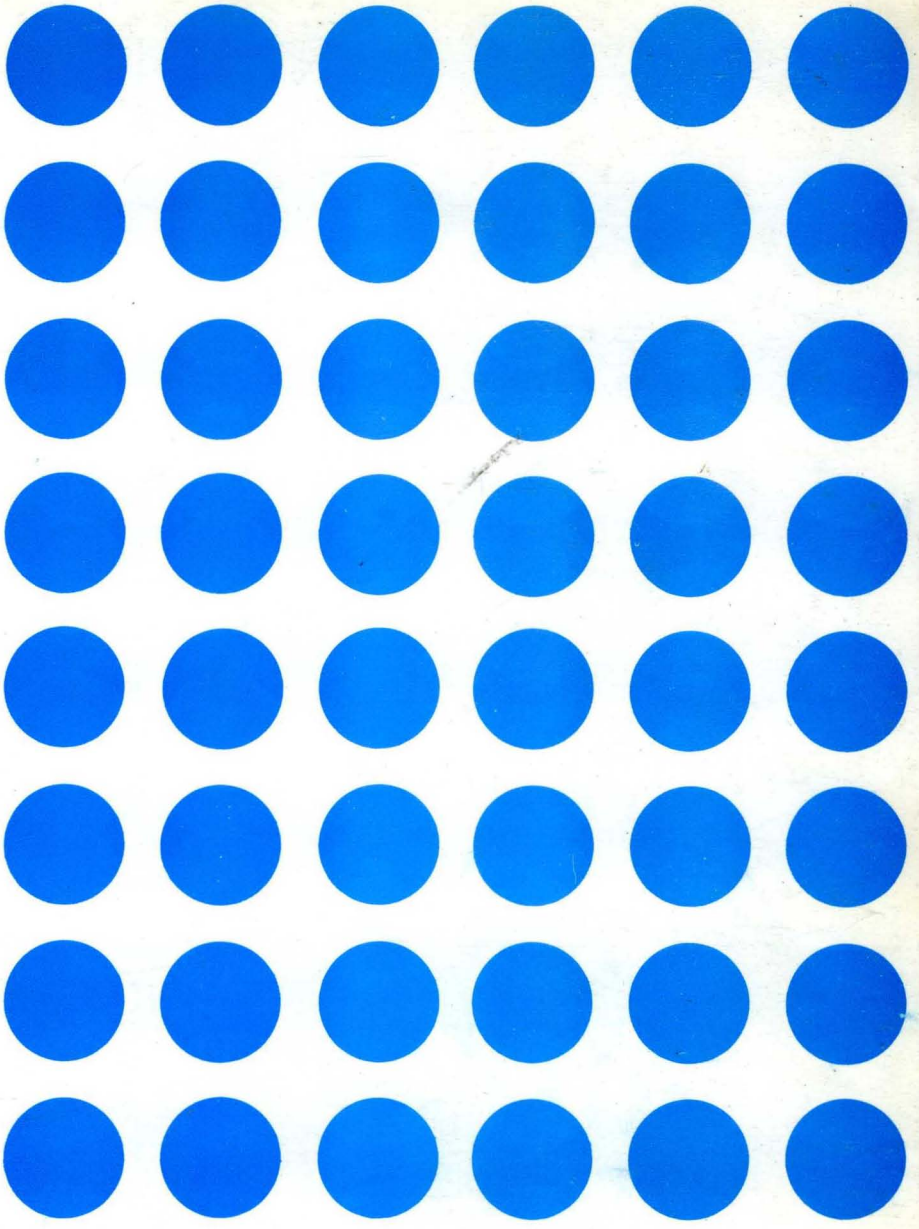
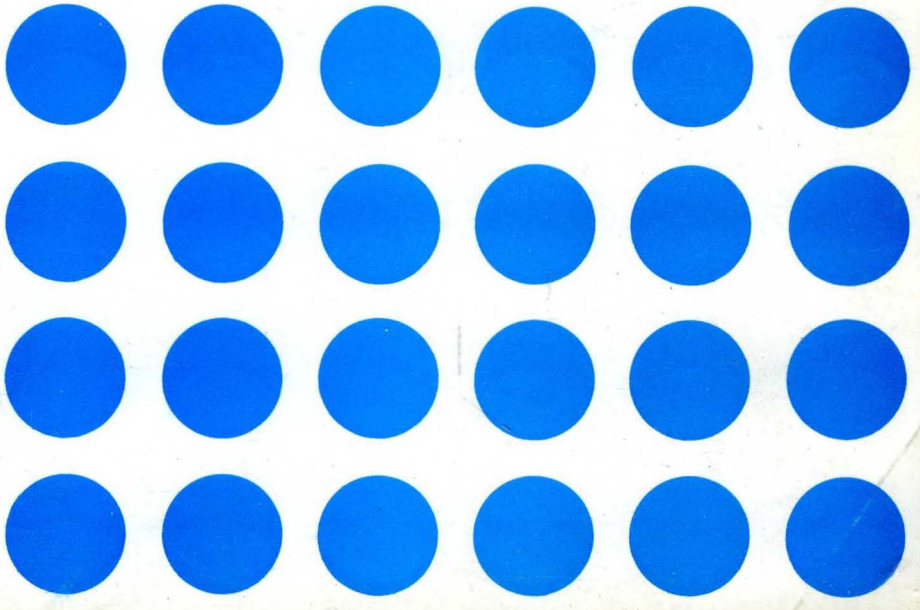


1977 DISK/TREND REPORT



RIGID DISK DRIVES

1977 DISK/TREND REPORT

RIGID DISK DRIVES

June, 1977

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FORWARD

The 1977 DISK/TREND Report is being published in two sections. This volume covers moving head rigid disk drives, and a separate report to be published in August will cover flexible disk drives.

Subscribers are invited to contact me if additional information or backup data is needed. I will be happy to provide any non-proprietary information from my files which can be extracted without extensive research. More elaborate projects requiring extended research and analysis can be addressed on a normal consulting basis if desired.

In any event, your comments and suggestions regarding the DISK/TREND Report are sincerely requested. It is intended that the DISK/TREND Report will be a practical working tool for subscribers, and your thoughts on content and format will be most helpful in increasing the usefulness of future editions.

James N. Porter

INTRODUCTION

How to use this DISK/TREND Report

The disk drive industry enjoys great diversity in products, distribution channels, applications and companies. DISK/TREND data is grouped by products, and the other key variables are analysed within each product group. With that organization of information in mind, here are a few suggestions for using this report:

* When looking for information on specific segments of the industry, check the appropriate product sections first.
* Look for industry-wide data and consolidated statistics in the summary section.
* You will find specifications on individual disk drives and background on each manufacturer in separate sections on these subjects.

Please note these key points

* All DISK/TREND projections are based on current or announced products, plus the effect of evolutionary improvements. Completely new configurations or technologies, when introduced, will create additional sales not included in this report.
* 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 should not be overlooked.
* All unit totals are given in spindles. A dual drive configuration, for example, is counted as two spindles.

SUMMARY

Industry size

The moving head rigid disk drive industry sold an estimated $1,876,000,000 in disk drives worldwide in 1976. U.S. manufacturers shipped 91% of this sales volume, or $1,713,800,000.

DISK/TREND forecasts, which are based on existing or announced products, with evolutionary enhancements, anticipate a peak in worldwide industry revenues in 1979 at $2,956,900,000, with a slight decline in 1980, to $2,917,900,000. Worldwide revenues for U.S. manufacturers are placed at $2,668,300,000 in 1979, $2,610,600,000 in 1980.

It is considered likely that new products not yet announced will prevent any decline in actual sales at the end of the decade. The forecasted average annual growth rate (AAGR) of 12% through 1980, representing the effects of old age in the product life of several of today's products, will be exceeded if significant new products are introduced at rates similar to past experience. A reasonable estimate of AAGR on this basis is 18-20%, which would place 1980 total revenues at $3,600,000,000 to $3,900,000,000.

Underlying the above estimates is the assumption that a healthy world economy will be maintained, since sales of data processing equipment is sensitive to economic conditions. 3-5% annual growth in U.S. GNP is assumed.

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TABLE 1

CONSOLIDATED WORLDWIDE SHIPMENTS

ALL EXISTING MOVING HEAD DISK DRIVE GROUPS

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	515.9	754.1	653.4	951.4	703.6	1051.7	723.0	1095.0	703.6	1059.6
Other U.S. Captive	279.9	455.2	360.5	576.2	455.7	723.8	514.1	813.7	503.7	790.9
TOTAL U.S. CAPTIVE	795.8	1209.3	1013.9	1527.6	1159.3	1775.5	1237.1	1908.7	1207.3	1850.5
PCM	209.6	254.3	163.8	201.1	225.1	272.1	239.6	292.0	247.0	301.8
OEM	171.0	250.2	224.1	335.5	297.6	430.7	328.4	467.6	323.9	458.3
TOTAL U.S. NON-CAPTIVE	380.6	504.5	387.9	536.6	522.7	702.8	568.0	759.6	570.9	760.1
TOTAL U.S. PRODUCTION	1176.4	1713.8	1401.8	2064.2	1682.0	2478.3	1805.1	2668.3	1778.2	2610.6
Non-U.S. Manufacturers										
Captive		111.8		145.2		177.2		205.3		215.7
OEM		50.4		55.2		67.5		83.3		91.6
TOTAL NON-U.S. PRODUCTION		162.2		200.4		244.7		288.6		307.3
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		1876.0		2264.6		2723.0		2956.9		2917.9
TOTAL WORLDWIDE CAPTIVE		1321.1		1672.8		1952.7		2114.0		2066.2
TOTAL WORLDWIDE NON-CAPTIVE		554.9		591.8		770.3		842.9		851.7

Industry structure

Moving head rigid disk drives are produced by 23 U.S. manufacturers, plus another 11 in Japan and Western Europe. Some U.S. manufacturers produce drives in non-U.S. locations.

About 70% of all drive revenues represent captive production, and the remainder are produced by the PCM and OEM markets. The industry structure can be confusing, even to industry participants, but follows most of the classic rules for free-market industries: As noted in Figure 1, non-captive manufacturers sell drives, alone or with related hardware, directly to every type of industry participant. Questions of technical capability, manufacturing facilities and quantity requirements control whether various industry levels buy directly from the drive manufacturer or through a reseller.

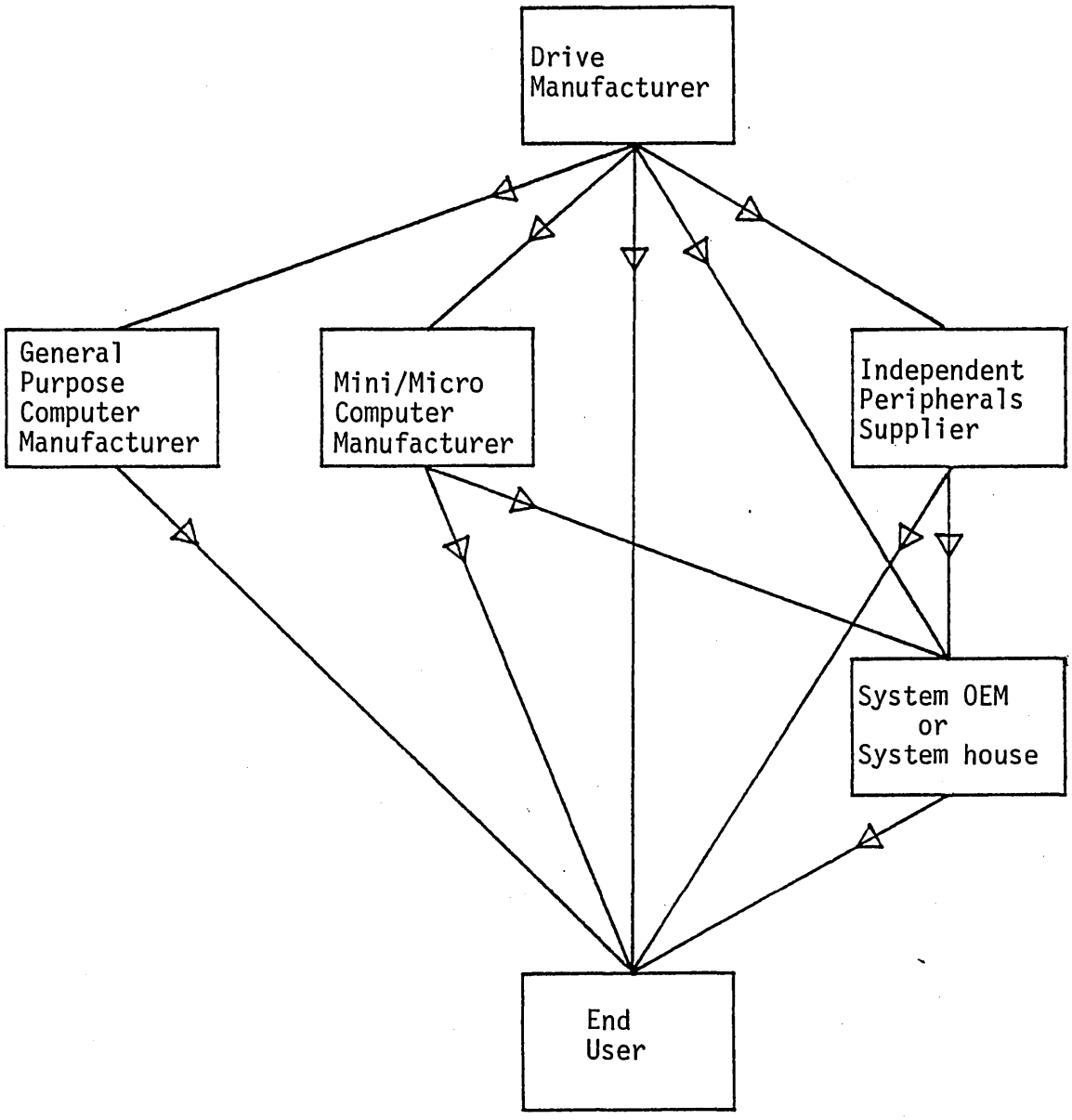
Vertical integration has been a strong tendency for many systems manufacturers with peripherals in general, including disk drives. With the exception of IBM, all the U.S. captive drive producers used to be OEM drive customers for all or part of their requirements. Growing quantity purchases and availability of critical parts on a stock basis have triggered most captive production programs.

Many drive manufacturers themselves, both captive and non-captive, have undertaken vertical integration programs, to produce heads, spindles, actuators, and various plastic and metal parts. Of course, several drive manufacturers also manufacture the recording disks required for both fixed and removable media drives.

Figure 1

NON-CAPTIVE MARKETING STRUCTURE

Moving Head Disk Drives



Marketing channels

IBM has been identified separately in most DISK/TREND data because of its dominant industry position. Actually, it is estimated that IBM accounts for only about 40% of worldwide drive revenues, a lower share than their 70% of the mainframe market. The difference is created primarily by the PCM programs of several drive manufacturers, which displace potential IBM revenue, and the disk drive requirements of the minicomputer segment of the industry, in which IBM has just started to compete.

Other U.S. captive drive production was estimated at 24% of worldwide revenues in 1976, and is expected to increase its share slightly for most of the rest of the decade. The short term loser in market share is the PCM business, which held 14% in 1976, but will drop to 9% and stabilize at that proportion, as independent manufacturers hurry their 3350 drives to the market to replace lost 3330 shipments. OEM production will add about three points to its 13% share of the 1976 market during the rest of the decade.

Non-U.S. manufacturers have been selling about 9% of the world's drives, on a total revenue basis, and this share is expected to change very little.

TABLE 2

CONSOLIDATED WORLDWIDE SHIPMENTS
MARKET CLASS REVIEW
REVENUE SUMMARY

Worldwide Revenues By Manufacturer Type	1976 Shipments		FORECAST							
			1977		1978		1979		1980	
	$M	%	$M	%	$M	%	$M	%	$M	%
U.S. Manufacturers										
IBM	754.1	40	951.4	42	1051.7	39	1095.0	37	1059.6	36
Other U.S. Captive	455.2	24	576.2	25	723.8	27	813.7	28	790.9	27
PCM	254.3	14	201.1	9	272.1	10	292.0	9	301.8	10
OEM	250.2	13	335.5	15	430.7	16	467.6	16	458.3	16
Total U.S. Mfg.	1713.8	91	2064.2	91	2478.3	91	2668.3	90	2610.6	90
Non-U.S. Manufacturers										
Captive	111.8	6	145.2	6	177.2	6	205.3	7	215.7	7
OEM	50.4	3	55.2	3	67.5	3	83.3	3	91.6	3
Total Non-U.S. Mfg.	162.2	9	200.4	9	244.7	9	288.6	10	307.3	10
WORLDWIDE TOTAL	1876.0	100	2264.6	100	2723.0	100	2956.9	100	2917.9	100

Product mix

DISK/TREND projections by product group indicate that fixed disk drives will account for more than half of all drive revenues by 1980. The other major gainer will be storage module drives, up to an 11.5% share of revenues.

Significant declines in revenue share are expected for Disk pack drives in both the 29-58 MB and over 100 MB groups, as well as for data module drives. Disk cartridge drives, with both DISK/TREND cartridge drive groups combined, will grow in actual revenues, with high density drives providing the impetus, but will decline slightly in total industry share.

OEM market

Fixed disk drives are also expected to grow rapidly in their share of OEM revenues starting in 1977, but the combination of all three DISK/TREND fixed drive groups will not exceed 23% in 1980, due to the considerable preference among many users and system manufacturers for removable media. Storage module drives will grow to 22% of total revenues by 1980, as a result of the continued rapid growth of larger minicomputer systems and small business systems.

Other OEM products will end the decade in decline, except for the disk cartridge drive group over 12 MB, which will partially offset the expected decline in cartridge drives under 12 MB, after a 1978 peak.

Control Data has a share of the OEM market estimated at 34%, followed by Diablo with 22%. No other manufacturer of OEM drives is even close to these levels.

Figure 2
CHANGING PRODUCT MIX
CONSOLIDATED WORLDWIDE DISK DRIVE SHIPMENTS

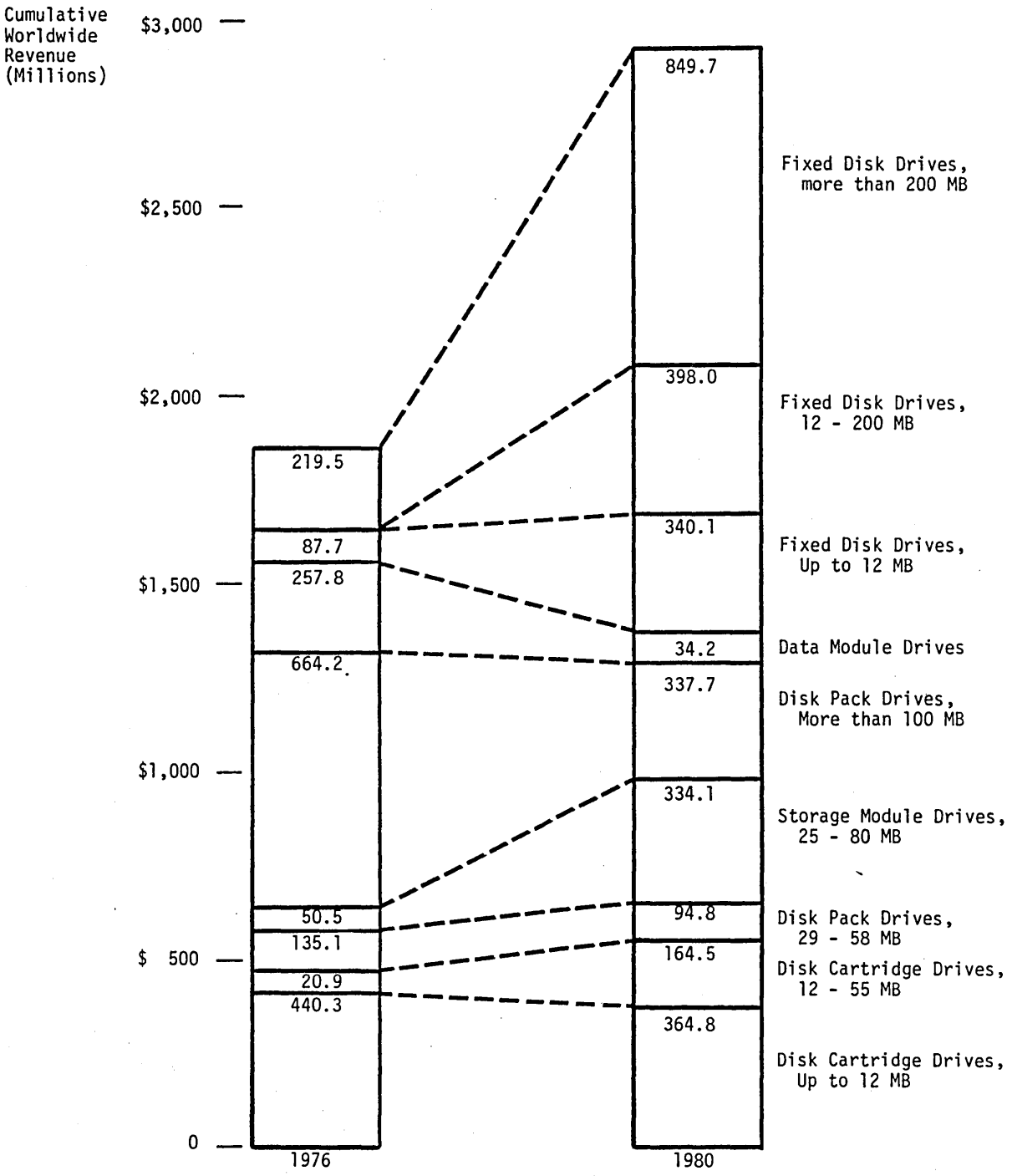


Table 3
CONSOLIDATED WORLDWIDE SHIPMENTS
PRODUCT CATEGORY REVIEW
REVENUE SUMMARY

Worldwide Revenues By Manufacturer Type	1976 Shipments $M	%	FORECAST 1977 $M	%	1978 $M	%	1979 $M	%	1980 $M	%
Disk Cartridge Drives Up to 12 MB	440.3	23.5	471.2	20.8	482.8	17.7	450.8	15.3	364.8	12.5
Disk Cartridge Drives 12-55 MB	20.9	1.1	47.8	2.1	85.3	3.1	125.7	4.3	164.5	5.6
Disk Pack Drives 29-58 MB	135.1	7.2	150.3	6.7	139.7	5.1	130.5	4.4	94.8	3.3
Storage Module Drives 25-80 MB	50.5	2.7	133.5	5.9	237.4	8.7	320.4	10.8	334.1	11.5
Disk Pack Drives More than 100 MB	664.2	35.4	472.0	20.8	466.5	17.1	401.2	13.5	337.7	11.6
Data Module Drives	257.8	13.7	221.9	9.8	167.6	6.2	86.4	2.9	34.2	1.2
Fixed Disk Drives Up to 12 MB	87.7	4.7	141.8	6.3	271.5	10.0	326.9	11.1	340.1	11.6
Fixed Disk Drives 12-200 MB	--	--	41.5	1.8	115.7	4.3	257.1	8.7	398.0	13.6
Fixed Disk Drives More than 200 MB	219.5	11.7	584.6	25.8	756.5	27.8	857.9	29.0	849.7	29.1
Total: WW Revenue	$1876.0	100%	$2264.6	100%	$2723.0	100%	$2956.9	100%	$2917.9	100%
% U.S. Mfg.	91.4%		91.2%		91.0%		90.2%		89.5%	
Annual Growth Rate	--		+20.7%		+20.2%		+ 8.6%		- 1.3%	

Table 4

OEM WORLDWIDE SHIPMENTS
PRODUCT CATEGORY REVIEW
REVENUE SUMMARY

Worldwide Revenues All Manufacturers	1976 Shipments		FORECAST 1977		1978		1979		1980	
	$M	%	$M	%	$M	%	$M	%	$M	%
Disk Cartridge Drives Up to 12 MB	125.8	41.9	145.6	37.3	158.7	31.9	147.6	26.8	124.1	22.6
Disk Cartridge Drives 12-55 MB	--	--	6.0	1.5	22.6	4.5	36.7	6.7	52.1	9.5
Disk Pack Drives 29-58 MB	57.7	19.2	56.7	14.5	47.9	9.6	38.7	7.0	28.2	5.1
Storage Module Drives 25-80 MB	19.0	6.3	53.6	13.7	91.8	18.4	118.5	21.5	122.6	22.3
Disk Pack Drives More than 100 MB	90.5	30.1	103.0	26.4	108.1	21.7	94.9	17.2	82.6	15.0
Data Module Drives	1.8	.6	10.3	2.6	16.6	3.3	15.4	2.8	12.0	2.2
Fixed Disk Drives Up to 12 MB	5.8	1.9	8.2	2.1	14.7	3.0	16.7	3.1	17.6	3.2
Fixed Disk Drives 12-200 MB	--	--	6.1	1.6	18.0	3.6	32.1	5.8	43.5	7.9
Fixed Disk Drives More than 200 MB	--	--	1.2	.3	19.8	4.0	50.3	9.1	67.2	12.2
Total: WW Revenue	$300.6	100%	$390.7	100%	$498.2	100%	$550.9	100%	$549.9	100%
% U.S. Mfg.	83.2%		85.9%		86.5%		84.9%		83.3%	
Annual Growth Rate	--		+ 30.0%		+ 27.5%		+ 10.6%		- 0.2%	

Table 5

1976 MARKET SHARES

LEADING U.S. DISK DRIVE MANUFACTURERS

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

	Captive		PCM		OEM		Total Industry	
Company	$M	%	$M	%	$M	%	$M	%
Ampex	--	--	5.0	2.0	5.8	2.3	10.8	.6
Burroughs	165.7	13.7	--	--	--	--	165.7	9.7
Calcomp	--	--	20.1	7.9	30.0	12.0	50.1	2.9
Control Data	48.0	4.0	12.6	5.0	85.6	34.2	146.2	8.5
Data 100	2.6	.2	--	--	8.2	3.3	10.8	.6
Data General	6.5	.5	--	--	--	--	6.5	.4
DEC	104.0	8.6	--	--	--	--	104.0	6.1
Diablo	--	--	--	--	55.2	22.2	55.5	3.2
Hewlett Packard	44.3	3.7	--	--	--	--	44.3	2.6
IBM	754.1	62.4	--	--	--	--	754.1	44.0
ISS	74.3	6.1	88.2	34.7	13.9	5.5	176.4	10.3
Memorex	--	--	103.1	40.5	15.4	6.1	118.5	6.9
Microdata	8.5	.7	--	--	1.0	.4	9.5	.6
Pertec	1.3	.1	--	--	18.0	7.2	19.3	1.1
STC	--	--	21.4	8.4	--	--	21.4	1.3
Wangco	--	--	--	--	8.9	3.6	8.9	.5
Others	--	--	3.9	1.5	7.9	3.2	11.8	.7
Total	1,209.3	100	254.3	100.0	250.2	100.0	1,713.8	100.0

TABLE 6

CURRENT PRODUCT LINES

U.S. MANUFACTURERS OF MOVING HEAD DISK DRIVES

COMPANY	Type	1 Disk Cartridge Drives <12 MB	2 Disk Cartridge Drives 12-55 MB	3 Disk Pack Drives 29-58 MB	4 Storage Module Drives 25-80 MB	5 Disk Pack Drives >100 MB	6 Data Module Drives	7 Fixed Disk Drives <12 MB	8 Fixed Disk Drives 12-200 MB	9 Fixed Disk Drives >200 MB
Ampex	P,O			X	X	X				
Ball	P,O				X					
Burroughs	C	X		X	X	X		X	X	
Calcomp	P,O			X	X	X				
Control Data	C,P,O	X		X	X	X	X	X	X	X
Data 100	O	X								
Data General	C	X				X				
DEC	C	X	X					X		
Diablo	O	X	X					X		
EMM	O	X	X					X		
Hewlett Packard	C	X	X		X					
IBM	C	X		X		X	X	X	X	X
ISS/UNIVAC	C,P,O		X	X	X	X				X
Kennedy	O								X	
Memorex	P,O					X			X	X
Microdata	C,O	X							X	
Okidata	O	X							X	
Pertec	C,O	X	X					X	X	
Storage Technology	P,O					X				X
Sycor	C							X		
Vermont Research	O		X							
Wangco	O,C	X	X					X		
Western Dynex	P	X						X		

Code: C = Captive
P = PCM
O = OEM

PCM market

In recent years, 3330-1 and 3330-11 have been the only game in town for suppliers of PCM drives, as far as new production disk drives are concerned. But IBM changed the rules again with the 3350, and again with the 3330 price reductions. So, in 1977, prices are down and the mainstream product is being phased out by IBM.

As covered in detail in the applicable product sections, revenues from PCM drives will dip in 1977, but the loss will be replaced by PCM 3350 versions in 1978. Memorex and ISS (through Itel and Telex) have been neck-and-neck for the lead in PCM sales in recent years, but Memorex appears to have a slight edge in 1976, with 40% of total revenues.

TECHNICAL REVIEW

Competing technologies

No competing technology is likely to have a significant impact on the market for moving head rigid disk drives prior to 1980, the time span covered by this report. Several emerging technologies will, however, find specialized segments of the data processing market responsive to the new capabilities offered, even at comparatively high prices. The production programs thus initiated will lead to future cost reductions which probably will have a greater effect on disk drive markets later in the 1980's. So far the one feature offered by disk memories not under attack by competing technologies is removability -- certainly not the least of the benefits derived from today's disk cartridge and disk pack drives. Here is the current status of leading alternative technologies:

* Charge coupled devices: 64 K-bit devices are now available, with 256 K-bit predicted by 1978-79, but no one expects cost per megabyte to approach that of moving head disk during this decade. Early likely applications will be those in which high access rates and non-mechanical reliability levels will be the dominating design factors, and in which CCD's volatility will not be important. Examples are in fast auxiliary memories associated with virtual memory computer systems and as small memories with limited capabilities used with I/O devices and displays. Head per track disk drives could well suffer from early CCD inroads.

* Magnetic bubbles: Texas Instruments has used their 92 K-bit single chip device in the first data processing product to date to use magnetic bubbles, a portable terminal. 256 K-bit devices and beyond are likely this decade. Compared to CCD's, bubbles offer nonvolatility, lower future prices per bit, but a somewhat slower access time and transfer rate. It is probable that bubbles will find their most significant applications in

providing storage for products not able to justify the cost or space for disk storage -- in connection with small programmable calculators, point of sale devices, portable terminals, memory typewriters and home computers. Cost per megabyte will not approach most moving head disk drives this decade, but some growth which would otherwise have gone to floppy disk drives may start to go to bubbles by 1980. The separate DISK/TREND Report on floppy disk drives will discuss magnetic bubbles in more detail.

* EBAM (Electron-beam accessed MOS storage): EBAM (or BEAMOS) utilizes a one micron electron beam, deflected as required, to store a charge in the oxide layer of an MOS target. It is a non-mechanical system, with the theoretical potential for high capacities, fast access and low cost. Possible difficulties involve gradual degradation of the MOS target with extensive usage and an unknown record for reliability. This technology bears watching, but little market impact is likely without the test of practical field experience and unless a major system OEM decides to take a chance on it.

* Optical memories: Commercial optical storage systems offered in the past have been read-only devices, usually with very slow access. Laser and holographic memories, even those with extraordinary capacities, will continue to be limited to highly specialized applications, due to the lack of a reversible storage medium.

Disk drive enhancements

Moving head disk drives are not a stationary target for the competitive methods of storing data. Disk drive areal densities have gone from 110 K-bits per square inch with the 2311 to 3 M-bits per square inch with the 3350. The 2311 offered storage at 439 bytes/dollar, while the 3350 provides 11,339 bytes/dollars. It is to be expected that recording densities will be further improved on drives to be announced prior to 1980, and that cost per byte will be further reduced, in all capacity ranges from disk cartridge drives and up. Through 1980, the required improvements will probably come in these areas:

* Thin-film heads: The ferrite heads used in the highest density disk drives now available operate in the range of 6,000 BPI at about 500 TPI -- and it is generally agreed in the industry that major improvements beyond these levels will be difficult and expensive. By contrast, it is claimed that thin-film heads could deliver 10,000 BPI at 1,000 TPI using conventional media in 1977, and enthusiasts talk about an ultimate development level of 50,000 BPI and 5,000 TPI. Other thin-film head advantages include the ability to operate at higher transfer rates, a production process lending itself to multiple head arrays, and the probability of lower cost.

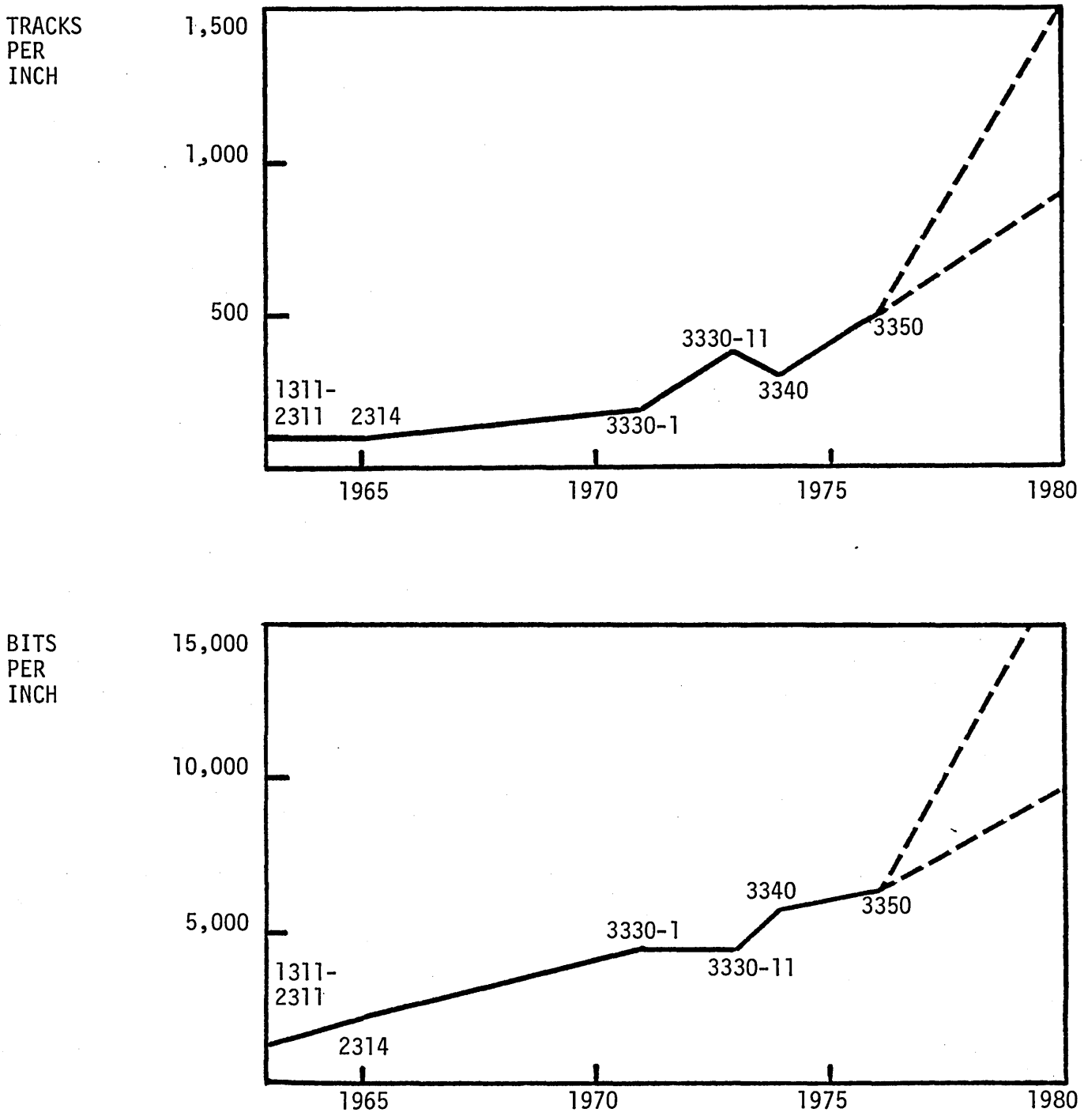
  Thin-film head development programs have been underway for up to ten years in several firms, including IBM, Burroughs, Control Data, Sperry Univac, Compagnie Internationale pour l'Informatique, Hitachi, Applied Magnetics and Information Magnetics. To date, the only drive on the market using thin-film heads is a Burroughs head per track drive introduced last year, which employs a single-turn head.

  Thin-film heads will undoubtedly be used broadly on commerical disk drives before the end of the decade, and the only real question is whether IBM will create another format standard for the industry by introducing a new drive (or drives) using the technology. While it would be foolhardy to assume IBM lacked the capability to announce such a drive today, an estimate of the situation influenced by the company's actions in recent years would have to predict delay for a few years, at least as far as the large capacity drives are concerned. It is probable that IBM plans a few more years of production for the basic 3344/3350. Enhancements are therefore likely to avoid obsoleting the basic drive or its major systems, and will probably provide double density through some combination of less drastic track and linear density improvements.

  IBM could introduce thin-film head technology on smaller drives first or on a fixed head option for a larger drive, and this course of action might have some advantages for them. With every recording technology it is reasonable to gain commercial experience with moderate recording densities before offering extremely high density versions. In addition, thin-film heads' potential for cost reduction could facilitate IBM's ability to offer a small, advanced series of drives as part of an enhanced minicomputer line designed to capture a major share of that market. And another possible IBM thrust could involve using thin-film heads with smaller disks, in the 8 to 10 inch range, to design a miniature drive for use with small business systems, word processing or electronic mail systems, or intelligent terminals.

  If IBM should fail to act, independent drive configurations will still arrive on the scene, but more slowly and with considerable

Figure 3
DISK RECORDING DENSITY
POTENTIAL IMPACT OF THIN-FILM HEADS



hesitation. Applications would probably be those requiring moderate capacities, in the 10 to 100 MB range. It is probable, although by no means certain, that the first steps will come from system manufacturers with captive disk drive facilities, who are in a position to underwrite development for an assured application. The availability of head production from industry vendors such as Applied Magnetics (now doing the industry's missionary selling job) and Information Magnetics will encourage captive producers to initiate such programs, and will facilitate development of manufacturing programs for the OEM market once some direction in formats is established.

An essential corollary question to that of the future of heads involves recording surfaces. Oxide coated surfaces probably cannot be expected to go much beyond 10,000 BPI. It is expected that plated surfaces of some kind will be used in higher density drives employing thin-film heads. Since plated surfaces tend to be more fragile, and because head flying altitudes will be even lower, fixed drives will be essential.

* Embedded servo data: The ability to accurately align heads to tracks is critical at any track density, but even more so at the higher densities employed today. There are definite limitations in the accuracy potential of a separate, dedicated surface used only for servo tracks matching each cylinder in the drive, the system used on most advanced drives now in production. Thermal variations and the build-up of mechanical tolerances are the problems.

  Embedded servo techniques utilize prerecorded servo data interspersed on each track. The same head then senses servo information as well as reading and writing data. Although more complicated electronics are required, this technique makes it possible for each head to align accurately with the track it is seeking. Embedded servo techniques have the potential to work satisfactorily with track densities of 1,000 TPI and beyond, and offer the additional benefit of freeing a recording surface that would otherwise have to be used for servo tracks. The technique could have its maximum benefit with drives using removable packs or cartridges, due to the mechanical tolerances involved, but may also be the the answer for extremely high densities on future fixed drives.

  Embedded servos have been utilized commercially on the Vermont Research 5017, an innovative 50 MB single disk cartridge drive, which has gone nowhere in the OEM marketplace. Burroughs uses the technique on its 174 MB model 9383-16, a 20 surface disk pack drive which is now a major Burroughs peripheral. And Diablo will use an embedded servo scheme on the Series 400 drives scheduled to ship later this year. The current outlook is for increased usage of this technique throughout the industry as track densities increase.

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 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 Itel 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 1977 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 would probably require establishment of new DISK/TREND product categories.

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

Medium/large scale 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/system houses: (1) OEMs which manufacture a system requiring disk drives, such as Foxboro, Basic/4 or Inforex. (2) System 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 system 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.

1977 DISK/TREND REPORT

DISK CARTRIDGE DRIVES, UP TO 12MB

Coverage

Examples of disk drives included in this group include:

IBM	5447, 5444, 2310
Diablo	31, 33, 43, 44B
Burroughs	9480-2, 9481-2, 9482-32
DEC	RK05J
Control Data	9427H
Data 100	3002, 3404, 3850, 3860
Data General	6045
DRI	3206, 3212
Hewlett Packard	7900A
Microdata	9100, 9200
Pertec	3311, 3421
Wangco	F-1111, F/T-1212, F/T-2221
Western Dynex	DD-6121, DD-6222
CII-HB	D120

Both removable-only and fixed/removable combination drives are included, whether cartridges are front loading (2315 type), top loading (5440 type) or a special design. Each fixed/removable combination drive is counted as one spindle.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	392.4	419.2	431.8	399.8	317.1
All manufacturers	440.3	471.2	482.8	450.8	364.8

Current production of disk cartridge drives is largely an independent affair, with IBM's activity centered on the 5447, the 5-10 MB successor to the 5444.

Independent manufacturing programs continue to be built on the scores of individual system adoptions of OEM drives introduced in the early 1970's. Starting with independent versions of IBM's front loading 2310 by Diablo, Caelus (now EMM) and Iomec (now Data 100) and later supplemented by 5444-type top loading designs, the independents obviously had the right products at the right time. Functionally, the product life of the cartridge drive has been extended well beyond its time through continuing capacity enhancements. The progression from IBM's original specifications to today's 200 TPI, 4400 BPI drives, and beyond, has extended this product type to such an extent that cartridge drives above 12 MB have been split into a separate DISK/TREND category.

Perhaps the central fact of life for OEM cartridge drive manufacturers has been the tendency for larger system manufacturers to substitute internal production programs for outside purchases. The largest of these programs were initiated by Burroughs and DEC in 1973-74, followed by Hewlett Packard -- and by the latecomer, Data General, in 1976.

Non-IBM U.S. captive manufacturing programs reached their production peak in 1976, with 38,600 drives, compared with 33,500 drives produced for the OEM market by U.S. manufacturers. Performance at this level by the OEM producers represents an impressive achievement, considering the magnitude of the business lost to the captive internal programs, and is a reflection of the strong growth in minicomputers and numerous other cartridge drive applications.

Market trends

For the captive programs, the outlook is all downhill in total production volume of cartridge drives below 12 MB. Drives in this group will still be in new production through the early 1980's but demand for higher capacities is shifting the average capacity level strongly upward. DEC, Burroughs and HP have all introduced cartridge drives and/or SMD's above 12 MB, and future growth is expected in that range, rather than below 12 MB. Newly designed fixed disk drives will also account for significant captive growth in this capacity range.

Peak OEM unit volume is not expected until 1978. This sales strength is created by the lag in availability of higher capacity OEM cartridge drives (e.g., Diablo Series 400), combined with the smaller average size of the hundreds of OEM accounts, with their reduced tendency to take the leadership in early adoption of new drives.

Average OEM prices will be essentially level through 1980, with a slight projected rise due to the continuing increase in average capacities. It is expected that minicomputer manufacturers will no longer be the dominant distribution channel for OEM cartridge drives by 1980, with equal volume by that date going to system OEMs and system houses.

Technical trends

No real impact on cartridge drives through 1980 is expected from flexible disk drives, magnetic bubbles, or CCDs. Cartridge drives as a class are already abandoning the lower capacity range, which is the only area vulnerable to such competition through that time frame.

Some competition may be offered from another quarter, however -- the CII-Honeywell Bull 10 MB drive using a 10.5" disk in a special cartridge. The success level of this drive will be highly dependent on its early functional performance record starting in 1978, plus the degree of support offered by Honeywell in the U.S. The current DISK/TREND forecasts envision a relatively modest OEM penetration for this drive.

Forecasting assumptions

1. The trend toward higher capacities per spindle will continue, creating strength in OEM price levels, but tending to weaken growth potential in disk cartridges below 12 MB.

2. Captive production of drives in this category will decline starting in 1977 due to commitments to higher capacity cartridge and/or storage module drives by Burroughs, DEC and Hewlett Packard.

3. OEM drive production will not peak until 1978, because of sales momentum insured by the diversity and quantity of OEM accounts.

4. Fixed disk drives will absorb much of the production growth which would otherwise have gone to cartridge drives through 1980.

5. The phenominal growth of flexible disk drives will have little effect on cartridge drives, since the lower capacity ranges have been largely abandoned by cartridge drives.

TABLE 7

DISK CARTRIDGE DRIVES, UP TO 12 MB

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	23.0	33.4	34.5	50.6	46.0	67.9	46.0	67.9	23.0	33.4
Other U.S. Captive	154.1	250.9	151.5	240.5	139.8	220.4	126.1	197.0	108.6	170.3
TOTAL U.S. CAPTIVE	177.1	284.3	186.0	291.1	185.8	288.3	172.1	264.9	131.6	203.7
PCM	2.2	2.2	3.3	3.3	3.9	3.9	4.5	4.5	4.5	4.5
OEM	77.1	105.9	89.0	124.8	100.8	139.6	94.1	130.4	79.0	108.9
TOTAL U.S. NON-CAPTIVE	79.3	108.1	92.3	128.1	104.7	143.5	98.6	134.9	83.5	113.4
TOTAL U.S. PRODUCTION	256.4	392.4	278.3	419.2	290.5	431.8	270.7	399.8	215.1	317.1
Non-U.S. Manufacturers										
Captive		28.0		31.2		31.9		33.8		32.5
OEM		19.9		20.8		19.1		17.2		15.2
TOTAL NON-U.S. PRODUCTION		47.9		52.0		51.0		51.0		47.7
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		440.3		471.2		482.8		450.8		364.8
TOTAL WORLDWIDE CAPTIVE		312.3		322.3		320.2		298.7		236.2
TOTAL WORLDWIDE NON-CAPTIVE		128.0		148.9		162.6		152.1		128.6

TABLE 8

DISK CARTRIDGE DRIVES, UP TO 12 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipment			Installed YE 1976	Forecast							
						1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	46.8	2.0	0	2.0	48.8	3.0	51.8	4.0	55.8	4.0	59.8	2.0	61.8
Non-IBM -- Units (000)	120.9	23.7	24.5	48.2	169.1	52.6	221.7	53.7	275.4	49.6	325.0	42.2	367.2
Total -- Units (000)	167.7	25.7	24.5	50.2	217.9	55.6	273.5	57.7	331.2	53.6	384.8	44.2	429.0
Worldwide Net Shipments													
IBM -- Units (000)	68.8	2.9	0	2.9	71.7	4.4	76.1	5.9	82.0	5.9	87.9	2.9	90.8
Non-IBM -- Units (000)	197.9	42.9	39.7	82.6	280.5	87.9	368.4	87.6	456.0	81.0	537.0	69.6	606.6
Total --- Units (000)	266.7	45.8	39.7	85.5	352.2	92.3	444.5	93.5	538.0	86.9	624.9	72.5	697.4

TABLE 9

DISK CARTRIDGE DRIVES, UP TO 12 MB

PRICE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments		FORECAST 1977		1978		1979		1980	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments										
OEM -- Units (000)	24.1	39.3	28.7	45.5	31.5	48.1	29.4	44.7	24.7	37.6
PCM -- Units (000)	.4	.4	.6	.6	.7	.7	.8	.8	.8	.8
Average Unit Price										
To OEMs ($)	3,100	3,200	3,100	3,200	3,200	3,300	3,200	3,300	3,200	3,300
To End Users ($)	5,400	5,400	5,500	5,500	5,500	5,500	5,600	5,600	5,600	5,600
Value of Shipments										
To OEMs ($M)	74.7	125.8	89.0	145.6	100.8	158.7	94.1	147.5	79.0	124.1
To End Users ($M)	2.2	2.2	3.3	3.3	3.9	3.9	4.5	4.5	4.5	4.5

TABLE 10

DISK CARTRIDGE DRIVES, UP TO 12 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution Channel	1976 U.S. Net Shipments Units (000)	%	FORECAST 1977 %	1978 %	1979 %	1980 %
Medium/large scale computer mfgrs	1.3	5.2	4.9	4.6	4.2	3.4
Mini/micro computer manufacturers	11.1	45.5	41.7	38.6	36.0	34.7
System OEMs/system houses	6.6	26.8	29.5	31.8	33.8	35.1
Independent peripherals suppliers	5.3	21.7	22.8	23.7	24.4	24.9
Direct to end user	.2	.8	1.1	1.3	1.6	1.9
TOTAL	24.5					

TABLE 11

DISK CARTRIDGE DRIVES, UP TO 12 MB

MARKET SHARE SUMMARY
Non-Captive Disk Drives

Drive Manufacturers	1976 Net Shipments To United States Destinations Units (000)	%	Worldwide Units (000)	%
Diablo	13.6	55.5	17.0	42.8
Pertec	3.5	14.3	5.0	12.6
Control Data	2.2	9.0	3.4	8.5
Wangco	2.1	8.6	2.8	7.1
Data 100	1.8	7.3	2.6	6.6
EMM	1.0	4.1	1.0	2.5
Others	.3	1.2	7.9	19.9
	24.5		39.7	

1977 DISK/TREND REPORT

DISK CARTRIDGE DRIVES, 12-55 MB

Coverage

Examples of disk drives included in this group include:

Diablo	Series 400
DEC	RK06
Hewlett Packard	7905A
EMM	312
Pertec	D3400E, D3600E
Vermont Research	5017
Fujitsu	M2201
Wangco	MC40/20, MC40/40
Univac	8415

The common denominator among drives in this group is a removable cartridge, which is usually, but not always, combined with one or more fixed disks.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	20.9	47.8	81.8	117.9	149.0
All manufacturers	20.9	47.8	85.3	125.7	164.5

This is essentially a new product area, with the Hewlett Packard 7905A accounting for the only significant shipments prior to 1977. IBM does not offer a cartridge drive in this capacity range, and System/3 users wishing more than 10 MB per spindle are forced to use the older 5445 (2314-type) drive or jump to the 3340, with its higher media cost.

DEC made its first shipments of the RK06 in December, 1976, providing its first upward path in capacity improvements from the RK05, aside from disk pack drives.

Great attention has been focused on Diablo's announced Series 400 drives, because of a combination of factors: (1) Diablo's dominance of the OEM disk cartridge market, (2) The drive's advanced features, (3) the low quoted prices, and (4) Diablo's failure to deliver production quantities in 1976, as planned. However, manufacturing start-up problems now appear solvable, and the firm has published a firm delivery schedule for two models, starting in October, 1977.

OEM adoptions of cartridge drives in this category have been deferred, for the most part, until systems designers can be sure of their footing.

Marketing trends

With an installed worldwide population by year-end 1977 of 444,500 cartridge drives under 12 MB, combined with the constantly increasing appetite by most users for more disk capacity, there is an obvious and large market for a step-up product. Less obvious is whether the higher capacity cartridge disk drives in this category will prevail, or whether the mainstream of the market will go to storage module drives or to the new generation of fixed disk drives. Unfortunately for the OEM cartridge drive manufacturers, the SMD has a three year lead in the marketplace, and a sizable proportion of the OEM cartridge drive customers have already made their step-up plans, bypassing the next generation of cartridge drives completely. But the SMD is not for everyone, despite its clear commercial success -- with its higher price, and media with higher costs and larger physical size. The new Winchester fixed disk drives have only a short lead on the enhanced cartridge drives, but

they certainly will penetrate a portion of the market that otherwise would have gone to cartridges. These drives will prevail in most applications not requiring disk removability, or when other methods of data back-up can be provided.

Captive disk cartridge programs are obviously responsive to the desires of parent company system designers. DEC's RK06 is, therefore, expected to have a big production future, displacing a large part of previous RK05 volume. HP's 7905A, on the other hand, is expected to be impacted greatly by HP's own SMD, introduced in 1977. And Burroughs, the other giant in captive cartridge drive production, is skipping the higher capacity cartridge drive area completely, in favor of its own manufacturing program for a SMD type drive.

OEM programs will start slow, due to the manufacturing start-up problems discussed above. However, DISK/TREND's projections are believed to be conservative, and could be exceeded if promised deliveries are kept, with drives which prove highly reliable.

Technical trends

The over-12 MB disk cartridge drives announced to date do not represent the evolutionary limit for this product group. Use of 400 TPI, alone, would increase capacity to over 100 MB in the typical one removable/three fixed configuration -- and other combinations of additional disks and improved densities are possible.

Two drives in this group utilize the embedded servo technique, in which track servo information is interspersed with user data on each track. This approach has the several advantages of avoiding dedication

of a usable surface to separate servo tracks, improved interchangability, improved environmental stability, and avoidance of the need for special CE cartridges for alignment. Vermont Research's 5017, one of the first drives using this technique, has not been a commercial success, but Diablo's industry position will create a climate of acceptance for this aspect of the Series 400's specifications. In addition to other innovations, the Series 400 feature attracting the most attention has been the separately controllable actuators for fixed and removable disks. Diablo seems to be alone so far in advocating this approach, but it is claimed that no serious engineering problems have been encountered with the actuator design, itself unconventional. Success in the market will undoubtedly stimulate emulation.

Two other drives utilize two disks in specially designed cartridges, using one of the four available surfaces for servo information, with no fixed disks. DEC's RK06, with a top-loading cartridge, has been announced so far only as a 13.89 MB drive, but clearly should be upgradable to double that capacity. Fujitsu's M2201 offers 50 MB, by using 370 TPI, 6135 BPI.

Forecasting assumptions

1. The key assumption made in this category is that Diablo will solve its manufacturing start-up problems and will initiate deliveries of two models of Series 400 by early 4Q77, thus tending to maintain its dominant market share of OEM cartridge drives.

2. Captive production will grow steadily, due to DEC's apparent intention to cover this capacity range with the RK06 and its subsequent capacity enhancements.

3. Capacities in 1977-78 will average in the 18-26 MB area, gradually increasing thereafter, but not enough to prevent a modest decline in average OEM unit price, as volume increases.

4. Various storage module drive formats will predominate at the upper capacity levels in which cartridge drives compete, due to their earlier availability, and fixed Winchester drives will displace cartridge drives where removability is not strongly desired by system designers and end users.

TABLE 12

DISK CARTRIDGE DRIVES, 12-55 MB

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	10.5	20.9	23.8	41.8	37.1	62.7	53.2	88.4	67.5	111.2
TOTAL U.S. CAPTIVE	10.5	20.9	23.8	41.8	37.1	62.7	53.2	88.4	67.5	111.2
PCM	--	--	--	--	--	--	.6	.6	1.2	1.2
OEM	--	--	4.3	6.0	14.8	19.1	22.2	28.9	28.1	36.6
TOTAL U.S. NON-CAPTIVE	--	--	4.3	6.0	14.8	19.1	22.8	29.5	29.3	37.8
TOTAL U.S. PRODUCTION	10.5	20.9	28.1	47.8	51.9	81.8	76.0	117.9	96.8	149.0
Non-U.S. Manufacturers										
Captive		--		--		--		--		--
OEM		--		--		3.5		7.8		15.5
TOTAL NON-U.S. PRODUCTION		--		--		3.5		7.8		15.5
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		20.9		47.8		85.3		125.7		164.5
TOTAL WORLDWIDE CAPTIVE		20.9		41.8		62.7		88.4		111.2
TOTAL WORLDWIDE NON-CAPTIVE		--		6.0		22.6		37.3		53.3

TABLE 13

DISK CARTRIDGE DRIVES, 12-55 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipments			Installed YE 1976	Forecast							
						1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM -- Units (000)	.4	1.1	--	1.1	1.5	3.6	5.1	7.8	12.9	11.7	24.6	15.1	39.7
Total -- Units (000)	.4	1.1	--	1.1	1.5	3.6	5.1	7.8	12.9	11.7	24.6	15.1	39.7
Worldwide Net Shipments													
IBM -- Units (000)	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM -- Units (000)	.8	2.2	--	2.2	3.0	5.9	8.9	12.4	21.3	19.1	40.4	26.0	66.4
Total -- Units (000)	.8	2.2	--	2.2	3.0	5.9	8.9	12.4	21.3	19.1	40.4	26.0	66.4

TABLE 14

DISK CARTRIDGE DRIVES, 12-55 MB

PRICE SUMMARY
Non-Captive Disk Drives

	FORECAST							
	1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments								
OEM -- Units (000)	1.1	1.5	3.9	5.8	6.0	9.7	7.8	14.1
PCM -- Units (000)	--	--	--	--	.1	.1	.2	.2
Average Unit Price								
To OEMs ($)	3,900	4,000	3,800	3,900	3,700	3,800	3,600	3,700
To End Users ($)	--	--	--	--	6,300	6,300	6,100	6,100
Value of Shipments								
To OEMs ($M)	4.3	6.0	14.8	22.6	22.2	36.9	28.1	52.2
To End Users ($M)	--	--	--	--	.6	.6	1.2	1.2

TABLE 15

DISK CARTRIDGE DRIVES, 12-55 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

	SHIPMENTS TO U.S. DESTINATIONS			
		FORECAST		
Distribution Channel	1977 %	1978 %	1979 %	1980 %
Medium/large scale computer mfgrs	--	3.5	4.3	4.8
Mini/micro computer manufacturers	59.1	51.6	45.8	41.1
System OEMs/system houses	30.4	32.8	34.8	36.2
Independent peripherals suppliers	10.5	12.1	13.9	16.0
Direct to end user	--	--	1.2	1.9

1977 DISK/TREND REPORT

DISK PACK DRIVES, 29-58 MB

Coverage

Examples of disk drives in this group include:

IBM	2314, 2319, 5445
Ampex	DM-313, DM-323
Burroughs	9384-6
Calcomp	212, 215
Control Data	9746, 9747
ISS	714, 715

The basic intent in this category is to cover drives which utilize the same basic physical configuration as IBM's 2314. Currently, most of the drives included are "double density" 58 MB units, but some drives have been arbitrarily included because of physical similarity, even though outside of the nominal capacity range.

Market status

DISK/TREND estimate of the total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	100.3	110.1	105.1	99.6	69.5
All manufacturers	135.1	150.3	139.7	130.5	94.8

The workhorse 2314 series has long been out of new production at IBM, and PCM suppliers have been living off their inventory of refurbished drives for almost as long.

But this drive doesn't die easily, as evidenced by healthy captive and OEM manufacturing programs in the U.S., Europe and Japan. Despite the fact that newer technologies have brought forth a plentiful supply of drives with larger capacities and lower cost/megabyte, DISK/TREND estimates

indicate worldwide production in 1976 of over 10,000 2314-type spindles, and over 11,000 in 1977. The net non-IBM total is somewhat lower in each case, however, due to PCM returns of leased drives.

Factors keeping up the momentum are the sales inertia of systems using these drives and the improved cost efficiency of double density drives. New installations of systems using 2314-type drives are still at a healthy level, and there is a substantial demand for add-on drives for existing installations.

Marketing trends

The outlook for the next few years in both captive and OEM production is essentially level. System OEMs tend to avoid the expense of redesigning interfaces and software to offer new disk drives on last year's systems, even though still in production. However, even an old workhorse like the 2314 will be put out to pasture eventually, and by 1980 production rates in both the captive and OEM areas will be in sharp decline. The reason: Phasing out of the systems still using 2314-type drives.

In the meantime, no new adoptions of drives in this category are expected. Competitive configurations are far too attractive, in cost, capacity and reliability.

Technical trends

Nothing new is expected. Worthy of note, however, is the Burroughs continued development of the 2314 format, using 3330 technology. This program has extended to the point that 174 MB is now offered on a single

spindle, using 3330-11 type heads and disks in a configuration with the appearance of the 2314 -- and employing an embedded servo technique (included in the over 100 MB category).

Forecasting assumptions

1. OEM production of double density 2314-type drives will continue through the remainder of this decade, although at a constantly declining rate.

2. Captive production will not decline markedly until the end of the decade, due to continued reliance on the configuration by companies such as Burroughs and Univac.

3. New system adoptions will be non-existent, with system designers preferring instead the newer high density cartridges, 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)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	--	--	--	--	--	--	--	--	--	--
Other U.S. captive	37.8	61.2	45.0	72.0	46.8	73.8	46.8	75.6	32.4	52.2
TOTAL U.S. CAPTIVE	37.8	61.2	45.0	72.0	46.8	73.8	46.8	75.6	32.4	52.2
PCM	--	--	--	--	--	--	--	--	--	--
OEM	20.0	39.1	19.1	38.1	15.3	31.3	12.0	24.0	8.0	17.3
TOTAL U.S. NON-CAPTIVE	20.0	39.1	19.1	38.1	15.3	31.3	12.0	24.0	8.0	17.3
TOTAL U.S. PRODUCTION	57.8	100.3	64.1	110.1	62.1	105.1	58.8	99.6	40.4	69.5
Non-U.S. Manufacturers										
Captive		16.2		21.6		18.0		16.2		14.4
OEM		18.6		18.6		16.6		14.7		10.9
TOTAL NON-U.S. PRODUCTION		34.8		40.2		34.6		30.9		25.3
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		135.1		150.3		139.7		130.5		94.8
TOTAL WORLDWIDE CAPTIVE		77.4		93.6		91.8		91.8		66.6
TOTAL WORLDWIDE NON-CAPTIVE		57.7		56.7		47.9		38.7		28.2

TABLE 17

DISK PACK DRIVES, 29-58 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipments			Installed YE 1976	Forecast							
						1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	33.4	(4.0)	--	(4.0)	29.4	(2.9)	26.5	(2.2)	24.3	(1.7)	22.6	(1.3)	21.3
Non-IBM -- Units (000)	42.0	2.1	1.0	3.1	45.1	3.8	48.9	3.7	52.6	3.4	56.0	2.4	58.4
Total -- Units (000)	75.4	(1.9)	1.0	(.9)	74.5	.9	75.4	1.5	76.9	1.7	78.6	1.1	79.7
Worldwide Net Shipments													
IBM -- Units (000)	55.7	(6.0)	--	(6.0)	49.7	(4.5)	45.2	(3.5)	41.7	(2.8)	38.9	(2.1)	36.8
Non-IBM -- Units (000)	65.9	4.3	4.8	9.1	75.0	10.3	85.3	9.6	94.9	8.7	103.6	6.4	110.0
Total -- Units (000)	121.6	(1.7)	4.8	3.1	124.7	5.8	130.5	6.1	136.6	5.9	142.5	4.3	146.8

TABLE 19

DISK PACK DRIVES, 29-58 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution Channel	1976 U.S. Net Shipments Units (000)	%	FORECAST 1977 %	1978 %	1979 %	1980 %
Medium/large scale computer mfgrs	.2	9.1	5.2	3.1	--	--
Mini/micro computer manufacturers	.4	18.2	15.4	12.6	8.5	5.1
System OEMs/system houses	1.3	59.1	65.3	69.6	75.2	77.0
Independent peripherals suppliers	.3	13.6	14.1	14.7	16.3	17.9
Direct to end user	--	--	--	--	--	--
TOTAL	2.2					

TABLE 20

DISK PACK DRIVES, 29-58 MB

MARKET SHARE SUMMARY
Non-Captive Disk Drives

Drive Manufacturers	1976 Net Shipments To United States Destinations Units (000)	%	Worldwide Units (000)	%
Control Data	.8	36.4	2.5	40.3
Calcomp	.8	36.4	1.0	16.1
Others	.6	27.2	2.7	43.6
	2.2		6.2	

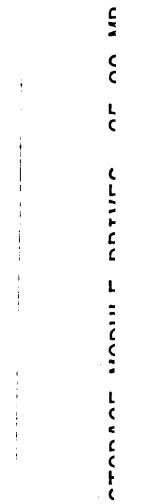
Note: PCM net shipments, a negative value for the years 1976 through 1980, have been eliminated from the two tables on this page to avoid distortion of OEM shipments.

TABLE 18

DISK PACK DRIVES, 29-58 MB

PRICE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments		FORECAST 1977		1978		1979		1980	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments										
OEM -- Units (000)	2.2	6.2	2.1	6.1	1.7	5.2	1.3	4.2	.9	3.1
PCM -- Units (000)	(1.2)	(1.4)	(.8)	(1.0)	(.6)	(.7)	(.5)	(.6)	(.3)	(.4)
Average Unit Price										
To OEMs ($)	9,100	9,300	9,100	9,300	9,000	9,200	9,000	9,200	8,900	9,100
To End Users	--	--	--	--	--	--	--	--	--	--
Value of Shipments										
To OEMs ($M)	20.0	57.6	19.1	56.7	15.3	47.9	11.7	38.7	8.0	28.2
To End Users ($M)	--	--	--	--	--	--	--	--	--	--



1977 DISK/TREND REPORT

STORAGE MODULE DRIVES, 25-80 MB

Coverage

Examples of disk drives in this group include:

Control Data	9760, 9762
Calcomp	T-25, T-50, T-80
Ball	BD-50, BD-80
Burroughs	8484-2, 8484-5
Hewlett Packard	7920A
Univac	8418-92, 8418-94
Ampex	DM-940, DM-980
Wangco	MP-40, MP-80

For the purposes of this report, the term "storage module" has been used as a generic description to include the Trident configuration by Calcomp, and the unique Hewlett Packard and Univac formats, as well as Control Data's SMD. The Burroughs drive is a Trident modification.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	50.5	133.5	219.5	285.9	285.2
All manufacturers	50.5	133.5	237.4	320.4	334.1

After a 2-3 year period of frustrating delays while system designers evaluated and pondered, serious production schedules for SMDs got underway in mid 1976. The largest individual manufacturing programs, a mix of captive and OEM activities, were generated by system requirements for major computer manufacturers: Univac, Burroughs, Honeywell and Hewlett Packard. Burroughs' 1976 requirements were supplied in total by Calcomp, but Burroughs' internal manufacturing program is expected to produce most of that company's Trident needs by the end of 1977.

OEM sales programs for the SMD have clearly gotten off to an excellent start, after the necessary evaluation delay. SMD usage is widely diffused among all types of distribution -- major mainframers, minicomputer manufacturers, small business systems and other system OEMs, independent peripherals suppliers, and even an emerging PCM business. Of all the newer disk configurations, the SMD is the one to beat. It was first to offer an up-to-date format filling the capacity gap between disk cartridges and 100 MB drives, and, at the moment, it has a pronounced sales lead over its newer rivals, high density disk cartridge drives and fixed Winchester drives.

Marketing trends

DISK/TREND projections indicate an average annual growth rate of 92% through 1979, but a peak for the growth pattern in 1980 -- based on the existing form of the SMD. Of course, it is probable that enhancements to the SMD of today will provide adequate sales stimulus to head off an actual slowdown in the growth rate by the end of the decade.

It is likely, however, that continued vertical integration by major system OEMs will occur within the next year or two, tending to dampen potential OEM growth somewhat. DEC and Data General are two obvious candidates for internal SMD manufacture. Also likely by 1978 are SMD programs by non-U.S. disk drive manufacturers, particularly in Japan. Both captive and OEM efforts are expected.

U.S. OEM sales leadership is held by Control Data, on the strength of highly competitive pricing, establishment of a defacto interface standard and the CDC SMD's position as part of the industry's broadest

line of disk drives. Control Data's interface is even available now on Trident drives from rival Calcomp, and on SMD type drives from every other competitor in the OEM marketplace.

The mix of drives actually shipped has leaned strongly toward the 80 MB versions during 1976, by a 2:1 ratio. It is expected that this trend will continue, especially in view of tough competition from new high density cartridge drives in the 25-50 MB range. One short-term effect of this trend will be to increase average unit prices for OEM drives during the next few years.

Technical trends

The most likely innovation to be offered by most OEM vendors is the fixed/removable SMD combination. Wangco has already announced such a drive for delivery in 1978, and it is expected that others will make similar moves.

On a long range basis, it would appear most likely that serious competition to the SMD format will come from disk drives offering similar capacities in a smaller space, at a lower price, in a removable or fixed/removable media configuration. Such an alternative is conceivable, but not likely before the end of the decade.

Forecasting assumptions

1. OEM sales momentum achieved in 1976 will continue, with production increasing through 1980. However, high density cartridge and fixed drives will also capture a respectable share of new system adoptions, preventing run-away growth for the SMD.

2. Captive production of SMD's will be substantial, due to continued healthy growth in low end general purpose systems offered by

Honeywell, Burroughs and Univac, and minicomputer systems offered by Hewlett Packard and possibly others.

3. OEM price levels will be strengthened by a continuing trend to higher capacities, but average unit prices will start to decline after 1978 due to volume.

TABLE 21

STORAGE MODULE DRIVES, 25-80 MB

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	--	--	--	--	--	--	--	--	--	--
Other U.S. captive	18.7	29.8	46.8	76.5	78.2	126.7	104.6	165.8	101.2	160.7
TOTAL U.S. CAPTIVE	18.7	29.8	46.8	76.5	78.2	126.7	104.6	165.8	101.2	160.7
PCM	1.7	1.7	3.4	3.4	6.1	6.1	10.6	10.6	14.2	14.2
OEM	14.2	19.0	37.5	53.6	60.0	86.7	75.5	109.5	75.4	110.3
TOTAL U.S. NON-CAPTIVE	15.9	20.7	40.9	57.0	66.1	92.8	86.1	120.1	89.6	124.5
TOTAL U.S. PRODUCTION	34.6	50.5	87.7	133.5	144.3	219.5	190.7	285.9	190.8	285.2
Non-U.S. Manufacturers										
Captive		--		--		12.8		25.5		36.6
OEM		--		--		5.1		9.0		12.3
TOTAL NON-U.S. PRODUCTION		--		--		17.9		34.5		48.9
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		50.5		133.5		237.4		320.4		334.1
TOTAL WORLDWIDE CAPTIVE		29.8		76.5		139.5		191.3		197.3
TOTAL WORLDWIDE NON-CAPTIVE		20.7		57.0		97.9		129.1		136.8

TABLE 22

STORAGE MODULE DRIVES, 25-80 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipments			Installed YE 1976	Forecast							
						1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM -- Units (000)	.4	2.2	3.1	5.3	5.7	13.4	19.1	21.9	41.0	28.9	69.9	29.2	99.1
Total -- Units (000)	.4	2.2	3.1	5.3	5.7	13.4	19.1	21.9	41.0	28.9	69.9	29.2	99.1
Worldwide Net Shipments													
IBM -- Units (000)	--	--	--	--	--	--	--	--	--	--	--	--	--
Non-IBM -- Units (000)	.4	3.5	4.0	7.5	7.9	19.9	27.8	35.1	62.9	47.4	110.3	49.8	160.1
Total -- Units (000)	.4	3.5	4.0	7.5	7.9	19.9	27.8	35.1	62.9	47.4	110.3	49.8	160.1

TABLE 23

STORAGE MODULE DRIVES, 25-80 MB

PRICE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments		FORECAST							
			1977		1978		1979		1980	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments										
OEM -- Units (000)	2.9	3.8	7.5	10.5	12.0	18.0	15.4	23.7	15.7	25.0
PCM -- Units (000)	.2	.2	.4	.4	.7	.7	1.2	1.2	1.6	1.6
Average Unit Price										
To OEMs ($)	4,900	5,000	5,000	5,100	5,000	5,100	4,900	5,000	4,800	4,900
To End Users ($)	8,400	8,400	8,400	8,400	8,700	8,700	8,800	8,800	8,900	8,900
Value of Shipments										
To OEMs ($M)	14.2	19.0	37.5	53.6	60.0	91.8	75.5	118.5	75.4	122.5
To End Users ($M)	1.7	1.7	3.4	3.4	6.1	6.1	10.6	10.6	14.2	14.2

TABLE 24

STORAGE MODULE DRIVES, 25-80 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

Distribution Channel	1976 U.S. Net Shipments Units (000)	%	FORECAST 1977 %	1978 %	1979 %	1980 %
Medium/large scale computer mfgrs	.9	29.0	10.1	7.1	6.6	6.4
Mini/micro computer manufacturers	.6	20.4	30.2	29.1	24.4	20.3
System OEMs/system houses	.7	23.2	31.3	34.3	37.1	38.3
Independent peripherals suppliers	.7	22.4	23.3	24.0	24.7	25.7
Direct to end user	.2	5.0	5.1	5.5	7.2	9.3
TOTAL	3.1					

TABLE 25

STORAGE MODULE DRIVES, 25-80 MB

MARKET SHARE SUMMARY
Non-Captive Disk Drives

Drive Manufacturers	1976 Net Shipments To United States Destinations Units (000)	%	Worldwide Units (000)	%
Control Data	1.3	41.9	1.9	47.5
Calcomp	1.5	48.4	1.7	42.5
Others	.3	9.7	.4	10.0
	3.1		4.0	

1977 DISK/TREND REPORT

DISK PACK DRIVES, MORE THAN 100 MB

Coverage

Examples of disk drives in this group include:

IBM	3330-1, 3330-11
ISS	7330-1, 7330-11
Memorex	3670, 3675, 677
Control Data	9780, 9764, 9766
Ampex	DM-330, DM-331, DM-9300
Burroughs	9383-16
Data General	6060, 6061
Siemens	PS 5-3, PS 5-5
Storage Technology	8100

Most of the drives included in this category are 100 and 200 MB versions of IBM's 3330, but the group also includes some 150 and 300 MB drives in the 3330 format, as well as some unique configurations. For instance, Burroughs 174 MB drives utilizing 3330 technology in a 2316-type disk pack with 20 recording surfaces are included, plus a Siemens 144 MB drive using a special 9 surface pack.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	590.4	373.9	362.6	307.5	258.3
All manufacturers	664.2	472.0	466.5	401.2	337.7

In 1976 disk pack drives over 100 MB constituted the largest DISK/TREND category in sales revenue, with 35% of worldwide net sales. Total production in the category is declining, however, and 1977 sales are expected to be only 20% of worldwide net sales of moving head disk drives.

IBM halted production of new 3330-1 drives in 1975, and the 3330-11, in 1976. With the current build-up in deliveries of 3344 and 3350 drives, IBM's installed population of 3330 spindles will start to decline in 1977, and a significant shift in the mix of owned/leased drives is expected to be generated by IBM's 15% reduction in purchase prices in April, 1977. 3330 business is currently the mainstay of PCM disk drive business, but under severe pressure as a result of IBM's 3350 strategy.

Marketing trends

PCM sales of 3330-11 drives will exist until the end of the decade, but at a sharply declining level each year. An average annual decline in PCM 3330 net sales of 32.6% is projected, but PCM suppliers will find 3350 shipments replacing lost sales volume after a dip in 1977.

Captive production of drives in this category is expected to peak in 1978, followed by slight annual declines through 1980. OEM production is also expected to peak in 1978, but sales momentum of systems using these drives will sustain the OEM market through the early 1980's with only a gentle decline in annual sales. Japanese OEM and captive production is expected to remain relatively constant through 1980, but declining by the end of the decade.

U.S. distribution channels for non-captive drives will undergo sharp realignments, as the PCM market declines. Sales by OEM manufacturers to system houses and minicomputer manufacturers will become dominant by 1980, reflecting the increasing importance of large data bases associated with smaller computers.

Technical trends

The bulk of the OEM and PCM market is already at the 200 MB level. It is expected that 300 MB drives, the 6000 BPI extension of the 3330-11 drive now offered by some OEM manufacturers as part of their SMD lines, will predominate by 1980.

Through 1980, no functional rival to the 3330 format is in view, for those applications demanding media removability. It is possible to imagine larger versions of the 3340/3348 in order to achieve improved drive cost/megabyte -- in other words, a removable 3350 -- but the media cost would be extremely high.

One possibility for improving the capacity limits of the existing 3330 format does exist: The embedded servo, in which servo information is interspersed with user data on each track. The potential advantage would be in increasing the current maximum TPI from 384 to a possible 500 to 600. With the embedded servo technique, adequate disk pack interchange between drives could be possible without dedicating a disk surface to separate servo tracks. The possible capacity per disk pack of such a drive would be 400 to 500 MB, depending on track density. Despite the technical possibility, however, it is problematical whether any independent disk drive manufacturer is prepared to pioneer the field.

Forecasting assumptions

1. IBM's installed population of 3330-1 and 3330-11 will start to decline in 1977, due to the improved cost/megabyte performance of 3350 and 3344, combined with aggressive marketing by PCM vendors.

2. PCM drives will start their sales decline in 1977, due to the impact of 3350, but will stay in production through 1980.

3. OEM drives will decline after 1978, but strength in 100-300 MB versions of SMD's will prevent a severe decline.

4. Most OEM drives are already in the 200-300 MB range, and slight price declines may be expected as OEM's attempt to keep their customers committed to the format.

TABLE 26

DISK PACK DRIVES, MORE THAN 100 MB

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	122.0	183.0	--	--	--	--	--	--	--	--
Other U.S. captive.	58.8	92.4	81.2	128.8	109.2	176.4	103.6	165.2	89.6	140.0
TOTAL U.S. CAPTIVE	180.8	275.4	81.2	128.8	109.2	176.4	103.6	165.2	89.6	140.0
PCM	189.2	233.9	119.3	153.4	65.1	92.4	39.8	62.7	27.0	47.9
OEM	55.6	81.1	56.1	91.7	57.6	93.8	49.5	79.6	43.4	70.4
TOTAL U.S. NON-CAPTIVE	244.8	315.0	175.4	245.1	122.7	186.2	89.3	142.3	70.4	118.3
TOTAL U.S. PRODUCTION	425.6	590.4	256.6	373.9	231.9	362.6	192.9	307.5	160.0	258.3
Non-U.S. Manufacturers										
Captive		64.4		86.8		89.6		78.4		67.2
OEM		9.4		11.3		14.3		15.3		12.2
TOTAL NON-U.S. PRODUCTION		73.8		98.1		103.9		93.7		79.4
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		664.2		472.0		466.5		401.2		337.7
TOTAL WORLDWIDE CAPTIVE		339.8		215.6		266.0		243.6		207.2
TOTAL WORLDWIDE NON-CAPTIVE		324.4		256.4		200.5		157.6		130.5

TABLE 27

DISK PACK DRIVES, MORE THAN 100 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipments			Installed YE 1976	Forecast 1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	49.3	4.0	--	4.0	53.3	(.5)	52.8	(2.7)	50.1	(3.5)	46.6	(4.2)	42.4
Non-IBM -- Units (000)	28.8	2.1	13.0	15.1	43.9	14.0	57.9	12.6	70.5	10.4	80.9	8.7	89.6
Total -- Units (000)	78.1	6.1	13.0	19.1	97.2	13.5	110.7	9.9	120.6	6.9	127.5	4.5	132.0
Worldwide Net Shipments													
IBM -- Units (000)	82.2	6.0	--	6.0	88.2	(.8)	87.4	(3.8)	83.6	(5.2)	78.4	(6.4)	72.0
Non-IBM -- Units (000)	49.4	5.6	18.0	23.6	73.0	24.8	97.8	24.3	122.1	20.8	142.9	17.6	160.5
Total -- Units (000)	131.6	11.6	18.0	29.6	161.2	24.0	185.2	20.5	205.7	15.6	221.3	11.2	232.5

TABLE 28

DISK PACK DRIVES, MORE THAN 100 MB

PRICE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments		FORECAST							
			1977		1978		1979		1980	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments										
OEM -- Units (000)	5.4	8.7	5.5	10.0	5.7	10.6	4.9	9.3	4.3	8.1
PCM -- Units (000)	7.6	9.3	5.6	7.1	3.0	4.2	1.8	2.8	1.2	2.1
Average Unit Price										
To OEMs ($)	10,300	10,400	10,200	10,300	10,100	10,200	10,100	10,200	10,100	10,200
To end users ($)	24,900	25,200	21,300	21,600	21,700	22,000	22,100	22,400	22,500	22,800
Value of Shipments										
To OEMs ($M)	55.6	90.6	56.1	103.4	57.6	108.6	49.5	95.3	43.4	82.9
To End Users ($M)	189.2	233.9	119.3	153.4	65.1	92.4	39.8	62.7	27.0	47.9

TABLE 29

DISK PACK DRIVES, MORE THAN 100 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

	SHIPMENTS TO U.S. DESTINATIONS					
	1976		FORECAST			
Distribution Channel	Units (000)	%	1977 %	1978 %	1979 %	1980 %
Medium/large scale computer mfgrs	.5	3.9	3.5	3.2	2.9	2.7
Mini/micro computer manufacturers	2.2	16.9	18.6	24.3	26.2	27.4
System OEMs/system houses	1.5	11.5	16.5	25.5	29.7	31.8
Independent peripherals suppliers	1.2	9.2	10.9	12.5	14.3	16.3
Direct to end user*	7.6	58.5	50.5	34.5	26.9	21.8
TOTAL	13.0					

TABLE 30

DISK PACK DRIVES, MORE THAN 100 MB

MARKET SHARE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments			
	To United States Destinations		Worldwide	
Drive Manufacturers	Units (000)	%	Units (000)	%
Memorex	4.4	33.9	5.6	31.1
ISS*	3.9	30.0	4.5	25.0
Control Data	2.5	19.2	4.5	25.0
Cal Comp	1.7	13.1	2.0	11.1
Others	.5	3.8	1.4	7.8
	13.0		18.0	

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

DATA MODULE DRIVES, 35-70 MB

Coverage

Examples of disk drives in this category include:

IBM	3340
Control Data	9770
Nippon Peripherals, Ltd.	NP20

Each of the above drives is designed to utilize standard IBM 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:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	256.9	219.3	164.1	83.0	31.6
All manufacturers	257.8	221.9	167.6	86.4	34.2

Production of data module drives was a booming business for a few years -- for IBM. However, the giant is now replacing 3340 volume with the newer 3344, and net shipments of data module drives will shrink almost to zero by 1980.

Except for Control Data and NPL, independent disk drive manufacturers passed up the 3340. And sales results for the two entrants in this market have been a severe disappointment. Control Data's only significant customer for the 9770 has been NCR, which markets it as the 6590 with the Criterion system introduced in 1976. NPL sells its drive through BASF in Europe and Memorex in the U.S., with minimal sales to date.

Marketing trends

IBM unit shipments of 3340 will decline at an average annual rate of 42% through 1980, according to DISK/TREND projections. Growth in disk capacity requirements for System/3 and smaller System/370 users will be satisfied by 3344, and in the process a large number of existing 3340s will be returned and remarketed by IBM, substantially reducing the need for new production.

Control Data's OEM sales to NCR started slowly in 1976, but will probably average well over 1,000 spindles per year through 1980. No signs of other important adoptions of this drive by system manufacturers are apparent, however, and it is assumed there will be none. Data module drives compare unfavorably with alternative drive formats, notably the SMD, in both drive and media cost. Most OEM buyers have already chosen other ways to cover this capacity range.

NPL's program is also destined to limited success. The large market is in the U.S., and Memorex, as U.S. PCM distributor, cannot afford to place a major sales effort behind a low-profit buy-out item. However, an increased level of sales activity is expected as a result of Memorex' announced sales campaign directed at System/3 users, combined with the side-effects of Memorex' plans to offer an independent 3344. Also likely to help is the Memorex purchase of BST, the successful independent peripherals supplier specializing in System/3 installations.

Technical trends

The 3340 was one of the industry's landmark products, the long awaited Winchester. However, in its 35-70 MB form Winchester's place

in IBM's strategy appears to have been fulfilled in the 3340, and evolution of this particular format is considered unlikely. The technology has moved on to utilization in larger and smaller fixed drives, but significant enhancements of the 3340 in the 35-70 MB range would be a great surprise.

Forecasting assumptions

1. IBM's rate of new 3340 installations has been declining since 1976 on both System/3 and System/370, due to the impact of the 3344. It is assumed that IBM will rely on the 3344 to cover the requirement for large capacity disk storage on larger System/3s and smaller System/370s through 1980, and will not enhance current 3340 capacity.

2. OEM markets for this drive will remain negligible, due to lower drive and media costs for SMDs and high density cartridge drives. Attempts to develop a PCM market will achieve very limited results due to market entry late in the product life cycle, and the restricted effort expected due to low profit margins.

TABLE 31

DATA MODULE DRIVES

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	165.8	256.0	137.6	211.6	97.7	151.0	45.9	71.0	14.8	22.2
Other U.S. captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	165.8	256.0	137.6	211.6	97.7	151.0	45.9	71.0	14.8	22.2
PCM	--	--	--	--	--	--	--	--	--	--
OEM	.9	.9	7.7	7.7	11.9	13.1	10.9	12.0	8.3	9.4
TOTAL U.S. NON-CAPTIVE	.9	.9	7.7	7.7	11.9	13.1	10.9	12.0	8.3	9.4
TOTAL U.S. PRODUCTION	166.7	256.9	145.3	219.3	109.6	164.1	56.8	83.0	23.1	31.6
Non-U.S. Manufacturers										
Captive		--		--		--		--		--
OEM		.9		2.6		3.5		3.4		2.6
TOTAL NON-U.S. PRODUCTION		.9		2.6		3.5		3.4		2.6
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		257.8		221.9		167.6		86.4		34.2
TOTAL WORLDWIDE CAPTIVE		256.0		211.6		151.0		71.0		22.2
TOTAL WORLDWIDE NON-CAPTIVE		1.8		10.3		16.6		15.4		12.0

TABLE 32

DATA MODULE DRIVES

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipments			Installed YE 1976	Forecast							
						1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	24.9	11.2	--	11.2	36.1	9.3	45.4	6.6	52.0	3.1	55.1	1.0	56.1
Non-IBM -- Units (000)	--	--	.1	.1	.1	.9	1.0	1.4	2.4	1.3	3.7	1.0	4.7
Total -- Units (000)	24.9	11.2	.1	11.3	36.2	10.2	46.4	8.0	54.4	4.4	58.8	2.0	60.8
Worldside Net Shipments													
IBM -- Units (000)	38.4	17.3	--	17.3	55.7	14.3	70.0	10.2	80.2	4.8	85.0	1.5	86.5
Non-IBM -- Units (000)	--	--	.2	.2	.2	1.2	1.4	1.9	3.3	1.8	5.1	1.4	6.5
Total -- Units (000)	38.4	17.3	.2	17.5	55.9	15.5	71.4	12.1	83.5	6.6	90.1	2.9	93.0

TABLE 33

DATA MODULE DRIVES

PRICE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments		FORECAST 1977		1978		1979		1980	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments										
OEM -- Units (000)	.1	.2	.9	1.2	1.4	1.9	1.3	1.8	1.0	1.4
Average Unit Price										
To OEMs ($)	8,800	8,900	8,600	8,800	8,500	8,700	8,400	8,600	8,300	8,500
Value of Shipments										
To OEMs ($M)	.9	17.8	7.7	10.6	11.9	16.5	10.9	15.5	8.3	11.9

TABLE 34

DATA MODULE DRIVES

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

	SHIPMENTS TO U.S. DESTINATIONS					
	1976		FORECAST			
	Units (000)	%	1977 %	1978 %	1979 %	1980 %
Distribution Channel						
Medium/large scale computer mfgrs.	.1	100.0	97.0	86.0	77.0	70.0
Mini/micro computer manufacturers	--	--	--	--	--	--
System OEMs/system houses	--	--	3.0	6.0	8.0	9.0
Independent peripherals suppliers	--	--	--	--	--	--
Direct to end user	--	--	--	8.0	15.0	21.0
TOTAL	.1					

FIXED DISK DRIVES, UP TO 12 MB

Coverage

Examples of disk drives in this category include:

IBM	4962, 5448, System/32
Control Data	9414
Pertec	D1451, D1452
Diablo	M-21, M-24, 33F
EMM	103
Wangco	N-1221, N-2211
DEC	RK05F
Burroughs	9493-9
Hitachi	DK62-10

Products in this group include drives which are essentially fixed versions of older cartridge drives (EMM 103), low capacity configurations of new fixed Winchester drives (IBM 4962), and a few with some characteristics from both of the above types (CDC 9414).

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	82.9	136.0	263.6	313.5	322.7
All manufacturers	87.7	141.8	271.5	326.9	340.1

IBM's highly successful System/32 small business system has generated the lion's share of disk drive shipments in this category. IBM shipped an estimated 80% of the 1976 worldwide total spindles. The disk drives integrated into System/32 are not sold as separate units, but are an integral part of each system shipped. Some shipments of IBM's 4962, the fixed Winchester disk offered with Series/1, were made in 1976, but the real production of this drive starts in 1977. System/34 shipments are scheduled for early 1978.

The older drives in this category offered by OEM manufacturers were primarily repackaged disk cartridge drives, which never did well commercially, as a group. Some of these lines are being quietly phased out. Any OEM drive left on the battlefield will have to be able to compete for business at levels below $2,000, to stay competitive with the newer Control Data and Pertec drives.

Marketing trends

IBM's unit shipments are expected to peak in 1979-80, at an annual shipment rate of 44,000 units, up from 1976 shipments of almost 14,000 units worldwide.

Captive production by others already exists in 1977, but should reach significant quantities in 1978 with boosts from Burroughs and DEC, followed by sharp growth through 1980 and beyond. Actual captive production levels at the end of the decade will be dependent on system manufacturers' strategies toward capacity: Emphasis on low capacity drives, a la IBM, will create additional volume in this category; emphasis on higher capacity fixed Winchester drives will create volume in the over-12 MB category.

It is interesting to note that none of the manufacturers presently offering OEM drives in this category have announced a small fixed Winchester drive (except CDC and Hitachi). Indeed, IBM, the innovator in this format, offers the only real selection of fixed Winchester drives below 12 MB. The reason appears to lie in the relatively small cost increment required for the additional capacity, and it is believed that this factor will tend to divert a large amount of OEM activity to drives

above 12 MB. Worldwide OEM shipments are projected to grow through 1980, but not exceeding 10,000 spindles per year during this decade. Most older OEM drives will have been discontinued within a few years, and other designs targeted for low cost and high reliability will be introduced.

OEM distribution channels will continue to be primarily system OEMs and system houses, plus a growing business with minicomputer manufacturers not large enough to make their own disk drives.

Technical trends

Low cost and high reliability is the key to viability for disk drives in this category. It is probable that most drives in the group will utilize Winchester technology and its variations by the end of the decade.

Physical size is also a significant factor in the small business systems which comprise the largest application for these drives. It would not be surprising to find an interest in disk diameters below 14 inches for a fixed Winchester drive in this capacity range, with outer physical dimensions strikingly smaller than anything now available. Realistically, however, independent manufacturers are not likely to risk the cost of pioneering this area, and development of such drives probably depends on IBM.

Forecasting assumptions

1. IBM's production of drives in this category will not peak until 1979-80, due to usage as a basic system element with System/32, System/34 and Series/1, and will start to decline in 1980 only because of a gradual shift to models with capacities above this category's limit.

2. Significant production by other captive manufacturers will commence by 1978.

3. OEM shipments of new drives will increase at a modest rate through 1980, since these drives will be the lowest cost moving head rigid disk drives available, but older designs will be phased out during the next two years.

TABLE 35

FIXED DISK DRIVES, UP TO 12 MB

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	62.7	78.7	91.8	122.6	156.8	224.0	176.1	251.9	170.4	244.0
Other U.S. captive	--	--	5.2	6.8	19.2	27.6	32.2	48.9	44.2	66.0
TOTAL U.S. CAPTIVE	62.7	78.7	97.0	129.4	176.0	251.6	208.3	300.8	214.6	310.0
PCM	--	--	--	--	--	--	--	--	--	--
OEM	3.2	4.2	4.9	6.6	8.8	12.0	9.4	12.7	9.2	12.7
TOTAL U.S. NON-CAPTIVE	3.2	4.2	4.9	6.6	8.8	12.0	9.4	12.7	9.2	12.7
TOTAL U.S. PRODUCTION	65.9	82.9	101.9	136.0	184.8	263.6	217.7	313.5	223.8	322.7
Non-U.S. Manufacturers										
Captive		3.2		4.2		5.2		9.4		12.5
OEM		1.6		1.6		2.7		4.0		4.9
TOTAL NON-U.S. PRODUCTION		4.8		5.8		7.9		13.4		17.4
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		87.7		141.8		271.5		326.9		340.1
TOTAL WORLDWIDE CAPTIVE		81.9		133.6		256.8		310.2		322.5
TOTAL WORLDWIDE NON-CAPTIVE		5.8		8.2		14.7		16.7		17.6

TABLE 36

FIXED DISK DRIVES, UP TO 12 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipments			Installed YE 1976	Forecast 1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	5.0	11.0	--	11.0	16.0	16.1	32.1	27.5	59.6	30.9	90.5	29.9	120.4
Non-IBM -- Units (000)	3.2	--	1.7	1.7	4.9	3.6	8.5	8.6	17.1	11.4	28.5	13.6	42.1
Total -- Units (000)	8.2	11.0	1.7	12.7	20.9	19.7	40.6	36.1	76.7	42.3	119.0	43.5	162.5
Worldwide Net Shipments													
IBM -- Units (000)	5.5	13.8	--	13.8	19.3	21.5	40.8	39.3	80.1	44.2	124.3	42.8	167.1
Non-IBM -- Units (000)	6.4	.6	2.9	3.5	9.9	6.2	16.1	14.0	30.1	20.0	50.1	24.4	74.5
Total -- Units (000)	11.9	14.4	2.9	17.3	29.2	27.7	56.9	53.3	110.2	64.2	174.4	67.2	241.6

TABLE 37

FIXED DISK DRIVES, UP TO 12MB

PRICE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments		FORECAST							
			1977		1978		1979		1980	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments										
OEM -- Units (000)	1.7	2.9	2.6	4.1	4.9	7.7	5.2	8.8	5.1	9.3
Average Unit Price										
To OEMs ($)	1,900	2,000	1,900	2,000	1,800	1,900	1,800	1,900	1,800	1,900
Value of Shipments										
To OEMs ($M)	3.2	5.8	4.9	8.2	8.8	14.6	9.4	16.7	9.2	17.7

TABLE 38

FIXED DISK DRIVES, UP TO 12 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

	SHIPMENTS TO U.S. DESTINATIONS					
	1976		FORECAST			
Distribution Channel	Units (000)	%	1977 %	1978 %	1979 %	1980 %
Medium/large scale computer mfgrs	--	--	--	5.2	9.8	11.2
Mini/micro computer manufacturers	.5	29.2	30.7	28.1	29.2	27.7
System OEMs/system houses	1.0	58.3	56.4	53.9	52.5	47.2
Independent peripherals suppliers	.2	12.5	12.9	12.8	13.5	13.9
Direct to end user	--	--	--	--	--	--
TOTAL	1.7					

TABLE 39

FIXED DISK DRIVES, UP TO 12 MB

MARKET SHARE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments			
	To United States Destinations		Worldwide	
Drive Manufacturers	Units (000)	%	Units (000)	%
Pertec	.9	52.9	1.1	37.9
Diablo	.6	35.3	.8	27.6
Others	.2	11.8	1.0	34.5
	1.7		2.9	

1977 DISK/TREND REPORT

FIXED DISK DRIVES, 12-200 MB

Coverage

Examples of disk drives in this category include:

IBM	Systems 32 and 34 (some models)
Control Data	9730
Memorex	601
Microdata	Reflex
Okidata	3300 series
BASF	6150
Kennedy	5300 series
Fujitsu	M2251, M2252, M2253
Hitachi	DK 62-20
Pertec	D-1661, D-1662
Burroughs	9493-18, 9493-28, 9493-37

With only two exceptions, the above drives utilize Winchester technology, and all except the drives used on IBM's System/32 will ship for the first time in 1977 or 1978.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	--	39.8	109.9	248.2	385.6
All manufacturers	--	41.5	115.7	257.1	398.0

This category represents a brand new area of activity for the disk drive business. For OEM manufacturers, it is an obvious capacity range to cover with the drives now made possible by Winchester technology. Availability of heads, disks and rotary actuators from standard industry suppliers has accelerated market entry by drive manufacturers without the resources to develop such critical elements internally, while several major

disk drive manufacturers have developed these items themselves for use with a broader range of Winchester technology drives.

For IBM, drives in this capacity range are merely an evolutionary enhancement in capacity of the "Gulliver" drives originally introduced with the System/32 in January, 1975. The drives in this family represented IBM's pioneering strategy of offering only a fixed system disk file on a small business computer system, leaving the user with no removable medium for back-up except the floppy disks utilized for I/O purposes. Despite the industry tongue-wagging on this aspect of the System/32, it has been a great commercial success, and IBM has now announced larger disk drives for System/32 and the yet-to-be-installed System/34.

Other captive drive manufacturers will probably emulate IBM's use of the cost-effective, highly reliable fixed Winchester in this capacity range for small business systems and minicomputers, but any widespread activity in the market is a few years away. For the moment the mainframers and larger minicomputer manufacturers with internal disk drive operations are sticking with other recently adopted programs to cover these capacities, mostly with removable drives, such as SMDs, high density cartridges and disk pack drives. Burroughs is the major exception at this time, but their announced drive series is 3330 technology level.

OEM programs by Control Data, Memorex and Microdata were advanced sufficiently to provide evaluation units to selected OEM customers in 1976, and have been joined by several others in mid-1977, with still others expected. Non-U.S. manufacturers apparently will make their strongest attempt to date to penetrate the U.S. OEM market with similar products.

OEM engineering evaluations and the usual decision-lag cycle are now underway, and little real production is expected in the short term -- with the possible exception of Control Data's 9730. CDC's drive shares interface and software commonality with their SMD family and may be utilized with some OEM SMD-using systems earlier than competitive drives.

Marketing trends

DISK/TREND projections show an worldwide average growth rate for all drives in this category of +116% through 1980. However, IBM's AAGR for the same period is projected at +137%, reflecting their upgrade opportunity for larger systems with the big, and growing, population of System/32s and its descendants. By 1980 IBM's unit volume of drives in this category is expected to approach its already high volume of fixed drives in the under 12 MB category.

OEM shipments will be at much lower levels through the balance of this decade, but by 1980 are expected nevertheless to be at twice the level of OEM fixed drives under 12 MB, on a unit shipment basis. After the inevitable 12-24 month delay from availability of evaluation units until commencement of volume shipments, the real shake-out will begin. At this time, most bets favor the U.S. leading disk drive manufacturers to gain the major shares of this market, since OEMs like to buy from safe, stable vendors whenever possible. There's room, though, for a non-U.S. newcomer to sell a drive with performance advantages at the right price, if adequate U.S. parts and service support are arranged.

One fascinating aspect of this category is the variability in capacities offered (drives below 12 MB included for reference):

	10MB	20MB	30MB	40MB	50MB	60MB	70MB
IBM System/32	3.2 5.1 9.2	13.8					
IBM/System/34	8.6	13.2	27.1				
IBM 4962	9.3						
BASF		14.1	28.2	42.3			
CDC 9730		12.2	24.4		48.9		
Fujitsu M2250		12.7	25.4			50.8	
Hitachi DK62	10.8		21.7				
Kennedy 5300		14.1		42.3			70.6
Memorex 601			25.1		50.3		75.4
Microdata Reflex	12.5			37.6		62.7	
Okidata 3300	12.4		24.8	37.2	49.6	62.0	74.4

Early OEM shipments are expected to cluster in the lower third of the above range, with later upward movement in average capacity size. This process will take years, however. Through 1980 OEM average unit prices are expected to decline slightly, despite some upward trend in capacities, due to the build-up in size of average shipments per year per customer.

Technical trends

This category is a new trend in itself. During the next few years, most engineering activity by manufacturers will revolve around the usual twin problems in a disk drive's early life: (1) How to develop the hoped-for experience curve cost benefits, and (2) How to deliver the promised reliability levels.

It is to be expected that the capacity range of already announced drives or closely related variations will be expanded upward to cover the 100 to 200 MB range. Reaction to the first generation, however, will determine the priority given to this task.

And, as mentioned in connection with the analysis of fixed drives under 12 MB, a possibility may exist for a physically smaller drive to obtain a large share of this market. The continual shrinking in size of other peripherals and processors could stimulate the demand for such a drive, but its birth will depend on a major system requirement from a firm with the desire to underwrite development.

Forecasting assumptions

1. Users of IBM small business and minicomputer systems will evolve toward higher capacity "Gulliver" drives on the type introduced during the last year on System/32 and System/34, creating more rapid growth for drives above 12 MB than for smaller fixed drives.

2. Major mainframers marketing smaller systems will not start to use substantial quantities of fixed drives in this capacity range until after 1978, relying instead on existing programs involving SMDs and high capacity cartridge drives.

3. OEM production, based on system adoptions by minicomputer and small business system manufacturers, will reach significant levels in mid 1978, after a slow 1977 -- the delay to be caused by the time required by OEMs to evaluate the numerous newly introduced drives, and to actually start system deliveries.

4. Attempts by non-U.S. drive manufacturers to penetrate the U.S. OEM market will meet with minimal success due to concern over engineering and service support, and limited depth of vendors' product lines.

TABLE 40

FIXED DISK DRIVES, 12-200 MB

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	--	--	19.5	24.2	54.6	72.5	121.7	173.9	207.5	296.4
Other U.S. captive	--	--	7.0	9.8	13.3	21.0	28.7	45.5	32.9	51.1
TOTAL U.S. CAPTIVE	--	--	26.5	34.0	67.9	93.5	150.4	219.4	240.4	347.5
PCM	--	--	--	--	--	--	--	--	--	--
OEM	--	--	4.3	5.8	12.0	16.4	20.9	28.8	27.8	38.1
TOTAL U.S. NON-CAPTIVE	--	--	4.3	5.8	12.0	16.4	20.9	28.8	27.8	38.1
TOTAL U.S. PRODUCTION	--	--	30.8	39.8	79.9	109.9	171.3	248.2	268.2	385.6
Non-U.S. Manufacturers										
Captive		--		1.4		4.2		5.6		7.0
OEM		--		.3		1.6		3.3		5.4
TOTAL NON-U.S. PRODUCTION		--		1.7		5.8		8.9		12.4
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		--		41.5		115.7		257.1		398.0
TOTAL WORLDWIDE CAPTIVE		--		35.4		97.7		225.0		354.5
TOTAL WORLDWIDE NON-CAPTIVE		--		6.1		18.0		32.1		43.5

TABLE 41

FIXED DISK DRIVES, 12-200 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipment			Installed YE 1976	Forecast							
						1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	--	--	--	--	--	2.5	2.5	7.0	9.5	15.6	25.1	26.6	51.7
Non-IBM -- Units (000)	--	--	--	--	--	2.4	2.4	5.9	8.3	11.3	19.6	14.3	33.9
Total -- Units (000)	--	--	--	--	--	4.9	4.9	12.9	17.8	26.9	44.7	40.9	85.6
Worldwide Net Shipments													
IBM -- Units (000)	--	--	--	--	--	3.1	3.1	9.3	12.4	22.3	34.7	38.0	72.7
Non-IBM -- Units (000)	--	--	--	--	--	3.5	3.5	9.4	12.9	18.0	30.9	22.8	53.7
Total -- Units (000)	--	--	--	--	--	6.6	6.6	18.7	25.3	40.3	65.6	60.8	126.4

TABLE 42

FIXED DISK DRIVES, 12-200 MB

PRICE SUMMARY
Non-Captive Disk Drives

	FORECAST							
	1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments								
OEM -- Units (000)	1.4	1.9	4.0	5.8	7.2	10.7	9.6	14.5
Average Unit Price								
To OEMs ($)	3,100	3,200	3,000	3,100	2,900	3,000	2,900	3,000
Value of Shipments								
To OEMs ($M)	4.3	6.1	12.0	18.0	20.9	32.1	27.8	43.5

TABLE 43

FIXED DISK DRIVES, 12-200 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

	SHIPMENTS TO U.S. DESTINATIONS			
		FORECAST		
	1977	1978	1979	1980
Distribution Channel	%	%	%	%
Medium/large scale computer mfgrs	--	4.0	7.0	8.0
Mini/micro computer manufacturers	27.0	29.0	29.0	26.0
System OEMs/system houses	65.0	57.0	51.0	51.0
Independent peripherals suppliers	8.0	10.0	13.0	15.0
Direct to end user	--	--	--	--

1977 DISK/TREND REPORT

FIXED DISK DRIVES, OVER 200 MB

Coverage

Examples of disk drives in this category include:

IBM	3344, 3350
Memorex	3650
Storage Technology	8800, 8350
Nippon Electric Company	D1500
ISS	7350
Control Data	33801
Siemens	PS 5-7

These drives represent several approaches to the physical design of large capacity fixed disk files, although all but one drive incorporates the ability to logically simulate both 3350 and 3330. PCM versions of the 3344 are expected by 1Q78, from Memorex, NPL and possibly others.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1976	1977	1978	1979	1980
U.S. manufacturers	219.5	584.6	739.9	812.9	791.6
All manufacturers	219.5	584.6	756.5	857.9	849.7

IBM installations of both 3344 and 3350 started in early 1976, and shipments are now at a high level, in response to the greatly improved cost/megabyte performance offered. As expected, 3350 installations have heavily impacted the 3330-11, with that drive now out of new production, and with heavy pressure on the 3330 PCM business. The 3344 has depressed the net shipment rate for 3340, with continual decline for that drive forecasted.

Two independent approaches to large fixed disk files using different combinations of 3330-11 level technology are currently being offered. The Storage Technology 8800 offers 800 MB using four stacks of disks served by heads controlled by a single rotary actuator. Control Data's 33801 uses two spindles of 3330 disks in one device to match 3350's capacity. The other product addressing the same market in ISS's 7330-12, which actually uses a removable disk pack, but matches 3350 capacity with 402 TPI, 6965 BPI on 19 data surfaces. All of these drives seem to have a limited future, because it's inevitably difficult to sell an IBM replacement drive in the PCM market without matching or improving upon IBM's technology, and because the 3350 technology may well deliver higher reliability, as claimed. STC and ISS have 3350 programs already, and it is probable that CDC will bring a 3350 look-alike drive out of the closet when IBM's plans for the long awaited 3350 upgrade become clear, if not before.

Marketing trends

IBM's shipments of 3340/3350 are projected to peak at just under 18,000 spindles in 1977, and to stay almost at that level through 1979. In 1980 the beginning of market saturation and continual gains by independent PCM suppliers will cause a decline in IBM's shipments. IBM's shipment decline will be offset by independent gains in 1980, so that total unit shipments will continue their growth that year, but worldwide dollar revenue is expected to decline in 1980 due to the difference in average unit price between IBM and the independents.

PCM suppliers are now struggling to establish volume 3350 production, and can easily ship all the drives they can make in 1977. Because IBM's 3350 shipments are putting a crimp in PCM 3330 sales, PCM 3350 sales are badly needed to replace lost sales volume, but 1977 shipments will be limited by availability of critical parts and the slow process of building up production know-how.

Total PCM revenues from new disk drive shipments will be impacted, according to DISK/TREND projections, but will recover after 1977:

Worldwide PCM sales ($M)	1976	1977	1978	1979	1980
Disk pack drives, over 100 MB	233.9	153.4	92.4	62.7	47.9
Fixed disk drives, over 200 MB	16.5	41.0	169.7	213.6	234.0
COMBINED TOTAL	250.4	194.4	262.1	276.3	281.9

An OEM business in 3350-type drives is expected to come into existence in 1978, and by 1980 is expected to grow to one third of the total independent shipments in the U.S. Mainframers and minicomputer manufacturers will constitute the initial OEM market for drive manufacturers, but system OEMs and system houses will also be significant buyers before 1980.

Technical trends

Conjecture on IBM's next step is an essential part of independent drive manufacturers' product planning. Currently, this is a highly active area, because of the lapsed time since IBM's last announcement of a large capacity disk file (3350/3344), and the number of functional options open.

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 is capable of doing all or any portion of the above. But as always the commercial decision regarding actual product announcements will undoubtedly be controlled by a desire to maintain overall growth and high profitability for the IBM data processing product line as a whole.

Thus, an evolutionary schedule of enhancements is probably the most likely course. It is probable that IBM management would like to see a few more years of 3344/3350 production, without obsoleting it with their own products prematurely. Double density is probably next.

IBM's thin film head program could provide extremely high track densities for large disk files, but first usage of this technology with smaller units is at least as probable. The same consideration applies to

thin film recording surfaces. CCDs and magnetic bubbles will probably not be cost-effective replacements for large disk files before 1980, but they most certainly will show up in numerous low capacity applications requiring their advantages before the end of the decade.

Forecasting assumptions

1. IBM's production peak will extend through the 1977-79 period, starting into significant decline in 1980. The expected mid-life enhancements will not change the basic character or purposes of the 3344/3350, and IBM will not cause obsolescence with greatly superior new products until late in the decade.

2. Other captive production will not start until 1978 and will be relatively small due to system architecture and applications requirements.

3. PCM and OEM shipments will achieve substantial levels in 1978, spearheaded by aggressive attempts to replace declining 3330 PCM shipments, and the requirement for large disk files associated with independent replacements for large IBM 370 systems.

TABLE 44

FIXED DISK DRIVES, MORE THAN 200 MB

REVENUE SUMMARY

	Disk Drive Revenues, by Shipment Destination ($M)									
			Forecast							
	1976 Shipments		1977		1978		1979		1980	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM	142.4	203.0	370.0	542.4	348.5	536.3	333.3	530.3	287.9	463.6
Other U.S. Captive	--	--	--	--	12.1	15.2	18.9	27.3	27.3	39.4
TOTAL U.S. CAPTIVE	142.4	203.0	370.0	542.4	360.6	551.5	352.2	557.6	315.2	503.0
PCM	16.5	16.5	37.8	41.0	150.0	169.7	184.1	213.6	200.1	234.0
OEM	--	--	1.2	1.2	16.4	18.7	33.9	41.7	44.7	54.6
TOTAL U.S. NON-CAPTIVE	16.5	16.5	39.0	42.2	166.4	188.4	218.0	255.3	244.8	288.6
TOTAL U.S. PRODUCTION	158.9	219.5	409.0	584.6	527.0	739.9	570.2	812.9	560.0	791.6
Non-U.S. Manufacturers										
Captive		--		--		15.5		36.4		45.5
OEM		--		--		1.1		8.6		12.6
TOTAL NON-U.S. PRODUCTION		--		--		16.6		45.0		58.1
Worldwide Recap										
TOTAL WORLDWIDE PRODUCTION		219.5		584.6		756.5		857.9		849.7
TOTAL WORLDWIDE CAPTIVE		203.0		542.4		567.0		594.0		548.5
TOTAL WORLDWIDE NON-CAPTIVE		16.5		42.2		189.5		263.9		301.2

TABLE 45

FIXED DISK DRIVES, MORE THAN 200 MB

UNIT SHIPMENT SUMMARY

	Installed YE 1975	1976 Shipments			Installed YE 1976	Forecast							
						1977		1978		1979		1980	
		Captive	Non-capt.	Total		Ship	Inst	Ship	Inst	Ship	Inst	Ship	Inst
U.S. Net Shipments													
IBM -- Units (000)	--	4.7	--	4.7	4.7	12.2	16.9	11.5	28.4	11.0	39.4	9.5	48.9
Non-IBM -- Units (000)	--	--	.3	.3	.3	1.6	1.9	8.1	10.0	11.6	21.6	13.9	35.5
Total -- Units (000)	--	4.7	.3	5.0	5.0	13.8	18.8	19.6	38.4	22.6	61.0	23.4	84.4
Worldwide Net Shipments													
IBM -- Units (000)	--	6.7	--	6.7	6.7	17.9	24.6	17.7	42.3	17.5	59.8	15.3	75.1
Non-IBM -- Units (000)	--	--	.3	.3	.3	1.7	2.0	9.7	11.7	15.7	27.4	19.2	46.6
Total -- Units (000)	--	6.7	.3	7.0	7.0	19.6	26.6	27.4	54.0	33.2	87.2	34.5	121.7

TABLE 46

FIXED DISK DRIVES, MORE THAN 200 MB

PRICE SUMMARY
Non-Captive Disk Drives

	1976 Net Shipments		FORECAST 1977		1978		1979		1980	
	U.S.	Worldwide	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
Non-Captive Shipments										
OEM -- Units (000)	--	--	.1	.1	1.5	1.8	3.2	4.7	4.3	6.4
PCM -- Units (000)	.3	.3	1.5	1.6	6.2	6.9	7.8	8.9	8.7	10.0
Average Unit Price										
To OEMs ($)	--	--	11,700	11,700	10,900	11,000	10,600	10,700	10,400	10,500
To End Users ($)	55,000	55,000	25,200	25,600	24,200	24,600	23,600	24,000	23,000	23,400
Value of Shipments										
To OEMs ($M)	--	--	1.2	1.2	16.4	19.8	33.9	50.3	44.7	67.2
To End Users ($M)	16.5	16.5	37.8	41.0	150.0	169.7	184.1	213.6	200.1	234.0

TABLE 47

FIXED DISK DRIVES, MORE THAN 200 MB

DISTRIBUTION CHANNEL SUMMARY
U.S. Non-Captive Disk Drives

	SHIPMENTS TO U.S. DESTINATIONS					
	1976		FORECAST			
Distribution Channel	Units (000)	%	1977 %	1978 %	1979 %	1980 %
Medium/large scale computer mfgrs	--	--	3.2	6.5	7.7	7.3
Mini/micro computer manufacturers	--	--	3.0	7.3	8.1	8.8
System OEMs/system houses	--	--	--	5.7	10.1	12.2
Independent peripherals suppliers	--	--	--	--	3.2	4.8
Direct to end user	.3	100.0	93.8	80.5	70.9	66.9
TOTAL	.3					

1977 DISK/TREND REPORT

DISK DRIVE SPECIFICATIONS

Coverage

Although this listing is probably not complete, it includes most 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 mentioned by specific model number in most cases are captive drives which are similar to OEM models made by the same manufacturer. In some cases, however, drives made by one drive manufacturer and resold by another drive manufacturer have been included, for identification purposes. Note also that ISS drives are listed separately from Univac, except that some drives made by ISS and sold only by Univac are listed under the Univac heading.

DISK/TREND categories

In most cases category assignments noted for individual drives are rather straightforward, but a few arbitrary decisions have been made, mostly in connection with category 3, disk pack drives, 29-55MB. This category is intended to be composed of 2314-type drives, and 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 interchangability. Individual drives may require media with a variety of special characteristics, including non-standard recording disks, sectors, initialization or servo tracks.

Technology type

The IBM drive model numbers used are intended as a general guide only, as an indication of the type of heads and recording disks employed. It should be recognized, however, that such an identification is based on a much broader interpretation than the original IBM specifications, with the products of independent manufacturers frequently utilizing much greater track densities and bit densities.

The generally used term "Winchester", IBM's pre-introduction code name for the 3340, is used to identify the technology employed in the 3340, 3344, 3350, 4962, and the Series 32 and 34 rigid disk drives, ignoring the other IBM code names for drives at this technology level, such as "Weatherby" and "Gulliver".

Capacities

An attempt has been made to give unformatted capacities for all drives, except in instances where information was not available from the manufacturer, in which cases formatted capacities are shown.

Accuracy

This information has been made as accurate as possible through extensive cross-checking. However, it is anticipated that some errors may be included, due primarily to the problem that few manufacturers' published specifications cover all of the items listed, and numerous verbal inquiries were necessary. Please point out any errors -- or omissions -- you may notice; your corrections will be most welcome and will be included in the next edition.

DISK/TREND DISK DRIVE GROUPS

Removable media

1. Disk cartridge drives, up to 12 MB
2. Disk cartridge drives, 12-55 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, up to 12 MB
8. Fixed disk drives, 12-200 MB
9. Fixed disk drives, over 200 MB

Manufacturer: AMPEX

DRIVE	DM-440	DM-441	DM-442	DM-443	DM-445	DM-446
DISK/TREND GROUP	1	1	1	1	1	1
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	2315	2315	2315	2315	5440	5440
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	2314	2314
CAPACITY (MBytes)	R:3.125	F:3.125 R:3.125	R:6.25	F:6.25 R:6.25	R:3.125	F:3.125 R:3.125
PERFORMANCE						
Recording surfaces per spindle	2	4	2	4	2	4
Tracks per surface	200	200	400	400	200	200
TPI	100	100	200	200	100	100
BPI	2200	2200	2200	2200	2200	2200
RPM	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400
Aver. positioning time (msec)	35	35	35	35	35	35
Aver. rotational delay (msec)	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5
Aver. access time (msec)	55/37.5	55/37.5	55/37.5	55/37.5	55/37.5	55/37.5
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5
FIRST CUSTOMER SHIPMENT	1975	1975	1975	1975	1975	1975

Manufacturer: AMPEX

DRIVE	DM-447	DM-448	DM-313	DM-323	DM-940	DM-980
DISK/TREND GROUP	1	1	3	3	4	4
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	5440	5440	2316	2316	Storage Module	Storage Module
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	3330-11	3330-11
CAPACITY (MBytes)	R:6.25	F:6.25 R:6.25	29.2	58.4	41.4	82.8
PERFORMANCE						
Recording surfaces per spindle	2	4	20	20	5	5
Tracks per surface	400	400	200/3	400/6	411	822
TPI	200	200	100	200	192	384
BPI	2200	2200	2200	2200	6038	6038
RPM	1500/2400	1500/2400	2400	2400	3600	3600
Aver. positioning time (msec)	35	35	32	32	30	30
Aver. rotational delay (msec)	20/12.5	20/12.5	12.5	12.5	8.33	8.33
Aver. access time (msec)	55/37.5	55/37.5	44.5	44.5	38.33	38.33
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	312.5	312.5	1209	1209
FIRST CUSTOMER SHIPMENT	1975	1975	1971	1973	10/75	1/76

Manufacturer:	AMPEX					
DRIVE	DM-330	DM-331	DM-9100	DM-9200	DM-9300	DM-401
DISK/TREND GROUP	5	5	5	5	5	7
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	3336-1	3336-11	3336-1	3336-11	3336-11	Fixed
TECHNOLOGY TYPE, DRIVE	3330-1	3330-11	3330-1	3330-11	3330-11	2314
CAPACITY (MBytes)	103	206	103	206	309	3.13
PERFORMANCE						
Recording surfaces per spindle	19	19	19	19	19	2
Tracks per surface	404/7	808/7	404/7	808/7	808/7	203
TPI	192	370	192	370	370	100
BPI	4040	4040	4040	4040	6038	2200
RPM	3600	3600	3600	3600	3600	1500/2400
Aver. positioning time (msec)	28	28	28	28	28	70
Aver. rotational delay (msec)	8.33	8.33	8.33	8.33	8.33	20/12.5
Aver. access time (msec)	36.33	36.33	36.33	36.33	36.33	90/82.5
Data transfer rate (KBytes/sec)	806	806	806	806	1209	195/312.5
FIRST CUSTOMER SHIPMENT	10/73	11/74	11/75	11/75	5/76	1977

Manufacturer:	AMPEX			BALL COMPUTER	
DRIVE	DM-402	DM-403	DM-404	BD-50	BD-80
DISK/TREND GROUP	7	7	7	4	4
MEDIA: Manufacturer's number	--	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Trident	Trident
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	3330-11	3330-11
CAPACITY (MBytes)	6.25	6.25	12.5	54.7	82.1
PERFORMANCE					
Recording surfaces per spindle	4	2	4	5	5
Tracks per surface	203	406	406	815	815
TPI	100	200	200	370	370
BPI	2200	2200	2200	4040	6060
RPM	1500/2400	1500/2400	1500/2400	3600	3600
Aver. positioning time (msec)	70	70	70	30	30
Aver. rotational delay (msec)	20/12.5	20/12.5	20/12.5	8.33	8.33
Aver. access time (msec)	90/82.5	90/82.5	90.82.5	38.33	38.33
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	195/312.5	806	1209
FIRST CUSTOMER SHIPMENT	1977	1977	1977	8/76	4/77

Manufacturer:	BASF			BURROUGHS	
DRIVE	6150-14	6150-28	6150-42	9480-2 9480-12	9481-2 9481-12
DISK/TREND GROUP	8	8	8	1	1
MEDIA: Manufacturer's number	--	--	--	9985-3	9985
Generic type	Fixed	Fixed	Fixed	2315	2315
TECHNOLOGY TYPE, DRIVE	Winchester	Winchester	Winchester	2314	3330-1
CAPACITY (MBytes)	14.1	28.2	42.3	R: 2.3	R: 4.65
PERFORMANCE					
Recording surfaces per spindle	1	2	3	2	2
Tracks per surface	640/60	640/60	640/60	200	200
TPI	300	300	300	100	100
BPI	6380	6380	6380	2200	4400
RPM	2976	2976	2976	1500	1500
Aver. positioning time (msec)	40	40	40	60	60
Aver. rotational delay (msec)	10.1	10.1	10.1	20	20
Aver. access time (msec)	50.1	50.1	50.1	80	80
Data transfer rate (KBytes/sec)	1000	1000	1000	193	193
FIRST CUSTOMER SHIPMENT	1Q78	1Q78	1Q78	--	--

Manufacturer:	BURROUGHS					
DRIVE	9482-32	9384-6 9384-7 9384-8 9388-2	9383-6 9383-7 9383-8 9486-4	9383-16 9383-17 9383-18 9484-8	9484-2	9484-5
DISK/TREND GROUP	1	3	3	5	4	4
MEDIA: Manufacturer's number	9985	9974-4	9974-4	9974-7	--	9974-5
Generic type	2315	2316	2316	2316	Trident	Trident
TECHNOLOGY TYPE, DRIVE	3330-1	2314	2314	3330-11	3330-11	3330-11
CAPACITY (MBytes)	R: 9.3	64.8	87.2	174.4	32.6	65.2
PERFORMANCE						
Recording surfaces per spindle	2	20	20	20	5	5
Tracks per surface	400	400	400	800	814	814
TPI	200	200	200	400	370	370
BPI	4400	2200	4400	4400	3020	6039
RPM	1500	2400	2400	2400	3600	3600
Aver. positioning time (msec)	35	30	30	30	25	25
Aver. rotational delay (msec)	20	12.5	12.5	12.5	8.3	8.3
Aver. access time (msec)	55	42.5	42.5	42.5	33.3	33.3
Data transfer rate (KBytes/sec)	387.5	625	625	625	605	605
FIRST CUSTOMER SHIPMENT	7/76	1974	1974	1976 Embedded Servo	--	--

SYCOR, INC.
100 Phoenix Drive
Ann Arbor, MI 48104 313/971-0900

1976 disk sales: --
1976 total net sales: $67,000,000 Net income: $5,000,000

Sycor's only announced rigid disk drive is a small fixed disk drive using 2314 technology, which is manufactured on a captive basis for use with its terminal systems. It is probable, however, that more advanced fixed disk drives may be announced by Sycor.

VERMONT RESEARCH CORPORATION
Precision Park
North Springfield, VT 05156 802/886-2256

1976 disk sales: --
1976 total net sales: $3,672,803 Net income: ($525,220)

VRC is a head per track drum and disk drive manufacturer. For the past two years the firm has been offering an advanced 50 MB disk cartridge drive which employs an embedded servo technique. Sales have been minimal to date, and perhaps VRC's program was too soon for the OEM market. A firm this size doesn't have a great deal of staying power, and it will be interesting to see if they can keep this program going.

WANGCO, INC.
Subsidiary of Perkin-Elmer Corporation
Perkin-Elmer Data Systems Group
5404 Jandy Place
Los Angeles, CA 90066 213/390-8081

1976 disk sales: $8,900,000
1976 total net sales: $349,341,000 Net income: $20,524,000

Following the acquisition of Wangco in 1976, Perkin-Elmer is in the process of putting together a combined marketing and management structure to exploit the strengths of Wangco, Interdata and the P-E terminal division. Wangco's position as a leader in small tape drives has been the platform on which the organization has attempted to build a disk drive program. With the addition of recently announced high density disk cartridge drives and storage module drives, Wangco may well be in a position to increase its share of the OEM disk drive market. More important, however, will be the wisdom exercised by management in structuring the new organization, of which Wangco is only a part.

WESTERN DYNEX
3536 West Osborn Road
Phoenix, AZ 85019 602/269-6401

1976 disk sales: $4,500,000

Western Dynex is a privately held company specializing in the manufacture of OEM cartridge disk drives. The firm supplies drives for resale to several others, including Ampex, Ball and Data Systems Design. Also now offering fixed versions of the cartridge drives, but ability to progress to higher technologies is unclear.

Manufacturer:	BURROUGHS			
DRIVE	9493-9	9493-18	9493-28	9493-37
DISK/TREND GROUP	7	8	8	8
MEDIA: Manufacturer's number	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	3330	3330	3330	3330
CAPACITY (MBytes)	9.4	18.8	28.2	37.6
PERFORMANCE				
Recording surfaces per spindle	2	4	6	8
Tracks per surface	400	400	400	400
TPI	200	200	200	200
BPI	4000	4000	4000	4000
RPM	1500	1500	1500	1500
Aver. positioning time (msec)	35	35	35	35
Aver. rotational delay (msec)	20	20	20	20
Aver. access time (msec)	55	55	55	55
Data transfer rate (KBytes/sec)	348	348	348	348
FIRST CUSTOMER SHIPMENT	7/77	7/77	7/77	7/77

Manufacturer:	CAL COMP					
DRIVE	CD12 CD22 114 212 214	CD25 215 213	225	T-25	T-50	T-80
DISK/TREND GROUP	3	3	5	4	4	4
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	2316	2316	2316	Trident	Trident	Trident
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	3330-1	330-11	3330-11
CAPACITY (MBytes)	29.176	58.35	116.7	27.4	54.7	82.1
PERFORMANCE						
Recording surfaces per spindle	20	20	20	5	5	4
Tracks per surface	203	406	406	400/8	800/15	800/15
TPI	100	200	200	185	370	370
BPI	2200	2200	4400	4040	4040	6060
RPM	2400	2400	2400	3600	3600	3600
Aver. positioning time (msec)	35	35	35	30	30	30
Aver. rotational delay (msec)	12.5	12.5	12.5	8.33	8.33	8.33
Aver. access time (msec)	47.5	47.5	47.5	38.33	38.33	38.33
Data transfer rate (KBytes/sec)	312.5	312.5	625	806	806	1209
FIRST CUSTOMER SHIPMENT	--	--	--	8/75	5/75	8/75

Manufacturer:	CAL COMP				
DRIVE	T-200	T-300	230 231	235-I	235-II
DISK/TREND GROUP	5	5	5	5	5
MEDIA: Manufacturer's number	--	--	--	--	--
Generic type	3336-11 Type	3336-11 Type	3336-1	3336-1	3336-11
TECHNOLOGY TYPE, DRIVE	3330-11	3330-11	3330-1	3330-1	3330-11
CAPACITY (MBytes)	208.1	312.1	100	100	200
PERFORMANCE					
Recording surfaces per spindle	19	19	19	19	19
Tracks per surface	800/15	800/15	404/7	404/7	808/7
TPI	370	370	192	192	370
BPI	4040	6060	4040	4040	4040
RPM	3600	3600	3600	3600	3600
Aver. positioning time (msec)	30	30	30	30	30
Aver. rotational delay (msec)	8.33	8.33	8.33	8.33	8.33
Aver. access time (msec)	38.33	38.33	38.33	38.33	38.33
Data transfer rate (KBytes/sec)	806	1209	806	806	806
FIRST CUSTOMER SHIPMENT	6/76	8/76	7/72	3Q75	3Q75

Manufacturer:	CII - HONEYWELL BULL			CONTROL DATA	
DRIVE	MSU 0113	MSU 0112 MSU 0116	D120	9427H	9746 9747
DISK/TREND GROUP	1	1	1	1	3
MEDIA: Manufacturer's number	M4020	M4020	"MIDIDISK"	9847 (100 TPI) 9848 (200 TPI)	9873
Generic type	5440	5440	Special Cartridge with 10.5" Disk	5440	2316
TECHNOLOGY TYPE, DRIVE	2314	2314	3330-11	5444	2314DD
CAPACITY (MBytes)	R: 5.8	F: 5.8 R: 5.8	10	F: 6.25 R: 6.25	62.5
PERFORMANCE					
Recording surfaces per spindle	2	4	2	4	20
Tracks per surface	400/6	400/6	392/1	400/6	400/6
TPI	200	200	508	200	200
BPI	2200	2200	4758	2200	2220
RPM	2400	2400	3600	2400/1500	2400
Aver. positioning time (msec)	40	40	75	35	35
Aver. rotational delay (msec)	12.5	12.5	8.33	12.5/20	12.5
Aver. access time (msec)	52.5	52.5	83.33	47.5/55	47.5
Data transfer rate (KBytes/sec)	312.5	312.5	920	312.5/195	312.5
FIRST CUSTOMER SHIPMENT	1975	1975	4Q77	8/74	1974
			Embedded Servo		

Manufacturer:	CONTROL DATA					
DRIVE	9754 9756	9780	9784 9786	9760	9762	9764
DISK/TREND GROUP	5	5	5	4	4	5
MEDIA: Manufacturer's number	9879	9883	9882	9876	9877	9883-91
Generic type	3336-1	3336-11	3336-11	Storage Module	Storage Module	3336-11
TECHNOLOGY TYPE, DRIVE	3330-1	3330-11	3330-11	3330-11	3330-11	3330-11
CAPACITY (MBytes)	100	200	200	40.7	81.5	154.8
PERFORMANCE						
Recording surfaces per spindle	19	19	19	5	5	19
Tracks per surface	404/7	808/14	808/14	404/7	808/15	404/7
TPI	192	384	384	192	384	192
BPI	4040	4040	4040	6038	6038	6038
RPM	3600	3600	3600	3600	3600	3600
Aver. positioning time (msec)	30	30	30	30	30	30
Aver. rotational delay (msec)	8.33	8.33	8.33	8.33	8.33	8.33
Aver. access time (msec)	38.33	38.33	38.33	38.33	38.33	38.33
Data transfer rate (KBytes/sec)	806	806	806	1200	1200	1200
FIRST CUSTOMER SHIPMENT	--	--	--	3/74	3/75	3/76
	PCM VERSION: 33301	PCM VERSION: 33302				

Manufacturer:	CONTROL DATA					
DRIVE	9766	9770	9414	9730-12	9730-24	9730-48
DISK/TREND GROUP	5	6	7	8	8	8
MEDIA: Manufacturer's number	9883-91	9778	--	--	--	--
Generic type	3336-11	3348	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	3330-11	3340	2314	Winchester	Winchester	Winchester
CAPACITY (MBytes)	309.5	R: 35/70 F: .502	12.5/6.25	12.2	24.4	48.9
PERFORMANCE						
Recording surfaces per spindle	19	3/6	4/2	1	2	2
Tracks per surface	808/15	348/696	400/8	606/60	606/60	606/60
TPI	384	300	200/100	300	300	600
BPI	6038	5636	2200	6220	6220	6220
RPM	3600	2964	2400/1500	3600	3600	3600
Aver. positioning time (msec)	30	25	65	40	40	40
Aver. rotational delay (msec)	8.33	10.1	12.5/20	8.33	8.33	8.33
Aver. access time (msec)	38.33	35.1	77.5/85	48.33	48.33	48.33
Data transfer rate (KBytes/sec)	1200	885	312.5/195	1200	1200	1200
FIRST CUSTOMER SHIPMENT	3/76	1976	9/76	5/77	5/77	4Q77

.502 MB
Fixed Heads
On -70F
Data Module

Manufacturer:	CONTROL DATA			DATA 100	
DRIVE	9790	33801-A2 33801-B2 33801-C2 (3330 Format)	33801-A2 33801-B2 33801-C2 (3350 Format)	3002	3004
DISK/TREND GROUP	9	9	9	1	1
MEDIA: Manufacturer's number	--	--	--	--	--
Generic type	Fixed	Fixed	Fixed	2315	2315
TECHNOLOGY TYPE, DRIVE	--	Winchester	Winchester	2314	2314
CAPACITY (MBytes)	300	(1.24 MB F. Head Option) 400	(1.72 MB F. Head Option) 317.5	F: 3 R: 3	F: 6 R: 6
PERFORMANCE					
Recording surfaces per spindle	40	*	*	4	4
Tracks per surface	800	*	*	203	406
TPI	400	*	*	100	200
BPI	6000	*	*	2200	2200
RPM	3600	3600	3600	1500/2400	1500/2400
Aver. positioning time (msec)	50	15	19	38	38
Aver. rotational delay (msec)	8.3	8.4	8.4	20/12.5	20/12.5
Aver. access time (msec)	58.3	23.4	27.4	58/50.5	58/50.5
Data transfer rate (KBytes/sec)	4840	1198	1198	195/312.5	195/312.5
FIRST CUSTOMER SHIPMENT	1975	--	--	--	--

* Specification not disclosed by CDC, as of June, 1977

Manufacturer:	DATA 100			
DRIVE	3402	3404	3850	3860
DISK/TREND GROUP	1	1	1	1
MEDIA: Manufacturer's number	--	--	--	--
Generic type	5440	5440	2315/5440	5440
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314
CAPACITY (MBytes)	F: 3 R: 3	F: 6 R: 6	F: 2.5/5 R: 2.5/5	F: 5 R: 5
PERFORMANCE				
Recording surfaces per spindle	4	4	4	4
Tracks per surface	203	406	203/406	406
TPI	100	200	100/200	200
BPI	2200	2200	2200	2200
RPM	1500/2400	1500/2400	1500/2400	2400
Aver. positioning time (msec)	38	38	38	38
Aver. rotational delay (msec)	20/12.5	20/12.5	20/12.5	12.5
Aver. access time (msec)	58/50.5	58/50.5	58/50.5	50.5
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	195/312.5	312.5
FIRST CUSTOMER SHIPMENT	--	--	7/77	7/77
			PCM DEC PDP-11	PCM DATA GENERAL

Manufacturer:	DATA GENERAL			DATA RECORDING INSTRUMENTS	
DRIVE	6045 6046 6047 6048	6060	6061	3206	3212
DISK/TREND GROUP	1	5	5	1	1
MEDIA: Manufacturer's number	--	--	--	--	--
Generic type	5440	3336-1	3336-11	2315	2315
TECHNOLOGY TYPE, DRIVE	2314	3330-11	3330-11	2314	2314
CAPACITY (MBytes)	F: 5.014 R: 5.014	96	192	R: 6	R: 12
PERFORMANCE					
Recording surfaces per spindle	4	19	19	4	4
Tracks per surface	408	404/7	808/7	404/6	404/6
TPI	200	192	370	200	200
BPI	2200	4040	4040	2200	4400
RPM	2400	3600	3600	1500	1500
Aver. positioning time (msec)	38	35	35	70	70
Aver. rotational delay (msec)	12.5	8.33	8.33	20	20
Aver. access time (msec)	50.5	43.33	43.33	90	90
Data transfer rate (KBytes/sec)	312.5	806	806	195	390
FIRST CUSTOMER SHIPMENT	1976	1976	1976	--	--

Manufacturer:	DIGITAL EQUIPMENT CORP.		
DRIVE	RK05J	RK05F	RK06
DISK/TREND GROUP	1	7	2
MEDIA: Manufacturer's number	RK05K	--	RK06K-DC
Generic type	2315-12	Fixed	Special
TECHNOLOGY TYPE, DRIVE	2314	2314	3330-1
CAPACITY (MBytes)	2.5	5.0	13.89
PERFORMANCE			
Recording surfaces per spindle	2	2	3
Tracks per surface	200/3	400/6	411
TPI	100	200	192.3
BPI	2040	2040	4040
RPM	1500	1500	2400
Aver. positioning time (msec)	50	56	38
Aver. rotational delay (msec)	20	20	12.5
Aver. access time (msec)	70	76	50.5
Data transfer rate (KBytes/sec)	180	180	537
FIRST CUSTOMER SHIPMENT	1975	7/76	12/76
	Original RK05 FCS 1972		Special Top Loading Cartridge With Two 75 Mil Disks

Manufacturer:	DIABLO SYSTEMS					
DRIVE	31	33	33F	43	44	44B
DISK/TREND GROUP	1	1	7	1	1	1
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	2315	2315	Fixed	5440	5440	5440
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	2314	2314
CAPACITY (MBytes)	R: 1.5/3	F: 1.5/3 R: 1.5/3	F: 3/6	F: 3.125 R: 3.125	F: 6.25 R: 6.25	F: 6.25 R: 6.25
PERFORMANCE						
Recording surfaces per spindle	2	4	4	4	4	4
Tracks per surface	200/3	200/3	200/3	200/4	400/8	400/8
TPI	100	100	100	100	200	200
BPI	1100/2200	1100/2200	1100/2200	2200	2200	2200
RPM	1500	1500	1500	2400	2400	2400
Aver. positioning time (msec)	70	70	70	38	38	38
Aver. rotational delay (msec)	20	20	20	12.5	12.5	12.5
Aver. access time (msec)	90	90	90	50.5	50.5	50.5
Data transfer rate (KBytes/sec)	97.5/195	97.5/195	97.5/195	312.5	312.5	312.5
FIRST CUSTOMER SHIPMENT	8/70	8/70	--	3/72	10/72	3Q76

Manufacturer: DIABLO SYSTEMS

DRIVE	410 F/T	411 F/T	412 F/T	413 F/T	M-21	M-24
DISK/TREND GROUP	2	2	2	2	7	7
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	2315/5440	2315/5440	2315/5440	2315/5440	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	3330-11	3330-11	3330-11	3330-11	2314	2314
CAPACITY (MBytes)	R: 13.3	F: 13.3 R: 13.3	F: 26.7 R: 13.3	F: 40.0 R: 13.3	3	6
PERFORMANCE						
Recording surfaces per spindle	2	4	6	8	2	2
Tracks per surface	430	430	430	430	200/3	400/8
TPI	200	200	200	200	100	200
BPI	4800	4800	4800	4800	2200	2200
RPM	2400	2400	2400	2400	1500	1500
Aver. positioning time (msec)	40	40	40	40	70	70
Aver. rotational delay (msec)	12.5	12.5	12.5	12.5	20	20
Aver. access time (msec)	52.5	52.5	52.5	52.5	90	90
Data transfer rate (KBytes/sec)	655	655	655	655	195	195
FIRST CUSTOMER SHIPMENT	1978	4Q77	1978	4Q77	1974	1975
	- - - - - - - - - - Embedded Servo - - - - - - - -					

Manufacturer:	EMM				
DRIVE	103	203-1	203-2	206-1	206-2
DISK/TREND GROUP	7	1	1	1	1
MEDIA: Manufacturer's number	--	--	--	--	--
Generic typed	Fixed	2315	2315	2315	2315
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	2314
CAPACITY (MBytes)	3	F: 3	F: 3 R: 3	R: 6	F: 6 R: 6
PERFORMANCE					
Recording surfaces per spindle	2	2	4	2	4
Tracks per surface	204	204	204	408	408
TPI	100	100	100	200	200
BPI	2200	2200	2200	2200	2200
RPM	1500	1500	1500	1500	1500
Aver. positioning time (msec)	75	60	60	35	35
Aver. rotational delay (msec)	20	20	20	20	20
Aver. access time (msec)	95	80	80	55	55
Data transfer rate (KBytes/sec)	199	199	199	199	199
FIRST CUSTOMER SHIPMENT	1/73	1/72	5/72	1/74	1/74

Manufacturer:	EMM					
DRIVE	303-1	303-2	306-1	306-2	412	312-25
DISK/TREND GROUP	1	1	1	1	--	2
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	5440	5440	5440	5440	Trident	5440
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	3336-11	3330-11
CAPACITY (MBytes)	R: 3	F: 3 R: 3	R: 6	F: 6 R: 6	54:768	F: 12.73 R: 12.73
PERFORMANCE						
Recording surfaces per spindle	2	4	2	4	5	2
Tracks per surface	204	204	408	408	815	815
TPI	100	100	200	200	370	370
BPI	2200	2200	2200	2200	4040	4680
RPM	1500	1500	1500	1500	3600	2400
Aver. positioning time (msec)	60	60	35	35	30	45
Aver. rotational delay (msec)	20	20	20	20	8.33	12.5
Aver. access time (msec)	80	80	55	55	38.33	57.5
Data transfer rate (KBytes/sec)	199	199	199	199	806	629
FIRST CUSTOMER SHIPMENT	1/74	1/72	1/74	1/74	1977	1Q78

Manufacturer:	EMM	
DRIVE	312-50	312-76
DISK/TREND GROUP	2	2
MEDIA: Manufacturer's number		
Generic type	5440	5440
TECHNOLOGY TYPE, DRIVE	3330-11	3330-11
CAPACITY (MBytes)	F: 38.19 R: 12.73	F: 63.68 R: 12.73
PERFORMANCE		
Recording surfaces per spindle	4	6
Tracks per surface	815	815
TPI	370	370
BPI	4680	4680
RPM	2400	2400
Aver. positioning time (msec)	45	45
Aver. rotational delay (msec)	12.5	12.5
Aver. access time (msec)	57.5	57.5
Data transfer rate (KBytes/sec)	629	629
FIRST CUSTOMER SHIPMENT	1Q78	1Q78

FUJITSU		
M 2201	M 2251	M 2252
2	8	8
M 2951	--	--
Special Front Loading Cart.	Fixed	Fixed
3330-11	Winchester (.3277 or .6554 F. Head Option)	Winchester (.3277 or .6554 F. Head Option)
50	12.7	25.4
3	1	2
815	620/10	620/10
370	300	300
6135	6230	6230
2400	2400	2400
30	40	40
12.5	12.5	12.5
42.5	52.5	52.5
819	819	819
4Q77	4Q77	4Q77

Manufacturer:	FUJITSU	HEWLETT PACKARD		
Drive	M2253	7900A	7905A	7920A
DISK/TREND GROUP	8	1	2	4
MEDIA: Manufacturer's number	--	12869A	12940A	13394A
Generic type	Fixed	2315	2315	Spec. SMD
TECHNOLOGY TYPE, DRIVE	Winchester (.3277 or .6554 F. Head Option)	2314	3330-1	3330-11
CAPACITY (MBytes)	50.8	F: 2.5 R: 2.5	F: 6.34 R: 12.68	50
PERFORMANCE				
Recording surfaces per spindle	4	4	3	5
Tracks per surface	620/10	200	406/5	815/8
TPI	300	100	192	384
BPI	6230	2200	4680	4680
RPM	2400	2400	3600	3600
Aver. positioning time (msec)	40	30	25	25
Aver. rotational delay (msec)	12.5	12.5	8.33	8.33
Aver. access time (msec)	52.5	42.5	33.33	33.33
Data transfer rate (KBytes/sec)	819	312.5	937.5	937.5
FIRST CUSTOMER SHIPMENT	4Q77	--	--	3/77

Manufacturer:	HITACHI					
DRIVE	DK62-10 DK62-10F	DK62-20 DK62-20F	MFD90-1	MFD90-2	MFD90-F1	MFD90-F2
DISK/TREND GROUP	7	8	--	--	--	--
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	Winchester	Winchester	--	--	--	--
	(.144 MB F. Head Option)	(.144 MB F. Head Option)			(.061 MB F. Heads)	(.143 MB F. Heads)
CAPACITY (MBytes)	10.8	21.7	1.3	2.6	1.95	1.95
PERFORMANCE						
Recording surfaces per spindle	1	2	1	2	2	2
Tracks per surface	602/2	602/2	128/4	128/4	128/4	128/4
TPI	300	300	48	48	48	48
BPI	5570	5570	3706	3706	3706	3706
RPM	2964	2964	3425	3425	3425	3425
Aver. positioning time (msec)	50	50	190	190	190	190
Aver. rotational delay (msec)	10.1	10.1	8.8	8.8	8.8	8.8
Aver. access time (msec)	60	60	198.8	198.8	198.8	198.8
Data transfer rate (KBytes/sec)	889	889	618	618	618	618
FIRST CUSTOMER SHIPMENT	4Q77	4Q77	1976	1976	1976	1976
	2 Heads per Data Surface	2 Heads per Data Surface				

Manufacturer:	IBM					
DRIVE	1131	2310	5444-1	5444-2/3	5444-A1	5444-A2/A3
DISK/TREND	1	1	1	1	1	1
MEDIA: Manufacturer's number	2315	2315	5440	5440	5440	5440
Generic type	2315	2315	5440	5440	5440	5440
TECHNOLOGY TYPE, DRIVE	2310	2310	5444	5444	5444	5444
CAPACITY (MBytes)	1.024	1.024	F: 1.22 R: 1.22	F: 2.45 R: 2.45	F: 1.22 R: 1.22	F: 2.45 R: 2.45
PERFORMANCE						
Recording surfaces per spindle	2	2	4	4	4	4
Tracks per surface	200	200	200	200	200	200
TPI	100	100	100	100	100	100
BPI	1100	1100	2200	2200	2200	2200
RPM	1500	1500	1500	1500	1500	1500
Aver. positioning time (msec)	520	520	153	269	86	126
Aver. rotational delay (msec)	20	20	20	20	20	20
Aver. access time (msec)	580	580	173	289	106	146
Data transfer rate (KBytes/sec)	97.5	97.5	199	199	199	199
FIRST CUSTOMER SHIPMENT	11/65	11/65	1970	1970	1971	1971
	1130	1130	S/3	S/3	S/3	S/3

Manufacturer:	IBM					
DRIVE	5022-1	5022-2	5022-3	5022-4	5447-A1	5447-A2
DISK/TREND GROUP	1	1	7	7	1	1
MEDIA: Manufacturer's number	5440	5440	--	--	5440	5440
Generic type	5440	5440	Fixed	Fixed	5440	5440
TECHNOLOGY TYPE, DRIVE	5444	5444	5444	5444	5444	5444
CAPACITY (MBytes)	F: 2.44 R: 2.44	F: 2.44 R: 2.44	2.44	2.44	F: 2.5 R: 2.5	F: 5 R: 5
PERFORMANCE						
Recording surfaces per spindle	4	4	2	2	4	4
Tracks per surface	200	200	200	200	200	400
TPI	100	100	100	100	100	200
BPI	2200	2200	2200	2200	2200	2200
RPM	1500	1500	1500	1500	1500	1500
Aver. positioning time (msec)	269	126	269	126	126	126
Aver. rotational delay (msec)	20	20	20	20	20	20
Aver. access time (msec)	289	146	289	146	146	146
Data transfer rate (KBytes/sec)	199	199	199	199	199	199
FIRST CUSTOMER SHIPMENT	1971	1971	1971	1971	1976	1976
	S/7	S/7	S/7	S/7	S/3	S/3

Manufacturer:	IBM					
DRIVE	5448	2311-1	2311-11	2311-12	2314-1	2314-A 2314-B 2312 2319
DISK/TREND GROUP	7	--	--	--	3	3
MEDIA: Manufacturer's number	--	1316	1316	1316	2316	2316
Generic type	Fixed	1316	1316	1316	2316	2316
TECHNOLOGY TYPE, DRIVE	5444	2311	2311	2311	2314	2314
CAPACITY (MBytes)	9.8	7.25	5.4	2.7	29.176	29.176
PERFORMANCE						
Recording surfaces per spindle	8	10	10	10	20	20
Tracks per surface	400	200/3	100/3	200/3	200/3	200/3
TPI	200	100	100	100	100	100
BPI	2200	1100	1100	1100	2200	2200
RPM	1500	2400	2400	2400	2400	2400
Aver. positioning time (msec)	126	75	60	75	75	60
Aver. rotational delay (msec)	20	12.5	12.5	12.5	12.5	12.5
Aver. access time (msec)	146	87.5	72.5	87.5	87.5	72.5
Data transfer rate (KBytes/sec)	199	156	156	156	312.5	312.5
FIRST CUSTOMER SHIPMENT	1977	6/65	11/70	11/70	4/65	A-8/69 B,2319-12/70
	S/3	S/360	S/360	S/360	S/360 S/370	S/360 S/370

Manufacturer:	IBM					
DRIVE	5445	3330-1/2	3330-11	3340	3340	3340
DISK/TREND GROUP	3	5	5	6	6	6
MEDIA: Manufacturer's number	2316	3336-1	3336-11	3348-35	3348-70	3348-70F
Generic type	2316	3336-1	3336-11	3348-35	3348-70	3348-70F
TECHNOLOGY TYPE, DRIVE	2314	3330-1	3330-11	3340	3340	3340
CAPACITY (MBytes)	20.48	100.018	200.036	34.9	69.8	(.502 MB F. Head) 69.388
PERFORMANCE						
Recording surfaces per spindle	20	19	19	3	6	7
Tracks per surface	200/3	404/7	808/7	696/2	696/2	696/2
TPI	100	192	384	300	300	300
BPI	2200	4040	4040	5636	5636	5636
RPM	2400	3600	3600	2964	2964	2964
Aver. positioning time (msec)	60	30	30	25	25	25
Aver. rotational delay (msec)	12.5	8.33	8.33	10.1	10.1	10.1
Aver. access time (msec)	72.5	38.33	38.33	35.1	35.1	35.1
Data transfer rate (KBytes/sec)	312.5	806	806	885	885	885
FIRST CUSTOMER SHIPMENT	6/72	8/71	1973	11/73	11/73	3Q74
	S/3	S/370	S/370	S/370 S/7	S/370 S/3 S/7	S/370 S/3 S/7

Manufacturer:	IBM					
DRIVE	System/32	System/32	System/32	System/32	System/34	System/34
DISK/TREND GROUP	7	7	7	8	7	8
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	WINCHESTER	WINCHESTER	WINCHESTER	WINCHESTER	WINCHESTER	WINCHESTER
CAPACITY (MBytes)	3.210	5.053	9.170	13.778	8.6	13.2
PERFORMANCE						
Recording surfaces per spindle	1	1	1	2	2	2
Tracks per surface	209	329	597	598/299	402/201	604/302
TPI	300	300	300	300	300	300
BPI	5636	5636	5636	5636	5636	5636
RPM	2964	2964	2964	2964	2964	2964
Aver. positioning time (msec)	50.4	70	72.5	72.5	35	40
Aver. rotational delay (msec)	10.1	10.1	10.1	10.1	10.1	10.1
Aver. access time (msec)	60.5	80.1	82.6	82.6	45.1	50.1
Data transfer rate (KBytes/sec)	889	889	889	889	889	889
FIRST CUSTOMER SHIPMENT	--	1/75	1/75	--	1/78	1/78
	2 Data Heads on one surface	2 Data Heads on one surface	2 Data Heads on one surface	2 Data Heads on one surface; 1 Data Head on other surface, with servo head	2 Data Heads on one surface; 1 Data Head on other surface, with servo head	2 Data Heads on one surface; 1 Data Head on other surface, with servo head

Manufacturer:	IBM					
DRIVE	System/34	4962-1 4962-2	4962-1F 4962-2F	3344-B2	3344-B2F	3350-A2 3350-B2 3350-C2
DISK/TREND GROUP	8	7	7	9	9	9
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	Winchester	Winchester	Winchester (.122 MB F. Heads)	Winchester	Winchester (1.004 MB F. Heads)	Winchester
CAPACITY (MBytes)	27.1	9.308	9.308	279.558	279.558	317.5
PERFORMANCE	(Drive consists of two spindles)					
Recording surfaces per spindle	2	1	1	15	15	15
Tracks per surface	604/302	606	F: 8 M: 606	1114	1114	1110
TPI	300	300	300	480	480	480
BPI	5636	5636	5636	5636	5636	6425
RPM	2964	2964	2964	2964	2964	3600
Aver. positioning time (msec)	40	40	40	25	25	25
Aver. rotational delay (msec)	10.1	10.1	10.1	10.1	10.1	8.4
Aver. access time (msec)	50.1	50.1	50.1	35.1	35.1	33.4
Data transfer rate (KBytes/sec)	889	889	889	885	885	1198
FIRST CUSTOMER SHIPMENT	1/78	4Q76	4Q76	2Q76	2Q76	1Q76
	2 Data Heads on one surface 1 Data Head on other surface with Servo Heads	2 Data Heads on one surface	2 Data Heads on one surface			
		Series 1	Series 1	S/370 S/3	S/370 S/3	S/370

Manufacturer:	IBM	ISS/UNIVAC			
DRIVE	3350-A2F 3350-B2F 3350-C2F	714	715	7330-1	7330-2
DISK/TREND GROUP	9	3	3	5	5
MEDIA: Manufacturer's number	--	--	--	--	--
Generic type	Fixed	2316	2316 DD	3336-1	3336-1
TECHNOLOGY TYPE, DRIVE	Winchester (1.144 MB F Heads)	2314	2314 DD	3330-1	3330-1
CAPACITY (MBytes)	317.5	29.2	58.4	100	100
PERFORMANCE					
Recording surfaces per spindle	15	20	20	19	19
Tracks per surface	1110	200/3	400/6	404/7	404/7
TPI	480	100	200	192	192
BPI	6425	2200	2200	4040	4040
RPM	3600	2400	2400	3600	2800
Aver. positioning time (msec)	25	32	29	27	27
Aver. rotational delay (msec)	8.4	12.5	12.5	8.33	10.7
Aver. access time (msec)	33.4	44.5	41.5	35.33	37.7
Data transfer rate (KBytes/sec)	1198	312.5	312.5	806	625
FIRST CUSTOMER SHIPMENT	1Q76	4/70	6/71	9/72	2/73
	S/370				

Manufacturer:	ISS/UNIVAC			
DRIVE	7330-10	733-11 7330-11	7330-12	7350
DISK/TREND GROUP	5	5	5	9
MEDIA: Manufacturer's number	--	--	--	--
Generic type	3336-1	3336-11	3336 (Spec)	Fixed
TECHNOLOGY TYPE, DRIVE	3330-1	3330-11	3330-11	3350
CAPACITY (MBytes)	100	200	317.5	317.5
PERFORMANCE				
Recording surfaces per spindle	19	19	19	15
Tracks per surface	404/7	808/7	887	1110
TPI	192	370	402	480
BPI	4040	4040	6965	6425
RPM	3600	3600	3600	3600
Aver. positioning time (msec)	27	27	30	25
Aver. rotational delay (msec)	8.33	8.33	8.33	8.4
Aver. access time (msec)	35.33	35.33	38.33	33.4
Data transfer rate (KBytes/sec)	806	806	1260	1198
FIRST CUSTOMER SHIPMENT	5/75	2/75	1977	4Q77

Manufacturer:	KENNEDY		
DRIVE	5301-14	5302-42	5303-70
DISK/TREND GROUP	8	8	8
MEDIA: Manufacturer's number	--	--	--
Generic type	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	Winchester	Winchester	Winchester
CAPACITY (MBytes)	14.112	42.336	70.560
PERFORMANCE			
Recording surfaces per spindle	1	3	5
Tracks per surface	700	700	700
TPI	300	300	300
BPI	6000	6000	6000
RPM	3000	3000	3000
Aver. positioning time (msec)	45	45	45
Aver. rotational delay (msec)	10	10	10
Aver. access time (msec)	55	55	55
Data transfer rate (KBytes/sec)	1000	1000	1000
FIRST CUSTOMER SHIPMENT	1Q78	1Q78	1Q78
	2 Heads Per Data Surface	2 Heads Per Data Surface	2 Heads Per Data Surface

Manufacturer:	MEMOREX					
DRIVE	3670-1/2	3675	677	3640	3650-A2 3650-B2 3650-C2	3650-A2F 3650-A2F 3650-A2F
DISK/TREND GROUP	5	5	5	6	9	9
MEDIA: Manufacturer's number	Mark X	Mark XI	Mark XI	Data Mark	--	--
Generic type	3336-1	3336-11	3336-11	3348	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	3330-1	3330-11	3330-11	3340	3350	3350 (1.144 MB F. Heads)
CAPACITY (MBytes)	100	200	208.118	35/70	317.5	317.5
PERFORMANCE						
Recording surfaces per spindle	19	19	19	3/6	15	15
Tracks per surface	404/7	808/7	808/7	348/696	1110	1110
TPI	192	384	370	300	480	480
BPI	4040	4040	4040	5636	6425	6425
RPM	3600	3600	3600	2964	3600	3600
Aver. positioning time (msec)	27	27	28.5	20	25	25
Aver. rotational delay (msec)	8.33	8.33	8.33	10.1	8.4	8.4
Aver. access time (msec)	35.33	35.33	36.83	30.1	33.4	33.4
Data transfer rate (KBytes/sec)	806	806	806	885	1198	1198
FIRST CUSTOMER SHIPMENT	10/72	10/74	1976	1977	6/77	6/77
	PCM	PCM	OEM	PCM Mfg. by Nippon Peripherals Ltd.	PCM	PCM

Manufacturer:	MEMOREX			MICRODATA	
DRIVE	601-25	601-50	601-75	2853 9100	2854 9101
DISK/TREND GROUP	8	8	8	1	1
MEDIA: Manufacturer's number	--	--	--	--	--
Generic type	Fixed	Fixed	Fixed	5440	5440
TECHNOLOGY TYPE, DRIVE	Winchester	Winchester	Winchester	2314	2314
CAPACITY (MBytes)	25.144	50.288	75.432	R: 2.5	R: 5
PERFORMANCE					
Recording surfaces per spindle	2	4	6	2	2
Tracks per surface	700	700	700	200/4	400/8
TPI	300	300	300	100	200
BPI	5640	5640	5640	2200	2200
RPM	2964	2964	2964	1500	1500
Aver. positioning time (msec)	30	30	30	35	35
Aver. rotational delay (msec)	10.1	10.1	10.1	20	20
Aver. access time (msec)	40.1	40.1	40.1	55	55
Data transfer rate (KBytes/sec)	885	885	885	200	200
FIRST CUSTOMER SHIPMENT	1977	1977	1977	1Q74	1/75
	(.5 or 1.0 MB Fixed Head Option) 2 Heads Per Data Surface	2 Heads Per Data Surface	2 Heads Per Data Surface	2400 RPM Option	2400 RPM Option

Manufacturer:	MICRODATA				
DRIVE	2855 9200	2856 9201	Reflex-A	Reflex-B	Reflex-C
DISK/TREND GROUP	1	1	8	8	8
MEDIA: Manufacturer's Number	--	--	--	--	--
Generic type	5440	5440	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	2314	2314	Winchester	Winchester	Winchester
CAPACITY (MBytes)	F: 2.5 R: 2.5	F: 5 F: 5	12.5	37.6	62.7
PERFORMANCE					
Recording surfaces per spindle	4	4	1	3	5
Tracks per surface	200/4	400/8	700	700	700
TPI	100	200	300	300	300
BPI	2200	2200	5636	5636	5636
RPM	1500	1500	2964	2964	2964
Aver. positioning time (msec)	35	35	30	30	30
Aver. rotational delay (msec)	20	20	10.12	10.12	10.12
Aver. access time (msec)	55	55	42.12	42.12	42.12
Data transfer rate (KBytes/sec)	200	200	885	885	885
FIRST CUSTOMER SHIPMENT	1Q74	1/75	1977	1977	1977
	2400 RPM Option	2400 RPM Option	2 Heads per Data Surface	2 Heads per Data Surface	2 Heads per Data Surface

Manufacturer:	NIPPON ELECTRIC COMPANY	NIPPON PERIPHERALS LTD.
DRIVE	D1500	NP20
DISK/TREND GROUP	9	6
MEDIA: Manufacturer's number	--	--
Generic type	Fixed	3348
TECHNOLOGY TYPE, DRIVE	3350 (1.144 MB F. Head Option)	3340
CAPACITY (MBytes)	317.5	35/70
PERFORMANCE		
Recording surfaces per spindle	15	3/6
Tracks per surface	1112	348/696
TPI	480	300
BPI	6370	5636
RPM	3600	2964
Aver. positioning time (msec)	20	20
Aver. rotational delay (msec)	8.4	10.1
Aver. access time (msec)	28.4	30.1
Data transfer rate (KBytes/sec)	1.2	885
FIRST CUSTOMER SHIPMENT	1Q78	1977

Manufacturer:	OKIDATA					
DRIVE	3301	3302	3303	3304	3305	3306
DISK/TREND GROUP	8	8	8	8	8	8
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	Winchester	Winchester	Winchester	Winchester	Winchester	Winchester
CAPACITY (MBytes)	12.4 (.74 MB F. Head Opt)	24.8 (2.23 MB F. Head Opt)	37.19 (.74 MB F. Head Opt)	49.59 (2.23 MB F. Head Opt)	61.99 (.74 MB F Head Opt)	74.39 (.74 MB F. Head Opt)
PERFORMANCE						
Recording surfaces per spindle	1	2	3	4	5	6
Tracks per surface	678	678	678	678	678	678
TPI	286	286	286	286	286	286
BPI	5636	5636	5636	5636	5636	5636
RPM	2964	2964	2964	2964	2964	2964
Aver. positioning time (msec)	38	38	38	38	38	38
Aver. rotational delay (msec)	10.12	10.12	10.12	10.12	10.12	10.12
Aver. access time (msec)	48.1	48.1	48.1	48.1	48.1	48.1
Data transfer rate (KBytes/sec)	916	916	916	916	916	916
FIRST CUSTOMER SHIPMENT	5/77	5/77	5/77	5/77	5/77	5/77
	2 Heads per Data Surface	2 Heads per Data Surface	2 Heads per Data Surface	2 Heads per Data Surface	2 Heads per Data Surface	2 Heads per Data Surface

Manufacturer:	PERTEC					
DRIVE	D3311/D3312	D3321/D3322	D3331/D3332	D3341/D3342	D3421/D3422	D3441/D3342
DISK/TREND GROUP	1	1	1	1	1	1
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	5440	5440	2315	2315	5440	2315
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	2314	2314
CAPACITY (MBytes)	R: 3.1	F: 3.1 R: 3.1	R: 3.1	F: 3.1 R: 3.1	F: 6.3 R: 6.3	F: 6.3 R: 6.3
PERFORMANCE						
Recording surfaces per spindle	2	4	2	4	4	4
Tracks per surface	200/3	200/3	200/3	200/3	400/6	400/6
TPI	100	100	100	100	200	200
BPI	2200	2200	2200	2200	2200	2200
RPM	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400	1500/2400
Aver. positioning time (msec)	35	35	35	35	40	40
Aver. rotational delay (msec)	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5	20/12.5
Aver. access time (msec)	55/47.5	55/47.5	55/47.5	55/47.5	60/52.5	60/12.5
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5	195/312.5

Manufacturer:	PERTEC		
DRIVE	D3621/D3622	D3400E	D3600E
DISK/TREND GROUP	2	2	2
MEDIA: Manufacturer's number	--	--	--
Generic type	5440	5440	5440
TECHNOLOGY TYPE, DRIVE	3330-1	2314	3330-1
CAPACITY (MBytes)	F: 12.6 R: 12.6	F: 19.0 R: 6.3	F: 38 R: 12.6
PERFORMANCE			
Recording surfaces per spindle	4	8	8
Tracks per surface	400/6	400/6	400/6
TPI	200	200	200
BPI	4400	2200	4400
RPM	1500/2400	1500/2400	1500/2400
Aver. positioning time (msec)	40	40	40
Aver. rotational delay (msec)	20/12.5	20/12.5	20/12.5
Aver. access time (msec)	60/52.5	60/52.5	60/52.5
Data transfer rate (KBytes/sec)	390/625	195/312.5	390/625

Manufacturer:	PERTEC			
DRIVE	D1451/D1452	DM1461/D1462	D1651/D1652	D1661/D1662
DISK/TREND GROUP	7	7	7	8
MEDIA: Manufacturer's number	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	2314	2314	3336-1	3336-1
CAPACITY (MBytes)	6	12	12	24
PERFORMANCE				
Recording surfaces per spindle	2	4	2	4
Tracks per surface	400/6	400/6	400/6	400/6
TPI	200	200	200	200
BPI	2200	2200	4400	4400
RPM	1500/2400	1500/2400	1500/2400	1500/2400
Aver. positioning time (msec)	70	70	70	70
Aver. rotational delay (msec)	20/12.5	20/12.5	20/12.5	20/12.5
Aver. access time (msec)	90/82.5	90/82.5	90/82.5	90/82.5
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	390/625	390/625

Manufacturer:	SIEMENS			
DRIVE	PS5-1 PS5-2	PS5-3 PS5-4	PS5-5 PS5-6	PS5-7 PS5-8
DISK/TREND GROUP	5	5	5	9
MEDIA: Manufacturer's number	V26374-Q7	V26374-Q9	--	--
Generic type	Special	Special	3336-11	Fixed
TECHNOLOGY TYPE, DRIVE	3330-1	3330-11	3330-11	Winchester (1.15 MB F. Head Option)
CAPACITY (MBytes)	73.3	146.6	300	517.1
PERFORMANCE				
Recording surfaces per spindle	9	9	19	19
Tracks per surface	404/7	808/15	808/15	1350
TPI	192	384	384	590
BPI	6060	6060	6060	6060
RPM	2400	2400	2400	2400
Aver. positioning time (msec)	23	23	23	20
Aver. rotational delay (msec)	12.5	12.5	12.5	12.5
Aver. access time (msec)	35.5	35.5	35.5	32.5
Data transfer rate (KBytes/sec)	806	806	806	806
FIRST CUSTOMER SHIPMENT	9/75	12/76	1977	1977 2 Heads Per Data Surface

Manufacturer:	STORAGE TECHNOLOGY CORPORATION			
DRIVE	8100	8400	8800	8350
DISK/TREND GROUP	5	9	9	9
MEDIA: Manufacturer's number	--	--	--	--
Generic type	3336-1	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	3330-1	3330	3330	3350
CAPACITY (MBytes)	100	400	800	317.5
PERFORMANCE				
Recording surfaces per spindle	19	114 (Per Device)	114 (Per Device)	15
Tracks per surface	404/7	552	552	1110
TPI	192	238	238	480
BPI	4040	4040	4040	6425
RPM	3600	3600	3600	3600
Aver. positioning time (msec)	28	30	30	25
Aver. rotational delay (msec)	8.33	8.33	8.33	8.4
Aver. access time (msec)	36.33	32.33	38.33	33.4
Data transfer rate (KBytes/sec)	806	806	806	119.8
FIRST CUSTOMER SHIPMENT	4/75	2/75	2/75	4/77

Manufacturer:	SYCOR		UNIVAC		
DRIVE	410	440	8415	8418-92	8418-94
DISK/TREND GROUP	7	7	2	4	4
MEDIA: Manufacturer's number	--	--	F1215-00	F1216-02	F1216-02
Generic type	Fixed	Fixed	5440	Storage Module	Storage Module
TECHNOLOGY TYPE, DRIVE	2314	2314	3330-11	3330-11	3330-11
CAPACITY (MBytes)	2.5	5.0	F: 31.9 R: 10.6	28.9	57.9
PERFORMANCE					
Recording surfaces per spindle	1	2	F: 3 R: 2	7	7
Tracks per surface	400	400	F: 808/7 R: 404/7	404/7	808/7
TPI	200	200	F: 370 R: 185	370	370
BPI	2200	2200	4040	4040	4040
RPM	2400	2400	2800	2800	2800
Aver. positioning time (msec)	70	70	33	27	33
Aver. rotational delay (msec)	12.5	12.5	10.7	10.7	10.7
Aver. access time (msec)	82.5	82.5	43.7	37.7	43.7
Data transfer rate (KBytes/sec)	312.5	312.5	625	625	625
FIRST CUSTOMER SHIPMENT	1975	1975	2/77	11/75	3/76

Manufacturer:	VERMONT RESEARCH	WANGCO			
DRIVE	5017	MC 20/5	MC 20/10	MC 20/15	MC 20/20
DISK/TREND GROUP	2	1	1	2	2
MEDIA: Manufacturer's number	VRC5517	--	--	--	--
Generic type	5440	5440	5440	5440	5440
TECHNOLOGY TYPE, DRIVE	--	2314	2314	2314	2314
CAPACITY (MBytes)	F: 26.2 R: 26.2	R: 5	F: 5 R: 5	F: 10 R: 5	F: 15 R: 5
PERFORMANCE					
Recording surfaces per spindle	4	2	4	6	8
Tracks per surface	1024/8	400/8	400/8	400/8	400/8
TPI	500	200	200	200	200
BPI	4000	2200	2200	2200	2200
RPM	3165	2400	2400	2400	2400
Aver. positioning time (msec)	35	39	39	39	39
Aver. rotational delay (msec)	9.5	12.5	12.5	12.5	12.5
Aver. access time (msec)	44.5	51.5	51.5	51.5	51.5
Data transfer rate (KBytes/sec)	763.8	312.5	312.5	312.5	312.5
FIRST CUSTOMER SHIPMENT	3/75	1Q78	1Q78	1Q78	1Q78
	Embedded Servo				

Manufacturer:	WANGCO					
DRIVE	MC 40/10	MC 40/20	MC 40/30	MC 40/40	F-1111	F-1121
DISK/TREND GROUP	1	2	2	2	1	1
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	5440	5440	5440	5440	2315	2315
TECHNOLOGY TYPE, DRIVE	3330-1	3330-1	3330-1	3330-1	2310	2310
CAPACITY (MBytes)	R: 10	F: 10 R: 10	F: 20 R: 10	F: 30 R: 10	R: 1.44	F: 1.56 R: 1.56
PERFORMANCE						
Recording surfaces per spindle	2	4	6	8	2	4
Tracks per surface	400/8	400/8	400/8	400/8	200/4	200/4
TPI	200	200	200	200	100	100
BPI	4400	4400	4400	4400	1025	1025
RPM	2400	2400	2400	2400	1500	1500
Aver. positioning time (msec)	39	39	39	39	40	40
Aver. rotational delay (msec)	12.5	12.5	12.5	12.5	20	20
Aver. access time (msec)	51.5	51.5	51.5	51.5	60	60
Data transfer rate (KBytes/sec)	625	625	625	625	90	90
FIRST CUSTOMER SHIPMENT	1Q78	1Q78	1Q78	1Q78	--	--

Manufacturer:	WANGCO					
DRIVE	F/T-1212	F/T-1222	F-2211	F/T-2212	F-2221	F/T-2222
DISK/TREND GROUP	1	1	1	1	1	1
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	2315/5440	2315/5440	2315	2315/5440	2315	2315/5440
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314	2314	2314
CAPACITY (MBytes)	F: 3.13	F: 3.13 R: 3.13	R: 6.25	R: 6.25	F: 6.25 R: 6.25	F: 6.25 R: 6.25
PERFORMANCE						
Recording surfaces per spindle	2	4	2	2	4	4
Tracks per surface	200/4	200/4	400/8	400/8	400/8	400/8
TPI	100	100	200	200	200	200
BPI	2200	2200	2200	2200	2200	2200
RPM	2400	2400	1500	2400	1500	2400
Aver. positioning time (msec)	35	35	35	35	35	35
Aver. rotational delay (msec)	12.5	12.5	20	12.5	20	12.5
Aver. access time (msec)	47.5	47.5	55	47.5	55	47.5
Data transfer rate (KBytes/sec)	312.5	312.5	195	312.5	195	312.5
FIRST CUSTOMER SHIPMENT	--	12/73	--	--	--	7/74
	1500 RPM Version: F/T-1211	1500 RPM Version: F/T-1221				

Manufacturer:	WANGCO					
DRIVE	T-2412	T-2422	N-1211	N-1212	N-1221	N-1222
DISK/TREND GROUP	1	2	7	7	--	--
MEDIA: Manufacturer's number	--	--	--	--	--	--
Generic type	5440	5440	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	3330-1	3330-1	2314	2314	2314	2314
CAPACITY (MBytes)	R: 12.5	F: 12.5 R: 12.5	3.13	3.13	6.25	6.25
PERFORMANCE						
Recording surfaces per spindle	2	4	2	2	4	4
Tracks per surface	400/8	400/8	200/4	200/4	200/4	200/4
TPI	200	200	100	100	100	100
BPI	4400	4400	2200	2200	2200	2200
RPM	2400	2400	1500	2400	1500	2400
Aver. positioning time (msec)	35	35	40	40	40	40
Aver. rotational delay (msec)	12.5	12.5	20	12.5	20	12.5
Aver. access time (msec)	47.5	47.5	60	52.5	60	52.5
Data transfer rate (KBytes/sec)	625	625	195	312.5	195	312.5
FIRST CUSTOMER SHIPMENT	--	12/75	--	--	12/73	12/73

Manufacturer:	WANGCO			
DRIVE	N-2211	N-2212	N-2221	N-2222
DISK/TREND GROUP	--	--	--	--
MEDIA: Manufacturer's number	--	--	--	--
Generic type	Fixed	Fixed	Fixed	Fixed
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314
CAPACITY (MBytes)	6.25	6.25	12.5	12.5
PERFORMANCE				
Recording surfaces per spindle	2	2	4	4
Tracks per surface	400/8	400/8	400/8	400/8
TPI	200	200	200	200
BPI	2200	2200	2200	2200
RPM	1500	2400	1500	2400
Aver. positioning time (msec)	40	40	40	40
Aver. rotational delay (msec)	20	12.5	20	12.5
Aver. access time (msec)	60	52.5	60	52.5
Data transfer rate (KBytes/sec)	195	312.5	195	312.5
FIRST CUSTOMER SHIPMENT	--	--	7/74	7/74

Manufacturer:	WANGCO			
DRIVE	MP40	MP80	MP80I	MP160I
DISK/TREND GROUP	4	4	4	5
MEDIA: Manufacturer's number	CDC 9876	CDC 9877	CDC 9877	CDC 9877
Generic type	Storage Module	Storage Module	Storage Module	Storage Module
TECHNOLOGY TYPE, DRIVE	3330-11	3330-11	3330-11	3330-11
CAPACITY (MBytes)	40	80	80	F:80 R:80
PERFORMANCE				F:5
Recording surfaces per spindle	5	5	5	R:5
Tracks per surface	411	823	823	823
TPI	185	370	370	370
BPI	6076	6076	6076	6076
RPM	3600	3600	3600	2400
Aver. positioning time (msec)	30	30	30	35
Aver. rotational delay (msec)	8.33	8.33	8.33	12.5
Aver. access time (msec)	38.33	38.33	38.33	47.5
Data transfer rate (KBytes/sec)	1213	1213	1213	800
FIRST CUSTOMER SHIPMENT	4Q77	4Q77	4Q78	4Q78

Manufacturer:	WESTERN DYNEX			
DRIVE	DD-6121	DD-6221	DD-6122	DD-6222
DISK/TREND GROUP	1	1	1	1
MEDIA: Manufacturer's number	--	--	--	--
Generic type	2315/5440	2315/5440	2315/5440	2315/5440
TECHNOLOGY TYPE, DRIVE	2314	2314	2314	2314
CAPACITY (MBytes)	R: 3.13	F: 3.13 R: 3.13	R: 6.25	F: 6.25 R: 6.25
PERFORMANCE				
Recording surfaces per spindle	2	4	2	4
Tracks per surface	200/3	200/3	400/6	400/6
TPI	100	100	200	200
BPI	2200	2200	2200	2200
RPM	1500/2400	1500/2400	1500/2400	1500/2400
Aver. positioning time (msec)	35	35	35	35
Aver. rotational delay (msec)	20/12.5	20/12.5	20/12.5	20/12.5
Aver. access time (msec)	55/47.5	55/47.5	55/47.5	55/47.5
Data transfer rate (KBytes/sec)	195/312.5	195/312.5	195/312.5	195/312.5
FIRST CUSTOMER SHIPMENT	9/72	9/72	9/72	9/72

1977 DISK/TREND REPORT

MANUFACTURER PROFILES

All known manufacturers of moving head rigid disk drives headquartered in the United States are listed in this section, with a capsule description. Throughout the listings, the heading "disk sales" refers to the DISK/TREND estimate of moving head rigid disk drive sales only -- no sales of other drive types are included, nor are sales of parts or other disk drive related products such as controllers.

AMPEX CORPORATION
Data Products Division
401 Broadway
Redwood City, CA 94063 415/367-2011

1976 disk sales: $10,800,000
1976 total net sales: $257,935,000 Net income: $8,032,000

Ampex data processing and related products produce 35% of total sales. Numerous changes in data products management during the past year. In recent years Ampex' posture has been that of a follower. Disk products have been industry standard items, but without aggressive pricing or marketing. Most productive current product program is SMD, and CDC second source strategy.

BALL COMPUTER PRODUCTS, INC.
Subsidiary of Ball Corporation
860 East Arques Avenue
Sunnyvale, CA 94086 415/733-6700

1976 disk sales: --
1976 parent company
total net sales: $397,005,000 Net income: $13,061,000

Ball is making Trident type drives under rights acquired from EMM. After program start-up in late 1976, Ball is now targeting sale of SMD subsystems to system houses. Also sells OEM drives to EMM for resale. This is still a formative activity, and Ball's strategy and energy level not yet clear.

BURROUGHS CORPORATION
Burroughs Place
Detroit, MI 48232 313/972-7000

1976 disk sales: $165,700,000
1976 total net sales: $1,870,845,000 Net income: $185,904,000

Burroughs remains one of the largest manufacturers of disk cartridge drives, and has done some innovative things with an embedded servo technique in a family of disk pack drives. Now scaling up production on a special version of the Trident under license from Calcomp. Burroughs has the only thin-film head drive in production, a head per track unit, but may not be in the forefront of thin-film head development. It is likely that Burroughs will remain the second largest producer of captive drives for the next few years, at least. Drive manufacturing is at Westlake Village, California; Winnipeg, Canada; Glen Rothie, Scotland; and Guadalajara, Mexico.

CALIFORNIA COMPUTER PRODUCTS, INC.
2411 West La Palma
Anaheim, CA 92801 714/821-2011

1976 disk sales: $50,100,000
1976 total net sales: $121,495,000 Net income: ($3,994,000)

At least 90% of Calcomp's business is in peripherals, and except for plotters most of it has been in trouble. In disk drives, the company has found the PCM world to be a harsh environment, and OEM acceptance for the Trident has been much lower than for CDC's SMD. Despite management claims that the company's future is in non-IBM disk formats, Calcomp will probably find it necessary to offer products with high sales potential in the OEM area, and most of these will of necessity follow the general pattern of IBM standards. Much reorganization of management earlier this year, but strategies still not clearcut.

CONTROL DATA CORPORATION
8100 34th Avenue South
Minneapolis, MN 55440 612/853-8100

1976 disk sales: $146,200,000
1976 total net sales: $1,331,012,000 Net income: $48,553,000

About one third of CDC's sales are generated by peripherals. CDC is unique among the mainframers in having built a large OEM disk drive business from the ground up. The company is clearly the leader in total OEM disk drive sales, and has a product line rivaling IBM's in completeness. It carries out its own development of heads and recording

disks, and has generally provided leadership in early introduction of new OEM products. Most CDC drive manufacturing capability is now embodied in Magnetic Peripherals, Inc., a joint venture in which ownership is shared with Honeywell. CDC, however, manages the MPI disk drive operations at Normandale, Minnesota, and Oklahoma City, Oklahoma, and seems to be providing the major portion of the product planning for the future. CDC has good products, in depth, with marketing momentum -- and seems sure to retain and build on its share of the OEM disk drive business.

DATA 100 CORPORATION
6110 Blue Circle Drive
Minnetonka, MN 55343 612/941-6500

1976 disk sales: $10,800,000
1976 total net sales: $121,939,000 Net income: $6,435,000

The Data 100 line of disk cartridge drives is the Iomec line, acquired and moved in 1976 to Minnesota, supplemented with some subsystems interfaced to sell on a PCM basis to DEC and Data General users. Data 100 has retained much of Iomec's OEM business, though not many of the people. The extent of Data 100's ambitions in disk drives is not yet clear.

DATA GENERAL CORPORATION
Route 9
Southboro, MA 01772 617/485-9100

1976 disk sales: $6,500,000
1976 total net sales: $161,117,000 Net Income: $18,948,000

Data General initiated internal production of disk cartridge drives and 3330 compatible drives in 1976, becoming the latest of the major disk drive OEM customers to launch captive production. Expansion of the program into other configurations is probable.

DIABLO SYSTEMS, INC.
Subsidiary of Xerox Corporation
24500 Industrial Blvd.
Hayward, CA 94545 415/786-5000

1976 disk sales: $55,500,000
1976 parent company
total net sales: $4,403,897,000 Net income: $358,906,000

Diablo has long been the leader in OEM disk cartridge drives, and will undoubtedly keep its lead. The Series 400, a family of innovative

drives announced in 1975, has been an embarrassment so far because of continuing delays in production start-up. First deliveries in October, 1977, have now been announced, and if the promise is kept, Diablo's dominance of the next generation of cartridge disk drives is assured. Not as clear is whether the firm will attempt early entry into higher disk technology areas, in order to build production volume in other emerging small disk drive areas.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754 617/897-5111

1976 disk sales: $104,000,000
1976 total net sales: $736,288,000 Net income: $73,400,000

DEC is one of the two giants in captive production of disk cartridge drives. To date the company has elected not to manufacture large capacity drives. The recent introduction of 3330 technology in an unconventional cartridge drive is the firm's most ambitious disk drive program so far. An SMD program is under consideration, but DEC may continue to be a significant, although difficult OEM drive customer.

ELECTRONIC MEMORIES & MAGNETICS CORPORATION
Peripheral Products Division
1015 Timothy Drive
San Jose, CA 95133 408/298-7080

1976 disk sales: $3,400,000
1976 total net sales: $92,000,000 Net income: $7,700,000

The early Caelus cartridge drive manufacturing operation was one of the early big winners when it landed Burrough's OEM drive business -- but it also became one of the early big losers when Burroughs took the program in-house. The continual management disruption which weakened the Caelus disk drive and media operations eventually led to a low activity level in 1975, the sale of an advanced drive program to Ball, and the sale of media operations to Univac. From the shambles, EMM has set up a new peripherals division at San Jose, with the old Caelus disk cartridge drive line and new people. New high density cartridge drives are starting to appear. If management keeps a cool head, it could prosper.

HEWLETT-PACKARD COMPANY
Disk Memory Division
11000 Wolfe Road
Cupertino, CA 95014 408/257-7000

1976 disk sales: $44,300,000
1976 total net sales: $1,111,648,000 Net income: $90,841,000

HP started internal disk drive manufacture with standard disk cartridge drives and has advanced in a few years to a successful drive in the storage module class. A disk pack drive in the 100 MB area is expected next, and a fixed Winchester drive wouldn't surprise anybody. HP buys only the recording disks outside the company; it makes all other critical parts internally, including heads. The firm even produces its own CE packs. Manufacturing operations are being moved to a new plant at Boise, Idaho.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504 914/765-1900

1976 disk sales: $754,100,000
1976 total net sales: $16,304,333,000 Net income: $2,398,093,000

IBM invented flying head disk drives. The company has pioneered more technology, made more drives, and operated at higher profit margins than any other manufacturer of disk drives can ever hope to. By developing technology early, and by virtue of its market position in computer systems, IBM has had some of the neatest product life cycles ever: Sharp production scale-up, assured volume requirements, few scheduling peaks and valleys, orderly phase-out. That's what low costs are made of. And since IBM has held price levels, the firm's parade of disk drives has contributed its share to a famous profit margin. What's next for disk drives? It's likely that no one knows for sure, even IBM's management. They like to keep their options open, by developing technological alternatives, then deciding only when necessary. So it could be something revolutionary, to replace disk memories or change their form. Or it could be something evolutionary, a double density here and a repackaging there. DISK/TREND is betting on evolution this year. Some important product life cycles haven't had much of a run yet, and it's too early to cause premature obsolescence.

ISS (See SPERRY RAND)

cartridge disk drives. Pertec is positioned to develop a growing share of the OEM disk drive business, but the unresolved question is whether the firm's management is prepared to underwrite development of the higher technology drives needed for expansion. In the long term, the high density cartridge drives announced to date will probably have to be supplemented with products in higher capacity ranges to stay in the ballgame.

SPERRY RAND CORPORATION
Sperry Univac Division
ISS operating unit

1976 disk sales: $176,400,000
1976 total net sales: $3,202,556,000 Net income: $145,294,000

ISS now enjoys major captive disk drive production programs for Univac, in addition to the pre-acquisition PCM program now carried on with excellent results by Itel, the ex-parent now in the customer role. Although ISS' sales to Itel are actually public sales to a separate company, DISK/TREND statistics include them in the PCM totals to avoid distortion of the true size of the total PCM segment of the industry. ISS also has an OEM marketing program, carried out with moderate success to date, but which will probably grow. ISS is one of the industry's high capability organizations, in the technical area. It has its own recording media facilities (acquired from EMM), makes many critical parts internally, and produces its own CE packs. The firm can be expected to keep up with the front-runners in disk technology.

STORAGE TECHNOLOGY CORPORATION
2270 South 88th Street
Louisville, CO 80027 303/666-6581

1976 disk sales: $21,400,000
1976 total net sales: $121,779,000 Net income: $7,645,000

Storage Technology has built a substantial company from a high level of expertise in tape drive engineering, starting in 1969. After establishing market dominance in high performance PCM tape drives, the company's results so far in disk drives have probably disappointed the firm's management. STC's PCM 3330 drives have not been a major market factor, and the unique 800 MB fixed "super disk" has attracted a lot of attention but sales in the hundreds of units, not thousands. The new 3350 program has more commercial promise and could finally do the job for STC in PCM disk drives. In the meantime, the organization is probably a contender in a neglected area, the OEM market. It will take time, but properly configured products and good marketing support could open doors for this well regarded company.