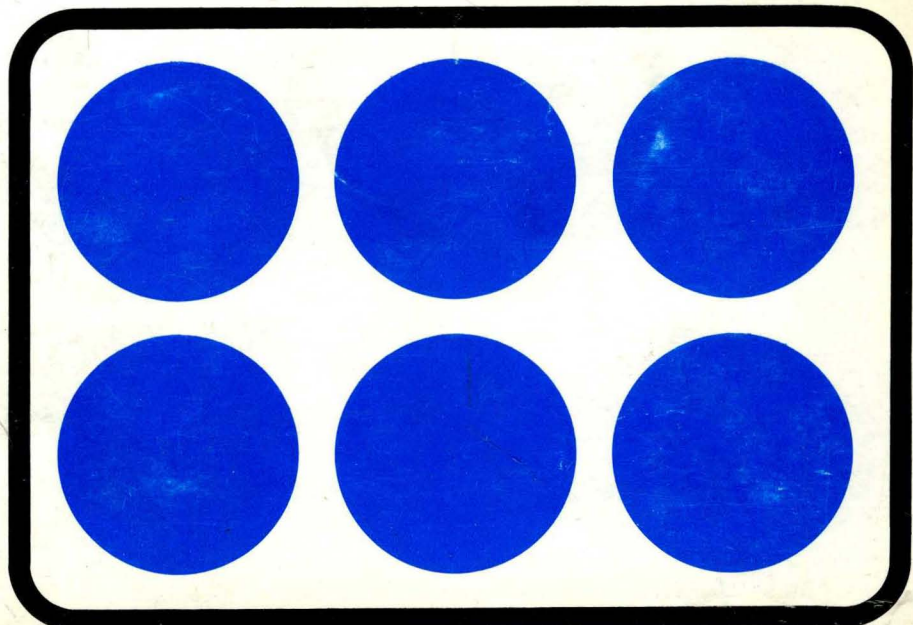


1978 DISK/TREND REPORT

RIGID
DISK
DRIVES



1978 DISK/TREND REPORT

RIGID DISK DRIVES

July, 1978

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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 will be published in two sections. This volume covers moving head rigid disk drives, and a separate report to be published in September will cover flexible 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

In 1977, estimated worldwide revenues generated by moving head rigid disk drives were \$2,813,400,000, of which U.S. manufacturers provided 91.5% or \$2,573,300,000.

This year's estimate of 1977 worldwide revenues is 24.2% higher than the forecast in last year's DISK/TREND Report. Most of the difference is attributable to the exceptional installation rate of IBM 3350 drives, plus greater than anticipated increases in captive manufacturing programs by U.S. manufacturers, especially for disk pack drives over 100 MB and for disk cartridge drives. DISK/TREND forecasts for succeeding years are also higher, with the major changes due to revised estimates for U.S. manufacturers' captive programs, including IBM.

Forecasts through 1981 anticipate uninterrupted growth for the industry, resulting from demand for new disk drives, including fixed disk drives of all sizes, storage module drives, and high capacity disk cartridges drives. Worldwide revenues for 1981 are forecasted at \$4,745,500,000, representing an average annual growth rate (AAGR) of 14.0%. The growth rate for U.S. manufacturers is placed lower -- an AAGR of 12.7%, with 1981 revenues of \$4,141,000,000. Non-U.S. manufacturers' share of worldwide revenues is expected to approach 13% by 1981.

Sale of data processing equipment is sensitive to economic factors, and 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 MOVING HEAD 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	761.8	1,236.6	702.2	1,156.7	667.8	1,117.9	916.3	1,569.3	1,012.9	1,757.8
Other U.S. Captive	538.1	837.1	647.7	1,037.4	799.6	1,260.0	891.2	1,413.9	962.2	1,522.4
TOTAL U.S. CAPTIVE	1,299.9	2,073.7	1,349.9	2,194.1	1,467.4	2,377.9	1,807.5	2,983.2	1,975.1	3,280.2
PCM	116.7	162.0	280.6	358.9	283.2	370.7	176.0	238.0	247.1	337.7
OEM	240.7	337.6	299.6	427.1	327.5	454.1	353.2	489.3	375.9	523.1
TOTAL U.S. NON-CAPTIVE	357.4	499.6	580.2	786.0	610.7	824.8	529.2	727.3	623.0	860.8
TOTAL U.S. PRODUCTION	1,657.3	2,573.3	1,930.1	2,980.1	2,078.1	3,202.7	2,336.7	3,710.5	2,598.1	4,141.0
<u>Non-U.S. Manufacturers</u>										
Captive	2.9	181.7	3.5	232.6	5.3	340.9	27.3	422.6	41.0	471.1
OEM/PCM	5.0	58.4	11.1	84.1	16.1	107.0	24.7	125.2	34.1	133.4
TOTAL NON-U.S. PRODUCTION	7.9	240.1	14.6	316.7	21.4	447.9	52.0	547.8	75.1	604.5
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION	2,813.4		3,296.8		3,650.6		4,258.3		4,745.5	
TOTAL WORLDWIDE CAPTIVE	2,255.4		2,426.7		2,718.8		3,405.8		3,751.3	
TOTAL WORLDWIDE NON-CAPTIVE	558.0		870.1		931.8		852.5		994.2	

Industry structure

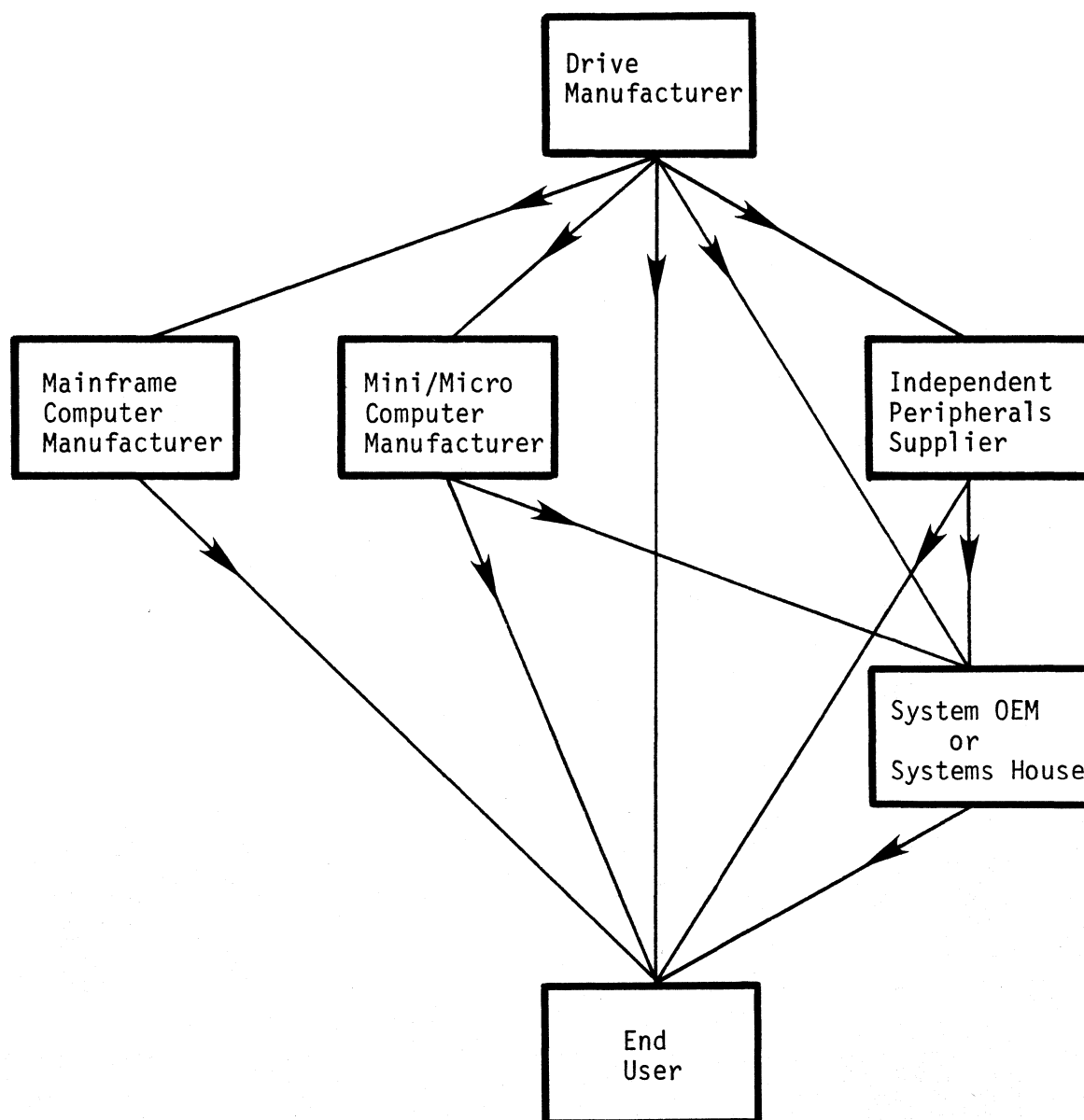
The list of manufacturers producing moving head rigid disk drives has now grown to 26 firms in the United States and 12 more in Japan and Western Europe. Not included in these totals are a few manufacturing operations in Eastern Europe making disk drives with older technology. Multinational manufacturing activities by IBM, Burroughs and others are counted as single operations.

The historical pattern for the introduction of most disk drive formats has been (1) introduction of an archetype drive by IBM, (2) delivery within a few years of PCM and/or OEM drives using the same technology with minor improvements, and (3) subsequent establishment of captive manufacturing programs by major system manufacturers of drives in various formats using the same technology.

With each succeeding generation of disk drives, IBM's designs for recording heads, disks and other components have tended to become the patterns for unofficial industry standards, insuring competitive prices and multiple sources for most unique components. Thus, market entry has been possible for a large number of small, as well as large firms.

Initiation of captive manufacturing programs by major system manufacturers is expected to continue, since attractive profit contributions may be expected, given a reasonable scale of operation. However, manufacturers of OEM drives are also expected to maintain their position in the industry, as suppliers of disk drives to hundreds of smaller system manufacturers and thousands of individual systems houses.

Figure 1
NON-CAPTIVE MARKETING STRUCTURE
Moving Head Disk Drives



Marketing channels

IBM continues to produce the largest share of worldwide disk drive revenues, but its share in any given year may vary greatly, depending on the status of the firm's individual disk drive programs. In 1977, IBM's 44% of worldwide revenues was swollen by heavy shipments of 3350's, at a relatively high price per spindle, plus healthy continuing shipments of data module drives and small fixed disk drives. DISK/TREND forecasts indicate a dip in IBM's share during 1979, based on an assumed shipment slowdown of 3350's while an enhanced version is phased in.

Other U.S. captive disk drive manufacturers appear to be growing to an industry share of revenues in the low 30% range, and establishing a plateau in that area. The largest captive revenue contribution through 1981 will continue to come from disk drives with removable media: Disk pack drives over 100 MB, storage module drives and disk cartridge drives of all sizes. Captive production of fixed disk drives will also show continuous growth, but peak production will probably come after 1981.

PCM disk drive manufacturers have been watching their shipments of 3330-type disk pack drives slide, as IBM stepped up shipments of the 3350. Now that PCM versions of the 3350 are in production, a PCM share of worldwide disk drive revenues in the 10% range is expected for a year or two. However, the roller coaster is destined to dip down again for a while when IBM introduces 3350 improvements.

OEM drives are expected to enjoy continuing growth through 1981, with a market share hovering between 11% and 13%. Manufacturers of OEM drives will certainly lose more customers to internal manufacturing activities, but their broad customer base will continue to grow in size, and new products will continue to add sales volume.

TABLE 2
 CONSOLIDATED WORLDWIDE SHIPMENTS
 MARKET CLASS REVIEW
 REVENUE SUMMARY

Worldwide Revenues By Manufacturer Type	1977 Shipments		FORECAST							
			1978		1979		1980		1981	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
<u>U.S. Manufacturers</u>										
IBM	1,236.6	44.0	1,156.7	35.1	1,117.9	30.6	1,569.3	36.9	1,757.8	37.1
Other U.S. Captive	837.1	29.7	1,037.4	31.4	1,260.0	34.5	1,413.9	33.2	1,522.4	32.1
PCM	162.0	5.8	358.9	10.9	370.7	10.2	238.0	5.6	337.7	7.1
OEM	337.6	12.0	427.1	13.0	454.1	12.4	489.3	11.5	523.1	11.0
Total U.S. Mfgr's.	2,573.3	91.5	2,980.1	90.4	3,202.7	87.7	3,710.5	87.2	4,141.0	87.3
<u>Non-U.S. Manufacturers</u>										
Captive	181.7	6.4	232.6	7.0	340.9	9.4	422.6	9.9	471.1	9.9
OEM/PCM	58.4	2.1	84.1	2.6	107.0	2.9	125.2	2.9	133.4	2.8
Total Non-U.S. Mfgr's.	240.1	8.5	316.7	9.6	447.9	12.3	547.8	12.8	604.5	12.7
<u>Worldwide Total</u>	2,813.4	100.0	3,296.8	100.0	3,650.6	100.0	4,258.3	100.0	4,745.5	100.0

Product mix

DISK/TREND forecasts indicate that fixed disk drives will increase their share of worldwide disk drive revenues from 36.5% in 1977, to 62.1% in 1981. Storage module drives are also expected to show a healthy increase in share during the forecast period, as are the new generation of high capacity disk cartridge drives.

Big losses in revenue share are predicted for older products: Disk cartridge drives less than 12 MB, disk pack drives 29-58 MB, disk pack drives more than 100 MB, and data module drives. As a combined group, their 55.9% 1977 share will sink to 18.3% in 1981.

OEM market

71.7% of worldwide OEM drive revenues are still expected to be derived from removable media disk drives in 1981 -- with major contributions from storage module drives, disk cartridge drives of all sizes, and disk pack drives over 100 MB. Fixed disk drives will grow in revenue generation also -- from 2.1% of the total in 1977 to 28.3% in 1981.

Control Data's full product line and broad customer base continue to dominate the U.S. OEM drive market, with a 42% share of 1977 OEM drive revenues by U.S. manufacturers.

PCM market

Memorex had the lead in 1977 PCM revenues by U.S. manufacturers at 35.2%, with ISS (through Intel and Telex) at 26.7% and Control Data at 21.3% -- all mostly on the strength of 3330 replacement drives. Based on 3350 performance during 1978, Storage Technology should be among the leaders next year.

Figure 2
CHANGING PRODUCT MIX
CONSOLIDATED WORLDWIDE DISK DRIVE SHIPMENTS

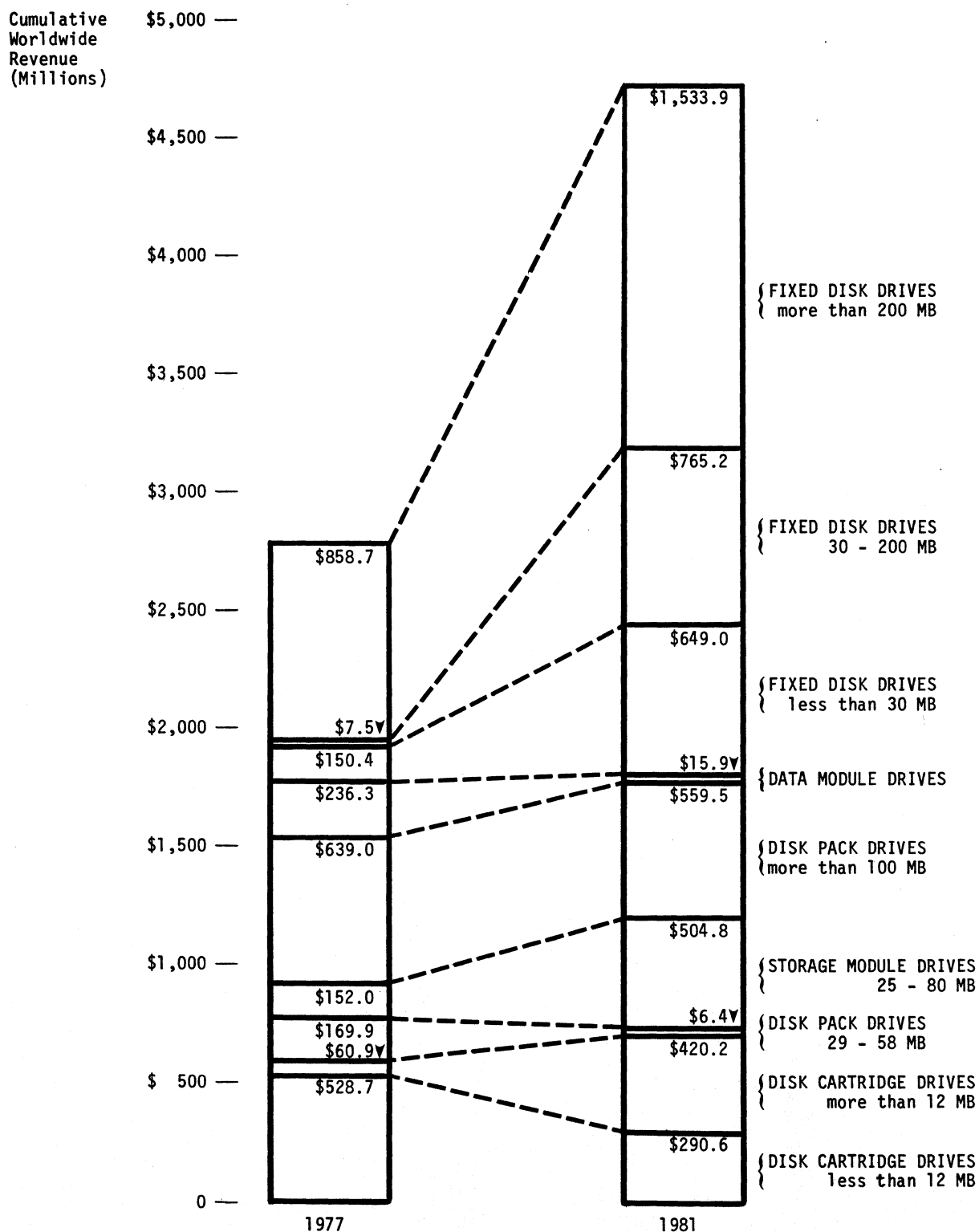


TABLE 3
 CONSOLIDATED WORLDWIDE SHIPMENTS
 PRODUCT CATEGORY REVIEW
 REVENUE SUMMARY

Worldwide Revenues All Manufacturers	1977 Shipments		FORECAST							
			1978		1979		1980		1981	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
Disk Cartridge Drives Less than 12 MB	528.7	18.8	555.9	16.9	509.7	14.0	401.2	9.4	290.6	6.1
Disk Cartridge Drives More than 12 MB	60.9	2.2	110.1	3.3	181.6	5.0	298.8	7.0	420.2	8.9
Disk Pack Drives 29-58 MB	169.9	6.0	99.7	3.0	51.6	1.4	22.9	.5	6.4	.1
Storage Module Drives 25-80 MB	152.0	5.4	230.8	7.0	330.6	9.1	434.3	10.2	504.8	10.7
Disk Pack Drives More than 100 MB	639.0	22.7	689.3	20.9	719.1	19.7	635.4	14.9	559.5	11.8
Data Module Drives	236.3	8.4	183.2	5.6	110.7	3.0	57.4	1.4	15.9	.3
Fixed Disk Drives Less than 30 MB	150.4	5.3	308.0	9.4	431.5	11.8	534.5	12.6	649.0	13.7
Fixed Disk Drives 30-200 MB	7.5	.3	24.1	.7	200.0	5.5	484.6	11.4	765.2	16.1
Fixed Disk Drives More than 200 MB	868.7	30.9	1,095.7	33.2	1,115.8	30.5	1,389.2	32.6	1,533.9	32.3
Total Worldwide Revenue	2,813.4	100.0	3,296.8	100.0	3,650.6	100.0	4,258.3	100.0	4,745.5	100.0
% U.S. Mfg.	91.5%		90.4%		87.7%		87.1%		87.3%	
Annual Growth Rate			+17.2%		+10.7%		+16.7%		+11.4%	

TABLE 4
OEM WORLDWIDE SHIPMENTS
PRODUCT CATEGORY REVIEW
REVENUE SUMMARY

Worldwide Revenues All Manufacturers	1977 Shipments		FORECAST							
			1978		1979		1980		1981	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
Disk Cartridge Drives Less than 12 MB	156.1	41.1	170.6	36.1	153.6	29.9	134.7	23.2	111.0	17.5
Disk Cartridge Drives More than 12 MB	2.7	.7	20.4	4.3	43.5	8.5	79.6	13.7	121.5	19.1
Disk Pack Drives 29-58 MB	48.7	12.8	40.3	8.5	17.9	3.5	6.0	1.0	1.7	.3
Storage Module Drives 25-80 MB	53.0	14.0	79.6	16.8	106.6	20.8	134.0	23.1	154.0	24.3
Disk Pack Drives More than 100 MB	110.6	29.1	121.3	25.7	97.9	19.1	81.0	14.0	61.1	9.6
Data Module Drives	.9	.2	5.1	1.1	6.7	1.3	7.5	1.3	5.8	.9
Fixed Disk Drives Less than 30 MB	6.6	1.8	27.0	5.7	34.0	6.6	43.0	7.4	54.5	8.6
Fixed Disk Drives 30-200 MB	1.1	.3	4.9	1.0	31.0	6.0	58.8	10.2	78.1	12.3
Fixed Disk Drives More than 200 MB	--	--	3.6	.8	22.0	4.3	35.3	6.1	46.9	7.4
Total Worldwide Revenue	379.7	100.0	472.8	100.0	513.4	100.0	579.9	100.0	634.6	100.0
% U.S. Mfg.	88.9%		90.3%		88.5%		84.4%		82.4%	
Annual Growth Rate			+24.5%		+8.6%		+13.0%		+9.4%	

Table 5

1977 MARKET SHARES

U.S. DISK DRIVE MANUFACTURERS

Based on Revenue Generated by Worldwide Shipments of
Moving Head Rigid Disk Drives By U. S. Manufacturers

Company	Captive		PCM		OEM		Total Industry	
	\$M	%	\$M	%	\$M	%	\$M	%
Ampex	--	--	2.2	1.3	8.8	2.6	11.0	.4
Burroughs	237.2	11.4	--	--	--	--	237.2	9.2
Calcomp	--	--	4.3	2.7	24.0	7.1	28.3	1.1
Control Data/MPI	177.6	8.6	34.6	21.3	141.8	42.0	354.0	13.8
Data 100	11.0	.5	--	--	8.3	2.5	19.3	.7
Data General	58.3	2.8	--	--	--	--	58.3	2.3
Diablo	--	--	--	--	52.8	15.6	52.8	2.0
Digital Equipment	154.7	7.5	--	--	--	--	154.7	6.0
Hewlett Packard	54.3	2.6	--	--	--	--	54.3	2.1
IBM	1,236.6	59.6	--	--	--	--	1,236.6	48.1
ISS/Univac	119.3	5.8	43.2	26.7	19.0	5.6	181.5	7.1
Memorex	--	--	57.0	35.2	30.3	9.0	87.3	3.4
Microdata	7.4	.4	--	--	1.3	.4	8.7	.3
Pertec	5.8	.3	--	--	17.4	5.2	23.2	.9
Storage Technology	--	--	20.7	12.8	--	--	20.7	.8
Wangco	--	--	--	--	18.5	5.5	18.5	.7
Western Dynex	--	--	--	--	9.9	2.9	9.9	.4
Others	11.5	.5	--	--	5.5	1.6	17.0	.7
	2,073.7	100.0	162.0	100.0	337.6	100.0	2,573.3	100.0

TABLE 6
CURRENT PRODUCT LINES
MANUFACTURERS OF MOVING HEAD DISK DRIVES

DISK/TREND CATEGORY:		1	2	3	4	5	6	7	8	9
		Disk Cartridge Drives <12 MB	Disk Cartridge Drives >12 MB	Disk Pack Drives 29-58 MB	Storage Module Drives 25-80 MB	Disk Pack Drives >100 MB	Data Module Drives	Fixed Disk Drives <30 MB	Fixed Disk Drives 30-200 MB	Fixed Disk Drives >200 MB
<u>U.S. Manufacturers</u>		Type								
Ampex	P,0			X	X	X		X	X	
Ball	P,0				X					
Burroughs	C	X		X	X	X		X	X	X
Calcomp	P,0		X	X	X	X		X		
Control Data	C,P,0	X	X	X	X	X	X	X	X	X
Data 100	C,0	X	X							
Data General	C	X	X		X	X				
Datapoint	C	X	X							
Diablo	0	X								
Digital Equipment	C	X	X					X		
EMM	0	X	X					X		
Hewlett Packard	C	X	X		X	X				
IBM	C	X		X		X	X	X	X	X
International Memories	0							X		
ISS/Univac	C,P,0		X	X	X	X			X	X
Kennedy	0							X	X	
Memorex	P,0					X		X	X	X
Microdata	C,0	X						X	X	
Okidata	0							X	X	
Pertec	C,0	X	X					X		
Shugart	0							X		
Storage Technology	P,0								X	X
Sycor	C							X		
Vermont Research	0		X							
Wangco	C,0	X	X		X	X				
Western Dynex	0	X						X		
<u>Japanese Manufacturers</u>										
Fujitsu	C,0		X			X		X	X	X
Hitachi	C,0					X		X	X	X
Hokushin	0	X								
Mitsubishi	C,0					X			X	
Nippon Electric Company	C,0	X		X		X		X	X	X
Nippon Peripherals, Ltd.	C,0						X			X
Toshiba	C,0	X				X		X	X	
<u>Western European Manufacturers</u>										
BASF	P,0			X				X	X	
CII-Honeywell Bull	C,0	X	X							
Data Recording Instruments	0	X								
Philips	C,0	X						X		
Siemens	C,0					X				X

Code: C = Captive
P = PCM
0 = OEM

TECHNICAL REVIEW

Competing technologies

Moving head disk drives remain the standard against which other potential candidates for the random access storage market are judged. It is usually difficult to make a fully objective comparison when reviewing the relative merits of disk drives and their various proposed replacements. One obvious problem is the unproven nature of the claims made for the performance of new technologies: Estimates of unit cost and functional performance are necessarily based on reported experimental data, and not on actual manufacturing costs or field performance. And, of course, most seasoned observers expect some slippage on cost and performance claims by the time a commercial product is delivered.

Another problem which is frequently overlooked in making comparisons is that a new technology requires the use of costly resources: For tooling, for development of new processes, for development of new software for operating systems and user applications. The system manufacturers which produce captive disk drives have investments in facilities and skilled manpower, which grow in value with evolutionary improvements in new disk drives -- but which would have to be written off if disk drives were replaced abruptly by something else. So it's not enough for a competing technology to be 50% better in unit cost, or speed, or whatever. The potential payoff will have to be very large -- and even then newcomers will have to demonstrate that they deserve to use investment funds, through each development and production start-up milestone.

Here is the current status of the alternative technologies most frequently discussed:

- * Optical memories: The commercial appeal of optical memories has been limited by the lack of a reversible storage medium. Examples of read-only products marketed with limited success have been the very large Unicom system of Precision Instruments and certain smaller holographic memories used in such applications as credit verification systems. So far, potential applications have been highly specialized, requiring the on-line availability of large data bases not subject to frequent update. More recent development activity involving optical disk storage systems has been undertaken by Philips and MCA (an outgrowth of work on home video recorders) and by Drexler Technology (a firm proposing to supply glass disks with a high resolution silver halide emulsion to potential drive manufacturers who would adapt Drexler's techniques to a finished optical storage system), and by others. It is possible that an optical disk storage system could be introduced within the next few years. Such a system would presumably exploit the capability of optical recording technology to achieve extremely high densities, combined with faster access times than previously offered on optical memories -- plus removability. The potential market available to such a system will depend on how clever its planners have been in identifying segments of the market for mass storage which can live with read-only capabilities.
- * EBAM (Electron-beam accessed MOS storage): Micro-Bit Corporation remains the lone exponent of EBAM, with the firm now controlled by Control Data, after other backers elected not to proceed with further funding. General Electric dropped a similar program previously. EBAM utilizes an electron beam, deflected as required, to store a charge in the oxide layer of an MOS target. It is non-mechanical, with the theoretical potential for high capacities, fast access and low cost. The appropriate applications for EBAM involve large systems with fast access requirements, and probably require a willingness to modify operating systems for optimum efficiency. So far, EBAM doesn't seem to fit in with anyone's plans.
- * Josephson junctions: IBM has carried out development work since at least 1965 on logic and memory circuits built with superconducting devices operated at temperatures close to absolute zero. Named for Brian Josephson, a British Nobel prize winner who predicted in 1962 that currents could flow through an insulator between superconductors under certain circumstances, Josephson devices can be made into extremely fast switching systems. At this time, it is expected that this technology could result in availability of computer systems by 1985 possessing cycle times at least 50 times faster than today's fastest commercial systems. Such a computer would probably contain all logic and memory circuits in a cube of about two inches, cooled to the temperature of liquid helium. Switching speed would be so

fast that logic and main memory could be separated by no more than a few inches, and the difficulty of connecting Josephson devices inside a cryogenic container with outside peripheral devices dictates that both logic and memory circuits be located together. Although highly promising, Josephson junctions necessitate solution of many very practical problems, and probably will require profound adjustments in computer architecture and patterns of usage. It is to be expected that they will stimulate the requirement for large additional amounts of auxiliary storage, but the nature of that requirement is not yet clear.

- * Charge coupled devices: Today's 64 K-bit CCD's will soon be followed by 256 K-bit and 1 M-bit devices. CCD's markets will still be limited to those needing high access rates and non-mechanical reliability, but which can tolerate volatility. An example of the new products made possible by CCD's is the recently announced Memorex 3770 "Disc Cache," designed to improve the efficiency of 3330 disk drives on IBM 370 systems. In this system, CCD's form a cache memory to store frequently-used data from the disk drives, providing a claimed 50% improvement in effective data transfer rate. Other CCD-based products have been offered as substitutes for head-per-track swapping disks, with improved access times and reliability the main benefits. It looks like CCD's will continue to make possible highly cost effective complementary, not competitive products to moving head disk drives.
- * Magnetic bubbles: American and Japanese companies are due to offer 256 K-bit bubble devices by early 1979, with 1 M-bit chips expected a year or two later. Bubble technology continues to develop, with the most advanced reported work so far from IBM -- an experimental demonstration of the formation of bubbles .4 micron in size, compared to the 3 to 5 micron size of the bubbles used today. It is reasonable to expect this and other advances to keep the bubble cost curve moving downward through the 1980's. Near-term, bubbles will surely find wide usage in terminals, smart typewriters, personal computers -- and in numerous new applications as auxiliary storage to microprocessors. However, at least through 1981, the scope of this report, bubbles will not provide a serious cost comparison challenge to moving head rigid disk drives.

Disk drive enhancements

As disk drive recording densities increase, and as disk recording systems are packaged into smaller space, using less power, at lower prices, coordinated by more intelligent controllers -- disk drives continually become more difficult targets for competing technologies. These are the areas in which key advances are probable:

- * Recording heads: There is great interest today in the potential performance of "thin film" heads, a term used to describe a variety of head designs formed by depositing thin films of magnetic materials, using methods borrowed from semiconductor processing methods. Advanced ferrite heads now operate in the 6,000 to 8,000 BPI range, but claims for the potential ultimate performance of thin film heads are in the range of 24,000 to 50,000 BPI. Since no present computer could use the data transfer rates which would result from such heads used on disks spinning at reasonable speeds, the principal interest at this time is in linear densities in the 8,000 to 12,000 BPI range. The other key performance feature of thin film technology is the potential ability to combine many heads on a single slider. This capability could lead to entirely new concepts of disk file cylinder organization and could produce significantly faster average access times by substituting electronic switching for much of the track-to-track movement required by single track heads.

Thin film head development programs have been underway for at least 10 years, and current activities include internal programs by major mainframers with disk drive interests in the U.S., Japan and Europe. Independent head manufacturers active in the area include Applied Magnetics, Information Magnetics, National Micronetics, and a new Oklahoma City firm funded by Exxon Enterprises, Magnex Corporation.

It is considered probable that IBM is using thin film heads on the new disk drive it will ship early in 1979 for System/34 and Series/1, which is becoming known in the industry by the IBM code word "Piccollo." Although IBM will not release the specifications until January, 1979, industry speculation centers on a two or three head thin film array, recording at 9,000 BPI or above, on a disk of about 8 inch diameter. If IBM has, in fact, decided to use thin film heads on these drives, the industry will finally have de facto standards for a specific thin film head configuration -- and both captive manufacturers and independent head manufacturers may be expected to push for the earliest possible production of similar heads. Without knowledge of the problems faced by IBM in development of these heads, however, the independents could well require a couple of years to match them.

- * Recording disks: Oxide coated disks, the standard recording medium for all moving head rigid disk drives at this time, are believed to be limited to linear densities of about 10,000 BPI, for practical purposes. Nickel cobalt plated disks are capable of providing the thinner magnetic films and higher resolution required for greater recording densities. In the past, plated disks could not match the surface durability of oxide coated disks, and were subject to excessive damage from head crashes, especially in view of contamination problems associated with removable disk packs and cartridges. Today, however, greatly improved plated disks are routinely manufactured for use in head-per-track drives. Sputtering is another process probably capable of depositing an acceptable thin film magnetic coating on disk surfaces. The actual usage of either plated or sputtered disks

on moving head disk drives will probably arrive in the near future, in order to take maximum advantage of the densities offered by improved recording heads. But disk media manufacturers all have substantial investments in existing equipment for producing oxide disks -- so large scale usage of plated or sputtered disks will have to wait for their introduction on moving head drives by a major system manufacturer.

- * Head positioning methods: Typical track density on high performance disk drives today is 480 TPI, but drives with up to 800 TPI have been announced. Disk drive designers have transitioned through several generations of actuators. The most frequently used type on current advanced drives is the track following servo system utilizing pre-recorded servo tracks on a separate disk surface, or portion of a surface. However, embedded servo techniques are gradually being introduced, even on some fairly moderate density drives.

The term "embedded servo" is loosely used in the industry to describe techniques in which servo data is interspersed between blocks of user data, as well as methods of multiple level recording of both servo information and user data in the same physical space. The methods in use today involve interspersed servo information.

Embedded servo methods will probably be necessary, as track densities increase and track widths decrease. The track densities made possible by thin film heads can probably be handled no other way, and the potential for extending the viability of removable pack drives is great. Even at much greater densities than those common today, interchange of removable media should be possible, and CE alignment packs could be dispensed with. Embedded servo drives are now being made by Burroughs and DEC, and more major disk drive manufacturers can be expected to follow.

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

Examples:

- * Drives sold by DEC, Hewlett Packard or Burroughs are considered captive, if internally manufactured.
- * In the case of a joint venture disk drive manufacturer such as Magnetic Peripherals, Inc., a joint venture of Control Data 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 or lease 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. Both OEM and PCM shipments are included in the non-captive category. Examples:

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

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

- * A storage module drive sold by Ball Computer to an end user is included.
- * On an arbitrary basis, ISS sales through IteI and Telex are included in PCM totals, in order to avoid distortion of total industry PCM activity.

OEM: Disk drives sold through any non-captive distribution channel except PCM. 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 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.

Revenue: Based on sale of disk drives alone, as normally sold by individual manufacturers, without controllers, formatters, 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. Prices used for leased drives are on an "if sold" basis, at captive or PCM levels, as appropriate. All projected prices are in 1978 constant dollars.

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, revised encoding schemes and improved fixed head options are anticipated in DISK/TREND forecasts.
- * Innovations such as plated disks, heads with greatly improved performance, disks in non-standard sizes, or new physical configurations may require establishment of new DISK/TREND product categories.

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

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

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

System OEMs/systems houses: (1) OEMs which manufacture a system requiring disk drives, such as Foxboro, Basic Four or Inforex. (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 and other equipment or software, and offer plug compatible subsystems to end users, system OEMs and systems houses. Examples are System Industries, Advanced Electronic Design, Microcomputer Systems, Diva and Telefile.

Direct to end user: Sales of plug compatible disk drives with any other necessary hardware directly to end users by disk drive manufacturers, whether or not title to the equipment is to be held by end users themselves or by lessors.

DISK CARTRIDGE DRIVES, LESS THAN 12 MB

Coverage

Examples of disk drives in this group include:

IBM	2310, 5444, 5447, 5022
Burroughs	9480-2, 9481-2, 9482-32
CII-Honeywell Bull	D 120
Control Data	9427H
Data 100	3002, 3404, 3850
Data General	6045, 6095
Datapoint	9360
Data Recording Instruments	3206, 3212
Diablo Systems	31, 33, 43, 44, 44B
Digital Equipment	RK05J, RL01
EMM	203, 206, 303, 306
Hewlett Packard	7900
Microdata	2850, 9100, 7400
Pertec	D3311, D3341, D3441
Wangco	F/T-1212, F/T-2412
Western Dynex	DD-6121, DD-6222

This category includes all disk drives with a total capacity per spindle of less than 12 MB, whether removable-only or fixed/removable configurations. Cartridges are front loading (2315 type), top loading (5440 type) or a special design. Each fixed/removable combination is counted as one spindle.

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	468.0	493.6	451.5	353.3	251.1
All manufacturers	528.7	555.9	509.7	401.2	290.6

Disk cartridge drives continue as the most popular rigid disk drives of all time, with a DISK/TREND estimate of 98,200 cartridge drives under 12 MB shipped worldwide in 1977. U.S. manufacturers shipped 86,500 spindles to U.S. and non-U.S. destinations, of which captive manufacturing programs provided 45,400, and manufacturers of OEM drives, 41,100.

The rapidly expanding markets for minicomputers and small business systems have kept sales growing for this product group -- assisted by the lack of more cost-efficient alternatives. In future years low cost fixed disk drives will supplant a significant portion of disk cartridge drive production, but the newer drives are only now starting to be available on an OEM basis. And the expected migration of system OEM's from disk cartridge drives under 12 MB to higher capacity disk cartridge drives has been relatively small to date. Many OEM's had been waiting for the Diablo Series 400 drives announced in 1975, with their promised low price and capacities extending upward from 13 MB to 53 MB. But Diablo has apparently scrapped the program, and most of the OEM's needing more capacity continued with disk cartridge drives for another year or two.

Captive drives have remained at higher production levels than expected, due to great strength in sales of small systems and to delays in development of new alternative drives. The continuation of several production programs in this group at high levels is also assured, with the 1978 introduction by DEC of the RL01, a completely new, low cost cartridge drive with advanced features, a new drive from Data General, and a new captive manufacturing program by Datapoint, at their Amcomp facility.

Market trends

Although the production peak for disk cartridge drives below 12 MB has been delayed, for the reasons mentioned above, it is expected that 1978 will be the peak year for both OEM and captive programs in this product group. 1979 will see significant production of small fixed Winchester drives and high capacity disk cartridge drives for the first time, and many of these drives will displace sales opportunities for disk cartridge drives below 12 MB. The decline, however, will be tempered by the broad usage of disk cartridge drives on hundreds of individual systems, many of which will continue in new production for years. The DISK/TREND estimate for worldwide production in 1981 is 61,700 spindles, slightly over half of which will be OEM drives.

The established trend toward fixed/removable combination drives continues, at the expense of front-loading removable-only drives -- for the twin reasons of the higher capacity available with the combination drives and the operational advantages of having both a fixed disk and a removable cartridge on the same spindle. Higher capacity per disk is also the pattern today, with 5 MB fixed and 5 MB removable (formatted) being the dominant drive configuration. Average OEM drive prices are not expected to decline, due to the relative maturity of the product group and the continuing shift to higher average capacities. It is also expected that system OEM's and systems houses will be the major distribution channel for these drives by the end of the decade, passing up minicomputer manufacturers.

Technical trends

Because of the trend away from disk cartridge drives in the lower capacity ranges, little impact on this product group is expected through 1981 from magnetic bubbles or CCD -- or from flexible disk drives. It is possible that floppy disks in the 5 MB area will be available before 1981, but the remaining 2.5 MB to 5 MB disk cartridge drives still in production will be used on older systems, which will not be redesigned to use new disk drives.

An interesting development is the introduction by DEC of an embedded servo head positioning technique on the new RL01 drive. Since the RL01 is destined to wide-scale usage, it will be the industry's first experience with a low cost, high production disk drive using servo information interspersed with data on the same tracks. The drive uses relatively low track densities (only 125 TPI), however, so the RL01 doesn't represent a significant test of the embedded servo concept -- unless DEC plans later capacity enhancements.

Forecasting assumptions

1. Captive production of drives in this category will decline starting in 1979, due to commitments to higher capacity cartridge drives, storage module drives and low cost fixed Winchester drives by mainframe and minicomputer manufacturers with internal disk drive production.
2. Production of OEM drives will also peak in 1978, but shipments will decline somewhat less sharply than for captive drives, due to the sales momentum of the large number of medium and small system OEM's using these drives.
3. Strength in OEM price levels will be created by the continuing increase in average capacity of drives shipped.

4. After 1978, a growing proportion of the market otherwise available to disk cartridge drives less than 12 MB will be lost to higher capacity disk cartridge drives, storage module drives and low cost fixed disk drives.
5. Any potential impact of flexible disk drives on the drives in this product group will be in the lower half of the capacity range, with no significant displacement of sales volume.

TABLE 7
DISK CARTRIDGE DRIVES, LESS THAN 12 MB
REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)									
	1977 Shipments		Forecast							
	U.S.	WW	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	22.5	36.0	30.0	46.5	30.0	47.3	15.0	24.0	7.0	12.0
Other U.S. Captive	186.9	296.4	191.1	296.7	171.4	266.6	134.0	207.7	90.4	139.9
TOTAL U.S. CAPTIVE	209.4	332.4	221.1	343.2	201.4	313.9	149.0	231.7	97.4	151.9
PCM	--	--	--	--	--	--	--	--	--	--
OEM	98.6	135.6	102.9	150.4	94.6	137.6	81.2	121.6	65.4	99.2
TOTAL U.S. NON-CAPTIVE	98.6	135.6	102.9	150.4	94.6	137.6	81.2	121.6	65.4	99.2
TOTAL U.S. PRODUCTION	308.0	468.0	324.0	493.6	296.0	451.5	230.2	353.3	162.8	251.1
<u>Non-U.S. Manufacturers</u>										
Captive	2.9	40.2	3.5	42.1	3.4	42.2	1.3	34.8	.7	27.7
OEM	--	20.5	--	20.2	--	16.0	--	13.1	--	11.8
TOTAL NON-U.S. PRODUCTION	2.9	60.7	3.5	62.3	3.4	58.2	1.3	47.9	.7	39.5
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		528.7		555.9		509.7		401.2		290.6
TOTAL WORLDWIDE CAPTIVE		372.6		385.3		356.1		266.5		179.6
TOTAL WORLDWIDE NON-CAPTIVE		156.1		170.6		153.6		134.7		111.0

TABLE 8
DISK CARTRIDGE DRIVES, LESS THAN 12 MB
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>U.S. Net Shipments</u>													
IBM	48.8	3.0	--	3.0	51.8	4.0	55.8	4.0	59.8	2.0	61.8	1.0	62.8
Non-IBM	172.6	26.0	30.8	56.8	229.4	62.5	291.9	56.2	348.1	46.4	394.5	34.9	429.4
TOTAL	221.4	29.0	30.8	59.8	281.2	66.5	347.7	60.2	407.9	48.4	456.3	35.9	492.2
<u>Worldwide Net Shipments</u>													
IBM	71.7	4.8	--	4.8	76.5	6.2	82.7	6.3	89.0	3.2	92.2	1.6	93.8
Non-IBM	284.0	46.1	47.3	93.4	377.4	102.4	479.8	93.4	573.2	78.3	651.5	60.1	711.6
TOTAL	355.7	50.9	47.3	98.2	453.9	108.6	562.5	99.7	662.2	81.5	743.7	61.7	805.4

TABLE 9

DISK CARTRIDGE DRIVES, LESS THAN 12 MB
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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)	30.8	47.3	34.3	53.3	30.5	48.0	26.2	42.1	21.1	34.7
<u>Average Unit Price</u>										
To OEMs (\$000)	3.2	3.3	3.0	3.2	3.1	3.2	3.1	3.2	3.1	3.2
<u>Value of Shipments</u>										
To OEMs (\$M)	98.6	156.1	102.9	170.6	94.6	153.6	81.2	134.7	65.4	111.0

TABLE 10
DISK CARTRIDGE DRIVES, LESS THAN 12 MB
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	2.2	7.1	6.5	5.6	4.2	2.7
Mini/micro computer manufacturers	12.9	41.9	38.9	36.2	34.4	33.4
System OEMs/systems houses	8.9	28.9	31.9	34.7	37.2	39.0
Independent peripherals suppliers	6.8	22.1	22.7	23.5	24.2	24.9
Direct to end user	--	--	--	--	--	--
TOTAL	30.8					

TABLE 11
DISK CARTRIDGE DRIVES, LESS THAN 12 MB
MARKET SHARE SUMMARY
Non-Captive Disk Drives

<u>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>
Diablo Systems	12.5	40.6	16.0	33.8
Control Data	6.2	20.1	8.8	18.6
Wangco	3.8	12.3	5.0	10.6
Pertec	3.1	10.1	4.4	9.3
Data 100	2.5	8.1	2.5	5.3
Others	2.7	8.8	10.6	22.4
	30.8		47.3	

DISK CARTRIDGE DRIVES, MORE THAN 12 MB

Coverage

Examples of disk drives in this group include:

Calcomp	H-32, H-64, H-96
CII-Honeywell Bull	D 140
Control Data	9448-32, 9448-64, 9448-96
Data 100	4406
Data General	6070
Datapoint	9374
Digital Equipment	RK06, RK07
EMM	312-25, 312-50, 312-76
Fujitsu	M-2201
Hewlett Packard	7905, 7906
ISS/Univac	8415
Pertec	D3461, D3481
Vermont Research	5017
Wangco	T-2422

Over half of the drives included in this group are new this year, reflecting the varied efforts of drive manufacturers to exploit the demand for higher capacity disk cartridge drives. The common denominator among these drives is a removable cartridge, which is usually, but not always, combined with one or more fixed disks. The design approaches employed can be classified as follows:

Conventional fixed/removable cartridge format -- drives which are essentially the same physical configuration as lower capacity cartridge drives, but which use 10 MB removable cartridges combined with 10 MB fixed disks (Data 100 4406, Data General 6070, Wangco T-2422).

High capacity fixed/removable -- drives using storage module (6000 BPI) technology to provide 16 MB removable cartridges, combined with up to 80 MB on fixed disks (Control Data 9448, Calcomp Hunter).

Unique configurations -- Drives such as Fujitsu's M-2201 (50 MB removable), CII-HB's D 140 (10 MB fixed/10 MB removable on 10.5" disks), DEC's RK06 and RK07 (up to 27.5 MB in a special two-disk 5440 type cartridge), and Vermont Research's 5017 (26 MB fixed/26 MB removable, with embedded servo).

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	59.3	87.1	145.5	253.7	368.3
All manufacturers	60.9	110.1	181.6	298.8	420.2

Through 1977, most of the drive production in this group was generated by four manufacturers: The captive programs of DEC and Hewlett Packard, and the smaller OEM programs of Wangco and Pertec.

Until recently, the industry was waiting with considerable interest for the Diablo Series 400, originally announced in 1975 for delivery in 1976. The Series 400 offered a range of capacities up to 53 MB, combined with advanced features and low prices -- a very interesting package for the many system OEM's wishing to stay with disk cartridge drives, but needing more capacity. The Series 400 seems to be dead, however, after a long series of delivery delays.

It now appears that Diablo did an excellent job of pioneering the concept of high capacity disk cartridge drives, but the drive shipments will be made by others. Control Data and Calcomp have both announced high capacity disk cartridge drive families, with capacities of 32, 64 or 96 MB, for delivery by the end of 1978. There are differences between the drives, but both use proven technology now in wide usage on storage module drives, and both use a 16 MB removable cartridge, on the same spindle with 1, 2 or

3 fixed disks. Because of competitive pricing and interface commonality with storage module drives, the new class of "cartridge module drives," to use the Control Data term, will probably achieve fast acceptance by many system OEM's. For many small business system and minicomputer applications they offer the desired increased capacity in a familiar package, and they provide an effective compromise between the opposing alternatives of all-fixed and all-removable disk storage.

Marketing trends

OEM sales activity in this group started to yield results in 1978, with increasing shipments for the two-year old Wangco and Pertec drives, and early shipments of the Control Data 9448 and EMM 312. It is believed, however, that the Control Data 9448 and Calcomp Hunter drives will eventually be the dominant type of drive in this group, and that both will achieve significant production in 1979. It is likely that other drive manufacturers will also offer roughly equivalent drives in the near future -- EMM's 312 is already fairly close in its specifications. The DISK/TREND estimate is 27,000 OEM drives shipped worldwide in 1981, a steep climb from the 800 drives in 1977. Average OEM prices are expected to increase constantly during this period, as the average capacity per drive also grows.

Non-U.S. disk drive manufacturers are also taking a keen interest in the U.S. market for drives in this group, so far with unique design approaches. CII-Honeywell Bull now offers a 10 MB fixed/10MB removable version of their drive using 10.5" disks, so far without any significant shipments to U.S. OEM's even though the drive is in production in France.

Fujitsu's 50 MB removable cartridge drive, in production in Japan, will apparently be the spearhead of a substantial marketing effort in the U.S. Fujitsu has started establishment of a U.S. marketing organization dedicated to disk drive sales, and has announced plans to manufacture this drive in California. Current DISK/TREND forecasts assume only a modest penetration of U.S. markets for these programs, primarily because numerous cost-effective disk drive alternatives are available from established U.S. manufacturers.

U.S. captive production of drives in the group will grow at a rate faster than previous forecasts, due to the addition of several new captive drives -- including Data General's 6070, Hewlett Packard's 7906, DEC's RK07, Data 100's 4406, Datapoint's 9374, and the expected Control Data/Honeywell usage of the 9448. Additional captive drives are also a likely prospect. Because of the several new captive programs and the known manufacturing programs of the several major system manufacturers involved, this year's DISK/TREND forecasts for captive drive production in this product group are significantly higher than those in the 1977 report. For example, this year's forecast for 1980 is approximately double the previous forecast for that year, with continuing growth expected for 1981.

Technical trends

Assuming the successful introduction of the Control Data 9448 and Calcomp Hunter, it is considered probable that other manufacturers will tend to standardize on the same general specifications for future drive introductions in this product group. These drives offer an upward growth path to higher capacities than any other design approach to date, yet

provide an entry threshold to the product family as low as 32 MB -- and do this while maintaining the same interface as the broadly used SMD's and many of the newer fixed Winchester drives. This kind of versatility will not be overlooked by designers of small business systems and other minicomputer based systems. Therefore, to the extent that they are equipped to handle the technology (essentially, a 6000 BPI version of 3330-11 technology), other disk drive manufacturers are likely to offer similar drives, including media interchangeability with either the Control Data or Calcomp drives.

Forecasting assumptions

1. Control Data's 9448 and Calcomp's Hunter drives will be shipped starting in 1978, with large scale shipments in 1979.
2. High capacity disk cartridge drives will secure a significant share of the disk storage requirements of small business systems and other minicomputer systems, in competition with storage module drives and fixed disk drives.
3. Due to the extended capacity range of the drives now available, and the continuing tendency toward higher capacity requirements, average OEM price per drive will gradually increase through 1981.
4. Penetration of U.S. markets for disk drives in this group by non-U.S. manufacturers will be relatively small.

TABLE 12
DISK CARTRIDGE DRIVES, MORE THAN 12 MB
REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)									
	1977 Shipments		Forecast							
	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	32.8	56.6	39.8	67.9	64.7	105.3	115.4	180.2	167.7	255.8
TOTAL U.S. CAPTIVE	32.8	56.6	39.8	67.9	64.7	105.3	115.4	180.2	167.7	255.8
PCM	--	--	--	--	--	--	--	--	--	--
OEM	2.4	2.7	14.8	19.2	31.2	40.2	56.3	73.5	86.2	112.5
TOTAL U.S. NON-CAPTIVE	2.4	2.7	14.8	19.2	31.2	40.2	56.3	73.5	86.2	112.5
TOTAL U.S. PRODUCTION	35.2	59.3	54.6	87.1	95.9	145.5	171.7	253.7	253.9	368.3
<u>Non-U.S. Manufacturers</u>										
Captive	--	1.6	--	21.8	--	32.8	--	39.0	--	42.9
OEM	--	--	--	1.2	1.2	3.3	3.4	6.1	5.3	9.0
TOTAL NON-U.S. PRODUCTION	--	1.6	--	23.0	1.2	36.1	3.4	45.1	5.3	51.9
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		60.9		110.1		181.6		298.8		420.2
TOTAL WORLDWIDE CAPTIVE		58.2		89.7		138.1		219.2		298.7
TOTAL WORLDWIDE NON-CAPTIVE		2.7		20.4		43.5		79.6		121.5

TABLE 13
DISK CARTRIDGE DRIVES, OVER 12 MB
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>U.S. Net Shipments</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	1.5	4.0	.7	4.7	6.2	8.9	15.1	16.4	31.5	29.0	60.5	42.2	102.7
TOTAL	1.5	4.0	.7	4.7	6.2	8.9	15.1	16.4	31.5	29.0	60.5	42.2	102.7
<u>Worldwide Net Shipments</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	3.0	7.1	.7	7.9	10.9	16.6	27.5	28.3	55.8	46.6	102.4	65.3	167.7
TOTAL	3.0	7.1	.7	7.9	10.9	16.6	27.5	28.3	55.8	46.6	102.4	65.3	167.7

TABLE 14

DISK CARTRIDGE DRIVES, MORE THAN 12 MB
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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)	.7	.8	3.8	5.1	8.1	10.6	14.2	18.5	20.8	27.0
<u>Average Unit Price</u>										
To OEMs (\$000)	3.4	3.4	3.9	4.0	4.0	4.1	4.2	4.3	4.4	4.5
<u>Value of Shipments</u>										
To OEMs (\$M)	2.4	2.7	14.8	20.4	32.4	43.5	59.6	79.6	91.5	121.5

TABLE 15
 DISK CARTRIDGE DRIVES, MORE THAN 12 MB
 DISTRIBUTION CHANNEL SUMMARY
 U.S. Non-Captive Disk, Drives

<u>Distribution Channel</u>	1977 U.S. Net Shipments		FORECAST			
	<u>Units (000)</u>	<u>%</u>	<u>1978 %</u>	<u>1979 %</u>	<u>1980 %</u>	<u>1981 %</u>
Mainframe computer manufacturers	--	--	--	3.0	4.1	5.3
Mini/micro computer manufacturers	.4	57.1	53.6	46.2	40.2	34.4
System OEMs/systems houses	.2	28.6	31.2	34.9	39.1	43.0
Independent peripherals suppliers	.1	14.3	15.2	15.9	16.6	17.3
Direct to end user	<u>--</u>	--	--	--	--	--
TOTAL	.7					

DISK PACK DRIVES, 29-58 MB

Coverage

Examples of disk drives in this group include:

IBM	2314, 2319, 5445
Ampex	DM-323
Burroughs	9384-6, 9388-2
Calcomp	114, 213, 215
Control Data	9746, 9747
ISS/Univac	715

Disk drives with the same basic physical configuration as IBM's 2414 are included in this category. Most of the drives now in production are "double density" 58 MB drives, but some drives have been included because of physical similarity, even though outside of the nominal capacity range.

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	121.8	66.8	28.2	10.5	1.7
All manufacturers	169.9	99.7	51.6	22.9	6.4

IBM and the PCM suppliers have been out of production of new 2314's for years, but other captive and OEM manufacturing still lingers on in Japan, Europe and the U.S. The DISK/TREND estimate for worldwide 1977 production of new drives is 13,800, but the worldwide net total is only 8,000 due to retirements of IBM and PCM drives.

The key factor propping up sales of drives in this group is the continuing sales of many systems on which they are used -- aided by the substantial demand for add-on drives to be used with installed systems.

Marketing trends

Production levels are expected to be all down hill from now on, with some existing captive and OEM drives phased out completely by 1980. A few drives may still be produced in very small quantities through 1981, but net worldwide shipments are expected to be negative by 1980.

In any event, no new adoptions of drives in this group are expected for systems of any kind. The newer drives, in several configurations, are clearly superior in price/performance, reliability and operating features.

Technical trends

No further refinements of this format are expected.

Forecasting assumptions

1. Captive production will continue to decline, with Burroughs remaining in production of drives longest, due to substantial usage of advanced drives in this configuration.
2. OEM production of double density drives will continue at least through 1980, but at a continually declining rate.
3. New system adoptions will be non-existent, with system designers preferring instead the newer high density cartridge drives, storage module drives or fixed disk drives to cover the same capacity requirements.

TABLE 16
DISK PACK DRIVES, 29-58 MB
REVENUE SUMMARY

DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)										
	1977		Forecast							
	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	51.0	84.0	19.5	31.5	7.5	12.0	3.0	4.5	--	--
TOTAL U.S. CAPTIVE	51.0	84.0	19.5	31.5	7.5	12.0	3.0	4.5	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	18.9	37.8	16.4	35.3	8.3	16.2	3.4	6.0	.8	1.7
TOTAL U.S. NON-CAPTIVE	18.9	37.8	16.4	35.3	8.3	16.2	3.4	6.0	.8	1.7
TOTAL U.S. PRODUCTION	69.9	121.8	35.9	66.8	15.8	28.2	6.4	10.5	.8	1.7
<u>Non-U.S. Manufacturers</u>										
Captive	--	37.2	--	27.9	--	21.7	--	12.4	--	4.7
OEM	--	10.9	--	5.0	--	1.7	--	--	--	--
TOTAL NON-U.S. PRODUCTION	--	48.1	--	32.9	--	23.4	--	12.4	--	4.7
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		169.9		99.7		51.6		22.9		6.4
TOTAL WORLDWIDE CAPTIVE		121.2		59.4		33.7		16.9		4.7
TOTAL WORLDWIDE NON-CAPTIVE		48.7		40.3		17.9		6.0		1.7

TABLE 17
DISK PACK DRIVES, 29-58 MB
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>U.S. Net Shipments</u>													
IBM	29.4	(2.9)	--	(2.9)	26.5	(2.2)	24.3	(1.7)	22.6	(1.3)	21.3	(1.0)	20.3
Non-IBM	56.1	3.4	1.2	4.6	60.7	2.4	63.1	.8	63.9	.1	64.0	(.3)	63.7
TOTAL	85.5	.5	1.2	1.7	87.2	.2	87.4	(.9)	86.5	(1.2)	85.3	(1.3)	84.0
<u>Worldwide Net Shipments</u>													
IBM	49.7	(4.5)	--	(4.5)	45.2	(3.5)	41.7	(2.8)	38.9	(2.1)	36.8	(1.6)	35.2
Non-IBM	100.0	8.0	4.5	12.5	112.5	7.6	120.1	3.5	123.6	1.2	124.8	--	124.8
TOTAL	149.7	3.5	4.5	8.0	157.7	4.1	161.8	.7	162.5	(.9)	161.6	(1.6)	160.0

TABLE 18

DISK PACK DRIVES, 29-58 MB
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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)	2.3	5.8	2.0	4.8	1.0	2.1	.4	.7	.1	.2
PCM -- Units (000)	(1.1)	(1.3)	(.9)	(1.1)	(.7)	(.8)	(.5)	(.6)	(.4)	(.5)
<u>Average Unit Price</u>										
To OEMs (\$000)	8.2	8.4	8.2	8.4	8.3	8.5	8.4	8.6	8.4	8.6
To End Users (\$000)	--	--	--	--	--	--	--	--	--	--
<u>Value of Shipments</u>										
To OEMs (\$M)	18.9	48.7	16.4	40.3	8.3	17.9	3.4	6.0	.8	1.7
To End Users (\$M)	--	--	--	--	--	--	--	--	--	--

TABLE 19
DISK PACK DRIVES, 29-58
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	.4	17.4	8.7	3.4	--	--
Mini/micro computer manufacturers	.4	17.4	14.8	12.6	8.8	5.1
System OEMs/systems houses	1.3	56.5	67.1	74.0	80.7	83.8
Independent peripherals suppliers	.2	8.7	9.4	10.0	10.5	11.1
Direct to end user	--	--	--	--	--	--
TOTAL	2.3					

TABLE 20
DISK PACK DRIVES, 29-58 MB
MARKET SHARE SUMMARY
Non-Captive Disk Drives

<u>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>
Conral Data	1.3	56.5	3.2	71.1
Calcomp	.7	30.4	.8	17.8
Others	.3	13.1	.5	11.1
	2.3		4.5	

Note: PCM net shipments, a negative value for the years 1977 through 1978, have been eliminated from the two tables on this page to avoid distortion of OEM shipments.

STORAGE MODULE DRIVES, 25-80 MB

Coverage

Examples of disk drives in this group include:

Ampex	DM-940, DM-980
Ball	BD-50, BD-80
Burroughs	9484-2, 9484-5
Calcomp	T-25, T-50, T-80
Control Data	9760, 9762, 270-10
Data General	6067
Hewlett Packard	7920
ISS/Univac	8418
Wangco	MP-80

The term "storage module drive" has been used throughout the DISK/TREND Report as a generic description for disk drives using 3330-type technology at 4000 or 6000 BPI, employing small disk packs. Currently, all drives in the group use packs with five recording surfaces, except the Univac 8418, which uses seven surfaces. Among the OEM drives, media interchangeability exists within certain drive groups: The Control Data, Ampex and Wangco drives all use the Control Data SMD packs, and the Calcomp and Ball drives use the Calcomp Trident packs.

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	152.0	230.8	306.0	342.0	371.8
All manufacturers	152.0	230.8	330.6	434.3	504.8

Worldwide unit shipments of SMD's totaled an estimated 16,800 units in 1977, 124% higher than the 1976 total of 7,500 drives. OEM drives accounted for 10,200 units worldwide, and grew at a faster rate than the group average, an increase of 168% over 1976. Captive production did not reach previously forecasted levels for 1977, but nevertheless totaled 6,600 drives worldwide, 89% over 1976. (1977 captive revenue estimates in this report are higher than the revenue estimates in last year's DISK/TREND Report, due to usage of a higher average unit selling price factor, which more closely represents actual levels.)

Among the new configurations for OEM disk drives, the SMD remains clearly in the lead -- primarily because the format for the last few years has offered the most cost effective storage in the gap between disk cartridge drives and the larger disk pack drives over 100 MB. Usage is now very broad, covering major mainframers, minicomputer manufacturers, small business systems and other system OEM's, and independent peripherals suppliers. The PCM business (direct from independent drive manufacturer to end user) has been slow to develop, but is now inevitable, with substantial interest by drive manufacturers in the growing installed base of IBM Series/1 systems.

Marketing trends

It is believed that the current dynamic growth in OEM shipments by U.S. manufacturers will slow to a modest 5% in 1981, due mostly to competition from high capacity disk cartridges and fixed disk drives covering the same capacity ranges. The SMD will remain an extremely efficient answer to the widespread need for moderate quantities of completely

removable disk storage, however, and is expected to remain in large-scale production well after 1981. Because of the popularity of the SMD format, DISK/TREND estimates assume the emergence of non-U.S. competition for U.S. manufacturers, starting in 1979 and growing to an annual shipping rate of 8,000 units per year by 1981. If such non-U.S. competition fails to develop, shipments available to U.S. manufacturers will, of course, be higher.

The PCM market for SMD's on IBM Series/1 systems will start in earnest in 1979. DISK/TREND forecasts for this market segment have been held to somewhat conservative levels, based on information so far available. The SMD will face competition from other disk formats for this market, not the least of which will be IBM's recently announced 4963, a fixed disk drive using an advanced technology not yet revealed by IBM. It is quite possible that PCM shipments could be much higher than forecasted, if user demand for disk removability prevails or if IBM should broaden the Series/1 family extensively.

Captive production is still increasing. Data General joined the ranks of the captive SMD producers in 1978. DEC's SMD drives, the RM02 and RM03, are manufactured by Control Data -- but start-up of an internal manufacturing program for these drives by DEC would not surprise anyone. No other major U.S. captive manufacturing programs for SMD's are expected.

OEM markets are dominated by Control Data, with 65.7% of worldwide shipments. OEM average selling prices are expected to decline only to a slight degree during the next few years, with the continuing trend to higher average capacities helping to support the price level.

Technical trends

It has been expected that manufacturers of SMD's would eventually attempt to extend the life cycle of these products by offering double track density versions. Ampex has announced such a drive for delivery before the end of 1978, the 165.8 MB DM-9160. If these drives don't cause unacceptable reliability problems in actual field usage, they will probably help to develop an attractive market with system OEM's using existing 80 MB SMD's, but which need more capacity. 160 MB on five recording surfaces will clearly be much cheaper than the same capacity on 19 surfaces, and the savings in floor space will also be attractive. Similar drives from other SMD manufacturers are to be expected. Shipments of these drives will not be included in this product group, but will be forecasted with disk pack drives over 100 MB.

Wangco has announced a drive using a standard Control Data storage module, but also using an equal number of fixed disks, to provide 80 MB fixed and 80 MB removable on the same spindle. This drive will apparently be delivered in 1979. Its chance for success will probably depend on attractive price comparisons with other drive formats offering equivalent capacity.

Forecasting assumptions

1. OEM sales momentum will continue, but with the growth rate declining through 1981, due to competition from high density cartridge drives and fixed disk drives.
2. Captive production will also increase through 1981, but at a relatively slow rate after 1979 due to availability of attractive storage alternatives.
3. OEM average unit prices will be subject to only a slight decline, because of continued growth in average capacity level.

TABLE 21
STORAGE MODULE DRIVES, 25-80 MB
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	64.5	99.0	98.6	151.2	120.9	191.1	128.3	205.7	130.2	209.6
TOTAL U.S. CAPTIVE	64.5	99.0	98.6	151.2	120.9	191.1	128.3	205.7	130.2	209.6
PCM	--	--	--	--	7.7	13.4	16.1	27.3	28.4	48.2
OEM	43.4	53.0	62.2	79.6	79.0	101.5	81.3	109.0	82.3	114.0
TOTAL U.S. NON-CAPTIVE	43.4	53.0	62.2	79.6	86.7	114.9	97.4	136.3	110.7	162.2
TOTAL U.S. PRODUCTION	107.9	152.0	160.8	230.8	207.6	306.0	225.7	342.0	240.9	371.8
<u>Non-U.S. Manufacturers</u>										
Captive	--	--	--	--	--	19.5	12.7	67.3	18.6	93.0
OEM	--	--	--	--	--	5.1	9.8	25.0	19.6	40.0
TOTAL NON-U.S. PRODUCTION	--	--	--	--	--	24.6	22.5	92.3	38.2	133.0
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		152.0		230.8		330.6		434.3		504.8
TOTAL WORLDWIDE CAPTIVE		99.0		151.2		210.6		273.0		302.6
TOTAL WORLDWIDE NON-CAPTIVE		53.0		79.6		120.0		161.3		202.2

TABLE 22
STORAGE MODULE DRIVES, 25-80 MB
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>U.S. Net Shipments</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	6.1	4.3	8.5	12.8	18.9	19.5	38.4	25.8	64.2	31.2	95.4	35.5	130.9
TOTAL	6.1	4.3	8.5	12.8	18.9	19.5	38.4	25.8	64.2	31.2	95.4	35.5	130.9
<u>Worldwide Net Shipments</u>													
IBM	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM	8.4	6.6	10.2	16.8	25.2	26.5	51.7	38.3	90.0	50.8	140.8	59.7	200.5
TOTAL	8.4	6.6	10.2	16.8	25.2	26.5	51.7	38.3	90.0	50.8	140.8	59.7	200.5

TABLE 23

STORAGE MODULE DRIVES, 25-80 MB
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)	8.5	10.2	12.2	15.3	15.8	20.9	18.6	26.8	20.8	30.8
PCM -- Units (000)	--	--	--	--	.7	1.2	1.5	2.5	2.7	4.5
<u>Average Unit Price</u>										
To OEMs (\$000)	5.1	5.2	5.1	5.2	5.0	5.1	4.9	5.0	4.9	5.0
To End Users (\$000)	--	--	--	--	11.0	11.2	10.7	10.9	10.5	10.7
<u>Value of Shipments</u>										
To OEMs (\$M)	43.4	53.0	62.2	79.6	79.0	102.0	91.1	134.0	101.9	154.0
To End Users (\$M)	--	--	--	--	7.7	13.4	16.1	27.3	28.4	48.2

TABLE 24
STORAGE MODULE DRIVES, 25-80 MB
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	.9	10.6	8.8	7.5	6.2	5.2
Mini/micro computer manufacturers	3.2	37.7	36.2	30.8	26.5	22.5
System OEMs/systems houses	2.4	28.2	30.8	33.1	35.3	36.1
Independent peripherals suppliers	2.0	23.5	24.2	24.4	24.5	24.7
Direct to end user	--	--	--	4.2	7.5	11.5
TOTAL	8.5					

TABLE 25
STORAGE MODULE DRIVES, 25-80 MB
MARKET SHARE SUMMARY
Non-Captive Disk Drives

<u>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>
Control Data	5.7	67.1	6.7	65.7
Calcomp	2.2	25.9	2.7	26.5
Others	.6	7.0	.8	7.8
	8.5		10.2	

DISK PACK DRIVES, MORE THAN 100 MB

Coverage

Examples of disk drives in this group include:

IBM	3330-1, 3330-11
Ampex	DM-9100, DM-9160, DM-9300, 331
Burroughs	9383-16, 9484-8
Calcomp	T-200, T-300, 225
Control Data	9764, 9766, 270-30, 9780, 33802
Data General	6060, 6061
Hewlett Packard	7925
ISS/Univac	733-10, 733-11, 7330-12
Memorex	3670, 3675, 677
Siemens	PS5-3, PS5-5

This group is intended to cover drives smaller to IBM's 3330-1 (100 MB) and 3330-11 (200 MB), but a variety of other capacities and physical configurations are included, all of which use similar technology. Noteworthy are Hewlett Packard's 7925 (120 MB on nine surfaces), Siemens' PS5-3 (146 MB on nine surfaces), Burroughs' 9383-16 (174 MB on twenty surfaces), Ampex' DM-9160 (160 MB on five surfaces), and ISS' 7330-12 (317.5 MB, the equivalent of IBM's 3350, on nineteen surfaces).

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	541.5	586.1	606.8	544.3	493.8
All manufacturers	639.0	689.3	719.1	635.4	559.5

1977 production of drives in this group generated only about 4% less in worldwide revenue than in 1976 -- a performance substantially higher

than previously forecasted. The group is no longer the largest DISK/TREND product group in revenues, but still represented 22.7% of worldwide disk drive revenues in 1977.

Production by U.S. captive manufacturers other than IBM during 1977 was actually at about twice the level anticipated in the 1977 DISK/TREND Report, reflecting the strong installation rates for non-IBM medium scale computer systems. But while revenues for captive drives dominate this product group, unit shipment totals for U.S. OEM drives producers were slightly ahead of captive drives, at 10,300 spindles, with the worldwide OEM total by all manufacturers at 11,400 spindles. Worldwide shipments by U.S. manufacturers of PCM drives continued their decline, under the impact of 3350 drives shipped by IBM and PCM manufacturers. 1977 PCM shipments totaled 6,400 spindles, down 39% from 1976.

The DISK/TREND estimate of IBM installed 3330 drives has been adjusted downward, in light of actual installation figures through the end of 1975 revealed in documents from the current U.S. vs. IBM antitrust trial. The change represents a reduction of about 20% for year end 1976 in the IBM installed base. No change was made in the PCM installed totals, which were also included in trial documents, since the 1977 DISK/TREND estimates were accurate.

Marketing trends

The trend toward 200 MB drives on IBM systems continue, as the following estimate of 100 MB vs. 200 MB drives (both IBM and PCM) installed on IBM systems in the U.S. indicates:

Drives installed on IBM systems in U.S.	1976		1977		1978	
	<u>Units</u>	<u>%</u>	<u>Units</u>	<u>%</u>	<u>Units</u>	<u>%</u>
3330-1 type (100 MB)	39,500	59.2	36,000	50.2	32,200	43.3
3330-11 type (200 MB)	<u>27,200</u>	<u>40.8</u>	<u>35,700</u>	<u>49.8</u>	<u>42,200</u>	<u>56.7</u>
Total	66,700	100.0	71,700	100.0	74,400	100.0

The causes for this shift are to be found in a preponderance of PCM drives being shipped as 200 MB units, plus a continuing conversion of IBM 3330-1's to 3330-11's via the "field upgrade" route.

The impact of IBM's 3350 fixed disk drive upon the 3330 market has been even more severe than expected. Because of the 3350's inroads, plus the effect of the expected improved drive to follow it, it is now expected that net PCM shipments will become negative by 1980. Net IBM shipment of all 3330 drives is believed to be zero at this time, due to returns.

However, captive production by other mainframers and major minicomputer manufacturers in the U.S. is not expected to peak until 1979/1980. The forecasted shipment levels represent a significant increase over the previous DISK/TREND forecasts for the corresponding years, reflecting the higher current production levels and a probable tendency of the non-IBM mainframers to emphasize removable media for a longer period.

It is expected that the DISK/TREND estimate of 12,500 spindles in 1978 will represent the peak for OEM shipments. OEM disk drive product life cycles tend to stretch out for many years after peak production, however, especially with a widely used drive type, and 1981 worldwide OEM production of drives in this group is forecasted at the 7,100 spindle level, 6,300 from U.S. manufacturers.

Technical trends

A growing portion of OEM drives in this group use 6000 BPI linear recording density, to offer 300 MB capacity in the standard 3330 configuration as extensions of storage module product lines, using standard SMD interfaces. By 1981, it is expected that the drives sold for use with 19 surface packs will largely be designed for 300 MB.

Another innovation expected from the SMD area is the drive designed to record 160 MB on 5 surface storage modules. Ampex has already announced such a drive, and the same kind of approach is to be expected from Control Data and Calcomp, in due course. It will be a lower priced method to provide capacity formerly requiring a larger drive -- and should be well received, once the bugs are worked out. In view of the impact expected from this sub-family of the product group a fairly steep decline in OEM average selling price has been forecasted, starting in 1980.

The data processing community's appetite for removable disk packs also makes it possible that the capacity of the standard 19 surface disk pack could be expanded beyond 300 MB, if a major drive producer cares to take the risk on development costs. If 800 TPI can be successfully used in a 5 surface storage module (per the Ampex 160 MB SMD), it could well be possible in a 19 surface disk pack, presumably yielding a capacity per spindle of up to 600 MB. Reliable drive operation and successful interchange between drives might require usage of embedded servo techniques on such a drive. It remains problematical whether any independent drive manufacturer is prepared to pioneer this project.

Forecasting assumptions

1. IBM's installed population of 3330 drives is now starting to decline, and PCM drives will follow starting in 1980, due to the impact of IBM's 3350/3344 and successor drives.
2. IBM will not introduce any other large removable disk pack drive.
3. OEM drives will decline after 1978, but strength in the 300 MB versions of SMD 19 surface pack drives, plus the introduction of 160 MB 5 surface storage module drives, will prevent a severe decline. The advent of the smaller SMD drives will cause a decline in OEM prices.

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

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)									
	1977		Forecast							
	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	13.0	23.4	--	--	--	--	--	--	--	--
Other U.S. Captive	187.6	280.0	229.6	394.8	302.4	478.8	296.8	476.0	274.4	439.6
TOTAL U.S. CAPTIVE	200.6	303.4	229.6	394.8	302.4	478.8	296.8	476.0	274.4	439.6
PCM	95.9	138.2	58.6	83.6	30.7	44.4	--	--	--	--
OEM	70.1	99.9	73.9	107.7	56.4	83.6	45.9	68.3	36.6	54.2
TOTAL U.S. NON-CAPTIVE	166.0	238.1	132.5	191.3	87.1	128.0	45.9	68.3	36.6	54.2
TOTAL U.S. PRODUCTION	366.6	541.5	362.1	586.1	389.5	606.8	342.7	544.3	311.0	493.8
<u>Non-U.S. Manufacturers</u>										
Captive	--	86.8	--	89.6	--	98.0	--	78.4	--	58.8
OEM	--	10.7	--	13.6	--	14.3	--	12.7	--	6.9
TOTAL NON-U.S. PRODUCTION	--	97.5	--	103.2	--	112.3	--	91.1	--	65.7
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		639.0		689.3		719.1		635.4		559.5
TOTAL WORLDWIDE CAPTIVE		390.2		484.4		576.8		554.4		498.4
TOTAL WORLDWIDE NON-CAPTIVE		248.8		204.9		142.3		81.0		61.1

TABLE 27
DISK PACK DRIVES, MORE THAN 100 MB
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>U.S. Net Shipments</u>													
IBM	40.8	.5	--	.5	41.3	--	41.3	(.5)	40.8	(2.0)	38.8	(3.0)	35.8
Non-IBM	44.8	6.7	11.8	18.5	63.3	18.6	81.9	18.2	100.1	14.7	114.8	12.0	126.8
TOTAL	85.6	7.2	11.8	19.0	104.6	18.6	123.2	17.7	140.9	12.7	153.6	9.0	162.6
<u>Worldwide Net Shipments</u>													
IBM	69.2	.9	--	.9	70.1	--	70.1	(.9)	69.2	(3.6)	65.6	(5.6)	60.0
Non-IBM	75.0	13.1	17.8	30.9	105.9	33.6	139.5	32.9	172.4	27.3	199.7	21.9	221.6
TOTAL	144.2	14.0	17.8	31.8	176.0	33.6	209.6	32.0	241.6	23.7	265.3	16.3	281.6

TABLE 28

DISK PACK DRIVES, MORE THAN 100 MB
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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)	7.3	11.4	7.7	12.5	6.0	10.3	5.1	8.9	4.3	7.1
PCM -- Units (000)	4.5	6.4	2.7	3.8	1.4	2.0	(1.0)	(1.4)	(2.1)	(3.0)
<u>Average Unit Price</u>										
To OEMs (\$000)	9.6	9.7	9.6	9.7	9.4	9.5	9.0	9.1	8.5	8.6
To End Users (\$000)	21.3	21.6	21.7	22.0	21.9	22.2	21.8	22.1	21.6	21.9
<u>Value of Shipments</u>										
To OEMs (\$M)	70.1	110.6	73.9	121.3	56.4	97.9	45.9	81.0	36.6	61.1
To End Users (\$M)	95.9	138.2	58.6	83.6	30.7	44.4	--	--	--	--

TABLE 29
DISK PACK DRIVES, MORE THAN 100 MB
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	3.0	25.4	20.3	17.9	16.5	14.8
Mini/micro computer manufacturers	2.0	17.0	20.2	26.1	29.7	29.9
System OEMs/systems houses	1.4	11.9	25.1	28.3	44.6	45.6
Independent peripherals suppliers	.9	7.6	8.4	8.8	9.2	9.7
Direct to end user*	<u>4.5</u>	38.1	26.0	18.9	--	--
TOTAL	11.8					

TABLE 30
DISK PACK DRIVES, MORE THAN 100 MB
MARKET SHARE SUMMARY
Non-Captive Disk Drives

<u>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>
Control Data	3.8	32.2	6.4	38.3
Memorex	4.3	36.5	5.5	32.9
ISS*	2.6	22.0	3.7	22.2
Others	<u>1.1</u>	9.3	<u>1.1</u>	6.6
	11.8		16.7	

* Includes Itel and Telex PCM shipments of drives manufactured by ISS

DATA MODULE DRIVES, 35-70 MB

Coverage

Examples of disk drives in this group include:

IBM	3340
Control Data	9770
Nippon Peripherals, Ltd.	NP20

Each of the above drives is designed to provide media interchangeability with standard 3348 data modules, or independent equivalents, in the 35 MB, 70 MB or 70F MB versions.

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	212.5	157.1	79.2	30.3	5.8
All manufacturers	236.3	183.2	110.7	57.4	15.9

Only IBM has achieved substantial production of 3340 type drives, the original "Winchester" technology drive. That production is now believed to be declining, since add-on requirements for increased disk storage on small System/370's and large System/3's are now being satisfied with the 3344, at improved cost per megabyte.

Control Data and Nippon Peripherals, Ltd., remain as the only independent manufacturers for this drive. Control Data's 9770 is an OEM drive sold mostly to NCR, which markets it as the 6590, with the Criterion system. NPL's drive is available as a captive drive by NPL's joint parent companies, Fujitsu and Hitachi, but the major share of current production

has apparently gone to Memorex for PCM distribution in the U.S. and to BASF for PCM distribution in Europe. The BASF activity has been the largest portion of NPL's shipments to date.

Documents from the U.S. vs. IBM antitrust trial, still in progress, have indicated that the previous DISK/TREND estimate of installed IBM 3340's was overstated, and this year's estimates have been adjusted downward. The new estimate for 3340 installed U.S. drive population at the end of 1976 is about 35% lower.

Marketing trends

IBM's shipments of 3340 drives are expected to decline sharply in the future, and the drive will probably be out of new production by 1981. A large portion of IBM's 3340 requirements for new system installations should be supplied by 3340's displaced by 3344's.

Control Data's production to support the NCR program should continue through 1981, but OEM sales to another major system OEM are considered unlikely. The data module compares unfavorably with other drive formats available to system OEM's, in both drive and media costs.

NPL's drive provides a useful companion product to Memorex' own version of the 3344, but it can be assumed that sales emphasis will be placed behind Memorex' own drive, with its more attractive gross margin. The BASF program is expected to continue at a somewhat higher shipment level than the Memorex program, for the next few years, but both will be closing out the business by 1981.

Technical trends

It would be a surprise if IBM should introduce any improvements in capacity or performance for the 3340, since that firm's development thrust seems to be in the direction of more advanced technology in both smaller and larger drives.

NPL, however, has announced a 140 MB version of the data module, by doubling the track density, for delivery in September, 1979. The NP22 drive will use a special data module, the NP21-140. At this time it is difficult to predict any substantial market for this innovation, in view of introduction late in the product life cycle, supported by relatively small-scale marketing programs, with single-source media availability.

Forecasting assumptions

1. IBM will not enhance the 3340 capacity, and will continue to rely on the 3344 for large add-on capacity increases.
2. OEM markets for this drive will remain negligible, due to the lower drive and media costs for alternative disk drives. Attempts to develop the PCM market will achieve limited results due to market entry late in the product life cycle.

TABLE 31
DATA MODULE DRIVES
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	137.6	211.6	98.3	152.0	46.8	72.5	15.2	22.8	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	137.6	211.6	98.3	152.0	46.8	72.5	15.2	22.8	--	--
PCM	--	--	--	--	--	--	--	--	--	--
OEM	.9	.9	5.1	5.1	6.7	6.7	7.5	7.5	5.8	5.8
TOTAL U.S. NON-CAPTIVE	.9	.9	5.1	5.1	6.7	6.7	7.5	7.5	5.8	5.8
TOTAL U.S. PRODUCTION	138.5	212.5	103.4	157.1	53.5	79.2	22.7	30.3	5.8	5.8
<u>Non-U.S. Manufacturers</u>										
Captive	--	7.5	--	7.5	--	10.6	--	13.7	--	7.7
OEM/PCM*	5.0	16.3	6.2	18.6	6.2	20.9	3.7	13.4	--	2.4
TOTAL NON-U.S. PRODUCTION	5.0	23.8	6.2	26.1	6.2	31.5	3.7	27.1	--	10.1
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		236.3		183.2		110.7		57.4		15.9
TOTAL WORLDWIDE CAPTIVE		219.1		159.5		83.1		36.5		7.7
TOTAL WORLDWIDE NON-CAPTIVE		17.2		23.7		27.6		20.9		8.2

* Includes Memorex and BASF shipments of drives manufactured by Nippon Peripherals, Ltd.

TABLE 32
DATA MODULE DRIVES
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>U.S. Net Shipments</u>													
IBM	23.2	9.3	--	9.3	32.5	6.6	39.1	3.1	42.2	1.0	43.2	--	43.2
Non-IBM	.1	--	.5	.5	.6	1.1	1.7	1.3	3.0	1.2	4.2	.7	4.9
TOTAL	23.3	9.3	.5	9.8	33.1	7.7	40.8	4.4	45.2	2.2	47.4	.7	48.1
<u>Worldwide Net Shipments</u>													
IBM	35.7	14.3	--	14.3	50.0	10.2	60.2	4.8	65.0	1.5	66.5	--	66.5
Non-IBM	.5	.5	1.4	1.9	2.4	2.6	5.0	3.2	8.2	2.9	11.1	1.4	12.5
TOTAL	36.2	14.8	1.4	16.2	52.4	12.8	65.2	8.0	73.2	4.4	77.6	1.4	79.0

TABLE 33
DATA MODULE DRIVES
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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	.1	.6	.6	.8	.8	.9	.9	.7	.7
PCM* -- Units (000)	.4	1.3	.5	1.5	.5	1.7	.3	1.1	--	.2
<u>Average Unit Price</u>										
To OEMs (\$000)	8.6	8.6	8.5	8.5	8.4	8.4	8.3	8.3	8.3	8.3
To End Users (\$000)	12.5	12.7	12.4	12.6	12.3	12.5	12.2	12.4	--	12.4
<u>Value of Shipments</u>										
To OEMs (\$M)	.9	.9	5.1	5.1	6.7	6.7	7.5	7.5	5.8	5.8
To End Users (\$M)	5.0	16.5	6.2	18.9	6.2	21.3	3.7	13.6	--	2.5

* Includes Memorex and BASF shipments of drives manufactured by Nippon Peripherals, Ltd.

TABLE 34
DATA MODULE DRIVES
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	.1	20.0	54.5	56.5	66.0	87.0
Mini/micro computer manufacturers	--	--	--	--	--	--
System OEMs/systems houses	--	--	--	3.0	5.0	7.0
Independent peripherals suppliers	--	--	--	2.0	4.0	6.0
Direct to end user*	<u>.4</u>	80.0	45.5	38.5	25.0	--
TOTAL	.5					

* Includes Memorex shipments of drives
manufactured by Nippon Peripherals, Ltd.

FIXED DISK DRIVES, LESS THAN 30 MB

Coverage

Examples of disk drives in this category include:

IBM	5448, System/32-34, 4962
Ampex	DF-900
BASF	6150-14, 6150-28
Burroughs	9493-9, 9493-18
Calcomp	M-10, M-20
Control Data	9414, 9730-12, 9730-24, 230-10
Digital Equipment	RK05F
EMM	103
Fujitsu	M-2251, M-2252
Hitachi	MFD 90, MFD 135, DK 62-10, DK 62-20
International Memories	7710, 7720
Kennedy	5301-14
Memorex	601-25
Microdata	7501
Nippon Electric Company	D 1210
Okidata	3301, 3302
Pertec	D1451, D1461
Philips Data Systems	X1250
Shugart Associates	SA 4004, SA 4008
Toshiba	MK-100F

The upper limit of this group has been changed to 30 MB, from the 12 MB level used in the 1977 DISK/TREND Report. The objective in setting the 30 MB limit is to include all fixed disk drives designed to be sold at the lowest possible cost per drive. As a result, the product group now includes such new low cost Winchester technology drives as the Shugart 4000 series and Calcomp Marksman series, plus a variety of other Winchester drives and drives using older technology.

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	142.0	286.1	390.0	480.2	573.7
All manufacturers	150.4	308.0	431.5	534.5	649.0

IBM continues as the major manufacturer of drives in this group, with various versions of its "Gulliver" drive used in System/32, System/34, Series/1, plus the 3790 and 3600 terminals. It is estimated that IBM shipped 17,000 spindles worldwide in 1977, with the rate increasing at least 80% in 1978, reflecting increased shipping rates for System/34, Series/1, and the older products, as well.

Other captive shipments were still small in 1977, none using Winchester technology drives, except in the Japanese domestic market.

U.S. manufacturers of OEM drives shipped only a few hundred units with Winchester technology, with the balance of the 3,300 total using essentially 2414-level technology. However, several new drives were announced in 1978 which may well be among the leaders in this product group in future years. Both the Shugart 4000 and Calcomp Marksman are designed to provide highly reliable Winchester performance at minimum cost, by simplification of the basic drive design, and through use of inexpensive stepping motor head positioning systems. And both are designed to make possible OEM prices well below \$1,500.

Low cost drives of this type are intended for use in small systems configured without the tape drives normally used for backup and archival storage on larger computer systems. Program loading and limited backup on systems using small fixed drives becomes an additional role to be assumed by the floppy disk drives invariably used with such systems.

International Memories, Inc., announced a Winchester technology drive using 200 mm disks. This drive, and others like it, may find an enthusiastic market with system OEM's wishing to shrink the physical bulk of word processing and small business systems, once in volume production.

Marketing trends

IBM's worldwide shipments of drives in this group are projected to reach 54,500 spindles in 1981. During the next three years, it is expected that IBM's shipments will reflect a continuing trend toward higher average capacities per spindle.

Burroughs' production of a 3330 technology fixed drive accounts for half of the 1978 captive production in this group, but the bulk of captive production will probably be in Winchester technology drives by 1980.

Most of the shipments of OEM drives will also be in Winchester technology drives, probably before 1980. The drives using older technology are expected to decline rapidly in shipments after 1979. It is also to be expected that a portion of the OEM drives shipped by 1981 will utilize the new recording technology IBM will introduce in early 1979 on its new System/34 and Series/1 disk drives. OEM drive shipments are expected to reach 36,300 spindles worldwide in 1981, with about 83% of this total from U.S. manufacturers, representing an average annual growth rate of 94%.

Independent shipments of PCM drives destined for IBM Series/1 users will start in 1979, with a modest success level forecast through 1981. IBM, of course, offers a drive in this product group, and the burden will be upon the independent vendor to establish adequate reason to go elsewhere.

Technical trends

Low cost and high reliability remain the key to viability for disk drives in this group. It is considered likely that Winchester technology will eventually force the retirement of older drives based on 2314 heads and disks. Newly introduced drives such as the Shugart 4000 and Calcomp Marksman have been optimized for the lowest possible production cost, compromising on such performance parameters as access time, to the degree necessary to reach cost targets.

During the next year or two, one of the most interesting unresolved questions will be the role of the "8 inch drive." Proposals to develop such drives, using Winchester technology, have been made within U.S. firms manufacturing disk drives for years.

Until recently, however, a reluctance to pioneer an unconventional recording format, and an awareness that 14" drives could be reduced still further in cost, had kept development efforts for fixed drives using small rigid disks to a minimum. Two 1978 developments have now changed the outlook: (1) A start-up company, International Memories, Inc. announced an intention to put an 11 MB drive with 200 mm (8 inches = 203 millimeters) disks into production by the end of 1978, and (2) IBM announced new 64 MB drives for early 1979 shipment, using an unannounced new technology which many industry observers believe involves a new type of recording head and disks of about 8" diameter.

There are now several programs underway in U.S. companies to develop drives using small disks, in minimum cost drives, but it is believed that most firms will not commit to final designs until they see exactly what IBM has done with its new drives. In the meantime, it appears that the IMI drive will be available for those OEM's in a hurry for small size in low cost drives.

Forecasting assumptions

1. IBM's production of drives in this category will continue to grow through 1981, as required by increasing installations of System/32, System/34, Series/1 and various terminals, but the rate of increase will decline due to a growing requirement for drives with capacities above 30 MB.
2. Captive production by other manufacturers will start to increase rapidly after 1979, with the introduction of Winchester technology drives.
3. Production of OEM drives will increase rapidly through 1981, as a result of high demand for low cost fixed drives on minimum level small business systems and other minicomputer based systems. Non-U.S. drives will not achieve a large share of the U.S. market during this period.
4. PCM drives will grow at a modest rate, due to competition from IBM drives and from independent drives in other configurations.

TABLE 35
FIXED DISK DRIVES, LESS THAN 30 MB
REVENUE SUMMARY

DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)										
	1977		Forecast							
	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	82.4	120.7	137.7	220.1	171.1	274.1	198.7	319.5	223.8	365.2
Other U.S. Captive	10.5	14.7	28.4	42.0	52.3	80.8	73.5	113.3	95.9	143.5
TOTAL U.S. CAPTIVE	92.9	135.4	166.1	262.1	223.4	354.9	272.2	432.8	319.7	508.7
PCM	--	--	--	--	3.2	5.5	6.5	11.4	11.5	20.0
OEM	5.3	6.6	18.5	24.0	22.4	29.6	27.4	36.0	33.6	45.0
TOTAL U.S. NON-CAPTIVE	5.3	6.6	18.5	24.0	25.6	35.1	33.9	47.4	45.1	65.0
TOTAL U.S. PRODUCTION	98.2	142.0	184.6	286.1	249.0	390.0	306.1	408.2	364.8	573.7
<u>Non-U.S. Manufacturers</u>										
Captive	--	8.4	--	18.9	1.9	37.1	7.5	47.3	13.3	65.8
OEM	--	--	--	3.0	.8	4.4	1.4	7.0	2.1	9.5
TOTAL NON-U.S. Production	--	8.4	--	21.9	2.7	41.5	8.9	54.3	15.4	75.3
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		150.4		308.0		431.5		534.5		649.0
TOTAL WORLDWIDE CAPTIVE		143.8		281.0		392.0		480.1		574.5
TOTAL WORLDWIDE NON-CAPTIVE		6.6		27.0		39.5		54.4		74.5

TABLE 36
FIXED DISK DRIVES, LESS THAN 30 MB
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>U.S. Net Shipments</u>													
IBM	12.4	11.6	--	11.6	24.0	19.4	43.4	24.1	67.5	28.8	96.3	33.4	129.7
Non-IBM	2.6	1.0	2.8	3.8	6.4	10.4	16.8	17.9	34.7	30.1	64.8	43.5	108.3
TOTAL	15.0	12.6	2.8	15.4	30.4	29.8	60.2	42.0	102.2	58.9	161.1	76.9	238.0
<u>Worldwide Net Shipments</u>													
IBM	15.7	17.0	--	17.0	32.7	31.0	63.7	38.6	102.3	46.3	148.6	54.5	203.1
Non-IBM	3.8	2.2	3.3	5.5	9.3	16.6	25.9	29.6	55.5	48.9	104.4	70.2	174.6
TOTAL	19.5	19.2	3.3	22.5	42.0	47.6	89.6	68.2	157.8	95.2	253.0	124.7	377.7

TABLE 37

FIXED DISK DRIVES, LESS THAN 30 MB
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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)	2.8	3.3	7.7	10.8	11.6	16.2	18.0	25.3	25.5	36.3
PCM -- Units (000)	--	--	--	--	.6	1.0	1.3	2.2	2.4	4.0
<u>Average Unit Price</u>										
To OEMs (\$000)	1.9	2.0	2.4	2.5	2.0	2.1	1.6	1.7	1.4	1.5
To End Users (\$000)	--	--	--	--	5.3	5.5	5.0	5.2	4.8	5.0
<u>Value of Shipments</u>										
To OEMs (\$M)	5.3	6.6	18.5	27.0	23.2	34.0	28.8	43.0	35.7	54.5
To End Users (\$M)	--	--	--	--	3.2	5.5	6.5	11.4	11.5	20.0

TABLE 38
FIXED DISK DRIVES, LESS THAN 30 MB

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	.8	28.5	26.5	21.2	16.7	13.8
Mini/micro computer manufacturers	.5	17.9	18.4	18.7	19.9	20.2
System OEMs/systems houses	1.2	42.9	44.1	44.7	46.4	47.2
Independent peripherals suppliers	.3	10.7	10.5	10.5	10.3	10.2
Direct to end user	--	--	--	4.9	6.7	8.6
TOTAL	2.8					

TABLE 39
FIXED DISK DRIVES, LESS THAN 30 MB

MARKET SHARE SUMMARY
Non-Captive Disk Drives

<u>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>
Control Data	1.5	53.6	1.8	54.6
Pertec	.9	32.1	1.1	33.3
Others	.4	14.3	.4	12.1
	2.8		3.3	

FIXED DISK DRIVES, 30-200 MB

Coverage

Examples of disk drives in the category include:

IBM	System/34, 4963
Ampex	DF-900
BASF	6150-42
Burroughs	9393-37
Control Data	9730-80
Fujitsu	M-2253
Hitachi	DK 62-40, DK 62-80
ISS/Univac	717
Kennedy	5302-42, 5303-70
Memorex	601-50, 601-75
Microdata	7502, 7503
Nippon Electric Company	D1220, D1240
Okidata	3303, 3304, 3305, 3306
Storage Technology	2707, 2710, 2720
Toshiba	MK-300F

The lower limit of this group has been changed to 30 MB, from the 12 MB level used in the 1977 DISK/TREND Report. It is believed that most fixed drives designed for lowest possible production cost will fall into the separate "less than 30 MB" DISK/TREND group, and that fixed drives classified in this group will tend to be optimized for higher performance. The earliest drive shipment in this group occurred in 1977.

Except for the Burroughs drive listed above, all independent disk drives in this group use Winchester technology -- and the IBM drives, not yet delivered, use an unannounced technology which is presumed to provide higher recording densities and improved production costs.

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	7.5	24.1	163.1	420.4	675.0
All manufacturers	7.5	24.1	200.0	484.6	765.2

DISK/TREND estimates of 1977 production in this group total only 700 spindles, split almost evenly between captive and OEM drives, and consisting entirely of previously announced drives from Burroughs, Microdata, Memorex and Okidata. IBM is not due to ship any drives in the group until early 1979.

The line-up of company participants in this product group is still forming: Mid-1978 announcements of new OEM drives were made by Storage Technology, ISS/Univac, Ampex, Control Data, Fujitsu, Hitachi and Nippon Electric Company.

Marketing trends

It is expected that production of all drives in this group will be boosted by the growing requirement for more disk storage on small business systems and other minicomputer based systems. The DISK/TREND projection of 35,400 IBM spindles shipped worldwide in 1981 is based on the expectation of extensive IBM usage of its new family of drives for System/34, Series/1, and in other applications to come.

Other captive drive manufacturers will undoubtedly use large quantities of drives in this group, in applications similar to IBM's, but on a later timetable. By 1979, several captive manufacturers will have started production of Winchester drives. By 1981, it is unlikely that captive drives using IBM's new technology will be in production.

OEM drive production is forecasted at 25,200 units worldwide in 1981, representing an average annual growth of 230% from 1978. U.S. manufacturers are expected to ship about 68% of the 1981 worldwide total; non-U.S. manufacturers are forecasted to ship only about 8% of the total to U.S. destinations, but about 65% of the total to non-U.S. destinations. The ability of independent manufacturers to ship OEM drives using IBM's technology by 1981 will depend on how different (and how difficult) the new technology turns out to be.

OEM shipments are expected to consist predominately of drives in the 80 MB range during the next one or two years, recognizing the difficulty of providing economical backup for drives in the 30 MB to 70 MB range. The clustering of initial shipment activity in the 80 MB area, combined with increasing shipment volume, will lead to continually declining average OEM prices through 1981.

PCM shipments, starting in 1979 with Winchester technology drives, are expected to remain at levels which will disappoint independent manufacturers. IBM's 4963 will probably be a tough act to follow, even with a lower price. Once the PCM drives offer the same technology, however, sales should increase markedly.

Technical trends

IBM's announcement of the new drives for System/34 (63.9 MB, plus a 128.4 MB double spindle version) and Series/1 (64 MB, plus a 58 MB version with fixed head option) is a critical event for independent disk drive manufacturers. IBM has indicated that the drives will use a new technology, which will not be defined until initial shipments of drives, starting in January, 1979. The problem for the independents is that IBM's

new technology will almost surely make it possible to deliver more megabytes per dollar -- therefore, there will be large bonuses in extra market share for those with the new technology on OEM drives early, and a potential disaster for those who arrive late.

If IBM is using thin film heads on the new drives, as many observers believe, it could take independent manufacturers two years to deliver a similar product, given the best possible results from the various thin film head development programs already underway by drive manufacturers and independent head manufacturers. Disks may well be smaller than the existing 14" standard, and could have a plated or sputtered magnetic surface, instead of an oxide coating. Such disks will cost independent manufacturers money for tooling and process start-up, but could probably be produced in the same time required for development of thin film heads.

Backup problems are unique with all fixed drives in this capacity range. Small fixed drives (below 30 MB) will normally be used with systems employing floppy disk drives for input/output of data, and whatever backup and program loading requirements are involved will be handled with the floppies. On the other hand a majority of the systems using disk drives above 80 MB will probably also use a tape drive on the system, which makes routine system backup reasonably fast and economical. Between 30 MB and 80 MB, however, is an awkward stage in which the backup requirement is too much for floppies, yet many of the systems are too small to justify the cost of a tape drive in addition to a rigid disk drive.

It is not yet clear whether any potential solutions the backup problem will be available at a satisfactory cost, including attempts to multiply the capacity of the 3M 1/4" tape cartridge. In the meantime, most independ-

ent system designers are reluctant to settle for systems without provision for backup of disk files. Shipments of OEM fixed disk drives in the 30 MB to 70 MB range are slow, and expected to remain that way.

Forecasting assumptions

1. IBM requirements for fixed disk drives in this capacity range will grow rapidly through 1981, caused by steady growth in larger small business systems, minicomputer systems, and other applications.
2. Substantial production of captive drives will commence in 1979, but total growth will be limited by parallel demand for storage module drives and high capacity disk cartridge drives.
3. OEM drive production by U.S. manufacturers will reach significant levels in 1979, after the normal delays for evaluation by system OEM's and start-up of system deliveries. Non-U.S. manufacturers of OEM drives will achieve their sales penetration primarily in non-U.S. markets.
4. PCM shipments will remain relatively low through 1981, due to inability to promptly match IBM's new technology drives.

TABLE 40
FIXED DISK DRIVES, 30-200 MB
REVENUE SUMMARY

DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)										
	1977		Forecast							
	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	--	--	--	--	53.9	92.4	139.7	242.0	227.7	389.4
Other U.S. Captive	4.8	6.4	12.8	19.2	30.8	44.8	78.2	124.2	129.2	206.9
TOTAL U.S. CAPTIVE	4.8	6.4	12.8	19.2	84.7	137.2	217.9	366.2	356.9	596.3
PCM	--	--	--	--	1.6	2.4	7.8	13.6	15.2	25.7
OEM	1.1	1.1	4.9	4.9	18.5	23.5	31.3	40.6	40.2	53.0
TOTAL U.S. NON-CAPTIVE	1.1	1.1	4.9	4.9	20.1	25.9	39.1	54.2	55.4	78.7
TOTAL U.S. PRODUCTION	5.9	7.5	17.7	24.1	104.8	163.1	257.0	420.4	412.3	675.0
<u>Non-U.S. Manufacturers</u>										
Captive	--	--	--	--	--	29.4	5.8	46.0	8.4	65.1
OEM	--	--	--	--	.7	7.5	2.2	18.2	3.3	25.1
TOTAL NON-U.S. PRODUCTION	--	--	--	--	.7	36.9	8.0	64.2	11.7	90.2
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		7.5		24.1		200.0		484.6		765.2
TOTAL WORLDWIDE CAPTIVE		6.4		19.2		166.6		412.2		661.4
TOTAL WORLDWIDE NON-CAPTIVE		1.1		4.9		33.4		72.4		103.8

TABLE 41
FIXED DISK DRIVES, 30-200 MB
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.S. Net Shipments													
IBM	--	--	--	--	--	--	--	4.9	4.9	12.7	17.6	20.7	38.3
Non-IBM	--	.3	.3	.6	.6	2.2	2.8	8.2	11.0	19.1	30.1	29.6	59.7
TOTAL	--	.3	.3	.6	.6	2.2	2.8	13.1	15.9	31.8	47.7	50.3	98.0
Worldwide Net Shipments													
IBM	--	--	--	--	--	--	--	8.4	8.4	22.0	30.4	35.4	65.8
Non-IBM	--	.4	.3	.7	.7	2.6	3.3	14.7	18.0	34.9	52.9	54.4	107.3
TOTAL	--	.4	.3	.7	.7	2.6	3.3	23.1	26.4	56.9	83.3	89.8	173.1

TABLE 42

FIXED DISK DRIVES, 30-200 MB
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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)	.3	.3	1.4	1.4	5.8	9.1	10.8	18.4	14.5	25.2
PCM -- Units (000)	--	--	--	--	.2	.3	1.0	1.7	2.0	3.3
<u>Average Unit Price</u>										
To OEMs (\$000)	3.5	3.5	3.5	3.5	3.3	3.4	3.1	3.2	3.0	3.1
To End Users (\$000)	--	--	--	--	7.9	8.1	7.8	8.0	7.6	7.8
<u>Value of Shipments</u>										
To OEMs (\$M)	1.1	1.1	4.9	4.9	19.1	30.9	33.5	58.9	43.5	78.1
To End Users (\$M)	--	--	--	--	1.6	2.4	7.8	13.6	15.2	25.7

TABLE 43
 FIXED DISK DRIVES, 30-200 MB
 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	--	--	--	--	3.0	5.0
Mini/micro computer manufacturers	--	--	6.0	22.8	27.3	28.6
System OEMs/systems houses	.3	100.0	88.0	63.5	48.9	39.8
Independent peripherals suppliers	--	--	6.0	10.4	12.3	14.5
Direct to end user	<u>--</u>	<u>--</u>	<u>--</u>	<u>3.3</u>	<u>8.5</u>	<u>12.1</u>
TOTAL	.3					

FIXED DISK DRIVES, MORE THAN 200 MB

Coverage

Examples of disk drives in this category include:

IBM	3344, 3350
Burroughs	9494-2, 9494-4
Control Data	9790, 9776, 33801, 819-21
ISS/Univac	735, 7350
Memorex	3644, 3650
Nippon Electric Company	D1500, D1510
Nippon Peripherals, Ltd.	NP24, NP25
Siemens	PS5-7
Storage Technology	8400, 8800, 8350

IBM's 3344/3350 established the performance standards for drives in this group. The majority of independent drives are close copies of IBM's "Madrid," the 3350 -- which represents a refinement of Winchester technology in a fixed head/disk assembly. Other design approaches are represented by such drives as the Control Data 33801/9776 (22 surfaces), Storage Technology's older drive, the 8800 Super Disk (4 spindles accessed by a single rotary actuator), and Burrough's newly announced drives (201 MB on 8 surfaces).

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	868.7	1,048.4	1,032.4	1,275.8	1,399.8
All manufacturers	868.7	1,095.7	1,115.8	1,389.2	1,533.9

The DISK/TREND estimate for IBM's 1977 and 1978 3350 shipments has been significantly increased, in view of the apparent high shipping rates

which have occurred. Users of 370 systems obviously like the 3350's cost/megabyte, to the extent that they have been installing all they can get.

In addition to IBM's heavy shipments, PCM equivalent drives are being installed at high rates in 1978, after small early deliveries in 1977. U.S. manufacturers' shipments for 1978 are forecasted for 11,100 spindles worldwide, with 9,100 of this total to U.S. destinations. The non-U.S. projected PCM total for 1978 of 800 spindles represents Nippon Peripherals, Ltd., shipments through Calcomp in the U.S. and BASF in Europe. All forecasted 1978 PCM totals are based on estimates of the total number of drives the independent manufacturers will be able to produce -- and they can probably ship more if they can make more. In any event, the heavy PCM activity will probably cause a modest decline in IBM's shipments.

During 1977 there were no shipments of other captive drives or of OEM drives. Initial shipments of several captive and OEM drive models are expected, however, in 1978.

Market trends

DISK/TREND projections of future IBM 3344/3350 shipments are predicated on an assumed announcement of an enhanced version of this drive. These forecasts assume a decline in shipments of the current drive during 1979, a start-up for shipments of a new drive during the same year, with a resulting dip in total shipments during 1979. Because of the assumed IBM product introduction during 1979, a slow up in PCM shipments is forecast for 1980, while the independents catch up with IBM's product changes.

IBM unit shipments are expected to grow to a high point of 29,500 spindles worldwide in 1981, generating \$991,200,000 in revenue. PCM unit shipments by U.S. manufacturers are forecasted to recover after matching IBM's product enhancements, to 13,500 spindles worldwide in 1981, generating revenues of \$243,800,000.

When worldwide PCM revenues to U.S. manufacturers for fixed drives in this product group are combined with PCM forecasted revenues for disk pack drives over 100 MB, the danger of a major decline in PCM revenues on "if sold" basis from new disk drives in the medium-to-large scale computer market is apparent, starting in 1980:

<u>Worldwide PCM revenues by U.S. manufacturers (\$M)</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
Disk pack drives, over 100 MB	138.2	83.6	44.4	--	--
Fixed disk drives, over 200 MB	<u>23.8</u>	<u>275.3</u>	<u>305.0</u>	<u>185.7</u>	<u>243.8</u>
COMBINED TOTAL	162.0	358.9	349.4	185.7	243.8

Once established in the 1978/1979 period, production programs by other captive manufacturers are expected to grow at about 25% per year through 1981 -- achieving a strikingly smaller production level than IBM's programs, due to a much greater reliance upon removable disk pack drives.

OEM drive production is forecasted at 4,600 spindles worldwide, of which 3,700 is from U.S. manufacturers. The relatively small size of the OEM market for drives in this group is due to the fact that there are very few makers of computers using such disk drives that do not have captive manufacturing operations.

Technical trends

Conjecture by independent manufacturers on IBM's next step in big disk drives is more intense than ever. Now that PCM drives are entering the market in quantity, the time for action by IBM could be close, and DISK/TREND forecasts are based on that assumption. As identified in the 1977 DISK/TREND Report, the possible scenarios include:

- * A double density 3350, with the increased capacity probably coming from some combination of improved track and bit density, and probably also including an enhanced fixed head capacity. The approach would provide the increased storage density needed for system growth, but is probably the easiest for independent PCM suppliers to match quickly and with modest cost.
- * Same as above, but with a 4 or 8 times increase in fixed head capacity, possibly introducing new head technology. A minority of 3350 drives have the fixed head option at present, so this approach would presumably be occasioned by IBM increased system requirements for fast access storage. Difficult for independents to match quickly if new heads are involved.
- * Bypass evolutionary 3350 improvements, and introduce dramatic increases in capacity through use of thin film or magneto resistive heads, possibly combined with thin film recording disks manufactured by plating or other processes. This approach would create huge problems for independent disk drive manufacturers because of the cost and time required to match the technology.
- * Bypass disks completely and use CCDs or magnetic bubbles for data storage, in order to eliminate electromechanical maintenance problems. An approach which would open the door to semiconductor manufacturers as the replacement for disk drives.

IBM still has the option of doing any of the above, but a double density drive continues to look like the most probable action. A drive with 635 MB per spindle is probably adequate for IBM's system requirements during the next few years, and a double density 3350 would stretch out the drive's production life a few more years, with very nice impact on profitability.

Forecasting assumptions

1. IBM will announce a mid-life kicker for the 3350 for delivery in 1979, causing temporary decline in the company's total shipments of drives in this product group in 1979. PCM shipment levels will be affected, following availability of the enhanced IBM drive, until independent versions are available.
2. Other captive production will be relatively small, with removable pack drives remaining more important than fixed drives in captive production programs.
3. OEM shipments will also remain relatively small, due to the limited number of potential customers among system OEM's without captive production programs for similar drives.

TABLE 44
FIXED DISK DRIVES, MORE THAN 200 MB
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	506.3	844.9	436.2	738.1	366.0	631.6	547.7	961.0	554.4	991.2
Other U.S. Captive	--	--	27.9	34.1	49.6	80.6	62.0	102.3	74.4	127.1
TOTAL U.S. CAPTIVE	506.3	844.9	464.1	772.2	415.6	712.2	609.7	1,063.3	628.8	1,118.3
PCM	20.8	23.8	222.0	275.3	240.0	305.0	145.6	185.7	192.0	243.8
OEM	--	--	.9	.9	10.4	15.2	18.9	26.8	25.0	37.7
TOTAL U.S. NON-CAPTIVE	20.8	23.8	222.9	276.2	250.4	320.2	164.5	212.5	217.0	281.5
TOTAL U.S. PRODUCTION	527.1	868.7	687.0	1,048.4	666.0	1,032.4	774.2	1,275.8	845.8	1,399.8
<u>Non-U.S. Manufacturers</u>										
Captive	--	--	--	24.8	--	49.6	--	83.7	--	105.4
OEM/PCM*	--	--	4.9	22.5	7.2	33.8	4.2	29.7	3.8	28.7
TOTAL NON-U.S. PRODUCTION	--	--	4.9	47.3	7.2	83.4	4.2	113.4	3.8	134.1
<u>Worldwide recap</u>										
TOTAL WORLDWIDE PRODUCTION		868.7		1,095.7		1,115.8		1,389.2		1,533.9
TOTAL WORLDWIDE CAPTIVE		844.9		797.0		761.8		1,147.0		1,223.7
TOTAL WORLDWIDE NON-CAPTIVE		23.8		298.7		354.0		242.2		310.2

* Includes Calcomp and BASF shipments of drives manufactured by Nippon Peripherals, Ltd.

TABLE 45
FIXED DISK DRIVES, MORE THAN 200 MB
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>U.S. Net Shipments</u>													
IBM	4.7	16.6	--	16.6	21.3	14.3	35.6	12.0	47.6	16.3	63.9	16.5	80.4
Non-IBM	.4	--	.8	.8	1.2	10.3	11.5	12.8	24.3	11.0	35.3	15.1	50.4
TOTAL	5.1	16.6	.8	17.4	22.5	24.6	47.1	24.8	71.9	27.3	99.2	31.6	130.8
<u>Worldwide Net Shipments</u>													
IBM	7.8	27.7	--	27.7	35.5	24.2	59.7	20.7	80.4	28.6	109.0	29.5	138.5
Non-IBM	.4	--	.9	.9	1.3	14.2	15.5	19.7	35.2	19.1	54.3	25.6	79.9
TOTAL	8.2	27.7	.9	28.6	36.8	38.4	75.2	40.4	115.6	47.7	163.3	55.1	218.4

TABLE 46

FIXED DISK DRIVES, MORE THAN 200 MB
SHIPMENT AND PRICE SUMMARY
Non-Captive Disk Drives

	1977 Net Shipments		FORECAST							
			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	.4	.9	1.9	1.8	3.3	2.5	4.6
PCM* -- Units (000)	.8	.9	9.3	11.9	10.3	13.6	7.2	9.8	10.2	13.5
<u>Average Unit Price</u>										
To OEMs (\$000)	--	--	9.0	9.0	11.5	11.7	10.5	10.7	10.0	10.2
To End Users (\$000)	26.0	26.4	24.4	24.8	24.0	24.4	20.8	21.1	19.2	19.5
<u>Value of Shipments</u>										
To OEMs (\$M)	--	--	.9	3.6	10.4	22.2	18.9	35.3	25.0	46.9
To End Users (\$M)	20.8	23.8	226.9	295.1	247.2	331.8	149.8	206.8	195.8	263.3

* Includes Calcomp and BASF shipments of drives manufactured by Nippon Peripherals, Ltd.

TABLE 47
FIXED DISK DRIVES, MORE THAN 200 MB
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	--	--	--	--	3.0	3.0
Mini/micro computer manufacturers	--	--	1.1	5.0	9.0	6.0
System OEMs/systems houses	--	--	--	3.0	6.0	8.0
Independent peripherals suppliers	--	--	--	--	2.0	3.0
Direct to end user	<u>.8</u>	100.0	98.9	92.0	80.0	80.0
TOTAL	.8					

TABLE 48
FIXED DISK DRIVES, MORE THAN 200 MB
MARKET SHARE SUMMARY
Non-Captive Disk Drives

<u>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>
Storage Technology	.7	87.5	.7	77.8
Memorex	<u>.1</u>	12.5	<u>.2</u>	22.2
	.8		.9	

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 are a number of IBM drives no longer in new production, but listed for reference.

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. In some cases, drives made by one drive manufacturer and resold by another drive manufacturer have been included for identification purposes.

DISK/TREND categories

Most category assignments for individual drives are clear, but a few arbitrary decisions have been made, mostly in connection with Category 3, disk pack drives, 29-58 MB. Some drives with capacities above and below the nominal range have been included, because they are similar in most respects to other drives included in the category.

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.

Technology type

The IBM drive model numbers used are intended as a general guide to the type of heads and recording disks employed. This identification is based on a much broader interpretation than the original IBM specifications, since other drives frequently use greater densities.

The generally used term "Winchester," IBM's pre-introduction code name for the 3340, is used to identify all similar technology employed in fixed disk drives.

Capacities

Capacities are listed as "U" for unformatted or "F" for formatted.

Accuracy

All information has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since few manufacturers' published specifications cover all of the items listed, and numerous verbal inquiries were necessary. Your corrections will be most welcome and will be included in the next edition.

DISK/TREND disk drive groups

- Removable media:
1. Disk cartridge drives, less than 12 MB
 2. Disk cartridge drives, more than 12 MB
 3. Disk pack drives, 29-58 MB
 4. Storage module drives, 25-80 MB
 5. Disk pack drives, more than 100 MB
 6. Data module drives, 35-70 MB

- Fixed media:
7. Fixed disk drives, less than 30 MB
 8. Fixed disk drives, 30 MB - 200 MB
 9. Fixed disk drives, more than 200 MB

MANUFACTURER PROFILES

Every known manufacturer of moving head rigid 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 "disk sales" refers to the DISK/TREND estimate of moving head rigid disk drives sales only -- no sales of other drive types are included, nor are sales of parts or other disk drive related products such as controllers. "Total net sales" are for each parent company's 1977 fiscal year.

AMPEX CORPORATION
Memory Products Division
1020 Kifer Road
Sunnyvale, CA 94086

408/738-4910

1977 disk sales: \$11,000,000

1977 total net sales: \$283,863,000

Net income: \$14,224,000

Although the industry's foremost pioneer in magnetic recording technology, Ampex entered the computer disk drive industry later than many of its competitors, through acquisition of a smaller firm. After several years of looking for the right strategy, the company has kept its disk drive business going by second sourcing some successful Control Data drives, notably the SMD -- and recently is starting to add other OEM drives to its product line. Data processing and related products produced 36% of total sales last year.

BALL COMPUTER PRODUCTS, INC.
Subsidiary of Ball Corporation
860 East Arques Avenue
Sunnyvale, CA 94086

408/733-6700

1977 disk sales: \$500,000

1977 total net sales: \$448,288,000

Net income: \$15,633,000

Ball's principal disk drive activity is the manufacture of Trident type drives under rights acquired from EMM. The program got started in 1976, and marketing strategy was directed to sale of subsystems to systems houses. After a management change last year, the firm is now aiming sale of this drive at the OEM market.

BASIC/FOUR CORPORATION

Subsidiary of Management Assistance, Inc.
 14101 Myford Road
 Tustin, CA 92680

714/731-5100

1977 disk sales: None

1977 total net sales: \$155,252,000

Net income: \$17,893,000

Basic/Four is using the Memorex 601 fixed Winchester disk drive in its new System 200 small business system and has a license to manufacture the drive. The company has announced that it intends to start manufacturing this drive by the end of 1978, and it is assumed that it will eventually be used in other new Basic/Four systems.

BURROUGHS CORPORATION

Burroughs Place
 Detroit, MI 48232

313/972-7000

1977 disk sales: \$237,200,000

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

Net income: \$215,179,580

After IBM, Burroughs remains the second largest manufacturer of captive disk drives. The company is now in production of Trident type drives under a Calcomp manufacturing license, and the firm remains a major manufacturer of disk pack drives and disk cartridge drives. Burroughs has been making the only thin-film head drive in production, for over a year, a head-per-track drive. Disk drive engineering and manufacturing is currently dispersed to four plants: Westlake Village, California; Glenrothes, Scotland; Winnipeg, Canada; and Guadalajara, Mexico.

CALIFORNIA COMPUTER PRODUCTS, INC.

1270 North Kraemer Blvd.
 Anaheim, CA 92806

714/632-0400

1977 disk sales: \$28,300,000

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

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

As a company, Calcomp's total sales have trended down in the last few years, but so has the size of the annual loss, and the firm could be back in the black soon. Disk drives and related items are the largest product group. The company's stated policy has been to withdraw from the IBM PCM market with products of its own manufacture, although continuing to sell IBM compatible products made by others. The current U.S. distribution agreement for Nippon Peripheral's version of the 3350 is evidence of a desire to stay in this market. Main disk drive emphasis, however, continues in the OEM market, with the Trident and other disk pack drives -- now supplemented by the Hunter high capacity disk cartridge drive and the Marksman low priced fixed Winchester drives, both potential high volume products.

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

612/853-8100

1977 disk sales: \$354,000,000
1977 total net sales: \$1,512,875,000 \$62,995,000

At this time Control Data is more of a peripherals manufacturer than a computer systems manufacturer, with about a third of total revenues coming from peripherals. Control Data's total estimated revenues from disk drives are second only to IBM's: The firm now makes disk drives in all DISK/TREND rigid disk drive categories, and not even IBM does that. CDC's disk drives are manufactured by Magnetic Peripherals, Inc., a joint venture with Honeywell, but managed by Control Data. The company has a dominant lead in OEM drives and continues to introduce new products with good potential. Control Data's marketing momentum, product development and manufacturing efficiency make it the OEM disk drive manufacturer most likely to keep on succeeding.

DATA 100 CORPORATION
6110 Blue Circle Drive
Minnetonka, MN 55343

612/941-6500

1977 disk sales: \$19,300,000
1977 total net sales: \$138,129,000 Net Income: \$6,094,000

Data 100 has maintained the OEM sales of its disk cartridge line, purchased with Iomec in 1976, and has added plug compatible subsystems for DEC and Data General computers, plus a new high density disk cartridge drive. However, Data 100 itself is now being acquired by Northern Telecom, which earlier in 1978 also acquired Sycor. The extent to which disk drives fit into Northern Telecom's plans for Data 100 is not clear.

DATA GENERAL CORPORATION
15 Turnpike Road
Westboro, MA 01581

617/366/8911

1977 disk sales: \$58,300,000
1977 total net sales: \$254,687,000 Net income: \$28,578,000

Following initiation of internal disk drive manufacturing programs, Data General has expanded the scope of its captive disk drive product line rapidly. Starting with disk cartridge drives, the firm has added 3330 type disk pack drives, a high capacity disk cartridge drive, a storage module drive and a Winchester head-per-track drive. The firm obviously intends to stay self-sufficient in disk drives.

DATAPOINT CORPORATION
Peripheral Products Division
686 West Maude Avenue
Sunnyvale, CA 94086

408/732-7330

1977 disk sales: None

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

Net income: \$8,400,000

Datapoint has renamed its Amcomp subsidiary the Peripheral Products Division. This operation had primarily made small tape drives and head-per-track disk drives until 1978. Datapoint has initiated captive manufacture of disk cartridge drives previously purchased from Wangco, under a manufacturing license from that firm.

DIABLO SYSTEMS, INC.
Subsidiary of Xerox Corporation
24500 Industrial Blvd.
Hayward, CA 94545

415/786-5000

1977 disk sales: \$52,800,000

1977 parent company

total net sales: \$5,076,900,000

Net income: \$406,627,000

Diablo is the traditional leader in OEM disk cartridge drives, and in 1977 still held about one third of the disk cartridge revenue shipped by U.S. manufacturers. The company stubbed its toe badly, however, in announcing the Series 400, a high capacity disk cartridge drive with advanced features and a low price -- and then failing to deliver. The market for disk cartridge drives is going to decline, and without new products with improved cost/performance it's hard to see a bright future for Diablo in the disk drive business.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

617/897-5111

1977 disk sales: \$154,700,000

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

Net income: \$108,500,000

DEC has been one of the two largest captive manufacturers of disk cartridge drives for years, and its 1977 sales of internally manufactured disk drives were generated entirely by the widely used RK05J, a fixed version of the same drive, and a newer high capacity disk cartridge drive. Although the firm continues to buy larger disk drives on an OEM basis from Control Data, ISS and Memorex, it has initiated manufacture of improved versions its disk cartridge drives at a new plant near Colorado Springs -- and may have plans for more vertical integration.

ELECTRONIC MEMORIES & MAGNETICS CORPORATION
 Peripheral Products Division
 1015 Timothy Drive
 San Jose, CA 95133

408/398-7080

1977 disk sales: \$3,900,000

1977 total net sales: \$108,944,000

Net income: \$4,706,000

The new management at EMM's disk drive operation has kept the business alive on the strength of the old Caelus disk cartridge drive product line, which survived the earlier sell-off of the original Caelus media manufacturing operations to Univac and the sale of a Trident type product line to Ball. Now, however, EMM has started production of a high capacity disk cartridge drive, and plans additional products -- and things are looking up.

HEWLETT PACKARD COMPANY
 Disk Memory Division
 11413 Chinden Blvd.
 Boise, Idaho 83707

208/376-6000

1977 disk sales: \$54,300,000

1977 total net sales: \$1,373,900,000

Net income: \$121,500,000

As Hewlett Packard becomes more and more a computer company, it may be expected that the company's commitment to internal development and manufacture of disk drives will continue. HP hasn't hesitated to adapt standard industry technology into slightly different drive configurations, thus offering disk drives with performance advantages against its key minicomputer competitors. HP runs a highly integrated manufacturing facility, making heads and most other critical parts internally. Manufacturing was moved to a new plant at Boise during 1977.

INTERNATIONAL BUSINESS MACHINES CORPORATION
 Route 22
 Armonk, NY 10504

914/765-1900

1977 disk sales: \$1,236,600,000

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

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

IBM's role in the disk drive industry has been dominant: Develop and introduce each generation of new drives, set de facto standards for most important drive configurations, generate more disk drive revenue than any other company. The company's main concern, of course, has been to provide efficient auxiliary storage for its computer systems and to make a high gross profit on a major peripheral -- but a large industry in its own right has come into existence in IBM's backwash. Ironically, IBM has almost abandoned the manufacture of removable media disk drives, for which it developed all the original formats. The major portion of non-IBM disk drive revenues are

still derived from drives with removable media, but IBM has moved on to high performance fixed disk drives which, with the 3340 Winchester drive, produced an estimated 95% of IBM's worldwide disk drive revenues in 1977. At this time, IBM appears to be on the threshold of introducing still another generation of technology, in another fixed drive configuration, for its minicomputers and small business systems. The rest of the world may be expected to follow.

INTERNATIONAL MEMORIES, INC.
10381 Bandley Drive
Cupertino, CA 95014

408/446-9779

1977 disk sales: None
1977 total sales: None

IMI was founded in 1977 with the objective of starting production of a Winchester technology drive using nominal eight inch (actually 200 mm) disks, before the end of 1978. During a brief period in mid-1978 the firm sold a reported one third interest to 3M, parted company with two of the founders, severed the 3M relationship, and installed new management. The firm still plans to make the announced product, but has probably slipped a few months from the planned shipping schedule.

ISS (See Sperry Rand)

KENNEDY COMPANY
540 West Woodbury Road
Altadena, CA 91001

213/798-0953

1977 disk sales: None

Kennedy is a privately held company claiming 1977 sales of approximately \$16,000,000. A well-established manufacturer of small tape drives, Kennedy announced a fixed Winchester disk drive in 1977, and started production in early 1978. The firm has indicated it is also developing an eight inch Winchester drive.

MEMOREX CORPORATION
San Tomas and Central Expressways
Santa Clara, CA 95052

408/987-1000

1977 disk sales: \$87,300,000
1977 total net sales: \$450,112,000

Net income: \$56,325,000

In recent years Memorex' primary source of disk drive revenues has been derived from its 3330 type drives, with the PCM business, always its primary thrust, providing the majority of the dollars. The PCM market for 3330's is fading fast, however, and Memorex is looking to its 3350

replacement to pick up the slack. The firm had a painful and slow startup with this product, but production volume has been building since early 1978, and Memorex should be able to retain a reasonable, but reduced, share of the PCM market. In the OEM rigid disk area, Memorex' product line is limited to 3330 drives sold primarily to DEC, plus a fixed Winchester drive still at low production levels. On balance, the Memorex strategy of concentrating on high volume PCM drives has produced a profitable but shaky role as one of the leaders in the PEM area, and a narrow OEM product line which can be sold to a limited segment of the OEM market.

MICRODATA CORPORATION
17481 Red Hill Avenue
Irvine, CA 92714

714/540-1113

1977 disk sales: \$8,700,000

1977 total net sales: \$37,717,000

Net income: \$1,917,000

After suffering extended delays in delivering its "Express" computer system and some announced peripherals, Microdata seems to be back on its normal rapid growth pattern. For a minicomputer manufacturer of its size, Microdata's vertical integration programs have been ambitious. It has been shipping disk cartridge drives since 1975, and was one of the early independents to announce a fixed Winchester drive, which has been shipped in limited quantities since 1977. Attempts to develop OEM sales volume for disk drives have yielded modest results so far, but the company is still working at it.

OKIDATA CORPORATION
111 Gaither Drive
Mt. Laurel, NJ 08054

609/235-2600

1977 disk sales: \$1,100,000

Okidata is a privately held firm, with ownership split between Oki Electric Industry Co., Ltd., Tokyo, and U.S. investors. Okidata's U.S. manufactured products are printers and card readers, as well as head-per-track disk drives. The firm's fixed Winchester drive is manufactured at Santa Barbara, California, with first deliveries in 1977. This program seems to be off to a good start, with the main problem to build up the production rate in 1978.

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

213/882-0030

1977 disk sales: \$23,200,000

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

Net income: \$4,691,000

Pertec's acquisition during the last few years of extensive key-to-disk and hobby computer operations has broadened the firm's scope greatly,

but the majority of revenues still are generated by the peripherals business: Tape drives, terminals and disk drives. Pertec's line of disk cartridge drives and related fixed disk drives needs to be supplemented with newer products if the company is to maintain its growth in the OEM market, and efforts to do so are apparently underway.

PRIAM CORPORATION
20730 Valley Green Drive
Cupertino, CA 95014

408/446-4626

1977 disk sales: None

Priam is a start-up operation, formed in 1978 to develop and manufacture a small fixed Winchester drive for the OEM market. The firm is privately held, with the founders previously at Memorex.

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

408/733-0100

1977 disk sales: None

1977 parent company

total net sales: \$5,076,900,000

Net income: \$406,627,000

Shugart is known primarily as the hugely successful manufacturer of floppy disk drives which dominates the OEM sector of that market. Exploiting its position in the floppy market, Shugart has introduced a fixed Winchester disk drive tailor-made for the same market. The Shugart drive is optimized for low production cost, using a stepping motor actuator and other design short cuts. A controller which can intermix floppies and the new drive may cut OEM design-in time, and help build early production volume. This drive looks like it's destined for large volume production -- and the company has hinted that it will follow with an eight inch fixed Winchester drive.

SPERRY RAND CORPORATION
Sperry Univac Division
ISS operating unit
10435 North Tantau Avenue
Cupertino, CA 95014

408/257-6220

1977 disk sales: \$181,500,000

1977 total net sales: \$3,370,008,000

Net income: \$156,826,000

ISS continues to develop its product line and maintain its role as one of the few disk drive manufacturing operations to participate in a combination

of the captive, PCM and OEM segments of the market. The firm has broken ground on a major new facility in Santa Clara which will eventually house all disk drive operations, now overflowing the original Cupertino buildings. In addition to making captive drives for Univac, ISS has a continuing OEM marketing activity, which has completed the industry's only major OEM sale of 3350 type drives to date, to DEC. ISS sales of PCM drives are actually made to Intel and Telex, which then market the drives to end users, but DISK/TREND statistics include these sales in the PCM totals to avoid distorting the true size of the PCM segment of the industry.

STORAGE TECHNOLOGY CORPORATION

2270 South 88th Street
Louisville, CO 80027

303/666-6581

1977 disk sales: \$20,700,000

1977 total net sales: \$162,272,000

Net income: \$11,427,000

STC is the dominant PCM supplier of high performance tape drives. Earlier attempts to duplicate this success in 3330 technology disk drives produced only marginal results, but the company is now apparently on its way to earning a significant share of the PCM disk market. STC achieved volume deliveries of 3350 type drives about six months ahead of other PCM vendors, and is expected to ship a major portion of the independent 3350's shipped in 1978. A further expansion in the disk drive area is represented by STC's mid-1978 announcement of a family of fixed Winchester drives designed for the OEM market. It seems clear that STC is destined to be a major factor in future disk drive markets.

SYCOR, INC.

100 Phoenix Drive
Ann Arbor, MI 48104

313/971-0900

1977 disk sales: --

1977 total net sales: \$76,769,000

Net income: \$3,184,000

Sycor was acquired in 1978 by Northern Telecom. The company's only rigid disk drive is a small fixed drive using 2314 technology, which is manufactured on a captive basis for use with its terminal systems.

VERMONT RESEARCH CORPORATION

Precision Park
North Springfield, VT 05156

802/886-2256

1977 disk sales: --

1977 total net sales: \$4,967,000

Net income: \$636,000

VRC is primarily a manufacturer of head-per-track disk drives, but has been offering an advanced 50 MB disk cartridge drive since 1973 with negligible sales. The drive is notable as probably the earliest announced disk drive using embedded servo techniques. The firm has finally made a sale of this drive in Europe, but its future in the OEM market seems limited.

WANGCO, INC.

Subsidiary of Perkin-Elmer Corporation

Perkin-Elmer Data Systems Group

5404 Jandy Place

Los Angeles, CA 90066

213/390-8081

1977 disk sales: \$18,500,000

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

Net income: \$26,562,000

Wangco's business was built with a family of small tape drives, which became an industry leader, later supplemented with disk cartridge drives. Wangco was acquired by Perkin-Elmer in 1976, and was merged into a new data systems group, with Interdata and the P-E terminal division. During the last year, several management changes have occurred at Wangco, as the new organization took shape. Wangco's current disk drive revenues are based entirely on disk cartridge drives, including a high capacity version. However, the firm has invested in the development of advanced disk drives, and has announced a family of storage module drives, including a unique SMD which combines 80 MB fixed with 80 MB removable, on a single drive.

WESTERN DYNEX CORPORATION

3536 West Osborn Road

Phoenix, AZ 85019

602/269-6401

1977 disk sales: \$9,900,000

Western Dynex is a privately held company, and has grown rapidly by specializing in the manufacture of OEM cartridge disk drives. A fixed version of the cartridge drives is now in production. Western Dynex will probably have to attempt expansion into more advanced disk drive technologies if growth is to continue after the cartridge business tops out.

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Ampex	Ampex	Ampex	Ampex	Ampex	Ampex	Ampex
DM-440	DM-441	DM-442	DM-443	DM-445	DM-446	DM-447
1	1	1	1	1	1	1
--	--	--	--	--	--	--
2315	2315	2315	2315	5440	5440	5440
2314	2314	2314	2314	2314	2314	2314
14"	14"	14"	14"	14"	14"	14"
--	U: 3.125	--	U: 6.25	--	U: 3.125	--
U: 3.125	U: 3.125	U: 6.25	U: 6.25	U: 3.125	U: 3.125	U: 6.25
U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 7,812
2	4	2	4	2	4	2
1	1	1	1	1	1	1
200	200	400	400	200	200	400
100	100	200	200	100	100	200
2200	2200	2200	2200	2200	2200	2200
1500/2400	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400
35	35	35	35	35	35	35
20/12.5	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5
55/37.5	55/37.5	55/37.5	55/37.5	55/37.5	55/37.5	55/37.5
195/312.5	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5
1975	1975	1975	1975	1975	1975	1975
Mfg. by Western Dynex	Mfg. by Western Dynex	Mfg. by Western Dynex	Mfg. by Western Dynex	Mfg. by Western Dynex	Mfg. by Western Dynex	Mfg. by Western Dynex

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Ampex	Ampex	Ampex	Ampex	Ampex	Ampex	Ampex
DM-448	DM-323	DM-940	DM-980	DM-9100	DM-9160	DM-9200
1	3	4	4	5	5	5
--	--	--	--	--	--	--
5440	2316	SMD	SMD	3336-1	3336-11	3336-11
2314	2314	3330-11	3330-11	3330-1	3330-11	3330-11
14"	14"	14"	14"	14"	14"	14"
U: 6.25	--	--	--	--	--	--
U: 6.25	F: 58.4	U: 41.4	U: 82.8	U: 103.17	U: 165.8	U: 206.3
U: 7,812	F: 7,294	U: 20,160	U: 20,160	U: 13,440	U: 20,160	U: 13,440
4	20	5	5	19	5	19
1	1	1	1	1	1	1
400	406	411	822	411	1645	815
200	200	192	384	192	800	370
2200	2200	6038	6038	4040	6038	4040
1500/2400	2400	3600	3600	3600	3600	3600
35	32	30	30	28	28	28
20/12.5	12.5	8.33	8.33	8.33	8.33	8.33
55/37.5	44.5	38.33	38.33	36.33	36.33	36.33
195/312.5	312.5	1209	1209	806	1209	806
1975	1973	10/75	1/76	11/75	4Q78	11/75
Mfg. by Western Dynex						

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Ampex	Ampex	Ampex	Ampex	Ampex	Ampex	Ampex
DM-9300	DM-331	DM-PTD Parallel Transfer Drive	DF-900	DF-900	DF-900	DF-900
5	5	5	7	8	8	8
--	--	--	--	--	--	--
3336-11	3336-11	3336-11	Fixed	Fixed	Fixed	Fixed
3330-11	3330-11	3330-11	Winchester	Winchester	Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
--	--	--	U: 12.5	U: 37.6	U: 62.7	U: 87.8
U: 309.5	U: 206.3	U: 312.177	--	--	--	--
U: 20,160	U: 13,440	U: 20,160	U: 17,920	U: 17,920	U: 17,920	U: 17,920
19	19	19	1	3	5	7
1	1	1	2	2	2	2
815	815	815	700	700	700	700
370	370	384	300	300	300	300
6038	4040	6038	5636	5636	5636	5636
3600	3600	3600	2964	2964	2964	2964
28	28	28	40	40	40	40
8.33	8.33	8.33	10.1	10.1	10.1	10.1
36.33	36.33	36.33	50.1	50.1	50.1	50.1
1209	806	1209	885	885	885	885
5/76	11/74	1978	3Q78	3Q78	3Q78	3Q78

AMPEX

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

				Ball Computer Products	Ball Computer Products	
Ampex	Ampex	Ampex	Ampex			BASF
DM-401	DM-402	DM-403	DM-404	BD-50	BD-80	6150-14
7	7	7	7	4	4	8
--	--	--	--	--	--	--
Fixed	Fixed	Fixed	Fixed	Trident	Trident	Fixed
2314	2314	2314	2314	3330-11	3330-11	Winchester
14"	14"	14"	14"	14"	14"	14"
U: 3.13	U: 6.25	U: 6.25	U: 12.5	--	--	U: 14.1
--	--	--	--	U: 54.7	U: 82.1	--
U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 13,440	U: 20,160	U: 20,160
2	4	2	4	5	5	1
1	1	1	1	1	1	2
203	203	406	406	815	815	700
100	100	200	200	370	370	300
2200	2200	2200	2200	4040	6060	6380
1500/2400	1500/2400	1500/2400	1500/2400	3600	3600	2976
70	70	70	70	30	30	40
20/12.5	20/12.5	20/12.5	20/12.5	8.33	8.33	10.1
90/82.5	90/82.5	90/82.5	90/82.5	38.33	38.33	50.1
195/312.5	195/312.5	195/312.5	195/312.5	806	1209	1000
1978	1978	1978	1978	8/76	4/77	1Q78
Mfg. by Western Dynex	Mfg. by Western Dynex	Mfg. by Western Dynex	Mfg. by Western Dynex			

AMPEX

BALL

BASF

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

BASF	BASF	BURROUGHS	BURROUGHS	BURROUGHS	BURROUGHS	BURROUGHS
6150-28	6150-42	9480-2 9480-12	9481-2 9481-12	9482-32	9384-6 9384-7 9384-8 9388-2	9383-6 9383-7 9383-8 9386-4
8	8	1	1	1	3	3
--	--	9985-3	9985	9985	9974-4	9974-4
Fixed	Fixed	2315	2315	2315	2316	2316
Winchester	Winchester	2314	3330-1	3330-1	2314	2314
14"	14"	14"	14"	14"	14"	14"
U: 28.2	U: 42.3	--	--	--	--	--
--	--	F: 2.3	F: 4.68	F: 9.3	F: 64.8	F: 87.2
U: 20,160	U: 20,160	F: 5,760	F: 11,520	F: 11,520	F: 10,800	F: 10,800
2	3	2	2	2	20	20
2	2	1	1	1	1	1
700	700	203	203	404	300	404
300	300	100	100	200	200	200
6380	6380	2200	4400	4400	4400	4400
2976	2976	1500	1500	1500	2400	2400
40	40	60	60	35	30	30
10.1	10.1	20	20	20	12.5	12.5
50.1	50.1	80	80	55	42.5	42.5
1000	1000	193	193	387.5	625	625
1Q78	1Q78			7/76	1974	1974

BASF

BURROUGHS

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Burroughs	Burroughs	Burroughs	Burroughs	Burroughs	Burroughs	Burroughs
9383-16 9383-17 9383-18 9484-8	9484-2	9484-5	9493-9	9493-18	9493-28	9493-37
5	4	4	7	7	7	8
9974-4		9974-5	--	--	--	--
2316	Trident	Trident	Fixed	Fixed	Fixed	Fixed
3330-11	3330-11	3330-11	3330-1	3330-1	3330-1	3330-1
14"	14"	14"	14"	14"	14"	14"
--	--	--	F: 9.4	F: 18.8	Drive consists of 2 spindles F: 28.2	Drive consists of 2 spindles F: 37.6
F: 174.4	F: 32.6	F: 65.2	--	--	--	--
F: 10,800	F: 16,200	F: 16,200	11,520	11,520	11,520	11,520
20	5	5	2	4	2	4
1	1	1	1	1	1	1
808	407	815	400	400	400	400
400	370	370	200	200	200	200
4400	6039	6039	4000	4000	4000	4000
2400	3672	3672	1500	1500	1500	1500
30	25	25	35	35	35	35
12.5	8.33	8.33	20	20	20	20
42.5	33.33	33.33	55	55	55	55
625	1210	1210	348	348	348	348
1976	1977	1977	1/77	1/77	1/77	1/77
Embedded Servo						

BURROUGHS

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Burroughs	Burroughs	California Computer Products	California Computer Products	California Computer Products	California Computer Products	California Computer Products
9494-2	9494-4	Hunter H-32	Hunter H-64	Hunter H-96	114	213 215
9	9	2	2	2	3	3
--	--	--	--	--	--	--
Fixed	Fixed	5440	5440	5440	2316	2316
3330-11	3330-11	3330-11	3330-11	3330-11	2314	2314
14"	14"	14"	14"	14"	14"	14"
	Drive consists of 2 spindles					
F: 201	F: 402	U: 16.6	U: 49.8	U: 83	--	--
--	--	U: 16.6	U: 16.6	U: 16.6	F: 29.176	F: 58.35
		U: 20,160	U: 20,160	U: 20,160	F: 7,294	F: 7,294
8	8	F: 1 R: 2	F: 3 R: 2	F: 5 R: 2	20	20
1	1	1	1	1	1	1
1564	1564	F: 823 R: 412	F: 823 R: 412	F: 823 R: 412	203	406
714	714	F: 384 R: 192	F: 384 R: 192	F: 384 R: 192	100	200
6551	6551	6060	6060	6060	2200	2200
3672	3672	3600	3600	3600	2400	2400
28	28	30	30	30	35	35
8	8	8.33	8.33	8.33	12.5	12.5
36	36	38.33	38.33	38.33	47.5	47.5
1300	1300	1209	1209	1209	312.5	312.5
4Q78	4Q78	4Q78	4Q78	4Q78		
B1800-B7800	B1800-B7800	Removable Disk Recorded Two Sides	Removable Disk Recorded Two Sides	Removable Disk Recorded Two Sides		

BURROUGHS

CALCOMP

MANUFACTURER	California Computer Products	California Computer Products	California Computer Products	California Computer Products	California Computer Products	California Computer Products	California Computer Products
DRIVE	Trident T-25	Trident T-50	Trident T-80 T-82	Trident T-200 T-202	Trident T-300 T-302	225	Marksman M-10
DISK/TREND GROUP	4	4	4	5	5	5	7
MEDIA: Manufacturer's number	--	--	--	--	--	--	--
Generic type	Trident	Trident	Trident	3336-11	3336-11	2316	Fixed
TECHNOLOGY TYPE, DRIVE	3330-11	3330-11	3330-11	3330-11	3330-11	2314	Winchester
NOMINAL DISK DIAMETER	14"	14"	14"	14"	14"	14"	14"
PERFORMANCE							
Total capacity (MBytes) FIXED	--	--	--	--	--	--	U: 10.08
REMOVABLE	U: 27.4	U: 54.7	U: 82.1	U: 208.1	U: 312.1	U: 125	--
Capacity per track (Bytes)	U: 13,440	U: 13,440	U: 20,160	U: 13,440	U: 20,160	U: 15,625	U: 24,000
Data surfaces per spindle	5	5	5	19	19	20	1
Heads per data surface	1	1	1	1	1	1	2
Tracks per surface	408	815	815	815	815	406	420
TPI	185	370	370	370	370	200	182
BPI	4040	4040	6060	4060	6060	4400	7545
RPM	3600	3600	3600	3600	3600	2400	2400
Average positioning time (msec)	30	30	30	30	30	35	60
Average rotational delay (msec)	8.33	8.33	8.33	8.33	8.33	12.5	12.5
Average access time (msec)	38.33	38.33	38.33	38.33	38.33	47.5	72.5
Data transfer rate (KBytes/sec)	806	806	1209	806	1209	625	960
FIRST CUSTOMER SHIPMENT	8/75	5/75	8/75	6/76	8/76		3Q78
COMMENTS							Stepping Motor Actuator

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

California Computer Products	CII- Honeywell Bu11	CII- Honeywell Bu11	Control Data	Control Data	Control Data	Control Data
Marksman M-20	D120	D140	9427H	9448-32	9448-64	9448-96
7	1	2	1	2	2	2
-- Fixed	"MIDIDISK" Special Cartridge	"MIDIDISK" Special Cartridge	9847 (100 TPI) 9848 (200 TPI) 5440	91204 Special	91204 Special	91204 Special
Winchester	3330-11	3330-11	2314	SMD	SMD	SMD
14"	10.5"	10.5"	14"	14"	14"	14"
U: 20.16	--	F: 10	U: 6.25	U: 16.289	U: 48.869	U: 81.446
--	F: 10	F: 10	U: 6.25	U: 16.289	U: 16.289	U: 16.289
U: 24,000	F: 12,800	F: 12,800	U: 7,812	U: 20,160	U: 20,160	U: 20,160
2	2	4	4	2	4	6
2	1	1	1	1	1	1
420	392	392	406	823	823	823
182	500	500	200	384	384	384
7545	4750	4750	2200	6038	6038	6038
2400	3600	3600	2400/1500	3600	3600	3600
60	75	75	35	30	30	30
12.5	8.33	8.33	12.5/20	8.33	8.33	8.33
72.5	83.33	83.33	47.5/55	38.33	38.33	38.33
960	920	920	312.5/195	1209	1209	1209
3Q78	1978	1978	8/74	3Q78	3Q78	3Q78
Stepping Motor Actuator	Embedded Servo	Embedded Servo	OEM	OEM Separate Servo Surface For Fixed and Removable Disks	OEM Separate Servo Surface For Fixed and Removable Disks	OEM Separate Servo Surface For Fixed and Removable Disks

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Control Data	Control Data	Control Data	Control Data	Control Data	Control Data	Control Data
9746 9747	9760	9762	270-10	9764	9766	270-30
3	4	4	4	5	5	5
9873	9876	9877	877	9883-91	9883-91	883-91
2316	SMD	SMD	SMD	3336-11	3336-11	3336-11
2314	3330-11	3330-11	3330-11	3330-11	3330-11	3330-11
14"	14"	14"	14"	14"	14"	14"
--	--	--	--	--	--	--
U: 62.5	U: 40.7	U: 81.5	F: 63	U: 154.8	U: 309.5	F: 240
U: 7,812	U: 20,160	U: 20,160	F: 15,360	U: 20,160	U: 20,160	F: 15,360
20	5	5	5	19	19	19
1	1	1	1	1	1	1
406	411	823	823	411	823	823
200	192	384	384	192	384	384
2220	6038	6038	6038	6038	6038	6038
2400	3600	3600	3600	3600	3600	3600
35	30	30	30	30	30	30
12.5	8.33	8.33	8.33	8.33	8.33	8.33
47.5	38.33	38.33	38.33	38.33	38.33	38.33
312.5	1209	1209	1209	1209	1209	1209
1974	3/74	3/75	1978	3/76	3/76	1978
OEM	OEM	OEM	Series/1 Interface	OEM	OEM	Series/1 Interface

CONTROL DATA

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Control Data	Control Data	Control Data	Control Data	Control Data	Control Data	Control Data
9754 9756	9780	9784 9786	9770	9414	9730-12	9730-24
5	5	5	6	7	7	7
9879	9883	9882	9778	--	--	--
3336-1	3336-11	3336-11	3348	Fixed	Fixed	Fixed
3330-1	3330-11	3330-11	3340 Winchester	2314	Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
--	--	--	--	U: 12.5/6.25	.96 MB Fixed Head Option U: 12.9	.96 MB Fixed Head Option U: 25.8
F: 100	F: 200	F: 200	F: 35/70	--	--	--
F: 13,030	F: 13,030	F: 13,030	F: 16,736	U: 7,812	U: 20,160	U: 20,160
19	19	19	3/6	4/2	1	2
1	1	1	2	1	2	2
411	822	822	696/2	408	640	640
192	384	384	300	200/100	296	296
4040	4040	4040	5636	2200	6220	6220
3600	3600	3600	2964	2400/1500	3600	3600
30	30	30	25	65	40	40
8.33	8.33	8.33	10.1	12.5/20	8.33	8.33
38.33	38.33	38.33	35.1	77.5/85	48.33	48.33
806	806	806	885	312.5/195	1209	1209
			1976	9/76	5/77	5/77
OEM Drive; PCM Version 33301	OEM Drive; PCM Version 33302	OEM	OEM	OEM	OEM	OEM

CONTROL DATA

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Control Data	Control Data	Control Data	Control Data	Control Data	Control Data	Control Data
230-10	230-20	9730-80	33801-A2 33801-B2 33801-C2 (3330 Format)	33801-A2 33801-B2 33801-C2 (3350 Format)	9776-A2 9776-B2 9776-C2	9790
7	7	8	9	9	9	9
--	--	--	--	--	--	--
Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Winchester	Winchester	Winchester	*	*	*	3330-11
14"	14"	14"	14"	14"	14"	14"
.74 MB Fixed Head Option F: 9.3	.74 MB Fixed Head Option F: 19.7	.96 or 1.93 MB Fixed Head Option U: 82.9	1.24 MB Fixed Head Option F: 400	1.72 MB Fixed Head Option F: 317.5	1.24 MB Fixed Head Option F: 400	U: 325.8
--	--	--	--	--	--	--
F: 15,360	F: 15,360	U: 20,160	*	*	*	U: 20,160
1	2	5	*	*	*	40
2	2	2	*	*	*	1
606	640	823	*	*	*	411
296	296	340	*	*	*	192
6220	6220	6220	*	*	*	6000
3600	3600	3600	3600	3600	3600	3600
40	40	30	25	25	25	50
8.33	8.33	8.33	8.33	8.33	8.33	8.33
48.33	48.33	38.33	33.33	33.33	33.33	58.33
1209	1209	1209	1198	1198	1198	4840
1Q79	1Q79	1Q79	1978	1978	1Q79	1975
Series/1 Interface	Series/1 Interface	OEM	PCM *Not yet announced	PCM *Not yet announced	OEM *Not yet announced	OEM

CONTROL DATA

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Control Data	Control Data	Data 100	Data 100	Data 100	Data 100	Data 100
819-11	819-21	3002	3004	3402	3404	3850
9	9	1	1	1	1	1
--	--	--	--	--	--	--
Fixed	Fixed	2315	2315	5440	5440	2315/5440
3330-11	3330-11	2314	2314	2314	2314	2314
14"	14"	14"	14"	14"	14"	14"
U: 325.8	U: 651.6	U: 3	U: 6	U: 3	U: 6	F: 2.5/5
--	--	U: 3	U: 6	U: 3	U: 6	F: 2.5/5
U: 20,160	U: 20,160	U: 7,500	U: 7,500	U: 7,500	U: 7,500	F: 6,144
40	40	4	4	4	4	4
1	1	1	1	1	1	1
411	823	203	406	203	406	203/406
192	384	100	200	100	200	100/200
6000	6000	2200	2200	2200	2200	2200
3600	3600	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400
50	50	38	38	38	38	38
8.33	8.33	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5
58.33	58.33	58/50.5	58/50.5	58/50.5	58/50.5	58/50.5
4840	4840	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5
1978	1978					7/77
						PCM DEC PDP-11

CONTROL DATA

DATA 100

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Data 100	Data 100	Data General	Data General	Data General	Data General	Data General
3860	4406	6045 6046 6047 6048	6095	6070	6067	6060
1	2	1	1	2	4	5
--	--	--	--	1145	1143	--
5440	5440	5440	5440	5440	SMD	3336-1
2314	3330-1	2314	2314	3330-1	3330-11	3330-1
14"	14"	14"	14"	14"	14"	14"
F: 5	U: 12	F: 5.014	F: 5.014	F: 10.027	--	--
F: 5	U: 12	F: 5.014	F: 5.014	F: 10.027	F: 50.074	F: 95.957
F: 6,144	U: 15,000	F: 6,144	F: 6,144	F: 12,288	F: 12,288	F: 12,288
4	4	4	4	4	5	19
1	1	1	1	1	1	1
406	406	408	408	408	815	411
200	200	200	200	200	370	192
2200	4400	2200	2200	4040	4040	4040
2400	2400	2400	2400	2400	3600	3600
38	38	38	38	38	35	35
12.5	12.5	12.5	12.5	12.5	8.33	8.33
50.5	50.5	50.5	50.5	50.5	43.33	43.33
312.5	625	312.5	312.5	625	806	806
7/77	1Q79	1976				1976
PCM DATA GENERAL						

DATA 100

DATA GENERAL

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Data General	Datapoint	Datapoint	Datapoint	Data Recording Instruments	Data Recording Instruments	Diablo Systems
6061	9350	9360	9374	3206	3212	31
5	1	1	2	1	1	1
-	80362	80362	80428	--	--	--
3336-11	2315	2315	5440	2315	2315	2315
3330-11	2314	2314	3330-1	2314	3330-1	2314
14"	14"	14"	14"	14"	14"	14"
--	--	F: 2.49	F: 10.027	--	--	--
F: 190.280	F: 2.49	F: 2.49	F: 10.029	U: 6	U: 12	U: 1.5/3.0
F: 12,288	F: 6,144	F: 6,144	F: 12,288	U: 7,812	U: 7,812	U: 3,750/7,500
19	2	4	4	4	4	2
1	1	1	1	1	1	1
815	203	203	408	410	410	203
370	100	100	200	200	200	100
4040	2200	2200	4400	2200	4400	1100/2200
3600	1500	1500	2400	1500	1500	1500
35	70	70	35	70	70	70
8.33	20	20	12.5	20	20	20
43.33	90	90	47.5	90	90	90
806	195	195	625	195	390	97.5/195
1976	1978	1978	1978			8/70

DATA GENERAL

DATAPPOINT

DRI

DIABLO

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Diablo Systems	Diablo Systems	Diablo Systems	Diablo Systems	Diablo Systems	Digital Equipment Corporation	Digital Equipment Corporation
33	43	44	44B	33F	RK05J	RL01
1	1	1	1	7	1	1
--	--	--	--	--	RK05K	RL01K
2315	5440	5440	5440	Fixed	2315	5440
2314	2314	2314	2314	2314	2314	3330-1
14"	14"	14"	14"	14"	14"	14"
U: 1.5/3.0	U: 3.125	U: 6.25	U: 6.25	U: 3.0/6.0	--	--
U: 1.5/3.0	U: 3.125	U: 6.25	U: 6.25	--	F: 2.49	F: 5.24
U: 3,750/7,500	U: 7,812	U: 7,812	U: 7,812	U: 3,700/7,500	F: 6,144	F: 10,240
4	4	4	4	4	2	2
1	1	1	1	1	1	1
203	204	408	408	203	203	256
100	100	200	200	100	100	125
1100/2200	2200	2200	2200	1100/2200	2040	3725
1500	2400	2400	2400	1500	1500	2400
70	38	38	38	70	50	55
20	12.5	12.5	12.5	20	20	12.5
90	50.5	50.5	50.5	90	70	67.5
97.5/195	312.5	312.5	312.5	97.5/195	180	512.5
8/70	3/72	10/72	3Q76		1975	4/78
					Original RK05 FCS 1972	Embedded Servo

DIABLO

DEC

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Digital Equipment Corporation	Digital Equipment Corporation	Digital Equipment Corporation	Digital Equipment Corporation	Digital Equipment Corporation	Electronic Memories & Magnetics Corp.	Electronic Memories & Magnetics Corp.
RK06	RK07	RM02	RM03	RK05F	203-1	203-2
2	2	4	4	7	1	1
RK06K Special Cartridge	RK07K Special Cartridge	-- SMD	-- SMD	-- Fixed	-- 2315	-- 2315
3330-1	3330-11	3330-11	3330-11	2314	2314	2314
14"	14"	14"	14"	14"	14"	14"
--	--	--	--	F: 4.99	--	U: 3.0
F: 13.89	F: 27.54	F: 67.42	F: 67.42	--	U: 3.0	U: 3.0
F: 11,264	F: 11,264	F: 16,384	F: 16,384	F: 6,144	U: 7,500	U: 7,500
3	3	5	5	2	2	4
1	1	1	1	1	1	1
411	815	823	823	406	204	204
192.3	384.6	384	384	200	100	100
4040	4040	6038	6038	2040	2200	2200
2400	2400	2400	3600	1500	1500	1500
38	36.5	30	30	56	40	40
12.5	12.5	12.5	8.33	20	20	20
50.5	49	42.5	38.33	76	60	60
538	538	806	1209	180	199	199
12/76	4/78	4/78	1977	7/76	1/72	5/72
		Manufactured by CDC	Manufactured by CDC		2400 RPM Optional	2400 RPM Optional

1978 DISK/TREND REPORT

MANUFACTURER	Electronic Memories & Magnetics Corp.	Electronic Memories & Magnetics Corp.	Electronic Memories & Magnetics Corp.	Electronic Memories & Magnetics Corp.	Electronic Memories & Magnetics Corp.	Electronic Memories & Magnetics Corp.	Electronic Memories & Magnetics Corp.
DRIVE	206-1	206-2	303-1	303-2	306-1	306-2	312-25
DISK/TREND GROUP	1	1	1	1	1	1	2
MEDIA: Manufacturer's number	--	--	--	--	--	--	
Generic type	2315	2315	5440	5440	5440	5440	5440
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	2314	2314	3330-11
NOMINAL DISK DIAMETER	14"	14"	14"	14"	14"	14"	14"
PERFORMANCE							
Total capacity (MBytes) FIXED	--	U: 6.0	--	U: 3.0	--	U: 6.0	U: 12.73
REMOVABLE	U: 6.0	U: 6.0	U: 3.0	U: 3.0	U: 6.0	U: 6.0	U: 12.73
Capacity per track (Bytes)	U: 7,500	U: 7,500	U: 7,500	U: 7,500	U: 7,500	U: 7,500	U: 15,625
Data surfaces per spindle	2	4	2	4	2	4	2
Heads per data surface	1	1	1	1	1	1	1
Tracks per surface	408	408	204	204	408	408	815
TPI	200	200	100	100	200	200	370
BPI	2200	2200	2200	2200	2200	2200	4680
RPM	1500	1500	1500	1500	1500	1500	2400
Average positioning time (msec)	40	40	40	40	40	40	45
Average rotational delay (msec)	20	20	20	20	20	20	12.5
Average access time (msec)	60	60	60	60	60	60	57.5
Data transfer rate (KBytes/sec)	199	199	199	199	199	199	625
FIRST CUSTOMER SHIPMENT	1/74	1/74	1/74	1/74	1/74	1/74	1Q78
COMMENTS	2400 RPM Optional	2400 RPM Optional	2400 RPM Optional	2400 RPM Optional	2400 RPM Optional	2400 RPM Optional	Separate servo surfaces for fixed and removable disks

1978 DISK/TREND REPORT

MANUFACTURER	Electronic Memories & Magnetism Corp.	Electronic Memories & Magnetism Corp.	Electronic Memories & Magnetism Corp.	Fujitsu	Fujitsu	Fujitsu	Fujitsu
DRIVE	312-50	312-76	103	M-2201	M-2251	M-2252	M-2253
DISK/TREND GROUP	2	2	7	2	7	7	8
MEDIA: Manufacturer's number	5440	5440	--	M-2951 Special Cartridge	--	--	--
Generic type	3030-11	3030-11	2314	3030-11	Winchester	Winchester	Winchester
TECHNOLOGY TYPE, DRIVE	14"	14"	14"	14"	14"	14"	14"
NOMINAL DISK DIAMETER							
PERFORMANCE					.3277 or .6554 F. Head Option	.3277 or .6554 F. Head Option	.3277 or .6554 F. Head Option
Total capacity (MBytes) FIXED	U: 38.19	U: 63.68	U: 3.0	--	U: 12.7	U: 25.4	U: 50.8
REMOVABLE	U: 12.73	U: 12.73	--	U: 50 F: 39.7	--	--	--
Capacity per track (Bytes)	U: 15,625	U: 15,625	U: 7,500	U: 20,480 F: 16,384	U: 20,480	U: 20,480	U: 20,480
Data surfaces per spindle	4	6	2	3	1	2	4
Heads per data surface	1	1	1	1	2	2	2
Tracks per surface	815	815	204	815	630	630	630
TPI	370	370	100	370	300	300	300
BPI	4680	4680	2200	6135	6230	6230	6230
RPM	2400	2400	1500	2400	2400	2400	2400
Average positioning time (msec)	45	45	75	30	40	40	40
Average rotational delay (msec)	12.5	12.5	20	12.5	12.5	12.5	12.5
Average access time (msec)	57.5	57.5	95	42.5	52.5	52.5	52.5
Data transfer rate (KBytes/sec)	625	625	199	819	819	819	819
FIRST CUSTOMER SHIPMENT	1Q78	1Q78	1/73	4Q77	7/78	7/78	7/78
COMMENTS	Separate servo surfaces for fixed and removable disks	Separate servo surfaces for fixed and removable disks					

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Hewlett Packard	Hewlett Packard	Hewlett Packard	Hewlett Packard	Hewlett Packard	Hitachi	Hitachi
7900	7905	7906	7920	7925	MFD 90-1	MFD 90-2
1	2	2	4	5	7	7
12869A	12940A	12940A	13394A	13356A	--	--
2315	2315	2315	Special SMD	Special Pack	Fixed	Fixed
2314	3330-1	3330-1	3330-11	3330-11	2314	2314
14"	14"	14"	14"	14"	14"	14"
F: 2.5	U: 6.34	U: 12.68	--	--	F: 1.3	F: 2.6
F: 2.5	U: 12.68	U: 12.68	U: 63.67	F: 120.18	--	--
F: 6,144	U: 15,625	U: 15,625	U: 15,625	F: 16,384	F: 10,200	F: 10,200
4	3	3	5	9	1	2
1	1	1	1	1	2	2
200	406	F-812 R-406 F-384 R-192	815	815	132	132
100	192		384	384	48	48
2200	4680	4680	4680	6250	3706	3706
2400	3600	3600	3600	2700	3425	3425
30	25	25	25	25	190	190
12.5	8.33	8.33	8.33	11.1	8.8	8.8
42.5	33.33	33.33	33.33	36.1	198.8	198.8
312.5	937.5	937.5	937.5	937.5	618	618
		3/78	3/77	6/78	1976	1976
		Replaces 7905			Stepping Motor Actuator	Stepping Motor Actuator

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Hitachi	Hitachi	Hitachi	Hitachi	Hitachi	Hitachi	Hitachi
MFD 90-F1	MED 135-1	MFD 135-2	MED 135-F	DK 62-10	DK 62-20	DK 62-40
7	7	7	7	7	7	7
--	--	--	--	--	--	--
Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
2314	Winchester	Winchester	Winchester	Winchester	Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
.061 MB Fixed Heads F: 1.95	F: 3.7	F: 7.4	.21 MB Fixed Heads F: 6.5	.144 MB Fixed Head Option U: 10.8 F: 2.2	.144 MB Fixed Head Option U: 21.7 F: 18.5	.144 MB Fixed Head Option U: 43.3 F: 37.0
--	--	--	--	--	--	--
F: 10,200	F: 14,500	F: 14,500	F: 14,500	F: 15,360	F: 15,360	F: 15,360
2	2	4	4	1	2	4
2/1	2	2	2/1	2	2	2
132	128	128	128	604	604	604
48	48	48	38	300	300	300
3706	5241	5241	5241	5570	5770	5570
3425	3425	3425	3425	2964	2964	2964
190	99	99	99	50	50	50
8.8	8.8	8.8	8.8	10.1	10.1	10.1
198.8	107.8	107.8	107.8	60.1	60.1	60.1
618	875	875	875	889	889	889
1976	2Q79	2Q79	2Q79	4Q77	4Q77	1979
Stepping Motor Actuator	Stepping Motor Actuator	Stepping Motor Actuator	Stepping Motor Actuator			

HITACHI

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Hitachi	IBM	IBM	IBM	IBM	IBM	IBM
DK62-80	1131	2310	5444-1	5444-2/3	5444-A1	5444-A2
8	1	1	1	1	1	1
--	2315	2315	5440	5440	5440	5440
Fixed	2315	2315	5440	5440	5440	5440
Winchester	2310	2310	5444	5444	5444	5444
14"	14"	14"	14"	14"	14"	14"
.144 MB Fixed Head Option U: 86.7 F: 74.0	--	--	F: 1.22	F: 2.45	F: 1.22	F: 2.45
--	F: 1.024	F: 1.024	F: 1.22	F: 2.45	F: 1.22	F: 2.45
F: 15,360	F: 2,560	F: 2,560	F: 6,144	F: 6,144	F: 6,144	F: 6,144
8	2	2	4	4	4	4
2	1	1	1	1	1	1
604	200	200	100	200	100	200
300	100	100	100	100	100	100
5570	1100	1100	2200	2200	2200	2200
2964	1500	1500	1500	1500	1500	1500
50	520	520	153	269	86	126
10.1	20	20	20	20	20	20
60.1	540	540	173	289	106	146
889	97.5	97.5	199	199	199	199
1979	11/65	11/65	1970	1970	1971	1971
	1130	1130	System/3	System/3	System/3	System/3

HITACHI

IBM

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

IBM	IBM	IBM	IBM	IBM	IBM	IBM
5022-1	5022-2	5447-A1	5447-A2	2311-1	2311-11	2311-12
1	1	1	1	--	--	--
5440	5440	5440	5440	1316	1316	1316
5440	5440	5440	5440	1316	1316	1316
5444	5444	5444	5444	2311	2311	2311
14"	14"	14"	14"	14"	14"	14"
F: 2.45	F: 2.45	F: 2.45	F: 7.35	--	--	--
F: 2.45	F: 2.45	F: 2.45	F: 2.45	F: 7.25	F: 5.4	F: 2.7
F: 6,144	F: 6,144	F: 6,144	F: 6,144	F: 3,625	F: 2,700	F: 2,700
4	4	4	8	10	10	10
1	1	1	1	1	1	1
200	200	200	200	203	203	103
100	100	100	100	100	100	100
2200	2200	2200	2200	1100	1100	1100
1500	1500	1500	1500	2400	2400	2400
269	126	126	126	75	75	60
20	20	20	20	12.5	12.5	12.5
289	146	146	146	87.5	72.5	87.5
199	199	199	199	156	156	156
1971	1971	1976	1976	6/65	11/70	11/70
System/7	System/7	System/3	System/3	System/360	System/360	System/360

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

IBM	IBM	IBM	IBM	IBM	IBM	IBM
2314-1	2314-A 2314-B 2312 2319	5445	3330-1	3330-11	3340	3340
3	3	3	5	5	6	6
2316	2316	2316	3336-1	3336-11	3348-35	3348-70
2316	2316	2316	3336-1	3336-11	3348-35	3348-70
2314	2314	2314	3330-1	3330-11	3340	3340
14"	14"	14"	14"	14"	14"	14"
--	--	--	--	--	--	--
F: 29.176	F: 29.176	F: 20.48	F: 100.018	F: 200.036	F: 34.9(S/370)	F: 69.8(S/370)
F: 7,294	F: 7,294	F: 5,120	F: 13,030	F: 13,030	F: 16,736	F: 16,736
20	20	20	19	19	3	6
1	1	1	1	1	2	2
203	203	203	411	815	696/2	696/2
100	100	100	192	384	300	300
2200	2200	2200	4040	4040	5636	5636
2400	2400	2400	3600	3600	2964	2964
75	60	60	30	30	25	25
12.5	12.5	12.5	8.33	8.33	10.1	10.1
87.5	72.5	72.5	38.33	38.33	35.1	35.1
312.5	312.5	312.5	806	806	885	885
4/65	A-8/69 B,2319-12/70	6/72	8/71	1973	11/73	11/73
System/360 System/370	System/360 System/370	System/3	System/370	System/370	System/370 System/7	System/370 System/7 System/3

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

IBM	IBM	IBM	IBM	IBM	IBM	IBM
3340	5022-3	5022-4	5448	System/32	System/32	System/32
6	7	7	7	7	7	7
3348-70F	--	--	--	--	--	--
3348-70F	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
3340	2314	2314	2314	Winchester	Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
--	F: 2.45	F: 2.45	F: 9.8	F: 3.210	F: 5.053	F: 9.170
.502 F. Head F: 69.388	--	--	--	--	--	--
F: 16,736	F: 6,144	F: 6,144	F: 6,144	F: 15,360	F: 15,360	F: 15,360
7	2	2	8	1	1	1
2	1	1	1	2	2	2
696/2	200	200	200	209	329	597
300	100	100	100	300	300	300
5636	2200	2200	2200	5636	5636	5636
2964	1500	1500	1500	2964	2964	2964
25	269	126	126	50.4	70	72.5
10.1	20	20	20	10.1	10.1	10.1
35.1	289	146	146	60.5	80.1	82.6
885	199	199	199	889	889	889
11/73	1971	1971	1Q77	4Q76	1/75	1/75
System/370 System/7 System/3	System/7	System/7	System/3			

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

IBM	IBM	IBM	IBM	IBM	IBM	IBM
System/32	System/34	System/34	System/34	4962-1 4962-2	4962-1F 4962-2F	System/34
7	7	7	7	7	7	8
--	--	--	--	--	--	--
Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Winchester	Winchester	Winchester	Winchester	Winchester	Winchester	*
14"	14"	14"	14"	14"	14"	*
F: 13.778	F: 8.6	F: 13.2	Drive consists of two spindles F: 27.1	F: 9.308	.122 MB Fixed Heads F: 9.308	F: 63.9
--	--	--	--	--	--	--
F 15,360	F 15,360	F 15,360	F 15,360	F 15,360	F 15,360	*
2	2	2	2	1	1	*
2/1	2/1	2/1	2/1	2	2	*
598/299	402/201	604/302	604/302	606	F: 8 M: 606	*
300	300	300	300	300	300	*
5636	5636	5636	5636	5636	5636	*
2964	2964	2964	2964	2964	2964	3125
72.5	35	40	40	40	40	27
10.1	10.1	10.1	10.1	10.1	10.1	9.6
82.6	45.1	50.1	50.1	50.1	50.1	36.6
889	889	889	889	899	899	1031
2Q76	1/78	1/78	1/78	4Q76	4Q76	1/79
				Series/1	Series/1	Also 128.4 MB version, in two spindles. * not yet announced.

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

IBM	IBM	IBM	IBM	IBM	International Memories, Inc.	International Memories, Inc.
4963	4963	3344-B2 3344-B2F	3350-A2 3350-B2 3350-C2	3350-A2F 3350-B2F 3350-C2F	7710	7720
8	8	9	9	9	7	7
--	--	--	--	--	--	--
Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
*	*	Winchester	Winchester	Winchester	Winchester	Winchester
*	*	14"	14"	14"	200 mm	200 mm
.131 MB Fixed Heads F: 58	F: 64	1.004 MB Fixed Head Option F: 279.558	F: 317.5	1.144 MB Fixed Heads F: 317.5	U: 11.12	U: 24
--	--	--	--	--	--	--
*	*	F: 16,736	F: 19,069	F: 19,069	U: 12,500	U: 12,500
*	*	15	15	15	3	3
*	*	2	2	2	1	1
*	*	1114	1110	1110	350	720
*	*	478	478	478	300	700
*	*	5636	6425	6425	5868	5868
3125	3125	2964	3600	3600	3600	3600
24	24	25	25	25	50	50
9.6	9.6	10.1	8.4	8.4	8.33	8.33
33.6	33.6	35.1	33.4	33.4	58.33	58.33
1031	1031	885	1198	1198	648	648
2/79	2/79	2Q76	1Q76	1Q76	3Q78	1Q79
Series/1 * not yet announced	Series/1 * not yet announced	System/370 System/3	System/370	System/370	Preliminary Specifications	Preliminary Specifications

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

ISS/Univac	ISS/Univac	ISS/Univac	ISS/Univac	ISS/Univac	ISS/Univac	ISS/Univac
Univac 8415	715	Univac 8418-92	Univac 8418-94	7330-1	733-10 7330-10	733-11 7330-11
2	3	4	4	5	5	5
F 1215-00	--	F 1216-01	F 1216-02	--	--	--
5440	2316	SMD	SMD	3336-1	3336-1	3336-11
3330-11	2314	3330-11	3330-11	3330-1	3330-1	3330-11
14"	14"	14"	14"	14"	14"	14"
F: 24.8	--	--	--	--	--	--
F: 8.3	F: 58.4	F: 28.9	F: 57.9	F: 100	F: 100	F: 200
F: 10,240	F: 7,294	F: 10,240	F: 10,240	F: 13,030	F: 13,030	F: 13,030
F:3 R:2	20	7	7	19	19	19
1	1	1	1	1	1	1
F: 815 R: 411	406	411	815	411	411	815
F: 370 R: 185	200	370	370	192	192	370
4040	2200	4040	4040	4040	4040	4040
2800	2400	2800	2800	3600	3600	3600
33	29	27	33	27	27	27
10.7	12.5	10.7	10.7	8.33	8.33	8.33
43.7	41.5	37.7	43.7	35.33	35.33	35.33
625	312.5	625	625	806	806	806
2/77	6/71	11/75	3/76	9/72	5/75	2/75
				GSA Version		

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

ISS/Univac	ISS/Univac	ISS/Univac	ISS/Univac	ISS/Univac	ISS/Univac	Kennedy
7330-12	717	717	717	735	7350	5301-14
5	8	8	8	9	9	7
--	--	--	--	--	--	--
3336 (Spec)	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
3330-11	Winchester	Winchester	Winchester	Winchester	Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
--	1.2 MB Fixed Head Option U: 66	1.2 MB Fixed Head Option U: 110	1.2 MB Fixed Head Option U: 154	1.26 MB Fixed Head Option U: 353.8	F: 317.5	U: 14,112
F: 317.5	--	--	--	--	--	--
F: 19,069	U: 19,968	U: 19,968	U: 19,968	U: 21,060	F: 19,069	U: 20,160
19	3	5	7	15	15	1
1	2	2	2	2	2	2
887	1120	1120	1120	1120	1110	700
402	476	476	476	476	480	300
6965	6366	6366	6366	6714	6425	6000
3600	3600	3600	3600	3600	3600	3000
30	35	35	35	23	25	45
8.33	8.33	8.33	8.33	8.33	8.33	10
38.33	33.33	33.33	33.33	31.33	33.33	55
1260	1198	1198	1198	1260	1198	1000
1977				1978	4Q77	1Q78
				Single spindle drive		

ISS/UNIVAC

KENNEDY

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Kennedy	Kennedy	Memorex	Memorex	Memorex	Memorex	Memorex
5302-42	5303-70	3670-1/2	3675	677	3640	601-25
8	8	5	5	5	6	7
--	--	Mark X	Mark XI	Mark XI	Data Mark	--
Fixed	Fixed	3336-1	3336-11	3336-11	3348	Fixed
Winchester	Winchester	3330-1	3330-11	3330-11	3340 Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
U: 42,336	U: 70,560	--	--	--	--	.5/1.0 MB Fixed Head Options U: 25,144
--	--	F: 100	F: 200	U: 208.18	F: 35/70	--
U: 20,160	U: 20,160	F: 13,030	F: 13,030	U: 13,440	F: 16,736	U: 17,960
3	5	19	19	19	3/6	2
2	2	1	1	1	2	2
700	700	411	815	815	348/696	700
300	300	192	384	370	300	300
6000	6000	4040	4040	4040	5636	5636
3000	3000	3600	3600	3600	2964	2964
45	45	27	27	28.5	20	32
10	10	8.33	8.33	8.33	10.1	10.1
55	55	35.33	35.33	36.83	30.1	42.1
1000	1000	806	806	806	885	885
1Q78	1Q78	10/77	10/74	1976	1977	1977
		PCM	PCM	OEM	PCM Mfg. by Nippon Peripherals, Ltd.	OEM

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Memorex	Memorex	Memorex	Memorex	Microdata	Microdata	Microdata
601-50	601-75	3644	3650-A2 3650-B2 3650-C2	2853 9100 7407	2854 9101 7403	2855 9200 7405
8	8	9	9	1	1	1
--	--	--	--	--	--	--
Fixed	Fixed	Fixed	Fixed	5440	5440	5440
Winchester	Winchester	Winchester	Winchester	2314	2314	2314
14"	14"	14"	14"	14"	14"	14"
U: 50.288	U: 75.432	1.004 MB Fixed Head Option F: 280	1.144 MB Fixed Head Option F: 317.5	--	--	U: 2.5
--	--	--	--	U: 2.5	U: 5.0	U: 2.5
U: 17,960	U: 17,960	F: 16,736	F: 19,069	U: 7,812	U: 7,812	U: 7,812
4	6	15	15	2	2	4
2	2	2	2	1	1	1
700	700	1114	1110	204	408	204
300	300	480	480	100	200	100
5636	5636	5636	6425	2200	2200	2200
2964	2964	2964	3600	1500	1500	1500
32	32	25	25	35	35	35
10.1	10.1	10.1	8.33	20	20	20
42.1	42.1	35.1	33.33	55	55	55
885	885	885	1198	200	200	200
1977	1977	7/78	4Q77	1974	1975	1974
OEM	OEM	PCM 3344	PCM 3350	2400 RPM Option	2400 RPM Option	2400 RPM Option

MEMOREX

MICRODATA

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Microdata	Microdata	Microdata	Microdata	Nippon Electric Co.	Nippon Electric Co.	Nippon Electric Co.
2856 9201 7401	Reflex 7501	Reflex 7502	Reflex 7503	D1210	D1220	D1240
1	7	8	8	7	8	8
--	--	--	--	--	--	--
5440	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
2314	Winchester	Winchester	Winchester	Winchester	Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
	.54 MB Fixed Head Option U: 12.5	.54 MB Fixed Head Option U: 37.6	.54 MB Fixed Head Option U: 62.7	.48 or .36 MB F. Head Option U: 20.8	.48 or .36 MB F. Head Option U: 41.5	.48 or .36 MB F. Head Option U: 83.1
U: 5.0	--	--	--	--	--	--
U: 7,812	U: 17,920	U: 17,920	U: 17,920	U: 19,968	U: 19,968	U: 19,968
4	1	3	5	1	2	4
1	2	2	2	2	2	2
408	700	700	700	1040	1040	1040
200	300	300	300	480	480	480
2200	5636	5636	5636	6370	6370	6370
1500	2964	2964	2964	3600	3600	3600
35	30	30	30	40	40	40
20	10.1	10.1	10.1	8.33	8.33	8.33
55	40.1	40.1	40.1	48.33	48.33	48.33
200	885	885	885	1200	1200	1200
1975	1977	1977	1975			
2400 RPM Option						

MICRODATA

NIPPON ELECTRIC

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Nippon Electric Co.	Nippon Electric Co.	Nippon Peripherals Limited	Nippon Peripherals Limited	Nippon Peripherals Limited	Nippon Peripherals Limited	Okidata
D1500	D1510	NP20	NP24	NP25-A2 NP25-B2 NP25-C2	NP22	3301
9	9	6	9	9	6	7
--	--	NP-21-35/70 3348 Data Module	--	--	NP-21-140 3348 Data Module	--
Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
3350 Winchester	3350 Winchester	3340 Winchester	3350 Winchester	3350 Winchester	3340 Winchester	Winchester
14"	14"	14"	14"	14"	14"	14"
1.144 MB Fixed Head Option F: 317.5	1.194 MB Fixed Head Option U: 331.5	--	1.004 MB Fixed Head Option F: 279.558	1.144 MB Fixed Head Option F: 317.499	--	0.74 MB Fixed Head Option U: 13.47
--	--	F: 35/70	--	--	F: 140	--
F: 19,069		F: 16,736	F: 16,736	F: 19,069	F: 16,736	
15	15	3/6	15	15	6	1
2	2	2	2	2	2	2
1122	1120	696/2	1114	1110	1392	678
480	480	300	480	480	600	286
6370	6400	5636	5636	6425	5636	
3600	3600	2964	2964	3600	2964	2964
20	20	20	20	20	20	38
8.33	8.33	10.1	10.1	8.33	10.1	10.1
28.33	28.33	35.1	30.1	28.33	35.1	48.1
1200	1200	885	885	1198	885	996
4Q77		1977	1977	1978	1979	7/77
		3340 PCM	3344 PCM	3350 PCM	3340 PCM	

1978 DISK/TREND REPORT

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Okidata	Okidata	Okidata	Okidata	Okidata	Pertec	Pertec
3302	3303	3304	3305	3306	D3311/D3312	D3321/D3322
7	8	8	8	8	1	1
--	--	--	--	--	--	--
Fixed	Fixed	Fixed	Fixed	Fixed	5440	5440
Winchester	Winchester	Winchester	Winchester	Winchester	2314	2314
14"	14"	14"	14"	14"	14"	14"
2.23 MB Fixed Head Option U: 26.94	0.74 MB Fixed Head Option U: 40.39	2.23 MB Fixed Head Option U: 53.86	0.74 MB Fixed Head Option U: 67.53	0.74 MB Fixed Head Option U: 80.80	--	U: 3.17
--	--	--	--	--	U: 3.17	U: 3.17
					U: 7,812	U: 7,812
2	3	4	5	6	2	4
2	2	2	2	2	1	1
678	678	678	678	678	203	203
286	286	286	286	286	100	100
					2200	2200
2964	2964	2964	2964	2964	1500/2400	1500/2400
38	38	38	38	38	35	35
10.1	10.1	10.1	10.1	10.1	20/12.5	20/12.5
48.1	48.1	48.1	48.1	48.1	55/47.5	55/47.5
996	996	996	996	996	195/312.5	195/312.5
7/77	7/77	7/77	7/77	7/77		

OKIDATA

PERTEC

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Pertec	Pertec	Pertec	Pertec	Pertec	Pertec	Pertec
D3331/D3332	D3341/D3342	D3421/D3422	D3441/D3442	D3461/D3462	D3481/D3482	D1451/D1452
1	1	1	1	2	2	7
--	--	--	--	--	--	--
2315	2315	5440	2315	5440	2315	Fixed
2314	2314	2314	2314	2314	2314	2314
14"	14"	14"	14"	14"	14"	14"
--	U: 3.17	U: 6.34	U: 6.34	U: 19.03	U: 19.03	U: 6.34
U: 3.17	U: 3.17	U: 6.34	U: 6.34	U: 6.34	U: 6.34	--
U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 7,812
2	4	4	4	8	8	2
1	1	1	1	1	1	1
203	203	406	406	406	406	406
100	100	200	200	200	200	200
2200	2200	2200	2200	2200	2200	2200
1500/2400	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400
35	35	40	40	40	40	70
20/12.5	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5
55/47.5	55/47.5	60/52.5	60/52.5	60/52.5	60/52.5	90/82.5
195/312.5	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5
				1977	1977	
						Also available as 12.68 MB: D1461/D1462 (4 surfaces)

PERTEC

MANUFACTURER	Philips Data Systems B.V.	Shugart Associates	Shugart Associates	Siemens	Siemens	Siemens	Siemens
DRIVE	X1250	SA 4004	SA 4008	PS5-1 PS5-2	PS5-3 PS5-4	PS5-5 PS5-6	PS5-7 PS5-8
DISK/TREND GROUP	7	7	7	5	5	5	9
MEDIA: Manufacturer's number	--	--	--	V26374-Q7	V26374-Q9	--	--
Generic type	Fixed	Fixed	Fixed	Special	Special	3336-11	Fixed
TECHNOLOGY TYPE, DRIVE	Winchester	Winchester	Winchester	3330-1	3330-11	3330-11	Winchester
NOMINAL DISK DIAMETER	14"	14"	14"	14"	14"	14"	14"
PERFORMANCE							
Total capacity (MBytes) FIXED	U: 9.62	0.144 MB Fixed Head Option U: 14.5	0.144 MB Fixed Head Option U: 29.0	--	--	--	1.115 MB Fixed Head Option 517.1
REMOVABLE	--	--	--	U: 73.3	U: 146.6	U: 309.5	--
Capacity per track (Bytes)	U: 20,830	U: 18,000	U: 18,000	U: 20,160	U: 20,160	U: 20,160	U: 20,160
Data surfaces per spindle	2	2	4	9	9	19	19
Heads per data surface	1	2	2	1	1	1	2
Tracks per surface	231	404	404	411	823	823	1350
TPI	100	172	172	192	384	384	590
BPI	6356	5534	5534	6060	6060	6060	6060
RPM	720	2964	2964	2400	2400	2400	2400
Average positioning time (msec)	232.5	87	87	23	23	23	20
Average rotational delay (msec)	41.67	10.1	10.1	12.5	12.5	12.5	12.5
Average access time (msec)	274.17	97.1	97.1	35.5	35.5	35.5	32.5
Data transfer rate (KBytes/sec)	250	889	889	806	806	806	806
FIRST CUSTOMER SHIPMENT	1978	3Q78	3Q78	9/75	12/76	1977	1977
COMMENTS	Stepping motor actuator	Stepping motor actuator	Stepping motor actuator				

MANUFACTURER	Storage Technology Corporation	Storage Technology Corporation	Storage Technology Corporation	Storage Technology Corporation	Storage Technology Corporation	Storage Technology Corporation	Storage Technology Corporation
DRIVE	8100	8400	8800	8350-A2 8350-B2 8350-C2	2707	2710	2720
DISK/TREND GROUP	5	9	9	9	8	8	8
MEDIA: Manufacturer's number	--	--	--	--	--	--	--
Generic type	3336-1	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	3330-1	3330	3330	Winchester	Winchester	Winchester	Winchester
NOMINAL DISK DIAMETER	14"	14"	14"	14"	14"	14"	14"
PERFORMANCE				1.144 MB Fixed Head Option F: 317.5			
Total capacity (MBytes) FIXED	--	F: 400	F: 800		U: 33	U: 80	U: 170
REMOVABLE	F: 100	--	--	--	--	--	--
Capacity per track (Bytes)	F: 13,030	F: 13,030 114	F: 13,030 114	F: 19,069			
Data surfaces per spindle	19	Per Drive	Per Drive	15	2	4	8
Heads per data surface	1	1	1	2	2/1	2/1	2/1
Tracks per surface	411	552	552	1110	1310	1310	1310
TPI	192	238	238	480	478	478	478
BPI	4040	4040	4040	6425	6,548	6,548	6,548
RPM	3600	3600	3600	3600	2250	2250	2250
Average positioning time (msec)	28	30	30	25	30	30	30
Average rotational delay (msec)	8.33	8.33	8.33	8.33	13.6	13.6	13.6
Average access time (msec)	36.33	38.33	38.33	33.33	33.6	33.6	33.6
Data transfer rate (KBytes/sec)	806	806	806	1198	768	768	768
FIRST CUSTOMER SHIPMENT	4/75	2/75	2/75	4/77	1Q79	1Q79	1Q79
COMMENTS	PCM	PCM	PCM	PCM	OEM Preliminary Specification	OEM Preliminary Specification	OEM Preliminary Specification

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Sycor	Sycor	Tokyo Shibaura Electric Co.	Tokyo Shibaura Electric Co.	Vermont Research	Wangco	Wangco
410	440	MK-100F	MK-300F	5017	F/T-1212	F/T-1222
7	7	7	8	2	1	1
--	--	--	--	VRC5517	--	--
Fixed	Fixed	Fixed	Fixed	5440	2315/5440	2315/5440
2314	2314	Winchester	Winchester	3330-11	2314	2314
14"	14"	14"	14"	14"	14"	14"
F: 2.5	F: 5.0	U: 12.0 F: 10.2	.262 MB Fixed Head Option U: 36.0 F: 30.6	F: 26.2	--	U: 3.13
--	--	--	--	F: 26.2	U: 3.13	U: 3.13
F: 6,144	F: 6,144	F: 16,384	F: 16,384	F: 12,800	U: 7,812	U: 7812
1	2	1	3	4	2	4
1	1	2	2	1	1	1
400	400	630	630	1032	204	204
200	200	318	318	500	100	100
2200	2200	5940	5940	4000	2200	2200
2400	2400	2800	2800	3165	2400	2400
70	70	40	40	35	35	35
12.5	12.5	10.8	10.8	9.5	12.5	12.5
82.5	82.5	50.8	50.8	44.5	47.5	47.5
312.5	312.5	896	896	763.8	312.5	312.5
1975	1975	1976	1977	1975		12/73
				Embedded Servo	1500 RPM Version: F/T-1211	1500 RPM Version: F/T-1221

SYCOR

TOSHIBA

VT. RESEARCH

WANGCO

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Wangco	Wangco	Wangco	Wangco	Wangco	Wangco	Wangco
F-2211	F/T-2212	F-2221	F/T-2222	T-2412	T-2422	MP-80
1	1	1	1	1	2	4
--	--	--	--	--	--	CDC 9877
2315	2315/5440	2315	2315/5440	5440	5440	SMD
2314	2314	2314	2314	3330-1	3330-1	3330-11
14"	14"	14"	14"	14"	14"	14"
		U: 6.25	U: 6.25		U: 12.5	
U: 6.25	U: 6.25	U: 6.25	U: 6.25	U: 12.5	U: 12.5	U: 82.959
U: 7,812	U: 7,812	U: 7,812	U: 7,812	U: 15,625	U: 15,625	U: 20,160
2	2	4	4	2	4	5
1	1	1	1	1	1	1
408	408	408	408	408	408	823
200	200	200	200	200	200	384
2200	2200	2200	2200	4400	4400	6038
1500	2400	1500	2400	2400	2400	3600
35	35	35	35	35	35	30
20	12.5	20	12.5	12.5	12.5	8.33
55	47.5	55	47.5	47.5	47.5	38.33
195	312.5	195	312.5	625	625	1209
			7/74	12/75	12/75	3Q78

MANUFACTURER

DRIVE

DISK/TREND GROUP

MEDIA: Manufacturer's number

Generic type

TECHNOLOGY TYPE, DRIVE

NOMINAL DISK DIAMETER

PERFORMANCE

Total capacity (MBytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

TPI

BPI

RPM

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

COMMENTS

Wangco	Western Dynex	Western Dynex	Western Dynex	Western Dynex		
MP-160	DD-6121	DD-6221	DD-6122	DD-6222		
5	1	1	1	1		
CDC 9877	--	--	--	--		
SMD	2315/5440	2315/5440	2315/5440	2315/5440		
3330-11	2314	2314	2314	2314		
14"	14"	14"	14"	14"		
U: 82.959		U: 3.13		U: 6.25		
U: 82.959	U: 3.13	U: 3.13	U: 6.25	U: 6.25		
U: 20,160	U: 7,812	U: 7,812	U: 7,812	U: 7,812		
10	2	4	2	4		
1	1	1	1	1		
823	203	203	406	406		
384	100	100	200	200		
6038	2200	2200	2200	2200		
3600	1500/2400	1500/2400	1500/2400	1500/2400		
30	35	35	35	35		
8.33	20/12.5	20/12.5	20/12.5	20/12.5		
38.33	55/47.5	55/47.5	55/47.5	55/47.5		
1209	195/312.5	195/312.5	195/312.5	195/312.5		
1Q79	1972	1972	1973	1973		