since started to emphasize OEM sales to manufacturers of microcomputer-based systems, and has added drives operating at the industry standard 48 TPI, as well as two sided drives. This firm has gotten off to a fast start, and will probably continue to be an industry innovator.

PER SCI, INC.
12210 Nebraska Avenue
West Los Angeles, CA 90025

213/820-3764

1977 FDD sales: \$2,300,000

PerSci was founded in 1974, as a privately held company, and struggled hard in its first few years to pioneer the market for a drive with a faster actuator than the standard stepping motor systems offered on all other floppy drives. However, the segment of the floppy market willing to pay a higher price for higher performance finally emerged, and PerSci is now struggling to meet the demand. The firm has greatly expanded its production facilities in 1978, and is now also shipping a two sided version of its 8 inch drive.

PERTEC COMPUTER CORPORATION
Pertec Division
9600 Irondale Avenue
Chatsworth, CA 91311

213/882-0030

1977 FDD sales: \$9,700,000

1977 total net sales: \$94,520,000

Net income: \$4,691,000

Pertec's floppy product line now includes 8 and 5.25 inch drives in both one sided and two sided models, and stretches from OEM versions to complete subsystems. Marketing activities to the microcomputer-based systems and hobbyist markets now constitute a major portion of Pertec's floppy drive sales, following acquisition during the last two years of iCOM and MITS. Pertec is getting its act together after years of reorganizing its peripherals management, and still has to demonstrate an ability to expand its floppy drive market share.

QUME CORPORATION
2323 Industrial Parkway West
Hayward, CA 94545

415/783-6100

1977 FDD sales: None

Qume's outstanding success in developing the market for daisywheel printers has put the firm in a position to produce other products for the same markets -- and floppy drives are one of the obvious choices. Qume has acquired a manufacturing license from YE Data (Yaskawa Electric) for 8 inch and 5.25 inch drives, and is expected to be an active participant in the OEM floppy drive market. The firm is privately owned.

QYX
Division of Exxon Enterprises, Inc.
329 Gordon Drive
Lionville, PA 19353

215/363-3000

1977 FDD sales: None

1977 total net sales: \$57,529,219,000

Net income: \$2,422,964,000

QYX is one of the numerous Exxon organizations established to utilize emerging technology in securing a major position in the high-growth markets for information processing equipment. The firm announced a family of intelligent typewriters early in 1978, using a daisywheel printer of unconventional design. 5.25 inch floppy drives are used on the high-end models of the QYX product line, and the firm is developing its own drives, to fit in a smaller space than currently available OEM drives. Shipments start in 1978, and QYX could develop into one of the largest captive manufacturers of floppy drives within a few years.

REMEX DIVISION
EX-CELL-O CORPORATION
1733 Alton Street
Irvine, CA 92713

714/557-6860

1977 FDD sales: \$300,000

1977 total net sales: \$446,635,778

Net income: \$29,062,784

REMEX, an industry leader in punched paper tape equipment, started its floppy drive manufacturing program in 1975. The firm's main marketing thrust for floppy drives has been in selling complete subsystems to systems houses and small system OEMs. Remex' market penetration to date has been small, but there have been several management changes in the past year, with indications that the firm plans more emphasis on floppy drives.

SHUGART ASSOCIATES
 Subsidiary of Xerox Corporation
 415 Oakmead Parkway
 Sunnyvale, CA 94086

408/733-0100

1977 FDD sales: \$40,100,000
 1977 total net sales: \$5,076,900,000 Net income: \$406,627,000

In 1977 Shugart increased its share of 8 inch, one sided floppy drive worldwide unit shipments by 54.3%, and retained its hold on 87% of the 5.25 inch, one sided drive OEM worldwide market. Results like this reflect the thoroughness of Shugart's marketing coverage, and the efficiency of its manufacturing program -- combined with a continuing policy of aggressive pricing. The firm has increased its share of the 8 inch drive market by making fewer mistakes than its competitors, and earned its position in 5.25 inch drives by pioneering the format, with the lowest prices ever available for floppy drives. Good profit margins have been made possible by the industry's largest production volume, with lower costs than competitors. Like its competitors, however, Shugart had great difficulty in establishing volume production for two sided drives, due to technical problems with the head/media interface. The problems now appear to be manageable with the shipping rate for two sided drives building up. In the meantime, Shugart sold a large number of one sided drives that otherwise wouldn't have been shipped.

SYCOR, INC.
 100 Phoenix Drive
 Ann Arbor, MI 48104

313/971-0900

1977 FDD sales: \$5,100,000
 1977 total net sales: \$76,769,000 Net income: \$3,184,000

Northern Telecom acquired Sycor in 1978. Sycor has been producing floppy drives since 1974, with most of its production used with the firm's various families of terminals. Although the firm offered floppy drives for sale in the OEM market, along with other internally manufactured peripherals, floppy OEM shipments have been small, and the program is being de-emphasized.

SYKES DATATRONICS, INC.
 375 Orchard Street
 Rochester, NY 14606

716/458-8000

1977 FDD sales: \$1,100,000
 1977 total net sales: \$5,008,001 Net income: \$495,420
 (Fiscal year ended 2/28/78)

Sykes makes and sells digital cassette and floppy disk drive hardware for minicomputers and communications terminals. Floppy drive manufacturing is under an Orbis license, with all drives sold as complete subsystems.

TANDON MAGNETICS CORPORATION
 20731 Prairie Street
 Chatsworth, CA 91311

213/998-8877

1977 FDD sales: None

Tandon Magnetix achieved a dominant share of the non-captive market for magnetic heads used with one sided floppy drives within a few years of the firm's founding. In the current struggle between competing designs for two sided floppy drives, Tandon is regarded as a leading competitor, regardless of which design eventually prevails. Recognizing that many floppy drive manufacturers have failed to proceed with internal development of 5.25 inch drive programs, Tandon has offered to provide such drives as a "trade" source to its magnetic head customers. Tandon will sell either complete or partial assemblies, and the drive manufacturer can add 5.25 inch drives, both one and two sided models, to his product line without the expenses and delays involved in an internal development program. In view of the current phenomenal growth rate of 5.25 inch floppy drives, Tandon may have picked another winner.

WANGCO, INC.
 Subsidiary of Perkin-Elmer Corporation
 Perkin Elmer Data Systems Group
 5404 Jandy Place
 Los Angeles, CA 90066

213/390-8081

1977 FDD sales: \$2,500,000

1977 total net sales: \$432,425,000

Net income: \$26,562,000

Wangco's floppy drive business has had to be rebuilt after the acquisition of Orbis, an early floppy drive manufacturer, in 1976. The firm lost DRI, its largest customer, to an internal manufacturing program. During the last year, several management changes have occurred at Wangco, as Perkin-Elmer reorganized its various data processing operating units. At present, Wangco still has not achieved significant sales momentum with 8 inch drives, but is expanding production of 5.25 inch drives rapidly to support sharp sales increases to OEMs in the hobby computer market.