
Quantum

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This book is intended as a reference guide on Quantum Corporation and the hard disk drive market. For further information, contact Joseph T. Rodgers, Jr., Executive Vice President, Finance, or Mark D. Wilson, Vice President, Marketing.

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QUANTUM CORPORATION

Corporate Background

Overview

Quantum designs, manufactures, and markets rigid disk drives for use by original equipment manufacturers (OEMs) in personal computers and workstations. In addition, Quantum's wholly-owned subsidiary, Plus Development Corporation, designs high-value-added, personal computer enhancement products and markets them through retail channels to end-users.

Quantum was founded in 1980 by a group of experienced managers from the disk-drive and computer manufacturing industries. Early equity financing was provided by Kleiner, Perkins, Caufield and Byers, the Mayfield Fund, and Sutter Hill, leading venture capital firms. The Company made its initial public offering in December 1982 at $20.50 per share, raising $32 million.

Products

Quantum currently offers the ProDrive Series™, a broad family of high performance 3 1/2-inch hard disk drives. Plus Development markets three hard disk product lines: the Hardcard™ family of fully integrated disk drives on expansion cards, the Plus Passport™ removable hard disk drive systems for personal computers, and the Plus Impulse™ expandable hard disk drive system for PC LANs.

Announced in February 1988, Quantum's ProDrive Series of high performance 3 1/2-inch hard disk drives provides formatted capacities ranging from 42 to 168 megabytes and a choice of SCSI (Small Computer System Interface) and AT-Bus interfaces. These drives are designed for use in high performance personal computers, workstations, and multi-user systems - applications which require the high performance and reliability provided by ProDrive Series drives.

ProDrive Series disk drives provide several advantages over competing 3 1/2-inch hard disk drives in both performance and reliability. All ProDrive™ products offer lower average seek times and faster data transfer to the host than competing products. The average seek time for all drives in the series is 19 milliseconds or less. ProDrive Series products also feature exceptional reliability, with lower unrecoverable data error rates and a significantly higher specified Mean Time Between Failures (MTBF) - 50,000 hours - than other 3 1/2-inch drives.

The ProDrive Series drives also feature Quantum's proprietary DisCache® buffer management system which decreases disk access time even further - as much as 50% in some applications. These drives feature embedded controllers that release the host computer from the task of managing data storage operations, permitting higher system performance and faster access to disk memory. In addition, the design of these drives allows systematic compensation for errors in disk media, resulting in higher production yields, lower manufacturing costs, and greater data storage integrity.

Quantum is currently phasing out its Q200 Series™ of intelligent, half-height, 5 1/4-inch hard disk drives - the first small disk drives with embedded SCSI controllers. This move

is part of the Company's new OEM business strategy announced in June 1987. Quantum is focussing OEM product development on high performance 3 1/2-inch drives and is transitioning out of its 5 1/4-inch products. Phasing out the Q200 Series is necessary to enable the Company to focus on the tremendous 3 1/2-inch market opportunity.

Quantum's subsidiary, Plus Development, markets mass storage products specifically designed for installation in IBM PC™/XT™/AT® systems and compatibles. Plus' original product offering, the 10-megabyte Hardcard, pioneered a new class of products - the popular hard-disk-on-an-expansion card product lines. The Hardcard products implement a 3 1/2-inch form factor drive on an expansion card and are designed to fit in a single full-length expansion slot in an IBM PC or compatible. In June 1986, Plus introduced the Hardcard 20 which features 21 megabytes of storage capacity, and an average seek time of 40 milliseconds. The Hardcard 40, originally introduced in May 1987, provides 42 megabytes of storage and features PlusCache™ disk caching software. With PlusCache, the Hardcard 40 achieves an effective average seek time of 28 milliseconds. These Hardcard products have established an industry standard for reliability with a 60,000 MTBF rating.

In April 1988, Plus launched a new product line with the Plus Passport products. These removable hard disk systems for personal computers provide 3 1/2-inch format drives in 20- and 40-megabyte capacities. The Plus Passport system offers complete compatibility and data interchange between IBM PC/XT/AT systems and PS/2™ microcomputers with IBM's new Micro Channel™ architecture. Optimized for high speed 286, 386, and PS/2 computers, Plus Passport products feature Hyperwrite™ for faster disk writing and a read-ahead buffer for faster data retrieval. These products provide effective access times of 28 ms, bringing high performance to the removable mass storage market. The MTBF of the Plus Passport hard drives is 60,000 hours, four to five times higher than the MTBF of other removable disk drive products.

In November 1988, Plus announced a third product category with the Plus Impulse hard disk drive systems for PC LANs. These products provide an unequalled combination of performance, expandability, and reliability for LAN environments and disk-intensive applications such as database, accounting, and CAD programs. The Plus Impulse system includes a 3 1/2-inch form factor hard disk drive with 40 or 80 megabytes of formatted capacity, and a 16-bit bus adapter card. It features Plus' proprietary Cluster Disk Interface™ which allows LAN administrators to configure the PC LAN initially with the amount of storage required and to incrementally increase the storage capacity of the LAN as required, up to 32 drives. The Plus Impulse system features exceptionally high LAN throughput rates with an effective access time of 12 milliseconds and a data transfer rate of up to 4 megabytes per second.

All Plus products are designed by Plus for manufacture in Japan by Quantum's manufacturing partner, Matsushita Kotobuki Electronics Industries Ltd. (MKE).

Product Development

Quantum operates in an industry noted for rapid technological changes. Accordingly, the Company is committed to the development of new products and the continuing evaluation of new technologies. Achieving efficient volume production of new products, and maintaining the efficiency of current manufacturing lines, requires a continuous investment of engineering resources in the development of tooling, production processes, and specialized test equipment.

The Company is currently concentrating much of its product development efforts on the higher capacity products (>100 megabytes) in the ProDrive Series of high performance, 3 1/2-inch disk drives. In addition, other 3 1/2-inch disk drive products in a variety of capacities are under development. For the three fiscal years ended March 31, 1988, 1987, and 1986, the Company's research and development expenses were $12,067,000, $11,499,000, and $11,298,000, respectively.

Manufacturing

Quantum is committed to manufacturing excellence and to developing and maintaining a manufacturing strategy which will give the Company a competitive edge in the disk drive industry. Quantum attributes its business success to the ability to quickly achieve high-volume production of reliable, cost-effective products. Rapid transition from product development to volume production reflects the Company's integrated approach to engineering and manufacturing. The approach involves developing product designs concurrently with production processes, applying proven technologies, and using readily available components in innovative ways.

Quantum currently enjoys a manufacturing partnership with Matsushita Kotobuki Electronics Industries, Ltd. (MKE), a Japanese firm renowned for its sophisticated, high volume, electromechanical manufacturing capabilities. MKE has produced all three generations of the Plus Hardcard products and is producing the 42, 84, and 105 megabyte ProDrive Series drives and the new Plus Passport removable hard disk drive systems.

The relationship with MKE has been rewarding, yielding products with consistently high quality and reliability, at competitive costs. To achieve higher production efficiencies, Quantum and MKE have worked together to develop manufacturing techniques, tools, and test equipment which reduce the labor and parts requirements for Quantum's products.

Quantum also operates a manufacturing facility in Milpitas, California. This facility is currently used to produce Quantum Q200 Series drives which are being phased out as the company transitions to the 3 1/2-inch form factor. This manufacturing facility will subsequently be used for pilot production of the higher capacity products in the ProDrive Series. This manufacturing line uses continuous-flow processing and automated work stations to increase output and production yield while reducing labor and work-in-process inventories. A Class 100 clean room controls environmental conditions in the final assembly area.

Two previous generations of Quantum hard disk drives, the Q2000 8-inch drive and the Q500 5 1/4-inch drive, were produced at the Company's manufacturing facility in Ponce, Puerto Rico. These products have been discontinued, and the Puerto Rico plant was closed in December, 1987.

Marketing

During fiscal 1988, Quantum Corporation's largest customers were Apple Computer and Microamerica, which accounted for approximately 39% and 11% of sales, respectively. By the second quarter of fiscal 1989, Apple Computer, Commodore, Memorex, and Tandy had chosen Quantum ProDrive Series drives to be used in a variety of their systems, and a number of other large OEMs have begun placing initial orders for ProDrive Series drives. The Company's OEM and VAR customers typically enter into 12 to 24-month agreements which provide for volume discounts if certain purchase levels are met.

Quantum's OEM products are sold domestically through the Company's own sales force and through independent distributors, such as Arrow Electronics, Inc. and Marshall Industries. Export sales are made to OEMs in Europe through direct sales personnel and through independent foreign distributors.

Plus Development markets its products through more than 2,500 dealers worldwide. In the U.S., Plus sells directly to the largest computer retailers and serves independent retailers and value-added resellers through independent distributors. Outside of the U.S., Plus sells its products through a network of independent distributors in Canada, Europe, Asia, and Latin America.

Quantum maintains OEM sales offices in Santa Clara, California; Salem, New Hampshire; Austell, Georgia; Dallas, Texas; Berkshire, England; Paris, France; and Frankfurt, West Germany. In addition, Plus maintains sales offices in Los Angeles, and Redwood City, California; Burlington, Massachusetts; Danbury, Connecticut; Atlanta, Georgia; Dallas, Texas; Schaumburg, Illinois; St. Louis, Missouri; and Vienna, Virginia.

Backlog

The Company's order backlog at June 12, 1988, was approximately $23.3 million, compared with approximately $31.6 million at June 14, 1987. The decrease in the backlog was due primarily to the ramping down of Q200 orders and the Company's transition to the 3 1/2-inch ProDrive product line. Backlog includes only firm orders for which delivery has been specified by the customer for shipment within six months. For this reason, and because of the possibility of customer changes in delivery schedules or cancellations of orders, Quantum's backlog as of any particular date may not be representative of actual sales for any succeeding period.

Competition

Quantum faces competition from several manufactures in each market segment. The main competition for the Company's new 3 1/2-inch disk drives is expected to come from Conner Peripherals, Control Data Corporation, MiniScribe, Rodime, and Seagate. Competition in this market is based primarily on product and vendor reliability, performance, price, and product availability.

Plus has become the dominant supplier of hard disk expansion boards for personal computers and has shipped over 400,000 Hardcard products to date. Plus faces competition from up to 30 other companies. However, no competitor has matched the combination of speed, reliability, capacity, convenience, and compactness offered by the Plus Hardcards. Plus currently holds about 80% of the board-mounted hard disk market.

The Plus Passport faces competition from other removable hard disks as well as from flexible disk cartridge systems. Major competition is expected to come from Iomega's flexible disk cartridge systems and Tandon's removable hard disk. Competition in the removable mass storage market is based primarily on performance, reliability, versatility, and price. Like the Hardcard products, the Plus Passport systems offer an unmatched combination of performance, reliability, and versatility.

The Plus Impulse faces competition from other LAN server disk drive suppliers and from some general purpose PC manufacturers who market manufacturer-installed disk drives in

their PCs. Major competition is expected from Storage Dimensions (a Maxtor subsidiary) in LAN server disk drives and from Compaq Computer Corporation in the manufacturer-installed disk drive category. Competition in the LAN disk drive market is based primarily on performance, scalability of capacity, breadth of compatibility, and price. The Plus Impulse products offer an unmatched combination of performance, expandability of capacity, and compatibility.

Patents and Licenses

Quantum owns 13 and Plus owns 3 United States Registered patents. The first of these patents was reissued by the Patent and Trademark Office of the U.S. Department of Commerce on January 28, 1986. The Company and Plus also have several foreign patents and pending United States and foreign patent applications.

The Company has a cross-licensing agreement with IBM which commenced on March 10, 1986 and runs until the expiration of the last IBM patent. The agreement allows Quantum to use certain patents owned by IBM and IBM to use certain patents owned by Quantum.

Patent Litigation

Quantum Corporation has favorably settled patent litigation in several instances resulting from infringement of one or more of its patents. Two specific patents have been the subjects of this litigation: a Quantum patent, U.S. Reissue Patent Number Re. 32,075; and a Plus Development patent, U.S. Patent Number 4,639,863.

Quantum's patent Re. 32,075 covers a unique wedge-servo disk architecture used in Quantum's disk drives. The patented features give Quantum's products a high degree of data recording and retrieval accuracy and provide storage capacity at a lower cost than traditional servo designs. The patent was originally issued in 1983 under patent number 4,369,959, and was subsequently reissued by the U.S. Patent Office in 1986.

Plus Development's patent 4,639,863, issued in January 1987, covers the hard disk expansion board product category Plus pioneered with its popular Hardcard products. The original Plus Hardcard was the first hard disk drive on a plug-in expansion board for personal computers. The Plus Hardcard products provide personal computer users with an easy-to-install means of upgrading the performance and storage capacity of their computers.

In January 1986, Quantum received $6,000,000 as a result of settlement of litigation against Computer Memories, Inc., a Chatsworth, California disk drive manufacturer. As part of the settlement, CMI agreed to cease the manufacture and sale of its CM6000 Series 5 1/4-inch rigid disk drives and was permanently enjoined from manufacturing and selling any product within the scope of the technology claimed in Quantum's patent, U.S. Reissue Patent Number Re. 32,075.

In October 1987, Quantum received $2,975,000 as a result of settlement of litigation against NEC Corporation, NEC Information Systems (NECIS), and Mountain Computer, Inc. The settlement followed a court order that granted Quantum's motion for summary judgment of infringement and ruled that NEC and NECIS infringed Quantum's patent Re. 32,075. In making the determination of infringement, the court ruled that NEC disk drive products, specifically NEC's D5126 (5 1/4-inch) and D3126 (3 1/2-inch) products, used

the wedge-servo architecture covered in Quantum's patent. In addition, as part of the settlement agreement, the defendants agreed to discontinue the manufacture and sale of products that infringed upon Quantum's patent.

In 1988, Quantum favorably settled litigation against Mountain Computer, Inc., concerning the Plus Hardcard patent, U.S. Patent Number 4,639,863. As part of the settlement agreement, Mountain agreed to pay Quantum an undisclosed cash settlement and to discontinue the manufacture and sale of its Drivecard product line.

Quantum currently has two suits pending. A suit pending against Western Digital Corporation, Irvine, California, alleges willful infringement of both Quantum's patent Re. 32,075 and Plus' patent 4,639,863. Filed in May 1988, the suit charges that Western Digital's Filecard, and certain disk drive products Western Digital acquired from Tandon as part of Western Digital's acquisition of Tandon's disk drive business, violate these two patents. In September 1988, Quantum filed suit against Tandon Corporation, Chatsworth, California. This suit alleges that certain products produced and/or sold by Tandon have also violated both the Quantum and Plus patents.

Employees

As of January 1989, the Quantum Corporation employed 551 persons, including 138 in engineering, 246 in manufacturing, 104 in marketing and sales, and 63 in general management and administration.

Properties

The Company's principal executive, administrative, manufacturing, and engineering operations are located in 5 modern buildings totalling approximately 178,000 square feet and located in Milpitas, California. Leases on these facilities expire in 1991. The Company also leases small domestic and international sales offices, typically on a short-term basis.

QUANTUM CORPORATION

Management Profiles

Stephen M. Berkley — **Chairman of the Board and Chief Executive Officer**

Mr. Berkley joined Quantum in October 1981 as vice president of marketing. In November 1983, he became the founding president of Plus Development Corporation, the Company's then majority-owned subsidiary. Mr. Berkley succeeded James L. Patterson as Chairman of the Board of Quantum and Chief Executive Officer in May 1987 and assumed immediate overall responsibility for managing the Company. Previously, Mr. Berkley served four years as an officer of Qume Corporation, including vice president and general manager of the Memory Product Division.

David A. Brown — **President and Chief Operating Officer, Quantum**

Mr. Brown has been with the Company since its inception in February 1980, initially serving as vice president of engineering. In 1983, he became a cofounder and executive vice president of operations at Plus Development Corporation, Quantum's then majority-owned subsidiary. He returned to Quantum in September 1986 to lead the engineering organization and direct the Company's thrust into the 3 1/2-inch disk drive market. Mr. Brown has been active in the disk drive business since 1970, serving in various engineering and management positions at Memorex Corporation and Shugart Associates. He owns several patents relating to disk drive design.

Joseph T. Rodgers — **Executive Vice President, Finance Secretary and Treasurer**

Mr. Rodgers joined Quantum in December 1980 as vice president of finance and was elected secretary in May 1981 and treasurer in September 1981. Mr. Rodgers became executive vice president in April 1986. Previously, Mr. Rodgers served as vice president of finance at Braegen Corporation, assistant vice president of finance at Plantronics Corporation, and vice president of finance, secretary, and treasurer at Consolidated Video Systems. In addition, he spent over nine years in management positions at Price Waterhouse.

Jeffrey Heimbuck — **President, Plus Development Corporation**

Mr. Heimbuck joined Plus Development Corporation as president in July 1988. Prior to joining Plus, Mr. Heimbuck was a venture capital partner with Montgomery Securities and sat on the boards of several companies in the PC industry. Previously, Mr. Heimbuck served as president and Chief Executive Officer of Koala Technologies and senior vice president of marketing and engineering at Atari Products. In addition, he held vice president of marketing positions at Joseph E. Seagram & Sons and Paul Masson Vineyards prior to entering technology industries.

QUANTUM CORPORATION

Financial Summary

($ Millions Except Per-Share Amounts)

Fiscal Year	Revenue	Net Income (Loss)	Earnings (Losses) Per Share
1986			
1Q	$ 34.0	$ 5.7	$ .60
2Q	29.0	4.4	.45
3Q	30.5	5.2	.54
4Q	27.7	6.9 (a)	.71 (a)
Year End	$ 121.2	$ 22.2	$ 2.30
1987			
1Q	$ 25.3	$ 2.5	$ .25
2Q	29.6	2.7	.30
3Q	34.0	0.7 (b)	.08 (b)
4Q	31.9	2.9	.32
Year End	$ 120.8	$ 8.8	$ .95
1988			
1Q	$ 40.2	$ (3.5) (c)	$ (.38) (c)
2Q	49.5	4.0 (d)	.44 (d)
3Q	56.6	4.7	.51
4Q	42.2	(8.4) (e)	(.86) (e)
Year End	$ 188.6	$ (3.2)	$ (.35)
1989			
1Q	$ 38.9	$ 0.6	$ .06
2Q	$ 39.8	$ 2.0	$ .20
3Q	$ 51.6	$ 3.3	$ .36

(a) Includes $6 million pretax settlement from patent litigation.

(b) Includes $3 million pretax charge for plant closing.

(c) Includes $3.5 million pretax charge for discontinuance of product.

(d) Includes $2.98 million pretax settlement from patent litigation.

(e) Includes $13.2 million pretax charge for write-down of excess manufacturing capacity.

SUMMARY OF ANALYST'S FORECASTS FOR YEARS ENDING MARCH 31, 1989 AND 1990

	Revenue (millions)					Earnings Per Share					1990	
	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Sales	EPS
Harvey Allison Wertheim & Co.	$39	$40	$51	$48	$178	$.06	$.20	$.36	$.30	$.92		
Dave Claridge Hambrecht & Quist	39	40	51	51	181	.06	.20	.36	.25	.87		
Ron Elijah Robertson, Colman & Stephens	39	40	51	50	180	.06	.20	.36	.38	1.00		
Gerard Hallaren (Consultant)	39	40	51	56	186	.06	.20	.36	.36	.98	$234	$1.28
Alexa McGloughan Goldman Sachs	39	40	51	57	187	.06	.20	.36	.40	1.02	245	1.60
Andy Neff Bear Sterns	39	40	51	58	188	.06	.20	.36	.42	1.04	258	1.35
John Rossi Alex Brown	39	40	51	55	185	.06	.20	.36	.41	1.03	250	1.70
Rick Ruvkin Morgan Stanley	39	40	51	60	190	.06	.20	.36	.38	1.00	240	1.50
Adams, Harkness & Hill	39	40	51	54	184	.06	.20	.36	.29	.91	245	1.55
Jim Stone (Consultant)	39	40	51	53	183	.06	.20	.36	.28	.90	226	1.23
Tom Rood Value Line	39	40	51	46	186	.06	.20	.36	.29	.91	220	1.50
Charles Wolf First Boston Research	39	40	51	60	190	.06	.20	.36	.35	.97	216	1.61
AVERAGE	**$39**	**$40**	**$51**	**$54**	**$184**	**$.06**	**$.20**	**$.36**	**$.34**	**$.96**	**$237**	**$1.48**

JTR 2/10/89

MICROCOMPUTERS AND PERIPHERALS
John T. Rossi

Quantum Physics--Out of phase doesn't equal out of sync

The O'Neil chart of Quantum Corporation presents a curious image when viewed against a backdrop of charts of other drive companies. Even though the drive companies have generally traded as a group, the progress of Quantum stock has almost always defied the group trend. In the December quarter of 1984, when the market laid waste to the drive stocks, and Seagate bottomed at $4 a share, Quantum traded as high as 23--a symbol of strength amid weakness. The drive stocks' glory days of 1986 brought a reversal: as Seagate surged upward from 7 to 21 (on its way to 45 in 1987), Quantum stock slumped, beginning the year at 28 and ending it at 19.

The generally disappointing June 1988 quarter marked a new inflection point for the drive group. Investors, anxious over signs of price competition and overcapacity in the industry and shaken by weak quarterly earnings reports, began to beat a hasty retreat from the drive stocks in July. After hitting highs for the year of 16, 30, 14, and 23, Maxtor, Micropolis, Miniscribe, and Seagate shares traded off to 8 1/8, 12 1/2, 11 3/8, and 10 3/8, respectively, by August 7. Quantum, in keeping with its peculiar tradition, bucked the trend

again, staying in a relatively narrow 10-11 price range through most of early summer.

At this juncture, the immediate future for the drive group appears clouded, uncertain at best. Yet, if the past is of any value as a guide, Quantum's fortunes may begin to look up in this setting.

Quantum's past countercyclical behavior has not come as a mere quirk nor as something mandated by market technicalities; the Company has generally run on a different development schedule than the rest of the industry. In 1983 and 1984, as the rest of the industry pushed forward with research and development programs for half-height 20-megabyte and full-height 85-megabyte 5 1/4-inch drives, Quantum harvested the bounty from established 40-megabyte 8-inch and 5 1/4-inch full-height products. In 1985, as other firms focused on mainstream products, Quantum, through its Plus subsidiary, introduced a patented hard-disk expansion board, Hardcard, for the PC aftermarket. In 1986, instead of sticking with the full-height form factor, ST506 interface, and oxide media for a high-capacity drive, Quantum forced itself into what looked like an ill-timed transition to the half-height form factor, thin-film media, and embedded SCSI interface for the Q200.

Countercyclicality was not only a trait of Quantum's product development, but also of its manufacturing strategy. In 1985 and 1986, as other companies rushed to manufacture offshore, mainly in Singapore, Quantum began winding down its Puerto Rican plant. In 1987, as the rest of the industry undertook a large capacity build-up, Quantum shut down or wrote down nearly all of its manufacturing capacity.

Now it looks as though Quantum's course may end up demonstrating what every commuter knows, that the highway is not always the best way. For instance, the issues of overcapacity and price competition hanging over the rest of the drive industry could have limited impact on Quantum. The Company has already purged its balance sheet and is not a likely candidate for further write-downs; at this point, the Firm has only $36 million in operating assets (accounts receivable, inventories, and PP&E) to produce annual revenues approaching $200 million. Moreover, two of the company's products--Hardcard, the hard-disk expansion board for IBM standard compatibles, and Passport, a removable, high-performance hard-disk drive--sell into specialized markets and are protected by patents and patents pending.

Where the Company will compete directly against mainstream drive manufacturers is in the market for new-generation 3 1/2-inch drives--small drives with thin-film media, embedded controllers, more than 40 megabytes' storage capacity, and access times of less than 30 milliseconds. Although generally viewed as a dark horse in the race for 3 1/2-inch drive market share, the Company is remarkably well positioned. From the Hardcard products, Quantum has gotten as much experience with high-density 3 1/2- inch drives as any company. Moreover, from both the Hardcard and Q200 programs, the Firm has developed the skills for designing thin-film-media equipped drives, embedded SCSI interfaces, and compact, surface-mount-device equipped boards.

The culmination of these various efforts is Quantum's Prodrive. With capacities of 40 and 80-megabytes, access time of 19 milliseconds, mean time between failure of 50,000 hours, and data transfer rate of 16 megabits per

second (asynchronous mode), Quantum's Prodrive series has the best performance of any 3 1/2- inch drives currently in volume production. In addition, the Prodrive requires fewer expensive recording components than rival products--only two disks and three heads to achieve storage of 40 megabytes, compared to three disks and six heads for some competing products.

What the Company does not have, by design, is production capacity for the Prodrive. The product will be manufactured by the Company's manufacturing partner of the past three years, Matsushita Kotobuki Electronic. Accordingly, Quantum stands to benefit from the potential explosion of demand for new-generation 3 1/2-inch drives, but has avoided the pitfalls of a "bet the ranch" manufacturing strategy.

With the Q200 winding down, the Hardcard products leveling off, and the brand-new Passport likely serving the needs of a collection of high-data-security niche markets, the Prodrive emerges as the key to Quantum's revenue growth, and therein lies the risk. Currently, the drive is in evaluation programs at 35 personal-computer, workstation, and communications companies. Although Quantum has won Tandy as a customer for the drive, in the main, demand visibility for the Prodrive remains unclear.

Without doubt, the critical account for the Prodrive to win for Quantum is Apple. In Quantum's fiscal 1988 (March), Apple's purchases of the Q200 for the use in the Macintosh II microcomputer accounted for 39 percent of Quantum's sales. Although Quantum has received follow-on orders from Apple for the Q200 that extend through the December 1988 quarter, shortly thereafter Apple will shift completely to 3 1/2-inch drives for the Macintosh II.

Currently, Apple is evaluating 40- and 80-megabyte drives for both the Macintosh SE and the Macintosh II. The list of potential suppliers is long: CDC, Conner Peripherals, Miniscribe, Quantum, Seagate, and others. At this point, we believe that Seagate has already passed qualification tests for its 40-megabyte drive and may begin shipping product to Apple in the September quarter. Quantum began the qualification process after Seagate, and news of Apple's acceptance of the Prodrive might not come until early fall. At this point, however, because of Quantum's strong current relationship with Apple and the superior performance of the Prodrive, Quantum appears likely to emerge as the primary supplier of 80-megabyte 3 1/2-inch drives and one of two suppliers of 40-megabyte drives to Apple.

With so much depending upon the fate of the Prodrive and the fate of the supply relationship with Apple, an investment in Quantum at this point is a calculated gamble. Although a gamble, the downside risk would seem to be limited. At the end of the June quarter, several fundamental measures presented a compelling picture for capital-conservation-minded investors. Book value was $11.41 per share, tangible book value was $10.43, and cash per share was $9.21 (before deduction of items senior to common), with no long-term debt. The fundamental value of the Company should continue to give the stock solid protection against downside risk.

Because of Quantum's strong fundamental valuation, the protected positions of the Company's retail products, and the promise of the Prodrive, we continue to recommend purchase of the stock, despite the woes of the most of the drive industry. We estimate EPS of $0.80 on sales of $192 million in fiscal 1989,

but point out that our sales forecast depends on Quantum's capture of key accounts for the Prodrive. In the December quarter, with strong seasonal sales of the Hardcard and Passport and the capture by the Prodrive of follow-on business with Apple, we envision the stock regaining momentum and moving into the lower end of its historical, pre-crash trading range of 15-35, and perhaps again defying the trend of the rest of the drive group.

Equity Research

First Boston

Industry Personal Computers
August 26,1988
MI2551

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Quantum Corp. QNTM

Quantum Receives the Apple Order; Moving from a Hold to a Buy and Raising Estimates; Opinion: BUY

Price 8/26/88[1]		Earnings Per Share[2]	P/E Ratios	Div'd Yield	52-Week Price Range
12¼	1990E	$1.25	9.8X	—	18¾–8
	1989E	0.80[3]	15.3	—	
	1988A	(0.35)			

Common Shares	10.0 mil.	**L.T. Debt as % Total Capital**	0%
Market Value	$123 mil.	**Return on Average Equity**	15%
Book Value/Share	$11.40	**Est. Future EPS 5 Yr. Growth Rate**	10–15%

[1]On 8/26/88 the DJIA closed at 2017.4 and the S&P 400 at 298.0
[2]Fiscal year ends March 31
[3]Previous estimate $0.75

Summary and Recommendation

Quantum announced yesterday that it had received an order from Apple Computer for its new ProDrive family of mass storage drives. This is undoubtedly the largest order in the company's history and creates the possibility of significant upside surprises in earnings, beginning in the December quarter and extending through fiscal 1990.

Consequently, we are raising our opinion from a Hold to a Buy and increasing our fiscal 1989 estimate from $0.75 to $0.80. Our initial estimate of fiscal 1990 earnings is $1.25. We believe this number is conservative. There continues to be minimal downside risk in the stock, since Quantum has $9.25 per share in free cash.

Discussion

The magnitude of the Apple order depends on whether the ProDrive, Quantum's new high-performance 3½-inch 40- and 80-megabyte drive family, is bundled with both the Macintosh II and Macintosh SE. The company was vague on this question. In its release, Quantum said ProDrive is "for use in various Apple products." One of our more reliable sources indicated that the ProDrive 40 will be bundled with the Mac SE 2/40, to be introduced this fall. Our estimates assume, however, that the ProDrive is configured only with the Macintosh II and, further, that Apple ships only 40-50% of Mac IIs bundled with a ProDrive.

We estimate that Apple could ship 300,000 Mac IIs in calendar 1989 (the Mac II run rate was 200,000 annualized for the June 1988 quarter). This translates, then, into 130,000-150,000 unit shipments of the ProDrive to Apple.

The potential number of ProDrives configured with Macintosh IIs could well exceed the 150,000 shipped directly to Apple. Many buyers purchase a hard disk drive separately, because they can obtain the same drive from a distributor at a significantly

Quantum Corp. QNTM

lower price. When Apple private-labels a peripheral and bundles it with a computer, it marks the price up almost 100%. In contrast, distributors and computer resellers are willing to work for much smaller margins. As many as 50,000 additional ProDrives might be configured with the Mac II by third parties.

Quantum has received a number of other major orders for the ProDrive. Tandy will configure the ProDrive with its Models 3000, 4000, and 5000 IBM-compatible computers, and Commodore International announced earlier this week that it will bundle the ProDrive with its computers, most likely the Amiga. Quantum indicated that Commodore's order is likely to be the third-largest the company has received, behind Apple's and a DEC order back in 1984. It is estimated that Commodore could ship 500,000 Amigas during the coming year, although it is unlikely that the ProDrive will be configured with the more popular Amiga 500.

In addition, Arrow Electronics and Marshall Industries will distribute the ProDrive to computer resellers and other OEMs. We expect additional orders for the ProDrive to materialize before the end of 1988, since it is at the beginning of a product cycle that could last two or more years.

In contrast with its ill-fated Q200 family of 5¼-inch 40- and 80-megabyte drives, Quantum should earn respectable (20%) gross margins on the ProDrive quite quickly. This is because Matsushita Kotobukei Electronics will manufacture it. MKE has over three years of experience manufacturing the Hardcard, a 3½-inch hard disk card, sold by Plus Development, a Quantum subsidiary. MKE achieved yields of 99% on the Hardcard. Yields on the ProDrive are reported to already exceed the highest yields typically achieved by other drives throughout their product cycles.

Since it is a performance leader in the 3½-inch mid-capacity market, the ProDrive should be relatively immune from the price competition that has racked the 5¼-inch 80-megabyte market. Moreover, once it undertakes the customization required to configure a particular drive with its computers, a manufacturer has a economic incentive to stay with the drive as long as it delivers competitive price/performance.

To add luster to the 1990 Quantum story, initial sales of the company's new removable hard disk product, Passport, have exceeded company expectations. A Passport removable drive holds the equivalent of up to 50 floppy disks and is targeted at the government and other markets where data security and portability are important features.

Our fiscal 1990 Quantum estimate assumes that the company will ship about 250,000-275,000 ProDrive hard disks. If Apple configures the ProDrive with the Mac SE, the number shipped could well exceed this estimate. This suggests there is room for upside surprises in the Quantum story in calendar 1989.

With orders from Apple, Tandy, and Commodore, Quantum has clearly achieved a competitive edge in the 3½-inch mid-capacity hard disk drive market. The company's ability to leverage this into a more permanent competitive position through the timely introduction of higher-capacity drives in 1989 will determine whether this is simply a trading opportunity or provides more permanent capital appreciation opportunities.

With $9.25 in free cash, a positive cash flow, minimum working capital needs, and no long-term debt, there is limited downside risk in Quantum at the current time.

N.B.: The First Boston Corporation makes a primary market in issues of Quantum Corp. and Apple Computer. August 26, 1988 closing prices

Apple Computer (AAPL)	40¼	Digital Equipment (DEC)	93⅞
Arrow Electronics (ARW)	8¼	Marshall Industries (MI)	15
Commodore Int'l (CBU)	12	Tandy Corp. (TAN)	39⅞

Table 1
Estimated 1989 and 1990 Results

$ in millions, except per share data

	Year ended March 31							% Increase (decrease)					
	Actual					Estimated		1985 vs. 1984	1986 vs. 1985	1987 vs. 1986	1988 vs. 1987	1989 vs. 1988	1990 vs. 1989
	1984	1985	1986	1987	1988	1989	1990						
Net sales	$67.1	$120.3	$121.2	$120.8	$188.5	$175	$199	79%	1%	0%	56%	-7%	13%
Less:													
Cost of sales	41.1	73.7	72.9	79.3	148.0	132	148	79	-1	9	87	-11	12
Marketing	4.0	5.4	10.7	13.8	17.0	18	19	33	97	30	23	7	4
General & adm	2.9	5.3	4.9	6.4	6.6	7	7	79	-7	31	4	4	8
Research & dev	3.2	7.2	11.3	11.5	12.1	12	13	128	57	2	5	2	5
Operating income	$15.8	$28.8	$21.5	$9.8	$4.9	$6	$11	82	-25	-54	-51	26	85
Int/other income	3.4	1.9	10.3	1.1	(9.0)	6	8	-46	457	-89	NM	NM	27
Pretax income	$19.2	$30.7	$31.8	$10.9	($4.2)	$12	$19	60	4	-66	NM	NM	55
Income tax	8.6	9.7	9.6	2.1	(2.1)	4	7	13	-1	-78	NM	NM	55
Effective tax rate	44%	32%	30%	19%	NM	35%	35%						
Net income	$10.7	$21.0	$22.2	$8.8	($2.1)	$8	$13	97	6	-60	NM	NM	55
Less:minority interest					(1.1)								
Net income	$10.7	$21.0	$22.2	$8.8	($3.2)	$8	$13	97	6	-60	NM	NM	55
Earnings per share	$1.12	$2.19	$2.30	$0.94	($0.35)	$0.81	$1.26	96	5	-59	NM	NM	55
Avg shares outstanding	9.5	9.6	9.7	9.4	9.3	10.0	10.0						
Percent of sales													
Gross margin	38.7%	38.8%	39.9%	34.4%	21.5%	24.8%	25.5%						
Cost of sales	61.3	61.2	60.1	65.6	78.5	75.2	74.5						
Marketing	6.0	4.5	8.8	11.4	9.0	10.4	9.5						
General & adm	4.4	4.4	4.0	5.3	3.5	3.9	3.8						
Research & dev	4.7	6.0	9.3	9.5	6.4	7.0	6.5						
Operating income	23.5	23.9	17.8	8.1	2.8	3.5	6.6						
Pretax tax	28.7	25.5	26.3	9.0	-2.2	7.1	9.7						
Net income	15.9	17.4	18.3	7.3	-1.7	4.6	6.3						

Table 2
1989 Sales/Earnings Forecast

units in thousands $ in millions, except per share data

	Act.	Estimated				
	89/1	89/2	89/3	89/4	1989	1990
Sales						
ProDrive	$2	$2	$14	$25	$44	$126
Q200	22	20	10	4	55	0
Hardcard	15	14	17	9	55	33
Passport	2	5	8	8	24	39
Total	$38.9	$40	$49	$47	$175	$199
Less:						
Cost of sales	29.6	31	36	35	132	148
Marketing	4.7	5	5	5	18	19
General & administrative	1.7	2	2	2	7	7
Research & development	3.3	3	3	3	12	13
Operating income	($0.4)	$0	$4	$2	$6	$11
Interest/other income (b)	1.4	2	2	2	6	8
Pretax income	$0.9	$2	$6	$4	$12	$19
Income taxes	0.3	1	2	1	4	7
Effective tax rate	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
Net income	$0.6	$1	$4	$3	$8	$13
Earnings per share	$0.06	$0.12	$0.36	$0.27	$0.81	$1.26
Average shares	10.1	10.1	10.0	10.0	10.0	10.0
Percent of sales						
Gross margin	23.9%	23.5%	26.7%	24.8%	24.8%	25.5%
Cost of sales	76.1	76.5	73.3	75.2	75.2	74.5
Marketing	12.0	11.1	9.1	9.7	10.4	9.5
General & administrative	4.5	4.2	3.6	3.7	3.9	3.8
Research & development	8.6	7.4	6.1	6.4	7.0	6.5
Operating income	-1.1	0.8	7.9	5.1	3.5	5.7
Pretax income	2.4	4.5	11.3	9.0	7.1	9.7
Net income	1.5	2.9	7.3	5.8	4.6	6.3

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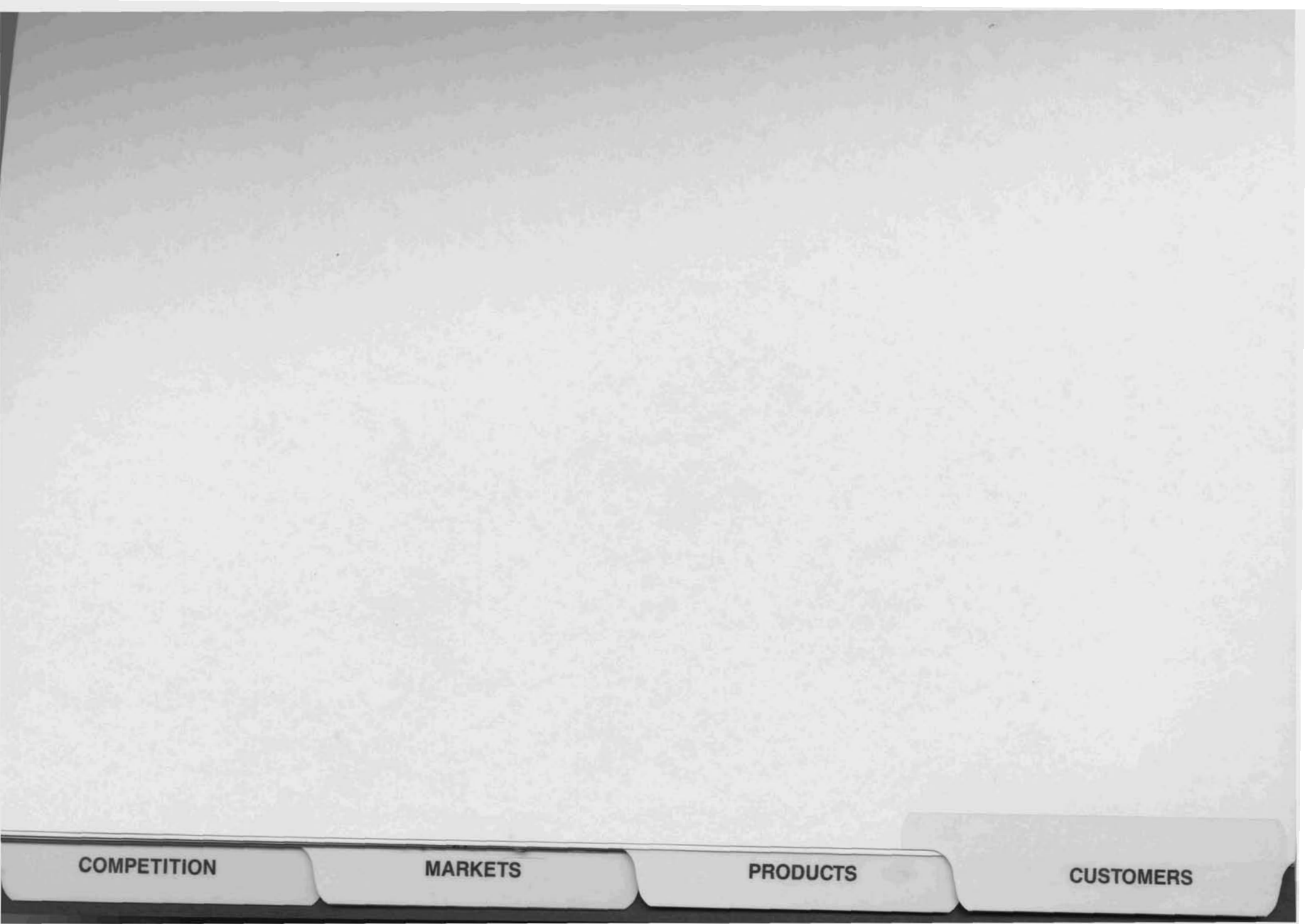
COMPETITION
MARKETS
PRODUCTS
CUSTOMERS

QUANTUM CORPORATION

Major Customers

ProDrive

Apple Computer

Arrow Electronics*

Commodore

Marshall Industries*

Memorex

Tandy

Q200

Apple Computer

Arrow Electronics*

Convergent

General Computer

Intergraph

Marshall Industries*

Olivetti

Siemens

* Quantum Distributors

PLUS DEVELOPMENT CORPORATION

WORLDWIDE DISTRIBUTION

September, 1988

Plus Development has 30 direct U.S. customers which represent over 6,500 retailers and value-added-resellers (VARS). Additionally, the company has distributors in another 27 countries who market its products to approximately 1800 dealers.

U.S. Distributors/Direct Dealers

Basic Computer Corp.
Bohdan Associates, Inc.
Businessland Corp.
Compu Com Systems, Inc.
Compushop
The Computer Factory
The Computer Shoppe
Computercraft
Computerland
Corporate Software Comp.Cntr
Data Systems Comp. Centre
Egghead Software
Entre Computer Centers
Forsythe Computers, Inc.
47th Street Computers
Gateway Computer Systems, Inc.
Government Technology Services, Inc.
Inacomp CA
Inacomp GA
Inacomp IL
Inacomp MI
Microamerica
Micro Center
Microage Computer Stores, Inc.
Nynex Business Centers
Pactel Information Systems
Sears Roebuck & Company
Softsel
Software Spectrum
Valcom, Inc.

International Distributors

Tech Pacific Pty Ltd.	Australia
Computer 2000 Ges.mbH	Austria
N.V. Positronika S.A.	Belgium
Adespro Informatica	Brazil
Compuserve	Canada
Computer Innovations (Computerland)	Canada
Datateam/DT Denmark A/S	Denmark
Businessman Oy	Finland
La Commande Electronique	France
Imagineering Micro Distributors Ltd.	Hong Kong
Imagineering	Indonesia
Editrice Italiana Software	Italy
IMD Korea Ltd. (Imagineering)	Korea
International Microsystems BV	Latin America (except Brazil)
Imagineering SDN. BHA.	Malaysia
Positronika Microsystems BV	The Netherlands
Tech Pacific Pty. LTD.	New Zealand
Datateam Norg	Norway
SKV International, Inc.	Phillipines
HSC Iberia LDA.	Portugal
Imagineering Micro Distributors PTE. LTD.	Singapore
HSC Industrial S.A.	Spain
Expander Informatic	Sweden
Computer 2000 AG	Switzerland
Imagineering Micro Distributors LTD.	Taiwan
Imagineering	Thailand
Computer Marketing PLC.	United Kingdom & Ireland
Computer 2000 AG	West Germany

COMPETITION

MARKETS

PRODUCTS

oDrive
S/80S
½ inch
sk Drives

42 and 84 Megabyte Formatted Capacity, 3½-inch Disk Drives with Integrated SCSI Controller

The ProDrive 40S and 80S are two drives in the ProDrive Series from Quantum, a broad family of 3½-inch disk drives with formatted capacities from 42 to 168 megabytes. Available with a choice of interfaces, all drives in the ProDrive Series provide the high performance and exceptional reliability you expect from Quantum products.

Quantum's ProDrive Series disk drives are the fourth generation of 3½-inch products from Quantum. With its subsidiary, Plus Development Corporation, Quantum pioneered the 3½-inch hard-disk-on-a-card product concept and successfully marketed the resulting Hardcard™ products through retail channels. With more than 300,000 shipped since 1986, these 3½-inch drives have earned a reputation for quality and reliability. The field proven Mean-Time-Between-Failure of the Hardcard products exceeds 70,000 hours.

The Quantum ProDrive Series combines the premier features of Quantum's Q200 Series™ of 5¼-inch intelligent disk drives, proven Hardcard technology, and Plus Development's design experience and manufacturing expertise in 3½-inch products. With features such as Quantum's proprietary DisCache™ buffer management system for faster access times, and patented AIRLOCK® automatic shipping lock, Quantum's ProDrive Series is again setting the standard.

High performance and exceptional reliability... the ProDrive Series from Quantum.

Performs Like a Pro

- 19 ms typical seek time
- DisCache™: 64K-byte Look Ahead Disk Caching with user programmable options
- Synchronous (4 Mbytes/sec) and asynchronous (2 Mbytes/sec) SCSI data transfer rates
- 1:1 Interleave
- Track and cylinder skewing to minimize rotational latencies
- Multiple block transfer up to 64K blocks

Runs Like A Pro

- 50,000 hour Mean-Time-Between-Failure
- Defect handling with user selectable options
  - In-line sector defect skipping
  - Reassignment of new defective sectors with no reformatting required
- Automatic retry for read errors
- Unrecoverable data error rate of 1 per 10^{14} bits read
- 48-bit ECC (Error Correcting Code) polynomial
- Patented AIRLOCK® shipping lock and dedicated landing zone
- 2 year warranty

SCSI COMMANDS

Format Unit	Request Sense
Inquiry	Reserve
Mode Select	Rezero Unit
Mode Sense	Seek
Read	Seek Extended
Read Buffer	Send Diagnostics
Read Capacity	Start/Stop Unit
Read Defect Data	Test Unit Ready
Read Extended	Verify
Read Long	Write
Reassign Block	Write Buffer
Release	Write and Verify

SPECIFICATIONS

Disk Drive Architecture	ProDrive 40S	ProDrive 80S
Capacity (formatted)	42 MB	84 MB
Heads	3	6
Disks	2	3
Track Format	28 and 35 sectors x 512 bytes	
Number of Data Zones	2	2
Tracks	2502	5004
Track Density (TPI)	1000	1000
Flux Density (FCI)	14,700	14,700
Recording Density (BPI)	22,050	22,050
Encoding Scheme	RLL 2,7	RLL 2,7

PERFORMANCE SPECIFICATIONS

Transfer Rates 2.0 Mbytes/sec Asynchronous
4.0 Mbytes/sec Synchronous

Seek Time (msec)	Typical
Average	19
Track-to-Track	6
Full Stroke	40

Seek times are at nominal environmental conditions and include settling.

DisCache™: 64K-byte Look Ahead Disk Cache with user programmable options.

*Effective access time with DisCache: 12 msec**

RELIABILITY SPECIFICATIONS

MTBF: 50,000 POH
PM: Not required
MTTR: 30 minutes
Component design life: 5 years

ERROR RATES
Soft Read Errors:*1 per 10^{10} bits read
Defect Read Errors: 1 per 10^{12} bits read
Unrecoverable Data Errors: 1 per 10^{14} bits read
Seek errors: 1 per 10^{6} seeks
*exclusive of ECC or retries

PHYSICAL SPECIFICATIONS

Mechanical Specifications:
Height: 1.625 in./41.3 mm
Width: 4.0 in./101.6 cm
Depth: 5.75 in./146.2 mm
Weight: 1.9 lbs./0.9 kg
50 pin dual in-line SCSI connector
4 pin industry standard power connector

Environmental Conditions:

	Operating	Non-oper
Temperature	4 to 50°C	−40 to
Humidity (non-condensing)	8 to 85% RH	5 to 95
Altitude	up to 10,000 ft.	up to 40,0
Shock (11 ms)	10 G	60 G
Vibration (peak to peak)	0.5 G	2.0 G

Power Requirements:
+5 VDC at: 0.5 A Idle
0.6 A 100% Seek
+12 VDC at: 0.5 A Idle
0.8 A 100% Seek
1.6 A Maximum at power on

Power Consumption:
Idle: 8 Watts
100% Seek: 10.5 Watts
Typical (30% seek): 9 Watts

*As with any caching scheme, actual performance depends on the application.

DOMESTIC OPERATIONS: Quantum Corporation, 1804 McCarthy Blvd., Milpitas, CA 95035, (408) 432-1100, TWX 910-338-2203, F (408) 943-0689; **Western Regional Office,** 4633 Old Ironsides Drive, Suite 270, Santa Clara, CA 95054, (408) 980-8555; **Southwest** 2659 Townsgate Road, Suite 101, Westlake Village, CA 91361, (805) 495-7955; **Eastern Regional Office,** 18 Pelham Road, Salem, NH (603) 893-2672; **Southeast Sales,** 2710 Jefferson Street, Austell, GA 30001, (404) 944-7442;
EUROPEAN OPERATIONS: Quantum GmbH, Hahnstrasse 70, D-6000 Frankfurt/M. 71, West Germany, (49)69-666-6167, Telex 417 Fax (49)69-666-1043. **Quantum Peripheral Products Ltd.,** Runnymede Malt House, Runnymede Road, Egham, Surry, TW20 9BO, E (011) 44-784-34377, Telex 919778, Fax (44) 784-31923.

Quantum

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roDrive
0AT/80AT
½ inch
isk Drives

42 and 84 Megabyte Formatted Capacity, 3½-inch Disk Drives with AT Bus Interface

The ProDrive 40AT and 80AT are two drives in the ProDrive Series from Quantum, a broad family of 3½-inch disk drives with formatted capacities from 42 to 168 megabytes. Available with a choice of interfaces, all drives in the ProDrive Series provide the high performance and exceptional reliability you expect from Quantum products.

Quantum's ProDrive Series disk drives are the fourth generation of 3½-inch products from Quantum. With its subsidiary, Plus Development Corporation, Quantum pioneered the 3½-inch hard-disk-on-a-card product concept and successfully marketed the resulting Hardcard™ products through retail channels. With more than 300,000 shipped since 1986, these 3½-inch drives have earned a reputation for quality and reliability. The field proven Mean-Time-Between-Failure of the Hardcard products exceeds 70,000 hours.

The Quantum ProDrive Series combines the premier features of Quantum's Q200 Series™ of 5¼-inch intelligent disk drives, proven Hardcard technology, and Plus Development's design experience and manufacturing expertise in 3½-inch products. With features such as Quantum's proprietary DisCache™ buffer management system for faster access times, and patented AIRLOCK® automatic shipping lock, Quantum's ProDrive Series is again setting the standard.

High performance and exceptional reliability... the ProDrive Series from Quantum.

Performs Like a Pro

- 19 ms typical seek time
- DisCache™: 16K-byte Look Ahead Disk Caching
- Data transfer rate up to 4 Mbytes/sec programmed I/O
- 1:1 Interleave
- Track and cylinder skewing to minimize rotational latencies
- Multiple block transfer up to 128K blocks

Runs Like A Pro

- 50,000 hour Mean-Time-Between-Failure
- Transparent Defect handling: In-line sector defect skipping
- Automatic retry for read errors
- Unrecoverable data error rate of 1 per 10^{14} bits read
- 48-bit ECC (Error Correcting Code) polynomial
- Patented AIRLOCK® shipping lock and dedicated landing zone
- 2 year warranty

A Company You Can Rely On. Passport is from Plus Development Corporation, a leader in innovative mass storage solutions for personal computers. Plus created the category of hard disk expansion boards with the Hardcard family of products. The Plus Hardcard has won more prestigious design awards and more technical journal recommendations than any other mass storage product. Plus dominates the hard disk expansion board category with customer driven product design, advanced technology and a commitment to customer service and responsiveness unmatched in the disk drive industry. Passport owners can expect the same level of commitment from Plus.

Packaged to Meet Your Needs. Passport is packaged and sold in a variety of configurations, with 40 Mb or 20 Mb hard disks and universal PC/XT/AT or Micro Channel™ adapters. The base housing can be mounted internally in most popular desktop computers or externally in a chassis that sits under the computer's monitor.

Passport supports DOS 3.0 and above as well as most popular network operating systems including those from Novell,® 3Com® and IBM.

For more information about our products, please call us at (800) 826-8022 (from the U.S. only) or contact your local distributor.

Specifications:

Performance

- Formatted capacity: 42.6 Mb/21.4 Mb
- Effective access time: 28 ms
- Sector interleave: 1:1
- Hyperwrite accelerates disk writing functions
- Read-ahead buffer speeds data retrieval

Reliability

- MTBF
  - Hard Disk: 60,000 (POH)
  - Base Housing and Adapter: 60,000 (POH)
- Media life: 5 years of continuous use
- Preventive maintenance: none
- Shock protection
  - Four high efficiency shock absorbers
  - Durable plastic and sheet metal casing
  - Read/write heads automatically retract to non-data zone and lock when power is interrupted
  - Non-operating shock: 150 G
  - Operating shock: 10 G
- Load/unload mechanism life: 10,000 cycles (5 years)
- Data reliability assured through 48-bit ECC on Data Field and 16-bit CRC on ID field with up to 11 bit burst correction
- Component life: 5 years

Physical Specifications

- Mounting
  - Internal in any standard 5.25" half-height or full-height cavity
  - External in an optional chassis
- Single or dual drive configurations available on a single host adapter
- Interchangeable 40 Mb and 20 Mb hard disks
- Mechanical dimensions

	Hard Disk	Base Housing	External Chassis
Height	1.26"/32mm	1.63"/41.4mm	2.65"/67.4mm
Width	4.8"/122mm	5.75"/146mm	13.4"/340mm
Length	7.7"/196mm	8.2"/208mm	14.5"/368mm
Weight	2.4 lbs.	1.5 lbs.	11.0 lbs.

Environmental Operating Limits

- Ambient temperature
  - Storage/shipping: −40° to +62°C
  - Operating: +4° to +46°C
- Ambient relative humidity
  - Storage/shipping: 5% to 95% RH
  - Operating: 8% to 80% RH
  - Max. wet bulb: 30°C
- Altitude
  - Storage: −1,000 to 30,000 ft. (9.1 km)
  - Operating: 0 to 10,000 ft. (3.0 km)
- Vibration
  - Non-operating: (10-500 Hz P-P): 2.0 G
  - Operating: (10-500 Hz P-P): 0.5 G
- EMI (Electro-Magnetic interference)
  - Operating: FCC Class B

Electrical Requirements
DC Power

- Voltage: +12V, ± 5% regulation
  +5V, ± 5% regulation
- Ripple and noise: 100 mV P-P (12V)
  50 mV P-P (5V)
- Current demand

	Base Housing with Hard Disk		PC Adapter	MC Adapter
	5V	12V	5V	5V
Average:	0.60A	0.48A	0.86A	1.6A
Running max:	0.67A	0.60A	0.95A	1.8A
Start up:	0.68A	1.4A	—	—
Average Power Consumption:	8.8W		4.3W	8.0W

AC Power (External unit only)

- Voltage: 100—120 V ac
  200—250 V ac also available
- Current demand: 1A
- Frequency: 50-60 Hz

Functional Specifications

- Interface: Universal IBM PC bus or Micro Channel bus
- Encoding scheme: RLL 2,7
- Rotational speed: 3,000 rpm
- Sector size: 512 bytes
- Logical sectors/track: 17
- Multi-sector data transfer with automatic head and cylinder
- Read/Write heads

	40 Mb
Physical:	4
Logical:	8

- Data disks: 2
- Time to load and spin up to 13 sec
- Time to spin down and unload 16 sec

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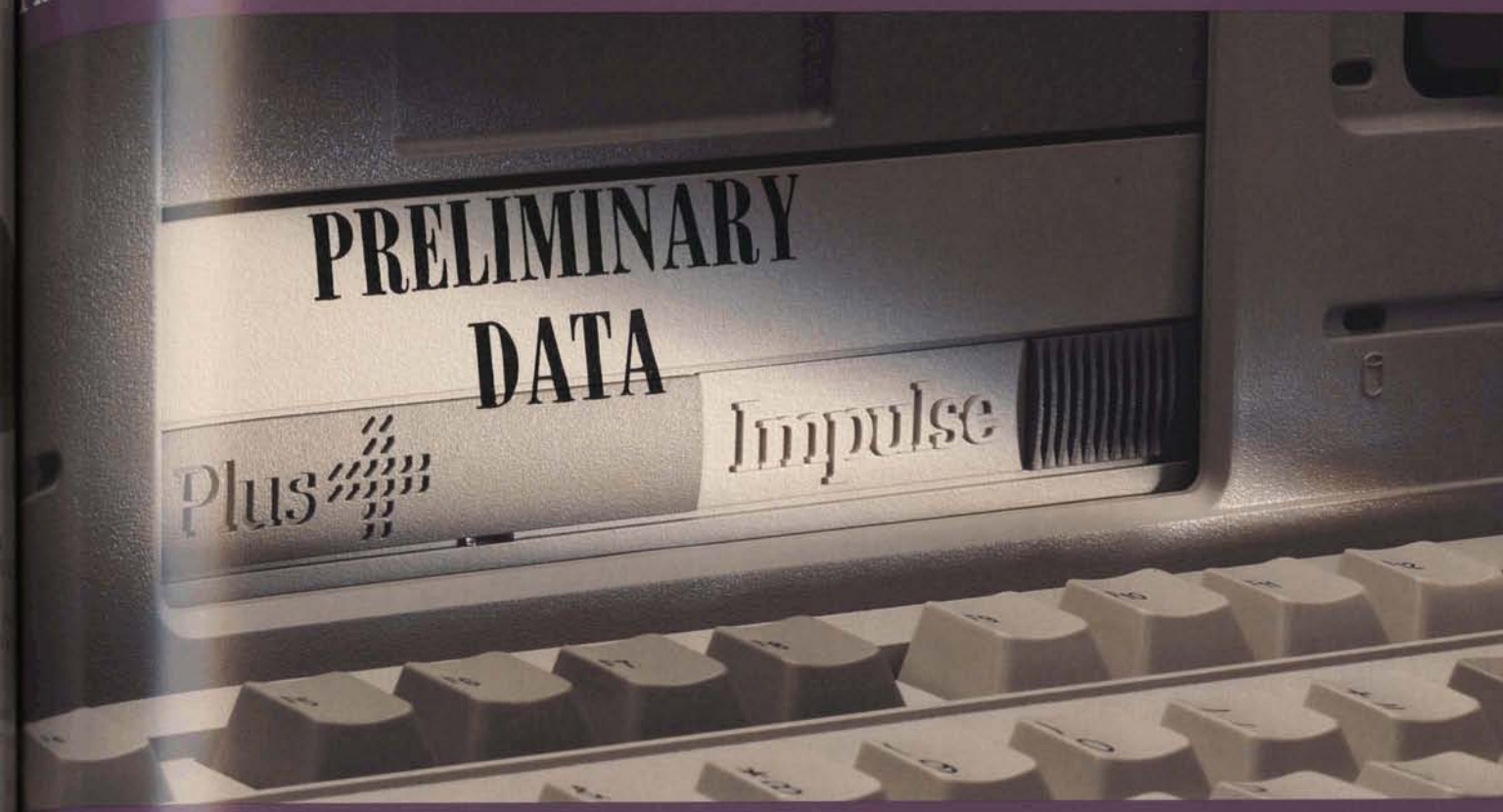
PP-80425

Plus Development Corporation
1778 McCarthy Boulevard
Milpitas, California 95035-7421

Plus

Plus Impulse™ The ultra fast, expandable hard disk system.



The Plus Impulse™ drive system delivers high speed and easy expansion capability for LAN environments and disk-intensive applications such as database and CAD/CAM programs.

Plus Performance. The Impulse hard disk achieves a 22-millisecond effective access time* and up to 4 Mbytes/sec data transfer rate using an on-board controller and the proprietary DisCache® architecture. DisCache, a 64 Kbyte, dual-ported embedded RAM uses a pre-fetch strategy to "look ahead" and store subsequent data in its cache. Then, employing a "least-recently-used data" algorithm, DisCache retains data and allows it to be accessed multiple times. Since 70 percent of typical requests are sequential, DisCache reduces mechanical head movement and retrieves data in microseconds, not milliseconds.

High-Level Expandability. Plus Impulse's Cluster Disk Interface™ (CDI) architecture provides high-level expandability with maximum performance. The CDI architecture allows you to install up to 32 drives serving a single host PC; up to four of those drives can be installed internally within the computer. Data transfer takes place at the rate of 512 bytes per transaction, compared to 1 byte per transaction for asynchronous SCSI. The CDI architecture can simultaneously direct data to and from multiple Impulse hard disks under advanced operating systems, such as OS/2.™ The Impulse drive system sets new standards for speed in multi-user disk-intensive environments.

Compatibility. The Impulse drive system includes a 40- or 80-Mbyte hard disk, the CDI host adapter card, and software that integrates Impulse into DOS, OS/2, and Novell® NetWare.® The 3.5-inch half-height Impulse drive comes configured with mountings for a 5.25-inch drive space. Impulse is compatible with 286/386-based systems from IBM,® Compaq,® AST,® Wyse,® Olivetti,® Zenith® and NCR.®

Dependability. The Impulse hard disk has a mean-time-between failure (MTBF) rating of 50,000 hours. This rating is 25 percent better than Impulse's nearest competitor's. Impulse hard disks also include a defect management system that recognizes deteriorating areas on the disk surface, removes data from these areas to close-by unused sectors, then locks out the deteriorating areas. This means that the disk presents a Defect-Free Interface™ to the operating system on an ongoing basis.

*With benefit of DisCache architecture; assumes 50% sequential and 50% random reads.

Plus®

High-Speed Database Operations. Impulse's DisCache architecture speeds up database operation by retaining parts of the index and data files in cache memory on the hard disk. This means you can access the retained data without the head moving between distant sectors of the disk. Because the cache is dual-ported, the system and drive can access the cache memory simultaneously. DisCache employs a "least-recently-used data" algorithm to determine which data will remain in the cache memory and which will be overwritten. These DisCache features in combination with a 4 Mbytes/sec transfer rate, 12-ms effective access time, and on-board controller make the Plus Impulse drive system ideal for high-speed database operations.

Large Capacity with High Performance. The Plus Impulse Cluster Disk Interface allows simultaneous multiple transactions between Impulse hard disks and advanced operating systems like OS/2. This configuration gives you the storage capacity equal to a single large drive without limiting you to one data transfer at a time. Because each Impulse hard disk has its own on-board controller and 64 Kbyte DisCache, you can have multiple databases located on different Impulse hard disks and access them faster than in any traditional single hard disk system. The Impulse drive system delivers the high capacity and high speed you need for your database operations.

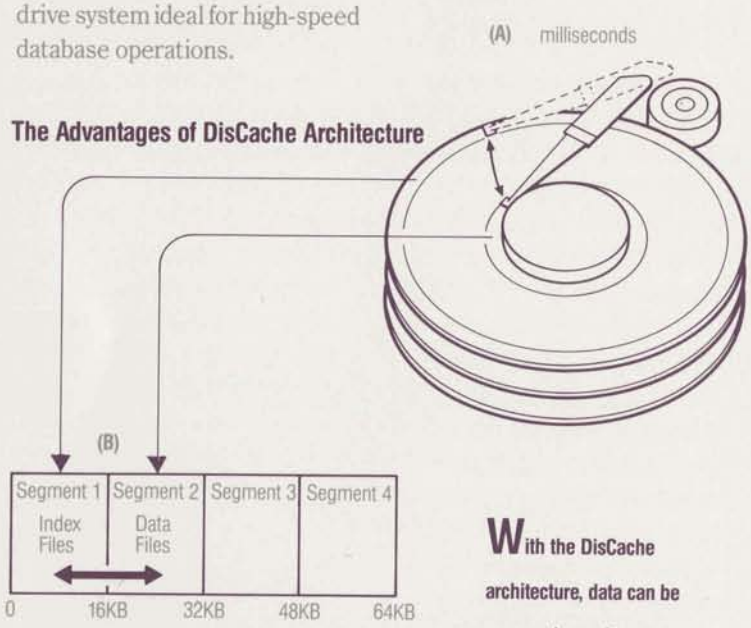
Efficient CAD/CAM Operations. The Plus Impulse hard disk gives you the rapid disk access that is vital for quick display and storage of CAD/CAM and other graphics data. Impulse's proprietary DisCache architecture speeds up CAD/CAM operation by retaining parts of library and data files in cache memory on the hard disk. This means you can access the data from the cache instead of the head moving between distant sectors of the disk. Because Impulse delivers a 4 Mbytes/sec transfer rate and 12-ms effective access time, the graphics you request will appear on the screen almost instantaneously. Impulse eliminates the long waits you've experienced in CAD/CAM operations.

Modular Expansion to Meet Your CAD/CAM Needs. Impulse's Cluster Disk Interface allows you to attach up to 32 hard disks to a single host computer. Your Impulse drive system's capacity can increase from 40 Mbytes up to 2.6 Gbytes in 40- or 80-Mbyte increments. With Impulse, you can design your disk storage system to meet your current needs, and easily expand the system to meet your precise requirements in the future.

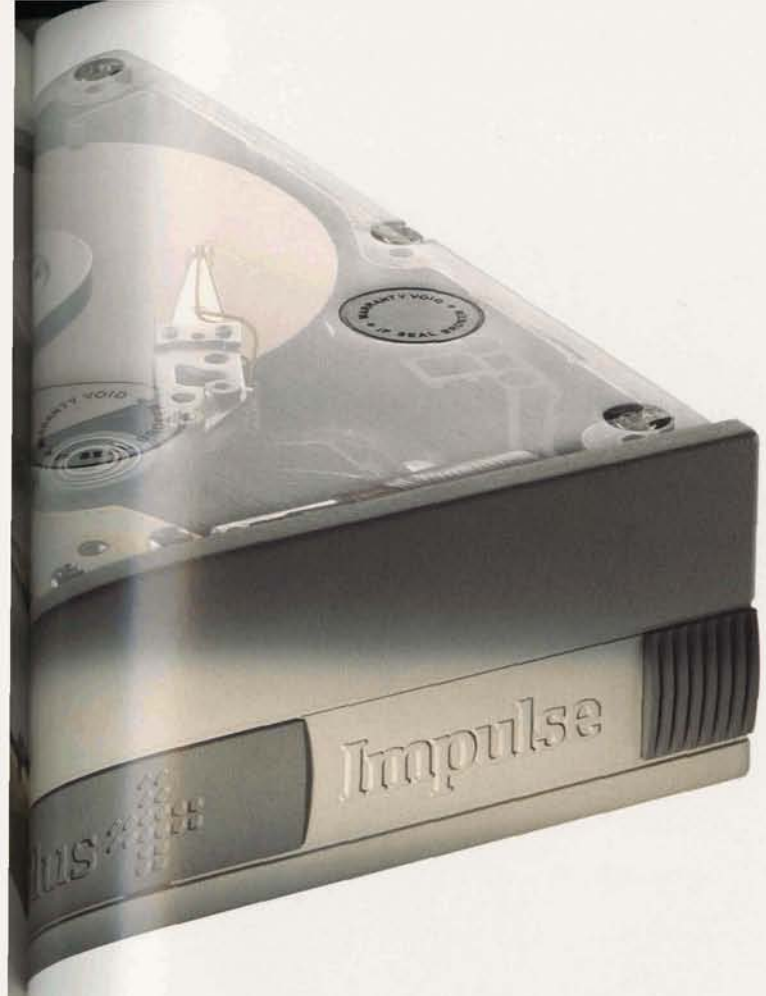
Impulse's Cluster Disk Interface supports up to four drives internally and up to a total of sixteen drives per Impulse adapter card.

Easy Expandability

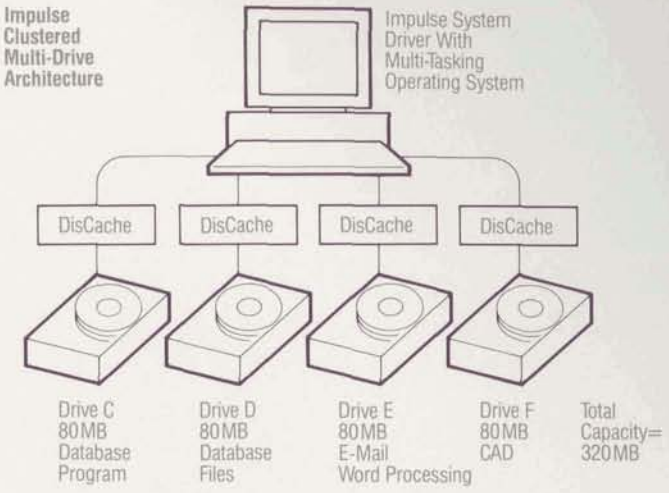
The Advantages of DisCache Architecture

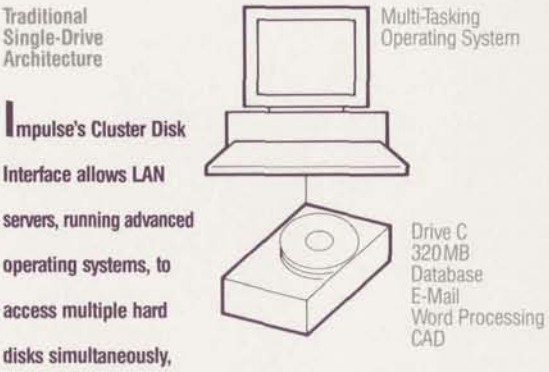


With the DisCache architecture, data can be accessed anywhere on the disk (A), and then it can be moved to the DisCache (B) where it can be repeatedly accessed by the computer in microseconds instead of milliseconds.



The Cluster Disk Advantage





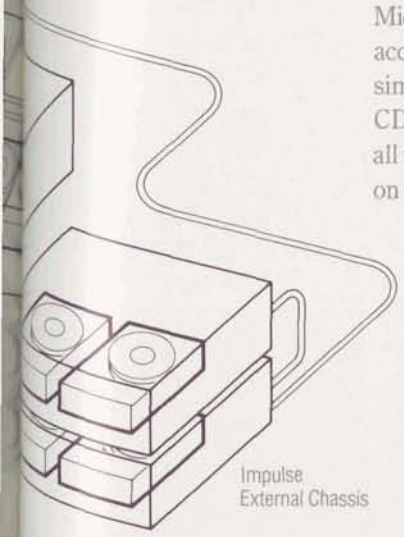
Impulse's Cluster Disk Interface allows LAN servers, running advanced operating systems, to access multiple hard disks simultaneously, each with their own DisCache; a real improvement over traditional single drive architecture.

Building Blocks for Your LAN. The Impulse drive system expands your LAN's capabilities while maintaining high performance. You can increase your LAN's storage capacity in building block style up to 2.6 Gbytes by adding Impulse hard disks. Whether your LAN requires 80 Mbytes or 2.6 Gbytes, Plus Impulse delivers the same 12-ms effective access time and 4 Mbytes/sec transfer rate, so your LAN functions at its maximum capacity. Impulse also optimizes speed because each hard disk's DisCache is segmented automatically allowing each application to run at optimum speed.

Innovation for the LAN Environment. Plus Impulse's innovative Cluster Disk Interface changes the concept of the LAN environment by allowing servers in advanced environments like Microsoft® LAN Manager to access multiple hard disks simultaneously. Because the CDI fills requests as they occur, all users running applications on the LAN are allowed rapid disk access. This means your applications will run at their highest speed.

LAN Compatibility. The Plus Impulse drive system is compatible with and includes drivers for major LANs, including Novell NetWare 2.1, 3Com® 3+,® 3Com 3+Open,™ and Microsoft LAN Manager. Plus Impulse is also compatible with PC network interface cards, and is certified for Novell NetWare. System fault tolerant features such as mirroring and duplexing are supported too.

As an added benefit, Impulse's Defect-Free Interface, which presents no bad sectors to the operating system, eliminates the need to run the full COMPSURF program before installing an Impulse hard disk on a Novell network. The entire COMPSURF program can take up to 36 hours to run.



Impulse
External Chassis

Packaged to Meet Your Needs. The Plus Impulse drive system is available in system kits of 40 MB or 80 MB; each kit includes the hard disk, the host adapter card, software, documentation, cables, and mounting kits for all supported systems. Impulse hard disk expansion kits are also available without an adapter in 40- and 80-MB versions. A two-drive external chassis, which can be daisy chained, will be available in the second quarter of 1989.

A Company to Rely On. Plus Development Corporation, the creator of the Plus Impulse drive system, is a leader in innovative mass storage solutions for personal computers. Plus developed the first hard disk expansion boards with the Hardcard® family of products. The Plus Hardcard has won more prestigious design awards and more technical journal recommendations than any other mass storage product. Plus also developed Plus Passport,™ a high-performance removable hard disk for the 286/386 and PS/2® market. Passport is Plus Development's solution for today's removable hard disk requirements.

Plus Development Corporation is dedicated to designing, developing, and manufacturing innovative and reliable products that are fully supported and generate a high degree of end-user satisfaction. For more information about Plus products, call (800) 826-8022 in the U.S., or outside the U.S., contact your local Plus distributor.

Specifications:

Hard Disk Performance

- Effective access time: 12 ms*
- Transfer rate: 4.0 Mbytes/sec (max.)
- Seek time:

Average:	19 ms
Track-to-track:	6 ms
Full stroke:	40 ms

Seek times are at nominal environmental conditions and include settling.

Functional Specifications

	80-MB hard disk	40-MB hard disk
Formatted capacity (million bytes):	84	42
Heads:	6	3
Disks:	3	2
Bytes/sector:	512	512
Number of data zones:	2	2
Tracks:	5004	2502
Track density (tpi):	1,000	1,000
Encoding scheme:	RLL 2,7	RLL 2,7

- DisCache architecture: 64 Kbyte dual-ported look-ahead disk cache

Hard Disk Reliability

- Hard disk MTBF: 50,000 POH
- Preventive maintenance: None required
- Component life: 5 years
- Error rates:
  - Soft read errors**: 1 per 10^{10} bits read.
  - Defect read errors: 1 per 10^{12} bits read.
  - Unrecoverable data errors: 1 per 10^{14} bits read.
  - Seek errors**: 1 per 10^{6} seeks.

*With benefit of DisCache Architecture: assumes 50% sequential and 50% random reads.
** Exclusive of ECC or retries.

Physical Specifications

- Mechanical specifications:

	Width	Length	Height
Hard disk:	4.0 in	5.75 in	1.625 in
	101.6 mm	146.2 mm	41.3 mm
Adapter:	4.25 in	8.75 in	0.75 in
	110 mm	225 mm	17.0 mm

- Environmental conditions:

	Operating	Non-operating
Temperature:	4° to 50° C	−40° to 65° C
Humidity:	8 to 85% RH	5 to 95% RH
Altitude:	10,000' max.	10,000' max.
Shock (11 ms):	10 G	60 G
Vibration (peak-to-peak):	0.5 G	2.0 G

Electrical Requirements

- Current demands:

	Adapter	Hard disk	
	5 VDC	12 VDC	5 VDC
Average:	1.52 A	0.5 A	0.5 A
Running max.:	1.82 A	0.8 A	0.6 A
Start-up:	—	1.6 A	—

- Power consumption:
  Adapter: 7.6 W
  Hard disk idle: 8 W

Computer Interface

- Impulse adapter
  BIOS address
  C8000h-C9FFFh
  CA000h-CBFFFh
  CC000h-CDFFFh
  CE000h-CFFFFh

  I/O address

Register Set 1	Register Set 2
1F0h-1F8h	3F6h-3F7h
170h-178h	376h-377h
320h-328h	32Eh-32Fh

- Interrupt levels: 14, 11, 12
- Configurations: Up to 2 internal Impulse hard disks supported per Impulse adapter. Impulse adapters support only Impulse hard disks.
- Bus interface: 16-bit (ISA)

Software

- Drivers supporting:
  DOS, version 3.0 and greater
  Novell NetWare, version 2.1 and greater
  OS/2, version 1.0 and greater
- Plus Impulse Software Diskette (5.25" high-density floppy diskette) includes:
  Operating system drivers
  Diagnostic program
  Install program, including automatic install for DOS and OS/2

Documentation

- Plus Impulse Software Installation and Reference Manual
- Plus Impulse Hardware Installation Guide
- Plus Impulse Quick Reference Guide

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Plus Development Corporation
1778 McCarthy Boulevard
Milpitas, California 95035-7421

Plus

Hardcard.™ The premier high-performance hard disk expansion board.

The Plus Hardcard 20® and ardcard 40™ represent the ost sophisticated design in rd disk drives. Because they ve been organized as fully- nfigured, end-user products, ardcard™ is the easiest way to grade a system with full hard ives or two floppy drives. his convenient mass storage n be added without removing— d discarding—the drives eady in the system.

The Hardcard 20 provides 8 Mbytes of data storage; e Hardcard 40 holds a full 26 Mbytes.

Still the only drive on a card occupy a single slot. Hardcards e by far the most popular hard k cards offered today. They e also the most reliable drives ailable in any format.

Hardcards are tested for mplete compatibility with M® PC, XT,™ or AT® computers, Compaq® Portable, Portable II,® and Portable III® computers, other Plus-approved compatibles, and 386-based systems. Hardcard 40 fits into 8-bit or 16-bit slots, so you can easily insert the Hardcard into any available slot.

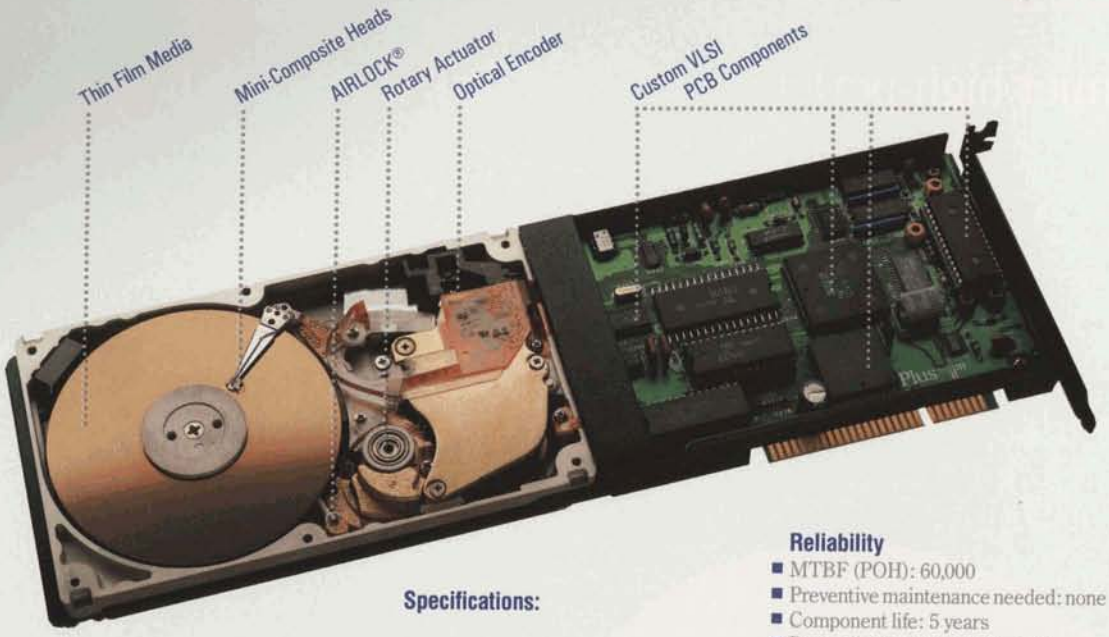
Your data will be secure when it's stored on a Hardcard, even when the power is turned off. Thanks to a proprietary AIRLOCK® feature, when power is interrupted, the read/write heads are automatically retracted to a non-data area called the landing zone. The heads are parked and locked in this safe area until power is restored. This is one of the reasons the Hardcards are so reliable; another is their non-operating shock rating of 100G, twice that of conventional drives. And, Hardcards are rated at a Mean Time Between Failure (MTBF) of 60,000 hours—nearly two times greater than the most reliable conventional drive.

Each Hardcard is a complete hard disk system, integrating miniaturized versions of proven Winchester technologies and custom VLSI circuit designs. Compared to conventional drives, the number of components on the Hardcard have been reduced by 50%. The controller and all of the drive electronics are fully integrated into a single printed circuit board that uses CMOS technology for reduced power consumption. Hardcard only draws 8 watts, less than any other drive and controller combination.

An effective access time of 28 ms has been achieved on the Hardcard 40 with new disk cache software, PlusCache.™ PlusCache uses your computer's RAM memory (conventional, expanded or extended) to hold data. A rotary voice coil actuator also helps the Hardcard achieve its superior access speeds, and a high-performance system transfer rate across the PC bus is achieved with an interleave of three to one. The Hardcard 20 has an average seek time of 40 ms.

To assure consistently accurate positioning of the heads, an essential element for reliability, Hardcard features an optical position encoder and a patented wedge servo design. These features offer greatly enhanced head positioning accuracy over conventional designs.

Plus®



Automatic installation software and a very clear, step-by-step manual will help you install your Hardcard quickly—usually less than a half hour from opening the box to running your applications. The software will help you divide the 40 Mbyte drive into a variety of volume sizes, according to your preference (four 10 Mbyte volumes, three 14 Mbyte volumes, or two 20 Mbyte volumes). Hardcard 20 features a special directory program that automatically creates sub-directories for easy access to a menu of software applications.

The Hardcard was the first product of its type, and it has won more design awards and technical journal recommendations than any other mass storage product.

Plus is dedicated to providing innovative and reliable products that are fully supported and generate a high degree of user satisfaction.

Specifications:

Performance

- Formatted capacity:
  Hardcard 20: 20.8 Mbytes (min)
  Hardcard 40: 42.26 Mbytes
- Effective average access time: 28 ms*
- Typical seek times, including settle time:
  Hardcard 20:

Track-to-track:	10 ms
Average:	40 ms
Full Stroke:	78 ms

  Hardcard 40:

Volume Size	Single Track	Average Length	Full Stroke
10MB	10 ms	29 ms	40 ms
20MB	10 ms	35 ms**	55 ms
30MB	10 ms	39 ms	65 ms
40MB	10 ms	40 ms	78 ms

- PlusCache software accelerates reading from and writing to Hardcard 40
- Average latency: 10 ms

Functional

- Interface: Universal IBM PC/XT/AT bus
- Rotational speed: 3,000 rpm ±0.25%
- Track density: 812 tpi
- Logical cylinders:
  Hardcard 20: 615
  Hardcard 40: 612
- Logical tracks:
  Hardcard 20: 2460
  Hardcard 40: 4896
- Read/write heads:
  Hardcard 20: 2 physical, 4 logical
  Hardcard 40: 4 physical, 8 logical
- Data disks:
  Hardcard 20: 1
  Hardcard 40: 2
- Encoding scheme: RLL 2, 7 Code
- Logical sectors/track: 17
- Bytes per sector: 512

* With PlusCache running with a 128-kilobyte cache.

** The factory-shipped configuration is two, 21.3 Mbyte volumes.

Reliability

- MTBF (POH): 60,000
- Preventive maintenance needed: none
- Component life: 5 years
- Data reliability assured through 48-bit ECC with up to 11-bit burst correction on the data field and 16-bit CRC on the ID field.
- AIRLOCK feature automatically parks and locks the heads in a non-data landing zone when power is shut off.

Physical Dimensions and Computer Interface

- Thickness: 1.0 inch (25.4 mm)
- Height: 4.2 inches (106 mm)
- Length: 13.4 inches (341 mm)
- Weight: 2.1 lbs (950 gm)
- Computer Interface:
  "1st"/"2nd" hard disk jumper
  Controller number for 1st: 0
  2nd: 1
  BIOS address for 1st: C8000H
  2nd: CA000H
  Port address for 1st: 320H-323H
  2nd: 324H-327H
- DMA Channel: 3
- Interrupt request level: 5
- Occupies one full-length 8- or 16-bit slot in IBM PC, XT, AT, or compatible computer.

Environmental Operating Limits

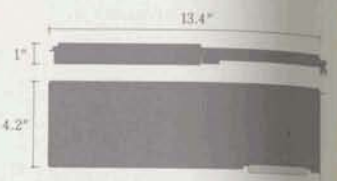
- Ambient temperature
  Storage/shipping: −40° to +62°C
  Operating: +4° to +50°C
- Ambient relative humidity
  Storage/shipping: 5% to 95% RH (non-condensing)
  Operating: 8% to 80% RH (non-condensing)
- Altitude
  Storage: 30,000 ft. (9.1 km)
  Operating: 10,000 ft. (3.0 km)
- Shock
  Storage (1/2 sine wave 10 ms): 100G
  Operating (1/2 sine wave 10 ms): 10G
- Vibration
  Storage (10-500 Hz P-P): 2.0 G
  Operating (10-500 Hz P-P): 0.5 G
- Acoustic noise output: 45 dbA (max) at 1 meter (39 in.)

Electrical

- DC power
- Voltage: +12V, ±5% regulation
  +5V, ±5% regulation
- Ripple and noise: 100 mV P-P (12V)
  50 mV P-P (5V)
- Current demand:

Average:	0.48 A (12V)
	0.45 A (5V)
Running max:	0.53 A (12V)
	0.50 A (5V)
Start-up:	1.27 A (12V)
	0.45 A (5V)

- Average power consumption: 8.0W (typical)



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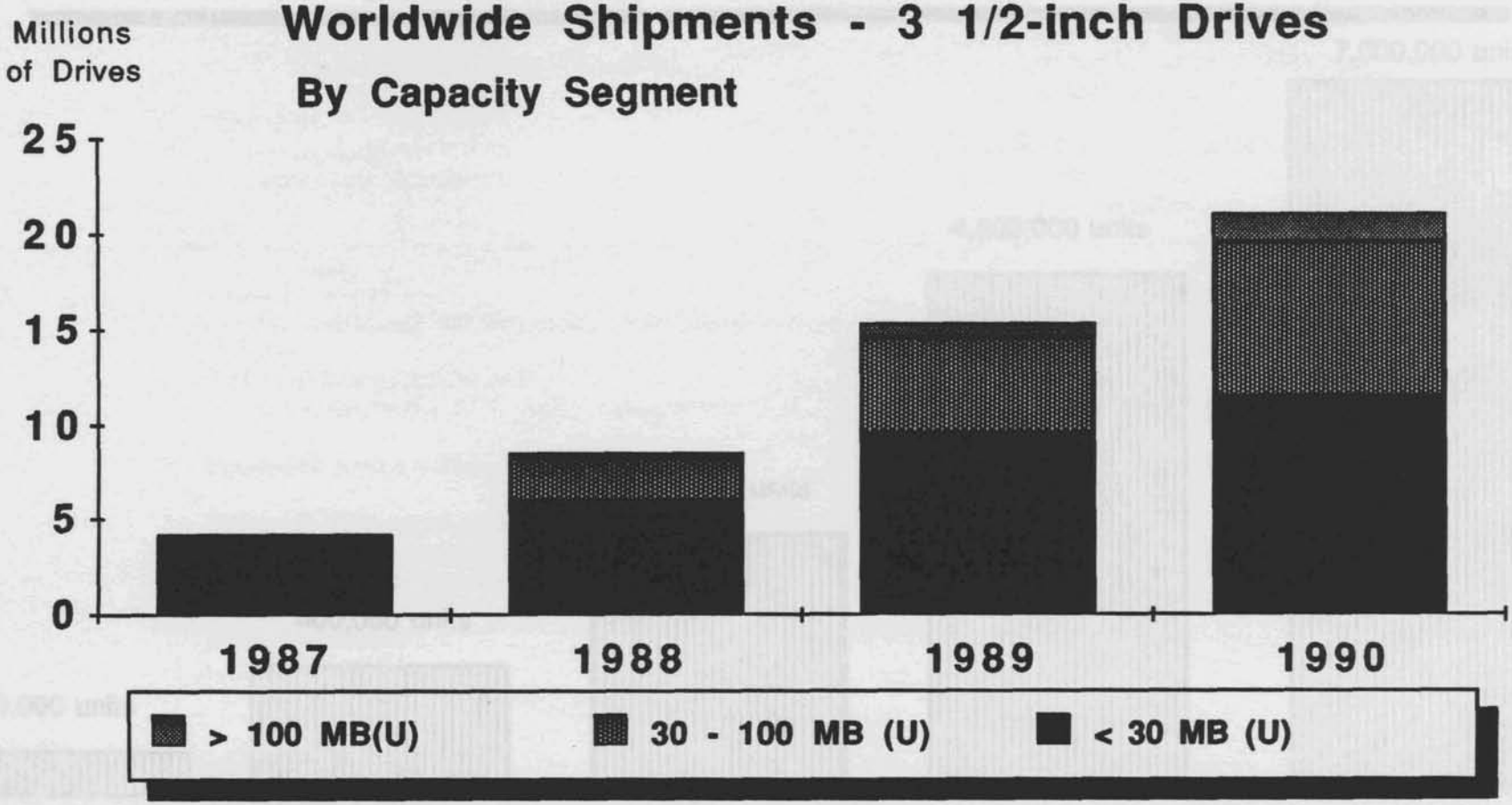
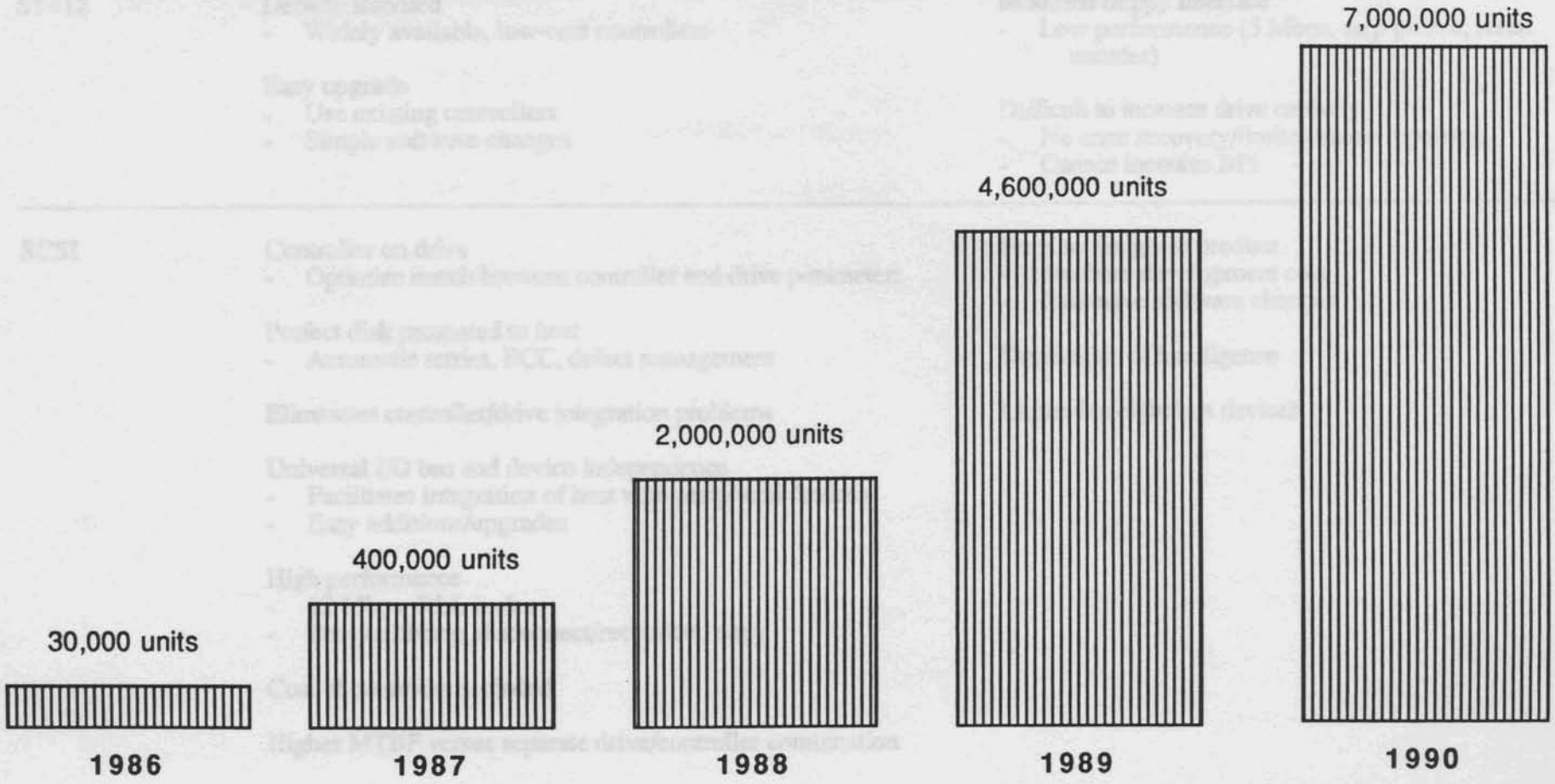
Plus



Source: Disk/Trend, October 1987

3.5" OEM DRIVE MARKET

Medium Capacity (30 - 100 MB)



SOURCE: October 1987 Disk/Trend Report

WINCHESTER INTERFACE STANDARDS

INTERFACE	CAPABILITIES/ADVANTAGES	LIMITATIONS/DISADVANTAGES
ST412	Defacto standard - Widely available, low-cost controllers Easy upgrade - Use existing controllers - Simple software changes	Modified floppy interface - Low performance (5 Mbps, step pulses, serial transfer) Difficult to increase drive capacity - No error recovery/limited status reporting - Cannot increase BPI
SCSI	Controller on drive - Optimize match between controller and drive parameters Perfect disk presented to host - Automatic retries, ECC, defect management Eliminates controller/drive integration problems Universal I/O bus and device independence - Facilitates integration of host with peripheral devices - Easy additions/upgrades High performance - 12 Mbps, RLL codes - Data buffering, disconnect/reconnect, copy Cost of controller included Higher MTBF versus separate drive/controller combination	Need to design-in product - Up-front development cost - Extensive software changes Duplication of intelligence Limited to eight bus devices

INTERFACE	CAPABILITIES/ADVANTAGES	LIMITATIONS/DISADVANTAGES
AT- BUS	Controller on drive - Optimize match between controller and drive parameters Perfect disk presented to host - Automatic retries, ECC, defect management Cost of controller included Higher MTBF versus separate drive/controller combination 16-bit data transfer to and from host - more convenient for host No device drivers needed; driver is built in (DOS 3.3 and higher)	Host needs to manage physical file locations and other housekeeping chores Duplication of intelligence Limited to 2 physical drives Small command set Defacto standard; not as well defined as SCSI

QUANTUM COMPETITIVE PRODUCTS

3.5" HIGHER PERFORMANCE HARD DISK DRIVES

Manufacturer	Product	Formatted Capacity (MB)	Interface	Avg Seek Time (ms)
Quantum	**ProDrive 40S**	42	SCSI	19
	ProDrive 40AT	42	AT-Bus	19
	ProDrive 80S	84	SCSI	19
	ProDrive 80AT	84	AT-Bus	19
	ProDrive 120S	120	SCSI	15.5
	ProDrive 120AT	120	AT-Bus	15.5
	ProDrive 170S	168	SCSI	15.5
	ProDrive 170AT	168	AT-Bus	15.5
Cardiff Peripherals	F3053	44.6	ST412	20
	F3080	68.2	SCSI	20
	F3127	109.7	SCSI	20
Conner Peripherals	CP340	42	SCSI, Compaq Bus	29
	CP342	42	AT-Bus	29
	CP3040	42.6	SCSI	25
	CP3044	42.6	AT-Bus	25
	CP3100	105	SCSI, AT-Bus	25
	CP3200	209.7	SCSI, AT-Bus	19
CDC	94351-107	107	SCSI, AT-Bus	15
	94351-134	134	SCSI	15
	94351-172	172	SCSI	15
	94354-134	134	AT-Bus	15
	94354-172	172	AT-Bus	15
	94355-100	83	ST506	15
	94355-150	128	ST506	15
C. Itoh	YD-3540	42	ST506/412	29
	YD-3042	43.5	SCSI	26
	YD-3082	87	SCSI	26
Fujitsu	M2612S	90.8	SCSI	20
	M2613S	136.6	SCSI	20
	M2614S	182.3	SCSI	20
Maxtor	LXT-100	96	SCSI	27
	LXT-200	201	SCSI	15

Manufacturer	Product	Formatted Capacity (MB)	Interface	Avg Seek Time (ms)
Micropolis	1743-5	112	AT-Bus	15
	1744-6	135	AT-Bus	15
	1744-7	157	AT-Bus	15
	1745-8	180	AT-Bus	15
	1745-0	202	AT-Bus	15
	1773-5	112	SCSI	15
	1774-6	135	SCSI	15
	1774-7	157	SCSI	15
	1775-8	180	SCSI	15
	1775-9	202	SCSI	15
Miniscribe	8051A	42	AT-Bus	28
	8051S	42	SCSI	28
PTI	PT238	32.7	ST412, SCSI, AT-Bus	35
	PT251	43.7	ST412, SCSI, AT-Bus	35
	PT357	49.1	ST412, SCSI, AT-Bus	35
	PT376	65.5	ST412, SCSI, AT-Bus	35
	PT4102	83.7	SCSI, AT-Bus	35
Rodime	3055	45.5	ST506/412	28
	3065	53.1	ST506/412	28
	3057S	45.3	SCSI	28
	3075R	59.5	ST506/RLL	28
	3085R	69.9	ST506/RLL	28
	3085S	69.9	SCSI	28
	3088	75.5	SCSI, AT-Bus	18
	3128	105.7	SCSI, AT-Bus	18
	3259	216.7	SCSI, AT-Bus	18
Seagate	ST125	21.4	ST412/MFM	28
	ST138	32.1	ST412/MFM	28
	ST138R	32.7	ST412/RLL	28
	ST138N	32.3	SCSI	28
	ST157R	49.1	ST412/RLL	28
	ST157N	48.6	SCSI	28
	ST177N	60.8	SCSI	24
	ST1096N	83.9	SCSI	24
Tandon	TM344	41.6	ST506/412	37
	TM346	62.5	ST506/412	37
Toshiba	MK-130FA	53.4(1)	ST506/412	25
	MK-232FB	45.4	SCSI	25
	MK-233FB	75.7	SCSI	25
	MK-234FB	106	SCSI	25

(1) Unformatted capacity

Dave Brown