AUGUST 1986

Mini-Micro Systems

THE MAGAZINE FOR COMPUTER SYSTEMS INTEGRATION

A CAHNERS PUBLICATION

SPECIAL REPORTS:

- **AI shapes up for mainstream use**
- **Compilers combine maturity, innovation**
- **Added functionality sparks STDbus rebirth**
- **Already potent PC/ATs gain power, versatility**

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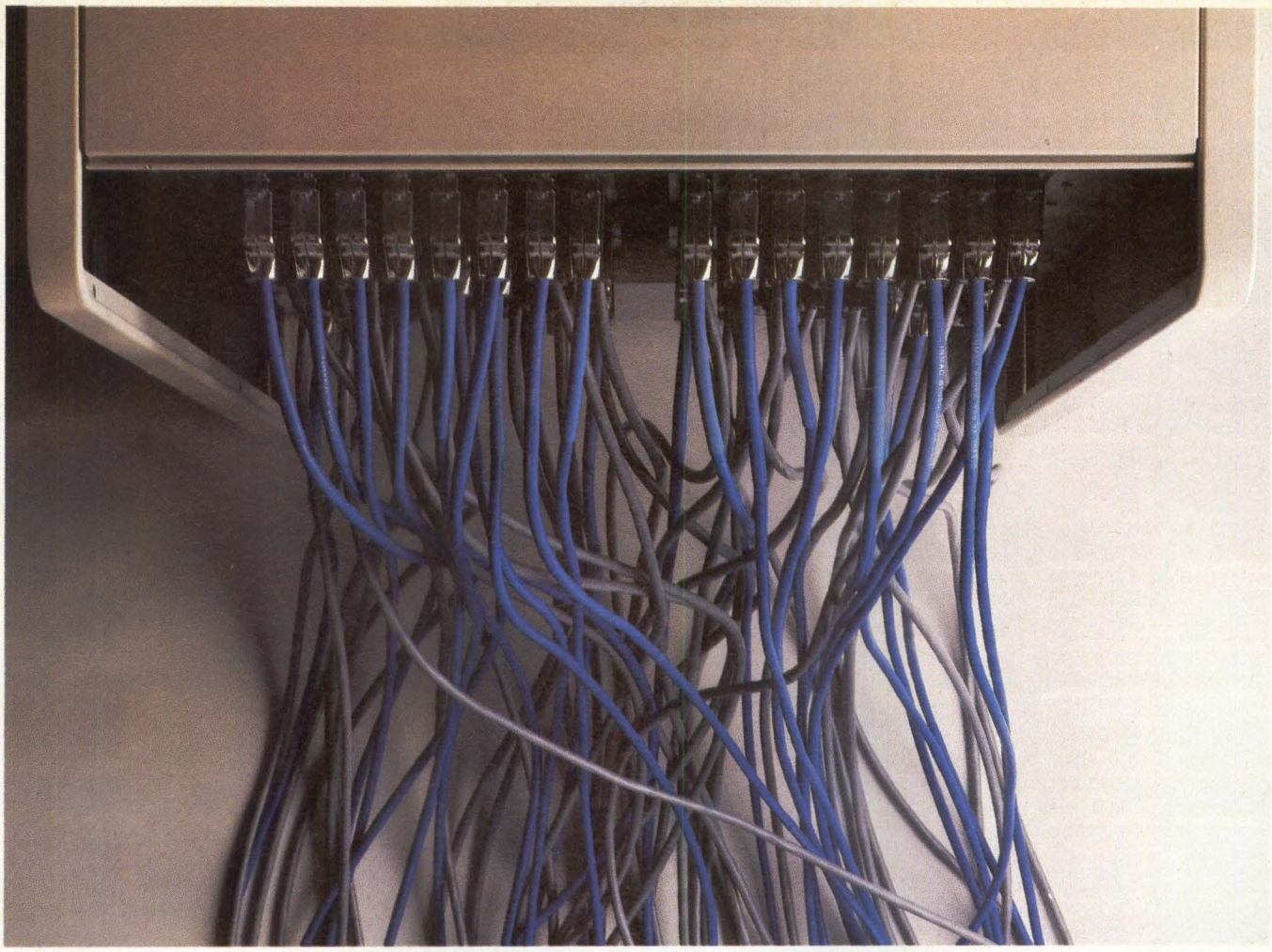

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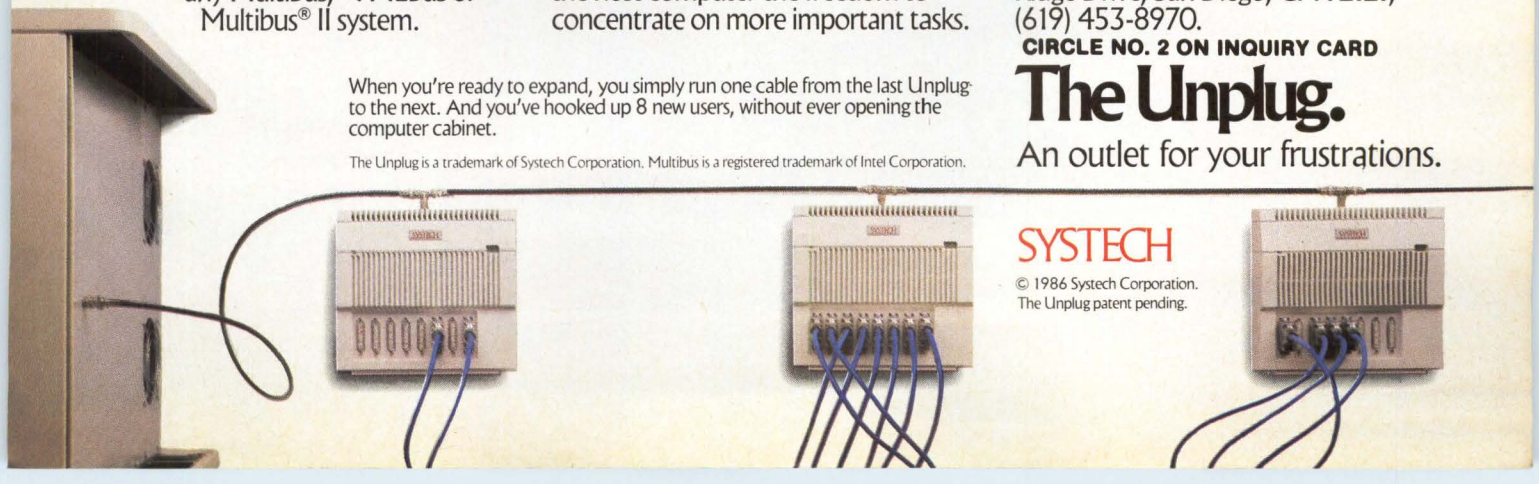

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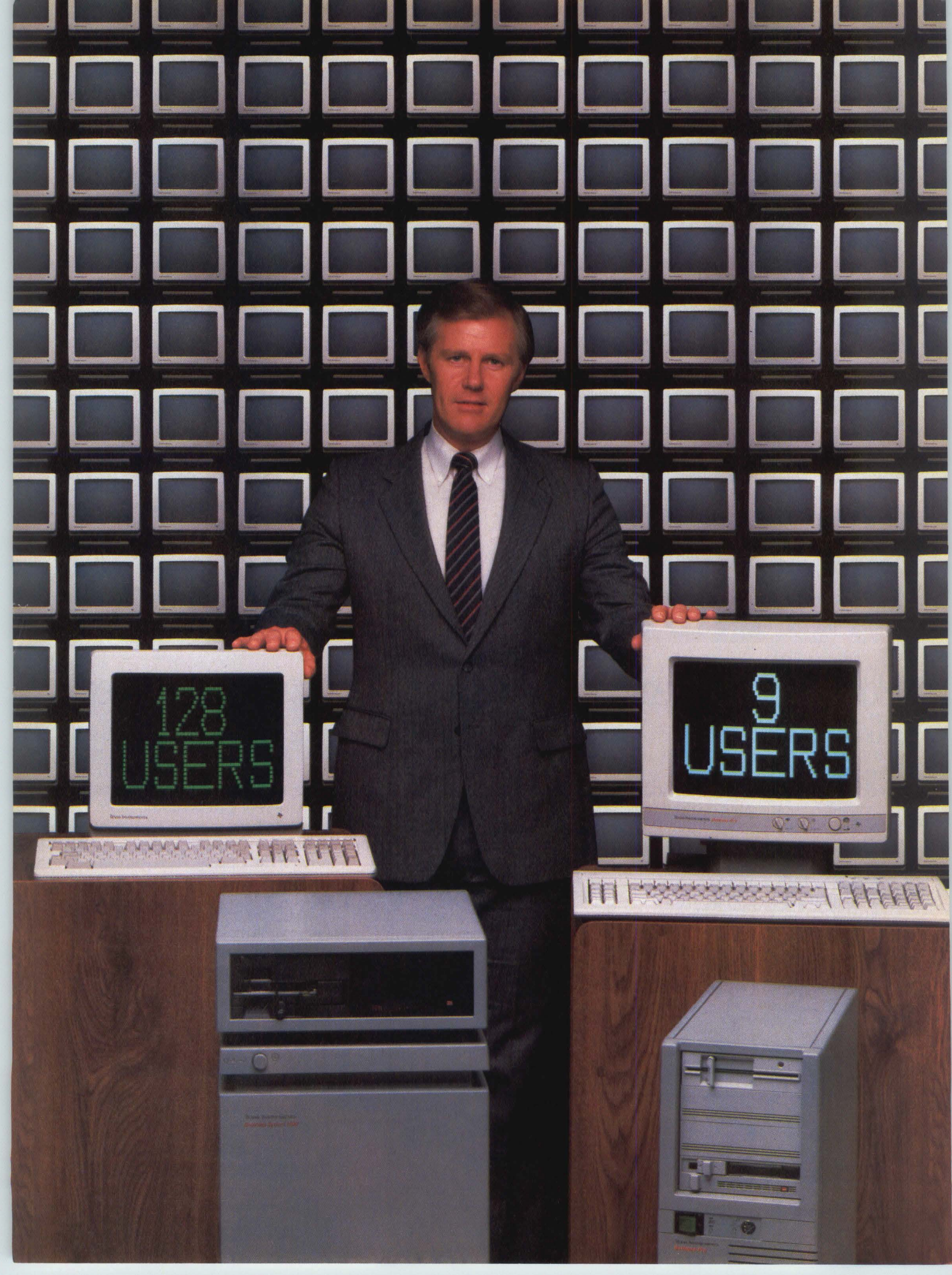
128
USERS
9
USERS

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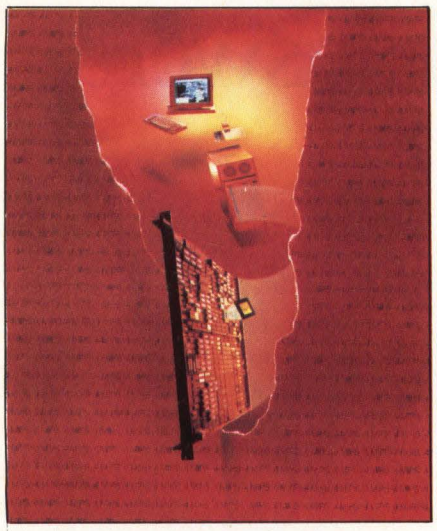
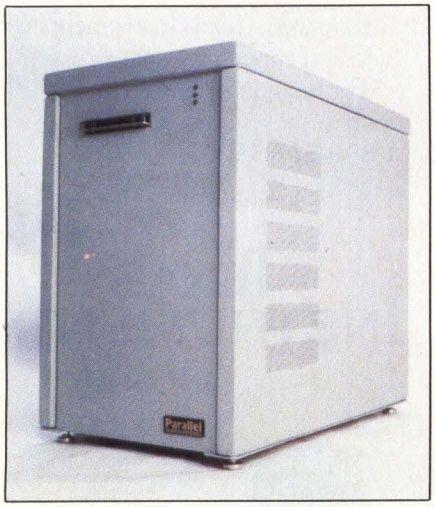
Mini-Micro

THE MAGAZINE FOR COMPUTER SYSTEMS



p. 25 . . . . . Sun introduces its 4-MIPS workstation. Art direction and design by Blankenship-Tavares. Courtesy of Sun Microsystems Inc.



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INTERPRETER

*EUROPEAN NEWS

*Appearing in the European edition only

*DEC DIRECTIONS

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*Appearing in issues of subscribers who have indicated having DEC computers

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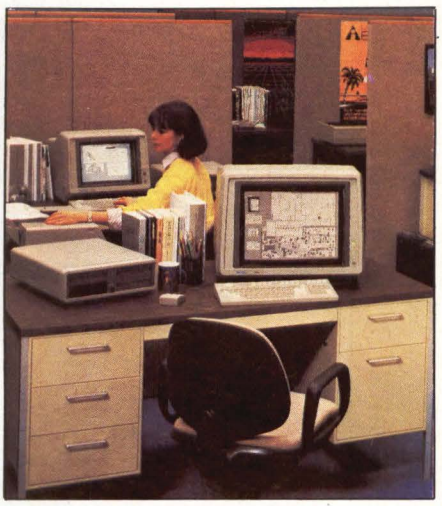

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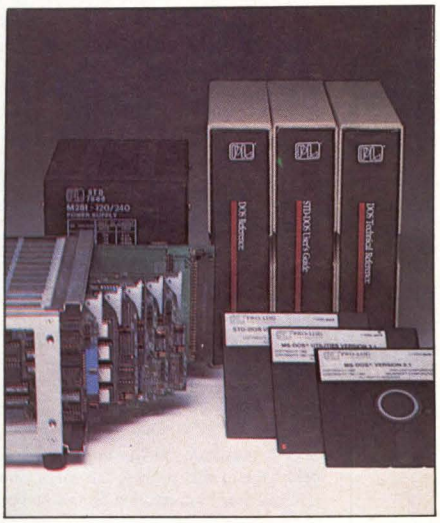

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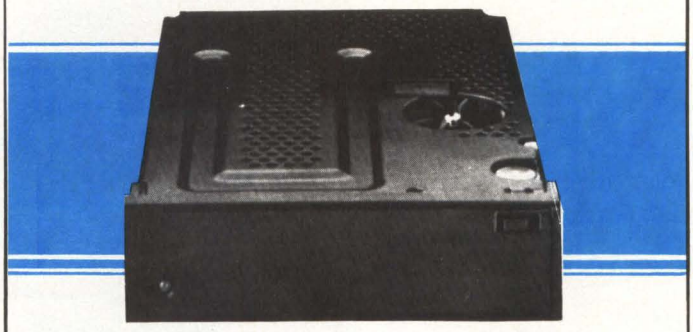

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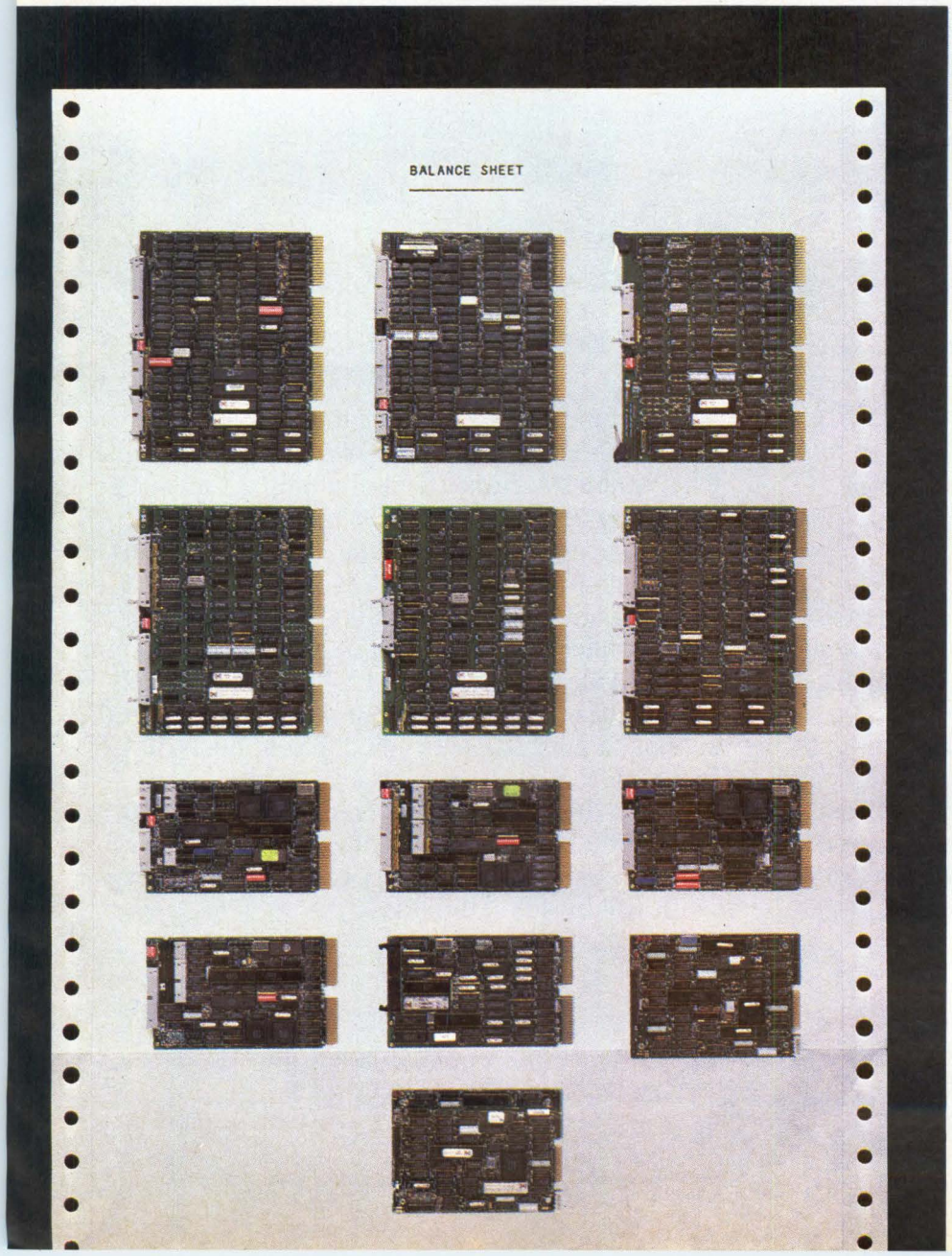

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EDITORIAL

PROMISES AND PITFALLS OF 'HUMAN FRONTIERS'

It's called "Human Frontiers." It's visionary. It's improbable. It will probably fail. But, if it succeeds, even if only in part, it will remake the world.

Human Frontiers is the current name of an R&D program recently proposed by the Japanese Ministry of International Trade and Industry (MITI). Essentially, it involves a close investigation of the functions of living beings in the hope that those functions might be reproduced in machines. In the near term, the Japanese plan to use this research to produce superior AI software and improved medicine. In the long term, they are seriously discussing biochips, biomotors and the cloning of organs for transplant.

The program is going to be expensive. The Japanese are talking about spending $5 billion just to get started. But, if the program achieves even a tenth of its stated goals, it would mean an industrial revolution. Leaving aside the biotechnical and medical aspects of the program, consider the effects on just the computer industry, if Frontiers were to make "biofabrication" a part of everyday engineering. In both this country and Japan, researchers have discussed designing electronics in which individual components would be assembled atom by atom via mechanisms similar to those used by biotech researchers to modify organic molecules. Success in perfecting such techniques could produce Turing machines with individual switches no larger than a single molecule.

Non-Japanese companies would share in Frontiers. In theory, the project is an open and international effort. In theory, foreign companies, universities and institutions would be invited, even encouraged, to join as full and equal partners.

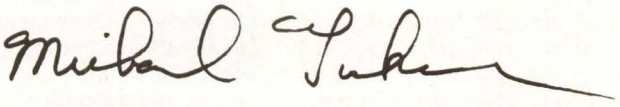
But theory and practice are rarely the same thing. Above and beyond the question of whether they are serious about making the project an international and open effort (the Fifth Generation also was supposed to be "open"), the Japanese have been vague about how the program is to operate, and how its results are to be conveyed to those who are not direct participants.

In short, even if the Japanese are acting with the best of intentions, the lack of clear-cut mechanisms to report on progress and developments is disturbing. There is a real chance that the West in general, and America in particular, might not benefit at all from Human Frontiers—simply because it would take too long for data to trickle down to the right groups. What's needed is an organization that could be an American, or Western, counterpart to the Human Frontiers administration in Japan. This organization would promote the program, help interested reseachers gain access to resources and safeguard Western interests.

Within recent years, Congress has passed a series of bills making it legal for private companies to cooperate in applied research. The most famous of such R&D collaborations is, of course, the Microelectronics and Computer Corp., Austin, Texas, formed in response to the Japanese Fifth Generation effort. There are others, and their numbers are growing.

Suppose, then, that an American or Western association were to be formed of computer, biotech and electronics companies. Suppose further that it included those federal labs that were relevant. And suppose finally that it were to be funded as an RDLP. Would not such an organization be the best vehicle for American participation in the Frontiers program? American companies would thus have a direct channel into the program's results, have greater control over the kind of research that was done and possess any resulting technology, without having to perform an expensive transfer operation.

It seems to make a certain sense.



Michael Tucker
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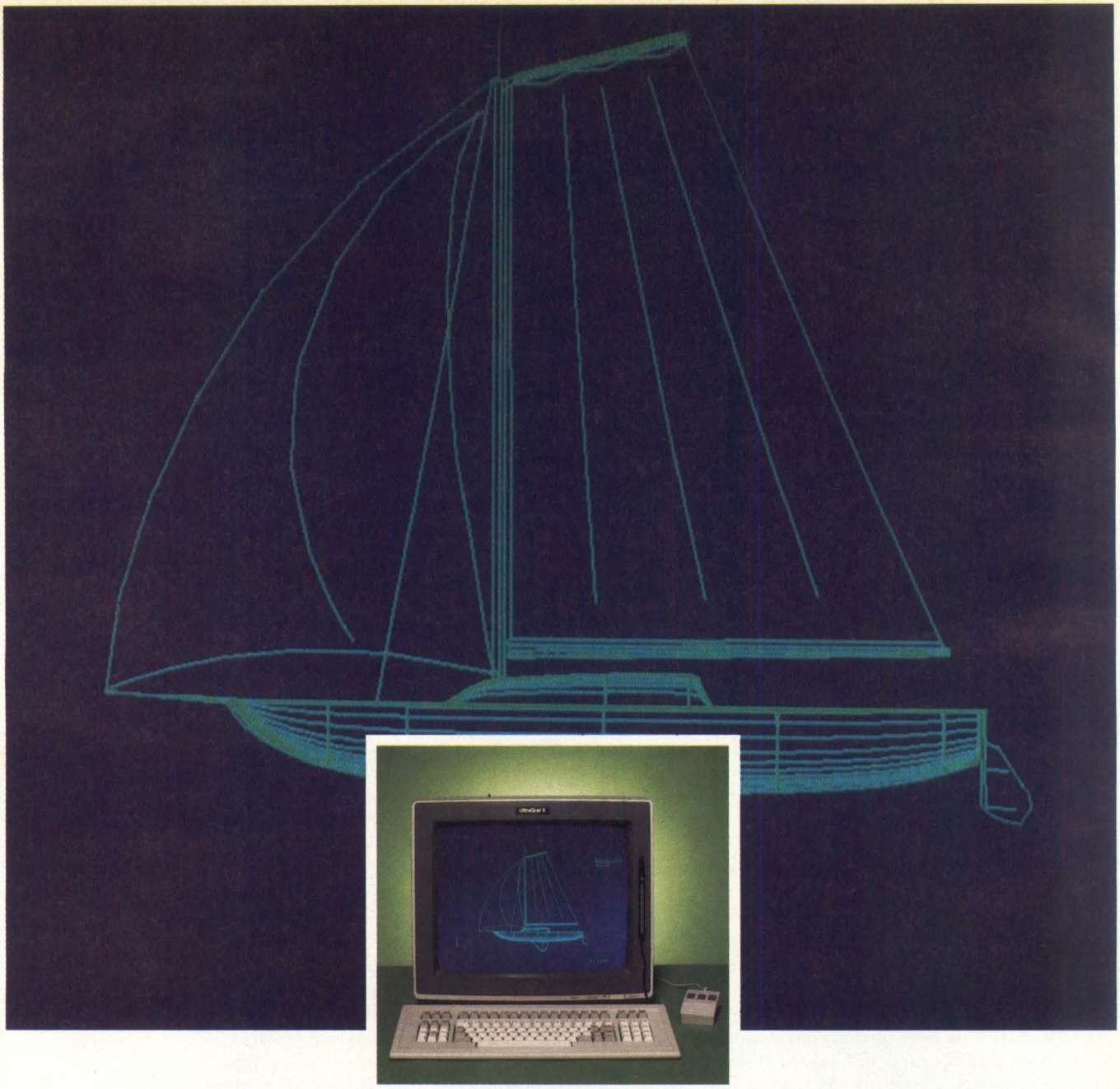

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BREAKPOINTS

DEC EXPANDS PDP FAMILY

Digital Equipment Corp., Maynard, Mass., says its new low-end MicroPDP-11/53 has twice the performance of the MicroPDP-11/23 and is fully compatible with existing PDP-11 software. The RX33, DEC's first half-height 5¼-inch flexible disk drive, works on the system and provides up to 1.2M bytes of storage capacity per disk. Markets for the MicroPDP-11/23 include real-time process control, small business and communications. Availability begins this month with prices starting at $9,270.
—Lynn Haber

IBM MAKES RT SMARTER

Developers who expect IBM Corp. to introduce an Intel Corp. 80386-based machine may be surprised by how the 32-bit microprocessor will be used. According to an IBM source, the company has no plans for upgrading the AT; rather, they will use the 80386 as an I/O processor on the RT-Plus. This machine will use the 64-bit version of the processor used in the RT. IBM may not have settled on the 80386 as the processor of choice, however: It is also exploring the Motorola Inc. MC68040, a 62-bit processor, to handle I/O chores. The reason: Intel is having difficulty manufacturing the 80386; quantity production isn't expected until 1987.*—Carl Warren*

INTERPHASE CONTROLLER TRIPLES VMEBUS THROUGHPUT

Interphase Corp., Dallas, will begin shipping in October the V/SMD 4200 ("Cheetah") disk controller. The new product is a follow-on to the popular V/SMD 3200, but it differs in two key respects: It has a 128K-byte cache memory (the 3200 had 16K bytes) and uses the proprietary BUSpacket Interface, a new technology that permits VMEbus DMA throughput of 30M bytes per second. Until now, VMEbus controllers have been limited to a throughput of 5M to 10M bytes per second. The company says that the BUSpacket Interface technology will be the cornerstone of future controller products. It decouples bus activity from other controller activity through high-speed bus FIFOs and an asynchronous-state machine that controls VMEbus signalling*—Dave Simpson*

SPEECH-TO-TEXT SYSTEM FOLLOWS NATURAL VOICE PATTERNS

Speech Systems Inc., Tarzana, Calif., is talking up its speech-to-text development system, now available to OEMs. The breakthrough, according to the company, centers on a 100-bit-per-second phoneme-recognition engine that allows continuous speech in natural rhythms and stress patterns. Potential users enroll in the system by reading a phonetically rich script to create a vocal model; the process takes as little as 15 to 20 minutes. The system currently runs on machines from Digital Equipment Corp., Gould

Inc. and Sun Microsystems Inc. Development systems cost $80,000 to $100,000. The first OEM business application, called Talkwriter, is due in early 1987.—*Gregory Solman*

CROMEMCO MOVES TOWARD HIGH-END GRAPHICS

Cromemco Inc. will introduce at SIGGRAPH in Dallas this month an expansion board that will give its new MC68020-based multiuser system, the CS420, real-time graphics capability. Priced at about $4,000, a single 1024KTP graphics board uses dual-ported video RAM to create 256 colors at 8 bits per pixel. Using three boards, the system has access to a palette of 16 million colors at 24 bits per pixel. Cromemco, Mountain View, Calif., says the 64-user CS420 is the first system to use the 16.7-MHz version of Motorola Inc.'s MC68881 math coprocessor. An entry-level CS420 with 2M bytes of RAM and 140M bytes of mass storage costs $27,995.
—*Mike Seither*

HEWLETT-PACKARD GETS RUGGED FOR FACTORY WORK

Two blue-collar computer products—a personal computer and a terminal —that are rugged enough to survive on the factory floor will be available from Hewlett-Packard Co.'s Cupertino, Calif., Advanced Manufacturing Systems Operation. The personal computer is a rack-mountable version of HP's Vectra line of microcomputers, available next month. The terminal, the 9666A Operator Interface Unit, is designed for people who have little experience with computers. Available now, it operates at temperatures ranging from freezing to 131 F. Both are priced at about $6,300. HP also is offering a factory cell-control system developed for General Motors Corp. in a price range of $100,000 to $150,000.—*Jim Donohue*

GENERAL ROBOTICS SUPERMICRO SUPPORTS 100 USERS

The Super Python supermicrocomputer from General Robotics Corp., Hartford, Wis., uses the new National Semiconductor Corp. 32381, a floating-point coprocessor and the 32383 memory-management unit to support more than 100 users under AT&T Co.'s UNIX Version 5.2 or 5.3. Three to six Q-bus boards provide rigid-disk controllers with multiple caches supporting more than 2G bytes of storage, a high-speed multiplexer and half-inch tape and streaming tape backup. The $19,950 basic CPU board has 16M bytes of RAM, expandable to 128M bytes.—*Jesse Victor*

VERSATEC EYES LOW END WITH DESKTOP COLOR PLOTTER

Versatec Inc. has added a new technology to its bag of tricks for hard copy output. Known chiefly for its high-end electrostatic plotters, the Santa Clara, Calif., company moves into thermal-transfer devices with a desktop color plotter aimed at the PC marketplace. The Versaplotter, to be unveiled this month at the SIGGRAPH trade show in Dallas, prints at a resolution of 300 dots per inch on cut-sheet opaque paper or transparent film. The plotter produces 8½-by-11-inch pages in 45 seconds. Versatec has packaged the paper and film in cartridges to make loading and changing media easy. The product lists for $8,950.—*Mike Seither*

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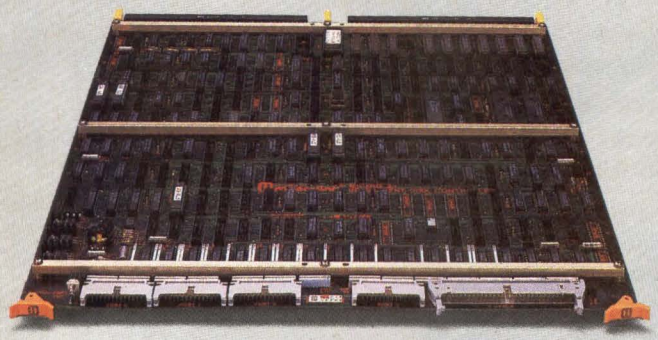

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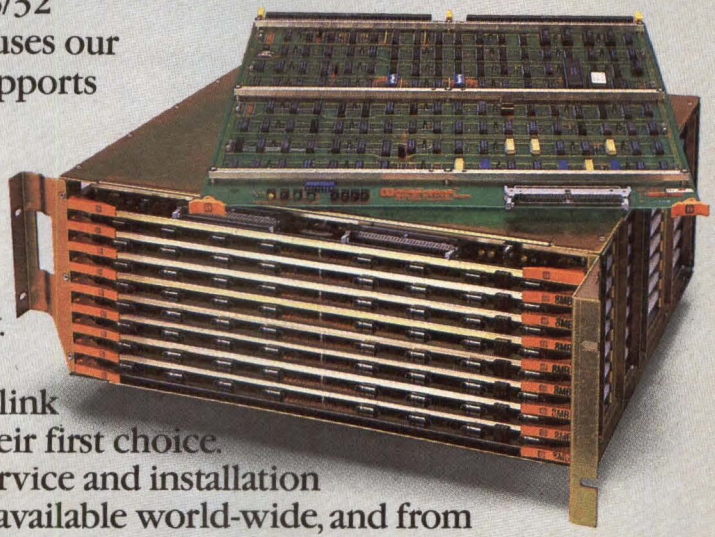

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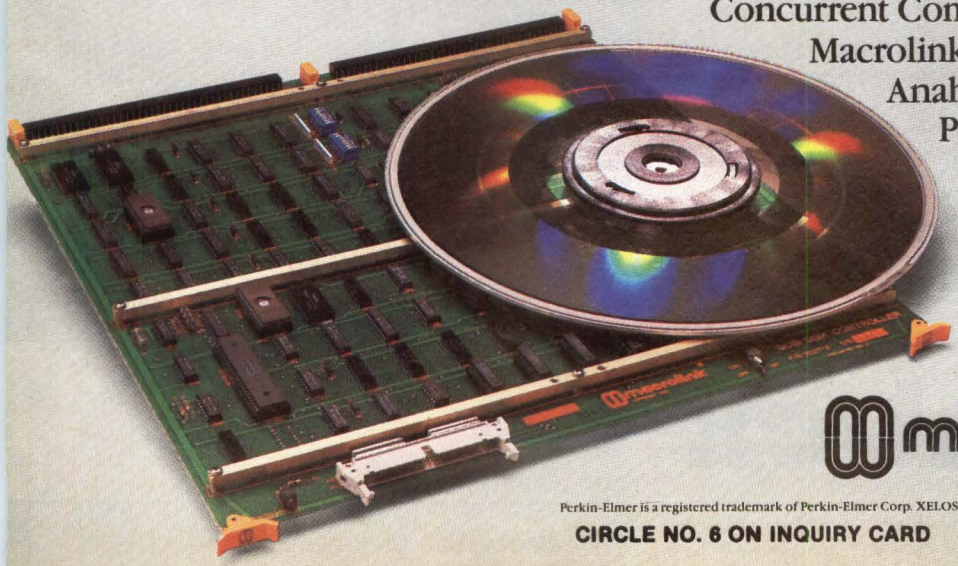

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Matrox now offers two new intelligent color graphics boards for the Q-Bus. The QG-1280 and QG-640 provide the speed and resolution necessary to upgrade DEC's MicroVAX and PDP computers into Professional Graphics workstations.

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CIRCLE NO. 7 ON INQUIRY CARD

KEYBOARD AUTOMATICALLY CONFIGURES ITSELF TO DIFFERENT PCs

Quimax Systems Inc., Sunnyvale, Calif., primarily known as a monitor manufacturer, has introduced its first keyboard for OEMs. The KM-5170 is compatible with the IBM Corp. PC and XT, which use different kinds of keyboards. An on-board microprocessor senses the difference in the PC's keyboard signals and automatically configures the keyboard for the proper machine. Quantity-one price is $119.—*Mike Seither*

THEOS ADDS MS-DOS TO MULTIUSER OPERATING SYSTEM

Earlier this summer, Theos Software Corp., Lafayette, Calif., began shipping THEOS 286-V, a multiuser operating system for Intel Corp.'s 80286 microprocessor, the backbone of the IBM Corp. PC/AT and compatibles. Next month, 286-V users can expect a bonus—THEOS-DOS, a utility that sits on top of the operating system and allows MS-DOS programs to run in a multiuser environment. Theos says that, while the utility runs with most MS-DOS programs tested, it does not operate with software that is copy-protected or intended for intensive graphics. THEO-DOS sells for $250. —*Mike Seither*

NOW APPEARING INSIDE THE PC/AT—A VECTOR SIGNAL PROCESSOR

Zoran Corp., Santa Clara, Calif., has spent the last two years trying to condense vector signal-processor components from several boards onto a single chip. In an effort to acquaint system integrators with its products, Zoran has put the chips on an application-development board that fits into a single slot in the IBM Corp. PC/AT. Priced at $3,000, the board and other tools are aimed at developers working on a variety of digital signal-processing applications, including medical imaging and satellite communications. A site license for Zoran's vector-processing simulation software costs $15,000.—*Mike Seither*

BRIDGE IMPLEMENTS TCP/IP PROTOCOLS ON BROADBAND LAN

Bridge Communications Inc., Mountain View, Calif., introduced four high-speed broadband local area network products, including two server units that implement the Transmission Control Protocol/Internet Protocol (TCP/IP). The broadband family operates at 5M bits per second on 6-MHz broadband channels and permits the integration of multiple computing environments, including IBM Corp. and Digital Equipment Corp., through the TCP/IP-based servers, according to the company. The products include the CS/1B modular communications server, the MB/1 eight-port Ethernet-to-broadband bridge, the CR/5 channel modulator and the RFM/5 modem. Products are available 60 days after order.—*Lynn Haber*

RICOH TESTS OPTICAL WATERS

Primarily thought of as a printer supplier, Ricoh Systems Inc., San Jose, Calif., is testing the OEM optical waters with an 8-inch optical disk drive

dubbed the Model RO-8070 WL. The company claims that the write-once drive can store up to 700M bytes per side. Pricing and the formal introduction date haven't been announced but,expect it in late 1987.—*Carl Warren*

KYOCERA OFFERS LASER PRINTER WITH FULL EMULATION

Kyocera OEM Sales, Cupertino, Calif., is offering the FBP-10 Compact Laser Printer for $3,900. This printer includes 1M byte of internal RAM, 300-dot-per-inch resolution and 10 page-per-minute output. In addition, the printer emulates the Hewlett-Packard Co. LaserJet Plus, Epson America Inc. FX-80 dot-matrix printers and the Diablo Systems Inc. 630 daisy-wheel printer. A page-description language called PRESCRIBE comes as part of the controlling ROM code.—*Carl Warren*

COLOR LASER PRINTER EXPECTED BY FEBRUARY

Shown only to a few observers at NCC this year was a $4,000, 10-page-per-minute, four-color laser printer. The printer, manufactured by a major Japanese company, uses a small-computer systems interface (SCSI), provides emulation of all popular laser and dot-matrix printers and includes 64 built-in fonts. The company, which asked not to be identified, says it plans to introduce the printer in January 1987. Deliveries start the next month.—*Carl Warren*

TANDEM DEBUTS CHEAPER LOW-END FAULT-TOLERANT SYSTEM

A year ago Tandem Computers Inc., Cupertino, Calif., decided to play in the low end of the transaction-processing field with its NonStop EXT fault-tolerant system. With a market apparently established for that class of machine, Tandem has doubled the performance and dropped the entry price by a third to $82,500 for its new EXT10, rated at 4.3 transactions per second.—*Mike Seither*

NOTES FROM OVERSEAS: The worldwide telecommunications and information technology activities of **ITT Corp.** will fall under French control when the Paris-based **Compagnie Générale d'Électricité (CGE)** completes its planned acquisition of a majority holding. ITT will retain a 30 percent share. The government-owned CGE is the leading manufacturer of central office digital switches in France and is interested in ITT's European telephone exchange manufacturing and marketing activities. —*Keith Jones*

Competition for faster disk storage is coming from a new company. **Anamartic Ltd.,** Cambridge, England, says it will launch a semiconductor memory system with a capacity of 40M bytes by the end of the year. The memory will offer access speeds "thousands of times" faster than Winchester disk storage while offering compatibility with industry-standard disk drive interfaces, according to the company. Costs will be held down by building the system from complete wafers of integrated circuits, thus avoiding the expense of dividing the wafers into individual chips, packaging them and mounting them on printed-circuit boards.—*Keith Jones*

TEXAS INSTRUMENTS

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Committed to your needs. Engineering to fill them.

That's the real story. Commitment to you and your market. From day one, our broad range of products, services and programs were designed and engineered to help you deliver better solutions. And we continue to do just that — engineering everything we offer so you can better fill the needs of your customers. Today, we have an installed base of over 100,000 minicomputers, 1,000,000 printers and terminals.

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Better software solutions need enhanced standards.

We started with the industry standards, and then designed in the kind of performance enhancements and ease-of-use features that deliver far more than standard performance. For example, on our new, top-of-the-line Business System 1500, TI System V is our commercially "tuned" operating system derived from the standard — the UNIX™ System V operating system. TI System V supports COBOL, C, and Pascal programming languages. COBOL offers a common development environment and compatible features with XENIX® V on the entry-level Business-Pro™. This allows you to preserve your end-user's software investment over our entire System V product family.

Overall, TI System V-based computers offer commercial enhancements that provide a superior application development environment, while allowing you to enter the UNIX software mainstream market. For example, we've taken the best features from the user interface to our highly successful VAR-proven DX10/DNOS minicomputer operating systems and created the TI Business Shell. This shell provides command entry with menus and prompt screens. Other TI commercial enhancements include: T-ISAM files; forced write-to-disk; record locking, an extent-based file system; a cursor-driven single-character command file manager; an on-line HELP system; sort/merge; software protection; multiple CPU load balancing; and a high-performance field-edit driver.

We also provide the COBOL System V enhanced programming language, which is supported on both the Business-Pro and the Business System 1500. This powerful language is derived from MicroFocus™ COBOL and provides an integrated set of COBOL programming tools which can dramatically increase productivity. This common development environment gives you a wide range of delivery configuration options without having to revise your existing applications software. COBOL System V also provides a powerful COBOL compiler which generates an intermediate interpretive code for fast compilations and debugging, or an optimized native code for production programs. Other COBOL System V features include: the ANIMATOR™ source-level COBOL debugger; selectable run-time environments; and an interactive forms designer. It is versatile, offering you unmatched programmer productivity and efficiency in designing flexible multi-user system solutions.

Hardware that works harder.

Our enhanced standards are not limited to advanced software developments. Since multi-user system designs demand an extra measure of performance, we developed advanced architectures to handle customized configurations of multiple processors, mass storage devices and communications options. And since you need the flexibility to move up or down the multi-user product family, our compact modular equipment designs offer standard features like front access for easy installation, expansion and maintenance, reduced cabling requirements, and plug compatibility with peripherals. This combination of state-of-the-art modular design and high-technology/high-performance microprocessors and coprocessors yields exceptional performance in a standard office environment, plus easy incremental expansion as needs grow.

Enhanced standards enhance value.

We enhanced the software and hardware standards to deliver better performance and ease of use. You can develop better solutions for your customers, which means they get a higher return on their investment. You get lower application maintenance costs, easier system upgrades, and increased programmer productivity. And since your customers can easily add to their systems, their cost of ownership stays desirably low for a long, long time.

Behind the TI product family is an even larger family.

On the cover of this piece is a "family portrait" of our products. Pictured below is a portrait of a different kind of family — a few of the people responsible for the research, design, development, testing, manufacture, quality control, marketing and sales, training, service and support of our VAR product line. All easy to work with, and all dedicated to one thing in particular. You.

Service programs designed for you *and* your customer.

The Service Division of the Data Systems Group helps you meet the specific maintenance needs of your customers. We offer a wide variety of packaged options, or we can custom design a service package to fill precise needs. When you work with DSG Service, you receive the attention of some of the most dedicated customer service representatives in the industry. Our highly skilled and professional technicians are available 24 hours a day, seven days a week, depending on the location and service level selected.

There are two service programs designed exclusively for Value-Added Resellers. Both programs recognize the need for your involvement in all aspects of your customer's business, including service. And each program offers financial benefits to you for assisting in your customer's service management.

The Group Maintenance Agreement (GMA) allows you to be the single point of contact for all of your customer's service needs, and provides you with a discount from the standard contract rates. If a service call is required, your phone call to TI, via our nationwide toll-free number, will initiate prompt and efficient service.

The Maintenance Agreement Preparation Program (MAPP) provides you with a finder's fee for signing your customers to a standard TI service contract. All of DSG's on-site service contracts may be provided under the GMA or MAPP programs.

If you choose to provide hardware service, we'll provide you with the best factory training available, detailed technical and maintenance manuals, and backup support from our own service department. Our TI Express program also provides ready availability of accessories, supplies and media for your systems and peripherals.

We believe that the service flexibility we offer is an important and integral part of the total sales solution you offer to your customers.

The printer family: Establishing the standards of reliability.

TI's Omni 800™ Series printers are known for the standards they uphold — premium performance and industrial quality. Every TI printer is made to do its job very well, for a very long time, and with a very healthy return on investment.

Most of the options offered by competitors are standard features on many of our microprinter and system printer models. Features like letter quality and color printing, snap-in front-loading font cartridges, 10″ and 16″ carriage widths, graphics capabilities, and speed. And, of course, reliability. TI's renowned 810 printer has set standards of reliability in demanding applications for almost a decade. Based on the same architecture as the 810, the Model 880 printers are twice as fast and still offer correspondence printing, raster graphics, forms handling, and AT-class software compatibility.

The three members of our new OmniLaser™ printer family are the first of the second generation of laser printers and are the perfect answer to the shared-resource environment. They last up to 15 times as long as their first-generation counterparts and deliver the lowest cost per page in the industry. OmniLasers are destined to be the "810" of laser printers.

Data terminals: Keeping the customer connected.

There's a TI data terminal to fit almost anyone's requirements, from heavy-duty desktop models to lightweight, portable units. In fact, we pioneered the development of portable data terminals and their markets. We set design standards with our introduction of the Silent 700™ Series, and continue to every time we add a product to the line. Today, the majority of this market belongs to us.

With TI portable data terminals, you can actually create whole new markets by customizing terminals to new user applications, or serve additional needs in your existing segments, because only TI terminals give you the flexibility of the Personal Application Cartridge. Application-specific cartridges can be developed with features and functions to help satisfy your customers' special communications, data entry and retrieval needs, such as remote sales automation, database inquiry or electronic mail.

The new TravelMate™ portable terminals feature an easy-to-read, 16-line, pop-up LCD screen with built-in editing capability. Their printer control keys allow selective printing. The TravelMates feature built-in communications capabilities and are available with either 300 or 300/1200 baud internal modems. And, one model was engineered specifically for direct connection to a customer's computer.

So when your customers tell you that they need to stay in touch with satellite offices, or that they need to supply a sales force with communications tools, or they need to access a remote database, you can tell them that TI's portable data terminals will keep them connected.

Artificial Intelligence: Putting Knowledge Technologies™ to work.

TI offers a broad range of AI products and programs for VARs, from development tools like the Explorer™ system — our advanced Lisp environment workstation, to speech technology to our Knowledge Engineering Department, which can help you pinpoint and begin developing expert systems opportunities. The bottom line is this — AI and expert systems are an ideal opportunity for you to develop and offer new solutions to your existing customer base.

The Personal Consultant™ Plus software package provides an easy-to-use development shell with which you can quickly build an expert system on a Business-Pro or any IBM-compatible PC. You can supply your customers with expert systems that can perform diagnostic analysis, help make decisions and assist in complex problem solving. And the addition of expert systems to your product line can give you a sharper competitive edge because you can provide new solutions to your customer. TI's Knowledge Technologies™ products and services bring artificial intelligence know-how out of our labs and into the commercial computing world.

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The Business-Pro: Minicomputer power in a micro package.

Designed specifically for low-end multi-user capabilities, the Business-Pro is an ideal VAR machine. The XENIX V-based Business-Pro supports up to nine users and can function as a network server in a PC LAN, supporting larger numbers of PCs and peripherals. As a stand-alone system, or connected to a high-end multi-user system like the Business System 1500, the Business-Pro provides high AT-class performance with unsurpassed expandability.

Its standard architecture features the 80286 16-bit CPU, 14 expansion slots (eight full-size and six half-size) on a standard AT bus structure and up to 15 MB memory capacity. The XENIX V-based Business-Pro enhanced standards include: a 120 MB disk drive, TI's low-cost 924 video display terminal, COBOL System V programming language, the TI Business Shell, the T-ISAM file system, and a conversion utility set for file transfer. The Business-Pro will run programs written for the IBM® Personal Computer AT™.

Overall, the Business-Pro brings increased speed, more memory, greater data storage, and greater ease of use to the delivery of both standard and advanced software solutions.

The Business System 1500: High performance for high-end use.

The Business System 1500 combines enhanced industry standards and advanced technology in a high-performance system that can handle up to 128 users. You get the speed and power of the 68020 processor in an open architecture, giving you software compatibility within the TI System V family. And its 32-bit multiple-processor design provides performance capabilities previously available only on small mainframes, and at a much lower cost.

Ease of expandability and configuration flexibility were key design goals of the Business System 1500. This was achieved through a combination of multiprocessors and terminal concentrators, which allow for quick and easy upgrades. Its 68010-based intelligent terminal concentrators support clusters of up to 16 workstations and printers. As your customers' needs grow, upgrades are easily and efficiently handled by adding more processors, terminal concentrators, and of course, the necessary peripherals.

Its sophisticated task distribution architecture provides highly efficient sharing of the system's load and maximum use of available processing power. Each processor board has a minimum of 2 MB of dynamic random access memory, upgradeable to 4 MB. Its high-speed NuBus™ has a 37.5 MB transfer rate with a 100 ns clock period, making it one of the fastest system buses available in the business computer marketplace.

You can customize disk subsystems with two types of mass storage controller boards, each with a 68010 microprocessor to help optimize peripheral control. The SCSI interface can support over 900 MB of storage with four mass storage enclosures containing a combination of hard-disk and streaming-tape devices. The SMD/SCSI mass storage controller board can extend storage to 3 GB, supporting larger and faster devices.

Summed up, its powerful 32-bit multiprocessor design delivers the performance you require for a broad range of commercial applications. Its modular hardware design and the long life expectancy of its architecture were engineered to allow you to expand the system in incremental stages to meet an organization's growing needs for years to come.

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CIRCLE NO. 9 ON INQUIRY CARD

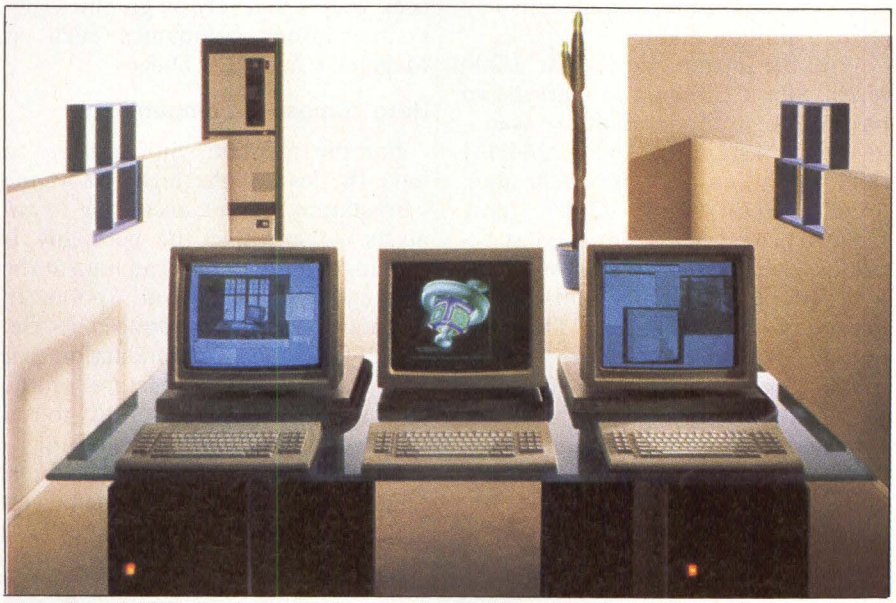
Sun Microsystems doubles speed with 4-MIPS workstations

Mike Seither
Associate Western Editor

The ante for players in the technical-workstation game has just been driven up in a big way. This month, Sun Microsystems Inc., Mountain View, Calif., brings to market the Sun-3/200, a powerful family of workstations that the company claims can operate at 4 million instructions per second (MIPS).

That's double the performance of any previous machine from Sun, or from its prime competitors, Apollo Computer Inc., Digital Equipment Corp. and IBM Corp.

"You can't compare it [the Sun-3/200] with IBM's RT PC or any of the others," says Dave Burdick, an analyst with Dataquest Inc., a San Jose, Calif., market-research company. "Its performance is higher by an order of magnitude. It's in the class of a DEC VAX 8600."



The Sun-3/200 series *can be used as either standalone technical workstations or network servers for compute-intensive applications such as geophysical analysis, electrical CAD and artificial intelligence.*

Although the VAX 8600 costs in excess of $300,000, Sun plans to sell its new systems for $55,000 to $87,000.

Indeed, Sun is pitching the new computer as an alternative to DEC-like workhorses. "We believe the Sun-3/200 will take us into markets where workstations have never been before," says Sun product marketing director John Hime. "By that we mean supermini-class applications like finite-element modeling, real-time graphics and high-end computer-aided publishing."

Where does the power come from? Like its predecessor, the 2-MIPS Sun-3/160, the new workstation uses Motorola Inc.'s 32-bit MC68020 processor, which runs on a VMEbus system architecture. But Sun is using a different breed of the 68020, one with a clock rate of 25 MHz. In its previous machines, Sun relied on the 16-MHz version of the 68020.

Coupled with the faster 68020 is a 64K-byte virtual-address cache memory that the CPU can both read from and write to. The cache clips along at 120 nsec, allowing the CPU to run at its top speed. Thanks to the cache, the 68020 never spends more than 5 percent of its time waiting for data from main memory. Apollo also uses the 16-MHz chip in its newest high-end workstations, the DN570 and DN580, rated at 1.5 to 2 MIPS.

As it has done with earlier computers, Sun still integrates a Motorola MC68881 floating-point coprocessor with all its CPUs to perform scientific and engineering calculations. Sun's $4,900 proprietary Floating Point Accelerator (FPA), which connects to the CPU by a high-speed memory bus and triples the performance of the 68881, is available as an option.

In an April 1986 report from the Argonne National Laboratory in Argonne, Ill., the Sun-3/160 with the FPA was rated at 0.40 million (double-precision) floating-point operations a second (megaflops), using the LINPACK linear-equation benchmark. In the same test, an IBM 4381-11 was rated at 0.39 megaflops, followed by a DEC VAX 8600 at 0.38 megaflops.

Sun officials point to those figures to bolster their claim that Sun machines can compete with higher cost superminicomputers for floating-point performance. For the 3/200

workstations, Sun has fine tuned the FPA to increase its performance by 40 percent, says Hime.

But Sun is relying on more than MIPS and megaflops to gain a toehold in new graphics and publishing ventures. It is bringing out a 19-inch monochrome monitor with a resolution of 1,600 columns by 1,280 rows. That works out to more than 2 million pixels on the screen, or about twice the resolution of today's high-resolution monitors, which display about 1 million pixels.

With the introduction of the 3/200 series, Sun is bringing to market two basic configurations. First are standalone workstations: the 3/260HM (high-resolution monochrome), 3/260C (color) and 3/260G (gray scale). These systems, designed as 12-slot deskside pedestals, start with 8M bytes of main memory and can be expanded to 32M bytes. They are bundled with a companion pedestal that stores a 280M-byte Winchester with a storage module device interface and a quarter-inch tape drive. They can also operate as diskless nodes; sharing file and printer resources via Ethernet.

A high-resolution monochrome workstation with 8M bytes of main memory, Winchester and tape drives, two serial ports, Ethernet controller, keyboard and mouse sells for $55,400. A comparably configured color system costs about $65,000.

Sun also offers the 3/200s as servers. The 3/280S, for instance, is configured as a 76-inch-high, rack-mounted file server with a 575M-byte Winchester, half-inch tape drive and 8M bytes of memory. It costs $77,600. A similarly equipped terminal server for 16 users costs $86,700. According to marketing director Hime, Sun plans to position its 3/260 workstations against two- and three-user VAXes that rely on graphics subsystems from companies such as Megatek Corp., San Diego.

Here comes PC compatibility

For the moment, Sun appears to have the lead at the high end of the workstation market, according to analysts. Meanwhile, the company is moving rapidly to play catch up at the low end with arch-rival Apollo. In February, Apollo introduced its Series 3000, a $15,000 workstation that offers the open architecture of the IBM PC/AT bus and the ability to run those myriad MS-DOS programs.

Says Dataquest analyst Burdick: "The Series 3000 has been the biggest story of the year, and Sun has suffered because of it." The reason: Apollo offered two key criteria for "big-buy" accounts in the 3000—compatibility with the MS-DOS operating system and low-cost color.

Sun has countered in a variety of ways. In June it introduced the SunIPC, a $1,995, Intel Corp. 80286-based coprocessor board that allows Sun workstations to run MS-DOS applications in a window under the UNIX operating system. At the same time, Sun brought out PC-NFS, a software package that allows IBM PCs and compatibles to access files and peripherals over Sun's Network File System. In quantities of 100, PC-NFS sells for $305; or for $955 bundled with an Ethernet interface.

Sun's low-end strategy includes a color workstation, the 3/100, also unveiled this month. The three-slot VMEbus-based 3/100 can be configured as either a desktop or pedestal workstation. Standard equipment includes the 16.7-MHz 68020, the 68881, 4M bytes of main memory and a frame buffer with 10 planes of graphics.

At both the low end and high end, Sun appears to have its house in order, at least for the time being. But, according to industry observers, a new round of product introductions is due from IBM, DEC and Apollo. IBM is expected to increase the clock rate of its RT PC from 5.8 MHz to 20 MHz, increase its CPU bandwidth and improve floating-point performance. DEC may well bring out a more powerful MicroVAX based on its new B1 bus, or a desktop system built around the Q-bus. □

Bringing the two worlds of UNIX together

When it took the wraps off its newest workstations this month, Sun Microsystems Inc. also announced the first phase of a program to wed the two dominant "standards" of the UNIX operating system—that is, to find a common application interface for System V and Berkeley Version 4.2. Sun agreed last September to cooperate with AT&T Co. on the effort.

The Sun Operating System is based on UNIX 4.2, but customers have been clamoring for some System V compatibility. So, in the latest release of its operating system, Sun users will see some of that System V functionality, says Martha Vivoli, Sun's operating system product manager. Unlike other vendors who have implemented a dual port of both versions of UNIX, Sun is providing its users with a single environment by which to find many of the system calls, commands and routines of System V and UNIX 4.2.

Vivoli notes that although there are differences in the two versions of UNIX there are also similarities, which Sun is seeking to unify in one environment. For example, in release 3.2 of the Sun Operating System, there are 133 systems calls. Of those, 53 are the same for System V and UNIX 4.2, and users will be able to gain access to them from a single directory. The remaining calls—13 for System V and 67 for UNIX 4.2—can be stored in "user bins," or directories tailored to the needs of individual application writers, says Vivoli.

The primary System V features that Sun users can expect to see are interprocess communication, shared memory, semaphors and messages.

Current users will not have to change what they are doing, Vivoli adds. "If they don't need the System V stuff, they won't have to load it."

Parallel claims niche with low-end fault-tolerance

Mike Seither
Associate Western Editor

Fault-tolerant computers, those systems designed to survive everything from power outages to internal component failures, have never come cheap. Fully configured models begin well above $100,000. And they have appealed chiefly to large customers such as banks, stock exchanges, automobile manufacturers and retail chains for on-line transaction-processing applications.

But there are other "operational" markets—hotels, hospitals, government agencies, engineering departments and communications companies—where it's desirable to keep a system running in order to deliver services or products. The problem for system integrators has been that these users have been unable to justify the high cost of fault tolerance and have opted instead for traditional small computer systems.

Parallel Computers Inc., Santa Cruz, Calif., is taking aim at these markets with its new XR line of fault-tolerant machines, the UNIX-based 200XR, 400XR and 500XR. They cost, with OEM discounts, between $21,000 and $50,000.

New niche beckons

Richard Eppel, Parallel's president, makes it clear that his company is not trying to play in the same league as Tandem Computers Inc., Stratus Computer Inc. or Tolerant Systems Inc., all of whom make fault-tolerant systems. Those companies offer high-end machines, and Eppel says he is content to let them fight it out for market share. Parallel, he explains, is bringing the basic functionality of those high-end systems down a notch or two.

"We think there's an opportunity to open up a market at a different price point and compete with super-micros," says Eppel.

The new XRs are cousins of the

The 200XR from Parallel *Computers features fault-tolerance in a desk-side pedestal. The MC68010 system can be upgraded in the field by replacing CPU and memory boards with 32-bit MC68020 versions.*

Parallel 300, the company's first system that runs Parallel's version of UNIX. The Parallel 300, a 16-bit Motorola Inc. MC68010-based machine, has been available for two years and has sold for between $60,000 and $80,000.

With the 200XR leading the way, Parallel's strategy is to clash head-on with non-fault tolerant systems such as the 3068 from Altos Computer Systems, the MicroVAX II from Digital Equipment Corp. and the Tower from NCR Corp. Those systems have been instrumental in building a growing UNIX end-user market for commercial operations.

Parallel reasons that because its computers are designed around redundant hardware—dual CPUs, disk drives and uninterruptible power supplies—they offer a higher degree of reliability than do competing systems. And, says Eppel, that's a feature certain classes of customers will pay a premium for: perhaps 20 percent to 30 percent above the cost of a typical multiuser system.

Dave Moschella, an analyst with International Data Corp. (IDC), a Framingham, Mass., market-research company, agrees, saying that there are buyers who are willing to pay more to guarantee a higher degree of reliability for their small systems. Parallel, he adds, has carved out a unique niche for itself.

"No one else is building a redundant supermicro," says Moschella. "Parallel has the lead, and there is plenty of room for them to grow." This year the market for multiuser systems used in commercial operations is expected to exceed $100 million, according to IDC.

Safety in numbers

Parallel's XR line offers a wide range of performance and has been designed so that users can upgrade in the field from 16- to 32-bit processors as the need grows for more computing power. All systems are built around the company's basic redundant architecture.

Under that architecture, identical processors run the same stream of instructions, which are compared by a synchronization module. Periodically, synchronization calls embedded in the operating system verify that the two processors have executed the same set of instructions. If the two CPUs get out of synch, diagnostics locate and isolate the faulty processor. Meanwhile, processing continues on the remaining CPU.

To ensure the integrity of data going to mass storage, redundant controllers operate a pair of small computer system interface (SCSI) disk drives inside the main cabinet. All

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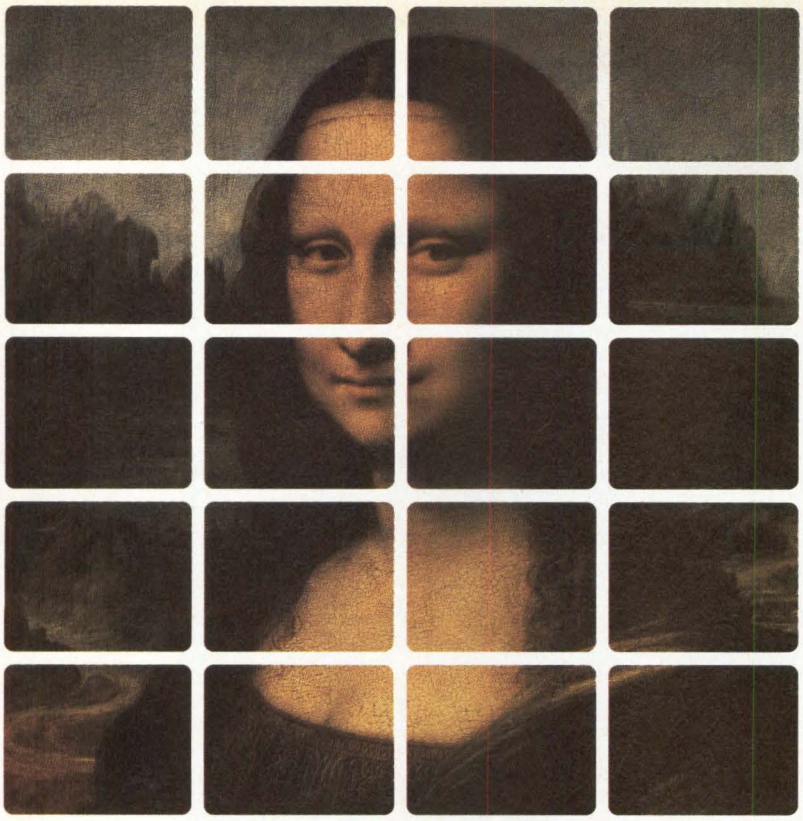

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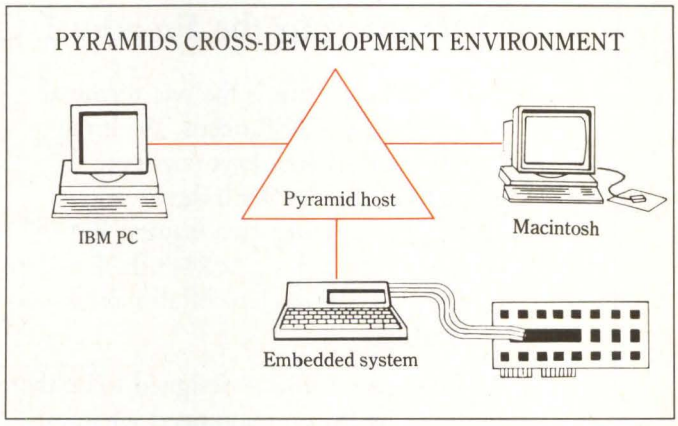

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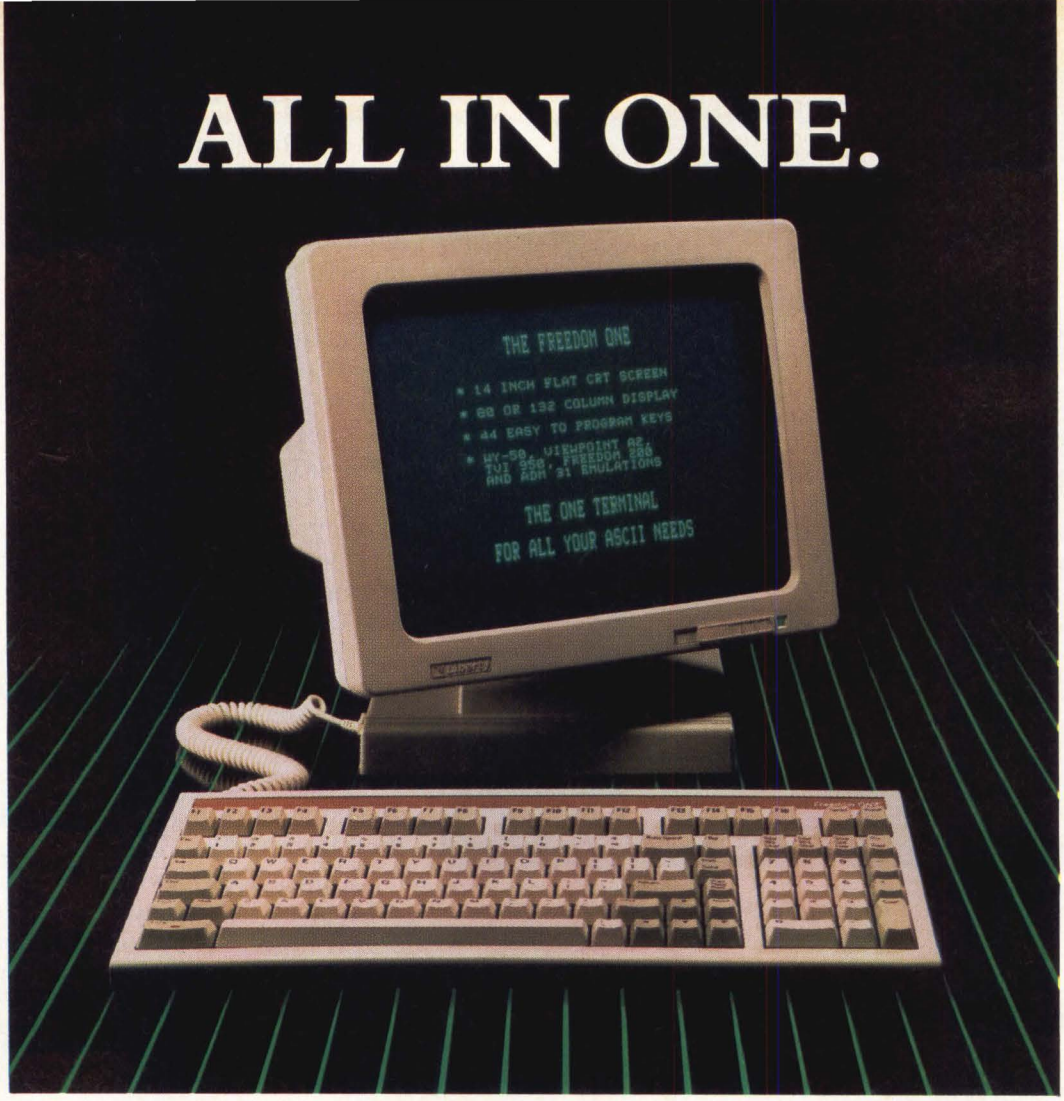

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The fault-tolerant machines' UNIX operating system has all the Berkeley Version 4.2 features, as well as some from System V, such as record locking and shared memory.

No machine is an island

Parallel has taken steps to keep its systems from becoming islands unto themselves. The company just announced, for instance, its support of Sun Microsystem Inc.'s Network File System protocol, which allows users to access files from a variety of different computers. In addition to its Ethernet connection, Parallel also markets the Advanced Communications Processor to handle user-defined protocols, as well as industry standards like CCITT's X.25 and X.29; and IBM Corp.'s Systems Network Architecture and 3270-3780.

Parallel's low-end 200XR is a deskside pedestal that, like the earlier 300, operates on the MC68010 16-bit CPU. It can support up to 16 I/O ports and be configured with 2M bytes or 4M bytes of memory per processor. Mirrored 5¼-inch Winchester disk drives are available in unformatted capacities of 86M bytes or 172M bytes.

Parallel's mid-range machine, the 400XR, comes with the same packaging, memory and disk-drive configurations as the 200XR, but uses the 32-bit MC68020 processor. It also accommodates more users, offering up to 24 serial I/O ports using Parallel's standard eight-port I/O controllers, and 128 with Parallel's Distributed I/O Processor (DIOP).

Parallel developed the DIOP to solve the problem of physically connecting a tangle of devices to a deskside computer cabinet. Available only on the 400XR and Parallel's high-end machine, the 500XR, a single DIOP allows up to 128 peripherals to tie into the computer through one 2.5M-bit-per-second coaxial cable that functions as a token bus. Within 1,000 feet of the main cabinet, MC68000-based cluster controllers can hook into the coaxial cable. Each cluster controller multiplexes up to 16 devices onto the cable.

Parallel's top-of-the-line machine, the 500XR, can handle two DIOPs, allowing a maximum of 256 devices to tie into the system. The 500XR is basically an upgraded version of the Parallel 300, except that it uses 32-bit processors. Larger than the 200XR and 400XR, it comes in a 48- or 56-inch-high cabinet, depending on mass storage options—either mirrored 168M-byte or 344M-byte, 8-inch Winchesters.

According to marketing director Brian Knowles, the key to Parallel's strategy is to offer OEMs a wide latitude of systems that customers can upgrade when necessary. For example, a low-end 200XR can be configured as a mid-range 400XR by simply replacing the 16-bit CPU and memory boards with 32-bit versions. The upgrade kit for such a conversion, with 2M bytes of main memory, costs $9,900. For the same price, customers with the Parallel 300 can also upgrade to a 500XR by trading in the old boards.

Now poised with a full line of fault-tolerant systems, Parallel officials believe they have a winning combination of technology and products to capture new business. And they appear to have support. In addition to a recent round of financing that brought in more than $7 million, Parallel recently licensed its technology to Ameritech Communications Inc., the Midwest regional Bell operating company based in Chicago.

Says IDC analyst Moschella: "The Ameritech deal is a vote of confidence in Parallel. It's pretty good evidence the technology works." □

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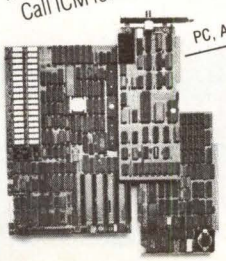

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CIRCLE NO. 15 ON INQUIRY CARD

Chip makers boost PC graphics performance

Lynn Haber, Associate Editor

New coprocessors that offload graphics functions from a personal computer's CPU are ushering in the next generation of personal computer graphics. Some analysts contend that these coprocessors, such as Intel Corp.'s 82786, will cut into sales of low-end specialized graphics workstations.

According to market research concern Dataquest Inc., San Jose, Calif., there were 1.5 million bit-mapped, graphics add-in cards installed on personal computers used in business last year. Lew Brentano, Dataquest's vice president for graphics industry service, expects that number to increase 70 percent per year, compounded, over the next few years.

By comparison, sales of standalone graphics terminals, beginning with an installed base of 100,000 units last year, are expected to grow only 20 percent per year over the same period.

"Depending upon implementation, these chips will improve performance three-to-10-times over the previous generation of products," Brentano says. He suggests that manufacturers of low-end graphics workstations may cut prices to compete.

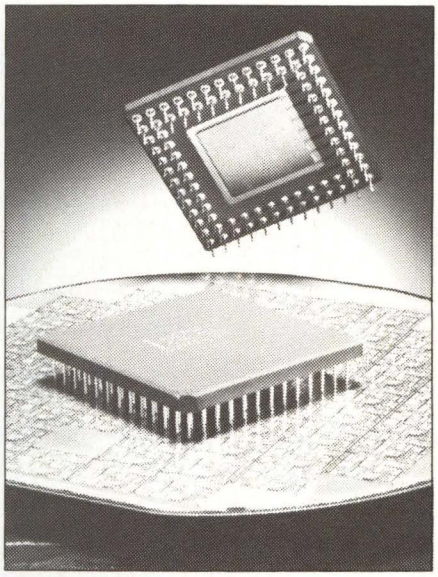
Advanced Micro Devices Inc., Sunnyvale, Calif., and Texas Instruments Inc., Dallas, have joined Intel in selling graphics coprocessors.

Advanced Micro sells a special-purpose graphics coprocessor, the Am95C60 Quad Pixel Dataflow Manager. Texas Instruments Inc., Dallas, is developing the TMS34010, a general-purpose, 32-bit microprocessor with special graphics-processing hardware embedded in the instruction set. First shipments for both products are scheduled in the fourth quarter.

Intel's 82786 graphics coprocessor incorporates two independent on-chip processors—a graphics processor and a display processor—to manipulate graphics and text while executing multiple windows. The chip also incorporates a bus interface unit, a dynamic RAM (DRAM) controller and supports the computer graphics interface (CGI) standard.

According to Intel, Santa Clara, Calif., the primary task of the graphics processor is to draw bit-mapped graphics. It claims the 82786 can draw graphics primitives such as points, lines, arcs, circles, rectangles, polygons and characters, in any of 256 colors. (The color details such as bits per pixel and exact color are programmable.)

Graphic coprocessors will aid in the adoption of industry software standards without compromising on performance, says Garth Wilson, gen-



Intel's 82786 *incorporates two on-chip processors—a graphics processor and a display processor—that operate concurrently. The 82786 also includes a bus interface unit and a DRAM controller.*

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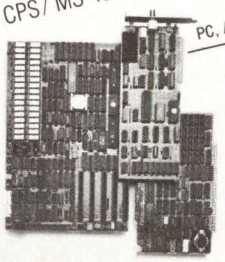

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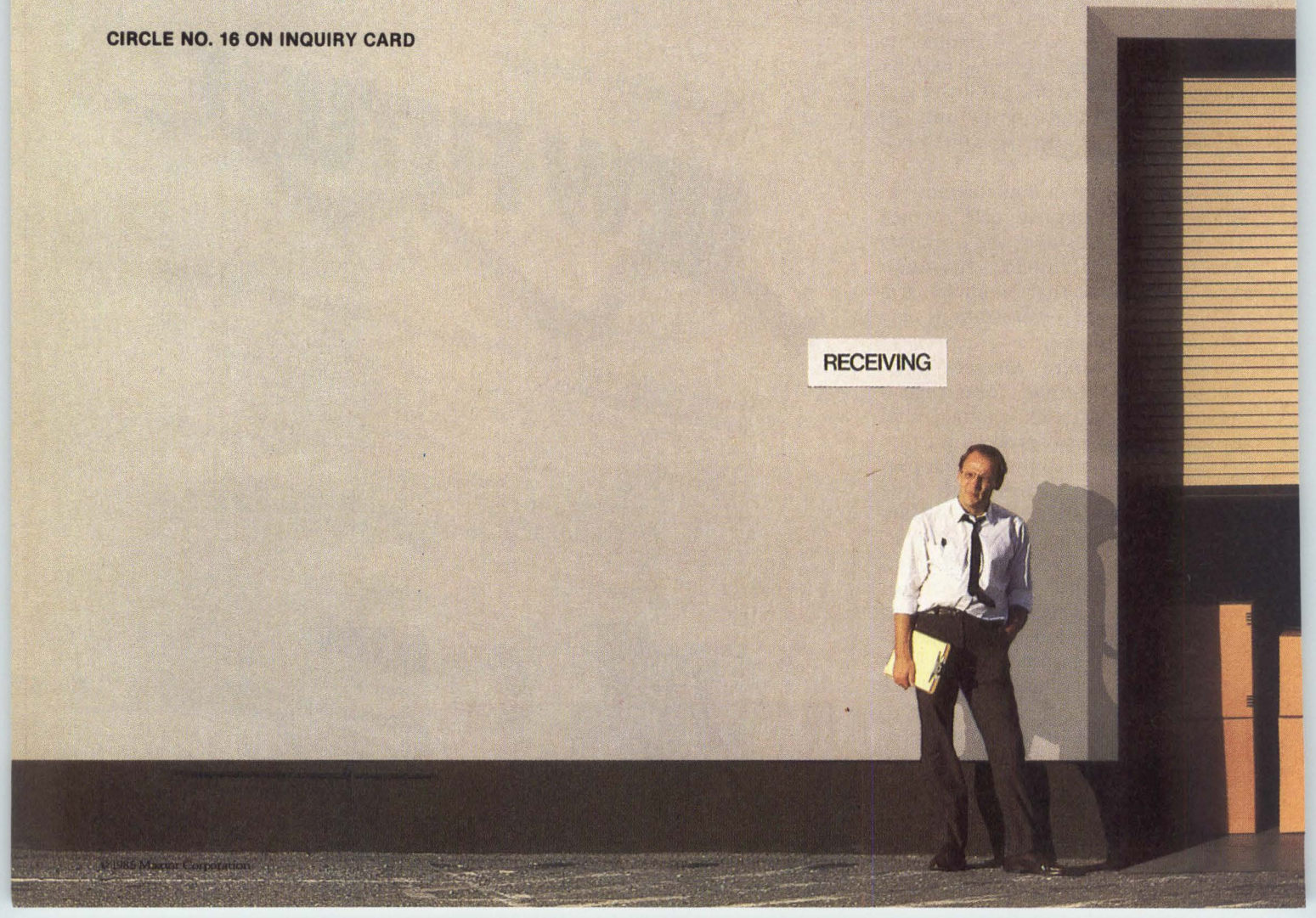

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eral manager of graphics component operations at Intel. When standard interfaces are written into software, they are implemented with complex algorithms that execute slowly, resulting in performance loss, Wilson explains. Software vendors often bypass standards to gain better performance. But graphics coprocessors such as the 82786 implement key functions of the standards in hardware.

Dataquest's Brentano believes that the performance improvements made possible by these coprocessors are especially important for windowing and multitasking interfaces such as Digital Research Inc.'s GEM, IBM Corp.'s TopView and Microsoft Corp.'s Windows. He says that personal computers equipped with IBM's Enhanced Graphics Adapter (EGA) boards are too slow to handle the processing requirements needed to manipulate more than one window on a screen, while simultaneously handling the CPU's processing requirements, such as overhead and data management.

"The Intel and TI chips can handle windows on the order of five times faster than an EGA card," because the chips have windowing support built into the hardware, he contends.

Brentano adds that these chips provide better resolution and color capability than do EGA cards: "I think that, as a result of these coprocessors, people will move to color quicker than they might have otherwise, as these chips make the technology more affordable."

Intel targets the office

Intel's Wilson says that the 82786 chip is intended for the office market, where personal computer applications such as desktop publishing and high-performance graphics are expected to gain wide acceptance. He adds that the 82786 is also aimed at designers who use their personal computer workstations for computer-aided design (CAD) and computer-aided engineering (CAE).

Advanced Micro's Am95C60 is a graphics coprocessor that maintains, updates and displays information on four bit-mapped video planes. According to a company spokesman, two support chips—the AM8171/2 Video Data Assembly and the Am8176 Video Clock Generator—were specifically designed to work with the Am95C60. Other members

HOW THE CHIPS FALL

Company/Product	Description
Advanced Micro Devices Am95C60 Quad Pixel Dataflow Manager	CMOS graphics coprocessor with a maximum clock speed of 20 MHz that can draw vectors up to 3.3 million pixels per second. The coprocessor can interface to an 8- or 16-bit bus. It supports the computer graphics interface (CGI) standard. Available in the fourth quarter. Pricing not available.
Intel Corp. 82786 graphics coprocessor	CHMOS graphics coprocessor that incorporates two on-chip processors—graphics and display—as well as a bus interface unit and a DRAM controller. Supports a maximum clock speed of 25 MHz and can display up to 256 colors simultaneously. The chip features hardware windows and supports CGI. Available at the end of this year. Priced at less than $100 in quantities of 1,000.
Texas Instruments Inc. TMS34010 graphics system processor	General-purpose, 32-bit CPU capable of handling 6 million instructions per second; draw rate of up to 48 million pixels per second. Supported by a C language compiler, CGI and real-time emulation. Available at the end of the year. Priced at $50 in quantities of 25,000.

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2.45 MByte/se transfer rate

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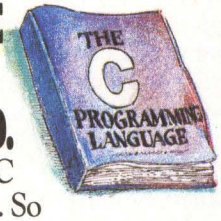
For openers, take the Falco 500's multi-host capabilities. They let you communicate with separate computers through two bidirectional ports—*concurrently.* Ports that can be configured automatically

2. THE UNIX WORLD.



as RS232C or RS422. So you can enter or retrieve data from any of the computer worlds shown here—plus hundreds of others. And switch between any of them with a single keystroke. *No other terminal today offers this kind of multi-host capability.* Period.

Then too, nobody does windows like the Falco 500. Nobody. It lets you create six windows on one screen—each one configured as a separate terminal. That means each one has its own operating

3. THE REMOTE TELECOM WORLD.

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5. THE LOCAL AREA NETWORK WORLD.

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of the display products family include an Enhanced Display Refresh Controller and a Graphics Color Palette. Targeted applications for the graphic coprocessor include personal computers, CAD and high-end video.

TI's TMS34010 offers users more flexibility and greater functionality than AMD's or Intel's coprocessors, a TI spokesman says. But, because it's a general-purpose CPU, it requires the user to create additional software. Intel's Wilson contends, "The TI chip is more flexible but doesn't give the performance in graphics applications that you get from dedicated hardware."

According to TI, TMS34010 microprocessor applications include those for personal computers, facsimile machines, laser printers, graphics terminals, workstations and desktop publishing systems.

Strong third-party support

TI reports that third-party support for its chip is being provided by Graphics Software System Inc. (GSS), Microsoft Corp. and Nova Graphics International Corp. GSS also supports the Intel chip.

GSS, Beaverton, Ore., recently announced the DGIS*82786 ROM kit, a firmware product that provides a high-level programmer interface to Intel's 82786 graphics coprocessor. The product, which GSS will license this summer, is emerging from a two-year cooperative effort between GSS and Intel, according to GSS.

A spokesman for GSS contends that both Intel's and TI's chips have their pluses and minuses. "The Intel chip has a rich graphics-instruction set but doesn't cover CPU capabilities, whereas the TI chip is an all-in-one solution; but not everyone would want to write a program directly to the [TI] chip," he says. The TMS34010 is capable of being programmed in languages such as C and is supported by a software-and-hardware development environment, according to the company.

Vendors endorsing Intel's 82786 coprocessor include Microsoft, Nova, Ashton-Tate, Digital Research Inc., Lotus Development Corp. and Number Nine Computer Corp. According to Intel, these companies are developing applications-support software, board products and development tools.

Number Nine Computer, Cambridge, Mass., plans to introduce the Pepper Graphic System, a board-level product for business graphics that implements the 82786, as its first foray into the low-end business arena. According to Will Frentz, Number Nine executive vice president, the company's family of board-level graphics products has traditionally targeted high-end graphics markets such as CAE, desktop publishing, imaging and video production. □

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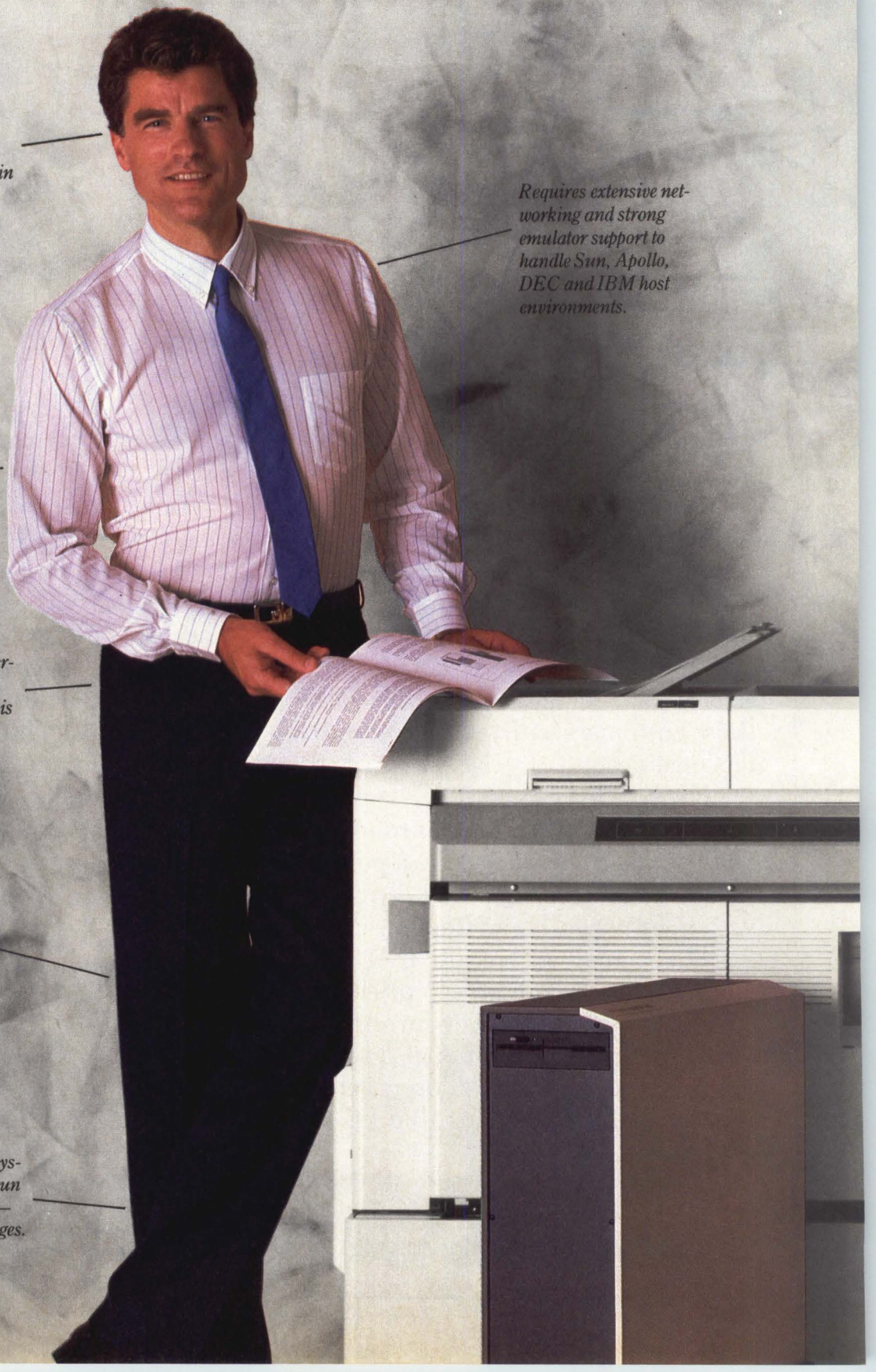
CIRCLE NO. 20 ON INQUIRY CARD

The Thinking



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Six years ago, we perfected the technology that optimized laser printing. And at IMAGEN today, we build intelligent laser printing systems with an independent "brain" that allows them to do what they do best, and frees your host computer to do what it does best.

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But our printing systems don't compromise quantity for quality.

For example, some suppliers claim their printers can deliver a certain number of pages per minute. But what they really do is print multiple copies of the same original per minute. With IMAGEN's newest system, you can print 20 completely different pages in the same 60 seconds.

IMAGEN laser printing systems offer a variety of innovative page management features that handle automatic duplexing, page reversal, electronic collation and jam recovery. This, combined with the ability to print on 11 x 17-inch paper, allows you to produce as much high-volume, high-quality documentation as you want. With as much technical detail as you need. And all our printers can be connected through Ethernet and other networks.

So, if you'd like to learn more about our laser printing systems, call IMAGEN today at (800) 556-1234 extension 199 in the Continental U.S. In California, call 1-800-441-2345 extension 199.

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Bell Labs models parallel processor on neural networks

Jesse Victor, Associate Editor

Researchers in the microscience group at AT&T Bell Laboratories, Holmdel, N.J., have turned to a massively parallel, non-Von Neumann architecture—one that is similar in some respects to that of simple biological neural networks—to overcome the fundamental performance limitations of both conventional digital computers and submicron integrated circuits (ICs).

The group has developed experimental, "neural-network" processors whose fundamental elements are resistors, not transistors. Capable of functioning as either content-addressable memories or optimizers, these processors use a form of "fuzzy" logic to provide fast solutions to complex problems—in some cases much faster than digital computers.

"We are running out of steam on conventional computers," asserts Richard E. Howard, a member of the Bell Labs research group. "We have to look at something different. A biological processor proves that a different way of doing computing is possible. It gives us cues for another way to go."

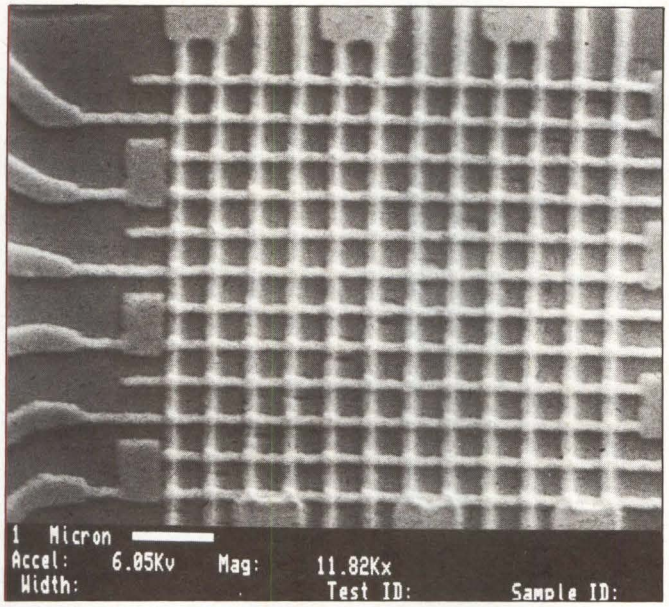
Using electron-beam lithography and plasma etching, the Bell Labs researchers have fabricated a silicon, narrow-channel metal oxide semiconductor field-effect transistor (MOSFET) with features as small as 25 nm—only about a hundred atoms wide. But chips like these are so small, Howard contends, that they exhibit two kinds of quantum effects at near room temperature from the wave nature and discrete energy levels of the electrons in the circuit.

Microfabrication is not the problem, explains Howard. "We can do lithography 100 times smaller than conventional line widths and make complex devices with 0.02 micron lines. But, at this point, you are getting very close to fundamental limits to increasing chip density."

The fundamental limits involve problems with thermal effects and discrete-switching effects—due to the few electrons in the circuit—and to the two kinds of quantum effects. One effect, associated with single electrons moving in and out of interface traps, causes wide swings in device conductivity, with device resistance fluctuating in factors of 30K ohms. The second effect, which results from interference between electron waves, also causes conductivity changes with variations in other parameters, such as gate voltage or magnetic-field strength.

Because of these effects, Howard warns, such submicron circuits do not behave like ordinary semiconductors. "We can predict the statistical distribution of these [conductivity] changes. But statistical distribution is not good enough when you are designing a circuit. Below 0.1 micron line widths, you have to talk about using completely different devices."

The Bell Labs group and other researchers have circumvented the limitations of submicron ICs by using massively parallel processors based on simple models of biological systems.



Fabricated of amorphous silicon *and tungsten wires, a 12-line-by-12-line resistive array for a neural-network processor packs 144 interconnects into an area 6 microns on a side using 0.1-micron line widths. Interconnect pads surrounding the grid lead to the off-chip amplifiers—essential elements of the neural-network processor.*

In biological neural systems, nerve cells (neurons) send pulses via nerve-fiber pathways (axons) to the inputs (dendrites) of other neurons, through synapses. In an electronic analog of a neural network, Howard says, the neurons are operational amplifiers and the synapses are resistors that determine how the output of one amplifier (an "axon") is connected through a capacitor to the input of another amplifier (a "dendrite").

Thus, the neural-network processor is basically an array of amplifiers with resistors at the crosspoints of a wire grid. The processor's operational states can be defined by a plot of potential energy or an energy "surface"; this in turn can be mathematically modelled as a function of the amplifiers' gain and of where the resistors are placed on the grid.

In operation, the processor, in effect, "rolls down hill" from higher to lower energy states until it reaches local valleys or pits in the energy surface: minimal or stable states where the neural-network's voltages are constant in time. These minimal voltages solve users' problems when the processor acts as an optimizer and

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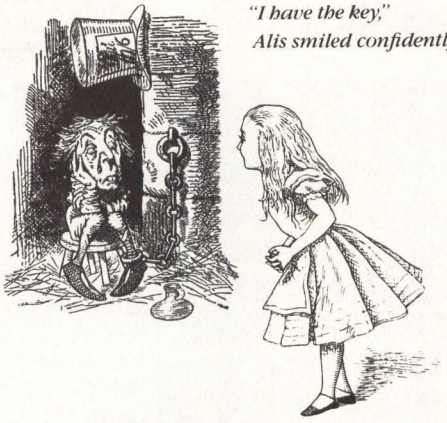

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store data when the unit serves as a content-addressable memory.

Like a human brain, the network exhibits parallel-processing operation, very high density and extensive fault tolerance. Thus, damage to many of the connections, or loss of data in the network, will not significantly affect the processor's output.

"The processor basically functions as an analog computer with digital outputs," Howard observes. "It is a computer that guesses in a reasonably intelligent way. In a digital circuit, each transistor is important. In a neural-network processor, only the collective state of the network is significant."

The microscience group at Bell Labs has fabricated several 22-line-by-22-line-matrix neural-network chips using amorphous silicon and 2-micron line widths. One version—coupled with its off-chip amplifiers—can store four 22-bit words. A 512-line-by-512-line array, which can store 128 512-bit words, has also been fabricated. It integrates all circuit elements, including CMOS amplifiers and multiplexers, on a 7-mm-by-7-mm chip.

"The advantage is that we can make the resistive elements as small as we wish," Howard comments. "For example, we've fabricated a 12-line-by-12-line tungsten-wire matrix chip, without active elements, using 0.1-micron lines, which fits into a square 6 microns on a side—about the same size as a cell within a conventional dynamic RAM."

Because the synapses are in parallel, the resistor network is not power-hungry. A 4-mm-by-4-mm network dissipates only 0.5W.

Functioning as a content-address-

In this computer simulation *of a neural-network processor acting as a content-addressable memory, the processor converges to a minimal voltage level (the bottom line) that recalls a full name and telephone number when only part of the name is entered.*

Time	Energy		
0	0.	john s	
0.20	−0.0784	john sdewirubneoimv	8109
0.40	−0.8426	john sdewirtbnenimv	8129
0.60	−0.8451	john sdewirtbnenimv	8129
0.80	−0.8581	john sdewirt nenkmv	8128
1.00	−0.9099	john sdewart denker	8128
1.20	−0.9824	john stewart denker	8128

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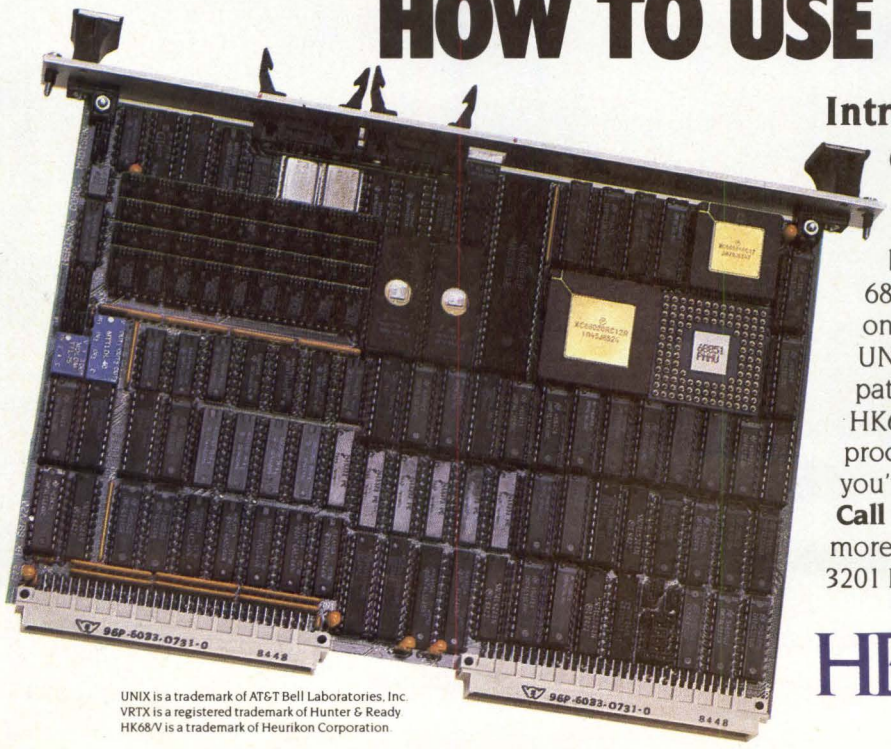

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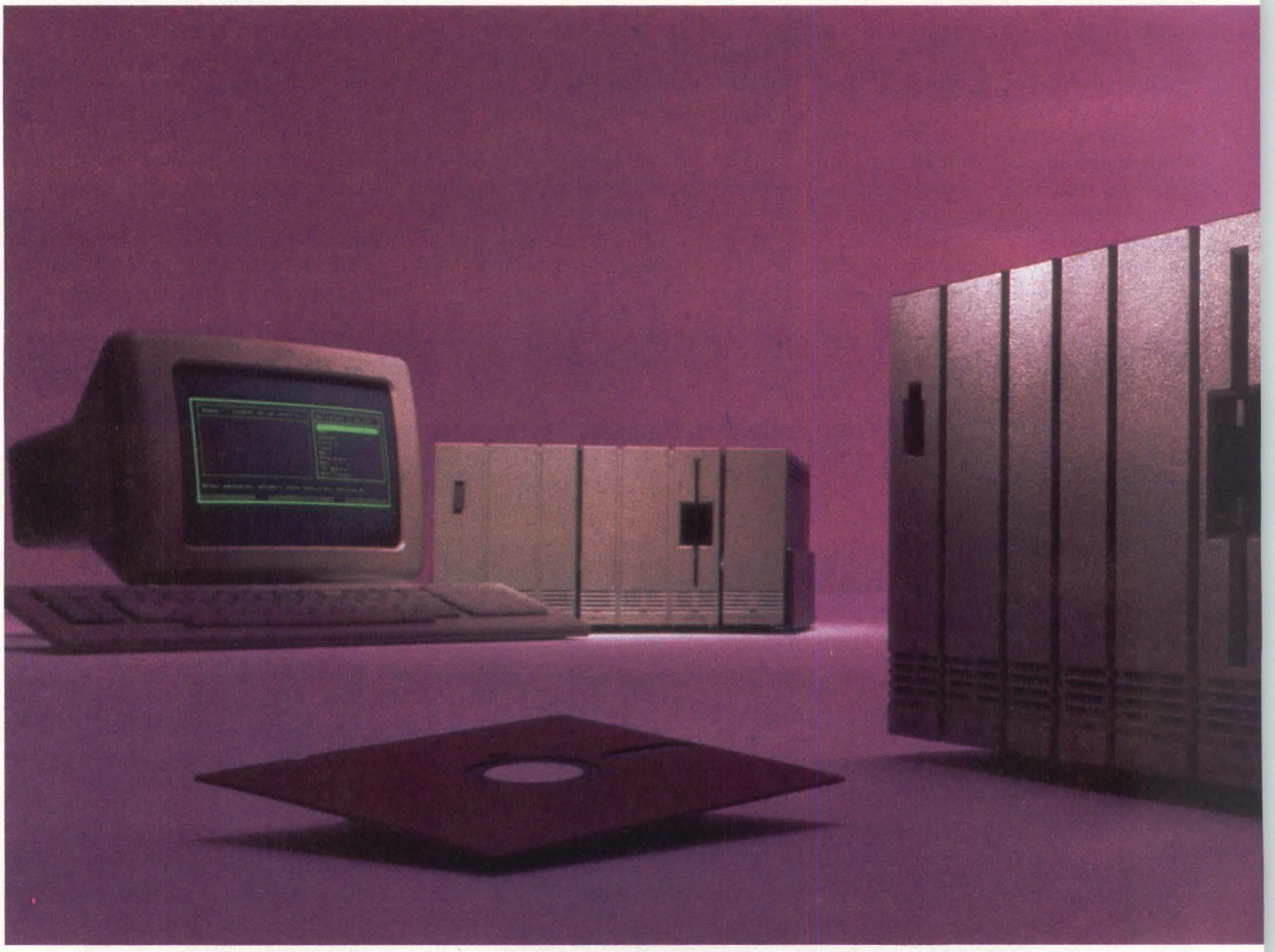

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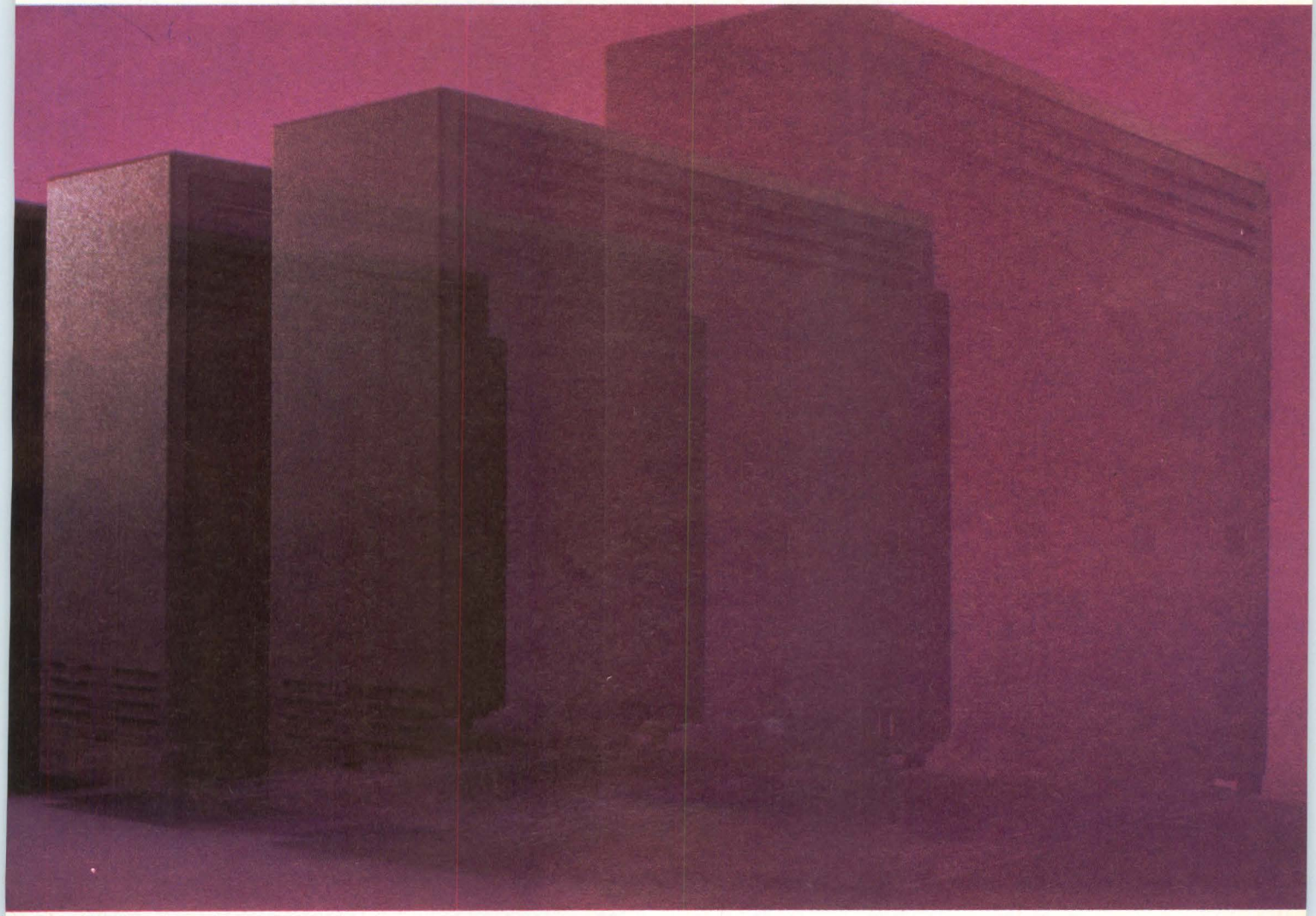

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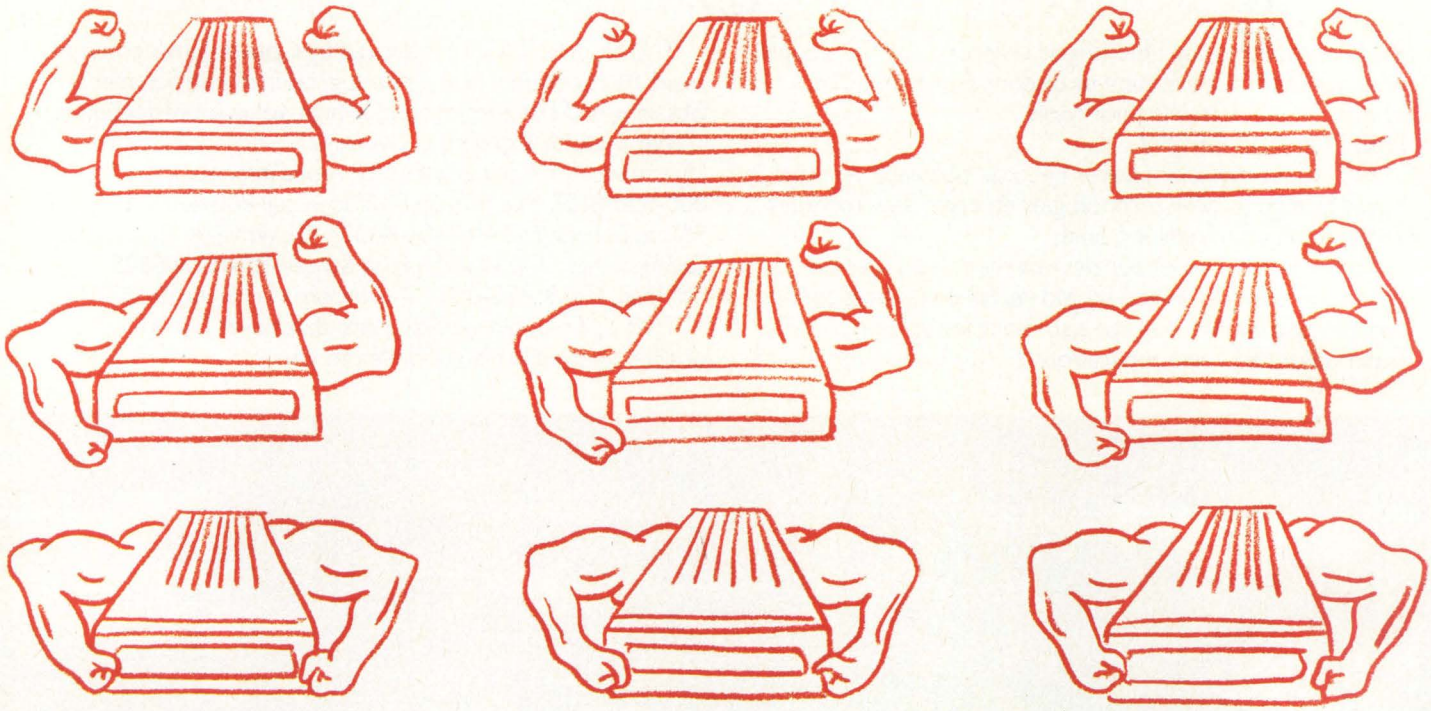

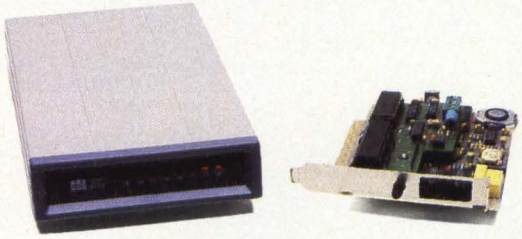

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able memory, the 22-line-by-22-line matrix can store four 22-bit strings of data. The data, however, is not retrieved by conventional addresses but by the meaning of the entered bit string.

"Any piece of the data brings up the rest of it," Howard explains. "If you enter, say, a good guess of a person's name, with possibly a few wrong bits, the 22-line-by-22-line circuit will find the whole correct name in a few microseconds; the 512-line-by-512-line processor, in 100 nsec. The processors, in effect, settle down to the nearest word stored that matches what you put in."

There is a tradeoff between "error correction" capability and storage, Howard says. Storing four words, the circuit corrects all 2-bit errors and some as large as 8 bits. Storing only two words, it always corrects 4- or 5-bit errors and sometimes 10-bit errors.

Voltages define problem

The neural-network processor is programmed using a computer and matrix algebra to design a resistor-network matrix and voltage states that correspond to the problem to be solved. When the processor operates as a content-addressable memory, some of the neuron voltages are set at levels representing data bits entered in the system. The network's final minimal voltage levels correspond to the data you want to recall.

John Hopfield, professor of biology and chemistry at the California Institute of Technology and a member of the Bell Labs staff, and David Tank, also a staff member, have simulated a neural-network processor's operational voltage levels using a Digital Equipment Corp. VAX-11/780 minicomputer in order to compute solutions to the traditional "travelling salesman" problem, which proves a time-consuming task for conventional digital computers.

The problem involves finding the shortest path between a fixed number of cities, visiting each city only once and then returning to the point of origin. To program the neural network, Howard says, one chooses net-

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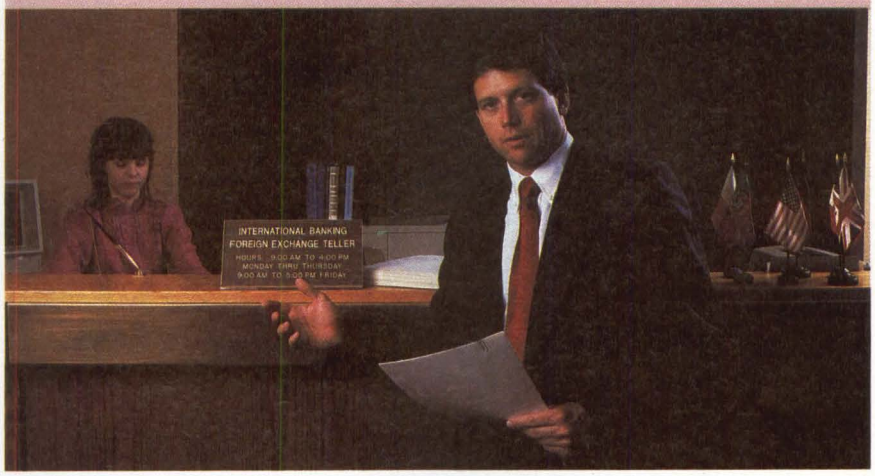

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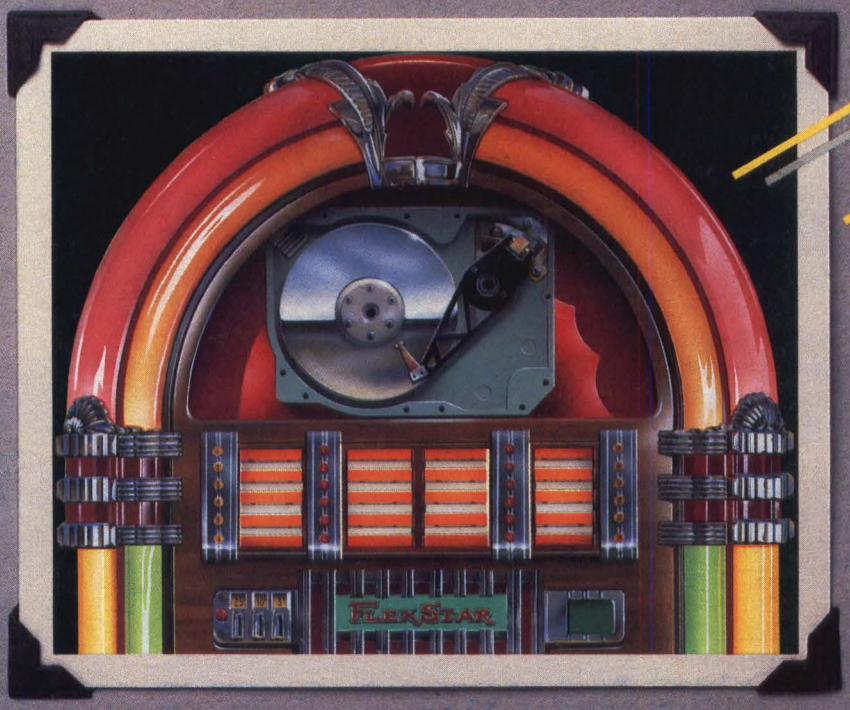

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work elements so that the equation describing the processor's energy states corresponds to a "cost" function. This cost function increases the greater the distance the "salesman" travels, when a city is visited more than once and if a city is not visited at all.

"It is not known how to find the best solution to the problem," Howard notes. "For 30 cities, with 10^{30} possible combinations of routes, the best known solution is described by a relative distance factor of 4.3. The neural-network processor simulation gives a solution of 5.07; and a neural-network processor designed to solve this problem should provide a solution in seconds—much faster than conventional digital computers. You may get a better solution with a VAX computer and a conventional algorithm, but you can get a very fast, okay solution with a neural network," he says.

Howard sees opportunities for further research in hierarchical arrays of neural-network processors—similar to the way biological vision systems are thought to function—as well as optically programmed networks and circuits that could "learn," reconfiguring themselves on the basis of experience.

"Finding the best set of resistors for a given problem is basically an optimization problem. We might use another neural network to solve it," Howard adds. "We would like to make the circuits completely programmable, more like electrically programmable ROMs than the basically masked ROMs we have now."

Howard also anticipates possible applications for the neural-network processor in pattern- and speech-recognition, signal processing and for a packet-switching network that contains the rules of how packets act within the system. However, he cautions that real-world applications are not around the corner.

"I would expect applications within 10 years, if the concept proves useful. We should know in a few years whether it is worthwhile to really push the development of this type of processor." □

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Emulation Capability	
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3163	IBM 3101 Model 881 DEC VT 52* DEC VT 100* TeleVideo 950*
3164	IBM 3101 Model 881

For example, our basic ASCII Display Station, the IBM 3161, emulates up to six terminals. And the advanced-function 3163 emulates a number of higher level ASCII data streams.

Features	3161	3163	3164
Screen size	12"	12"	14"
Lines x characters	25x80	25x80	25x80
Character matrix	8x16	8x16	8x16
Double-sized characters	No	Yes	Yes
Line drawing characters	24	24	24
Vertical scroll	Jump	Jump/ Smooth	Jump/ Smooth
Definable function keys	24	24	24
Windowing	No	Yes	Yes
Partitioning	Horiz.	Vert./ Horiz.	Vert./ Horiz.
Characters in buffer	1920	7680	7680

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Our unique plug-in cartridges allow for considerable flexibility in your operation. For example, simply by switching cartridges you can shift a terminal from one data stream to another.

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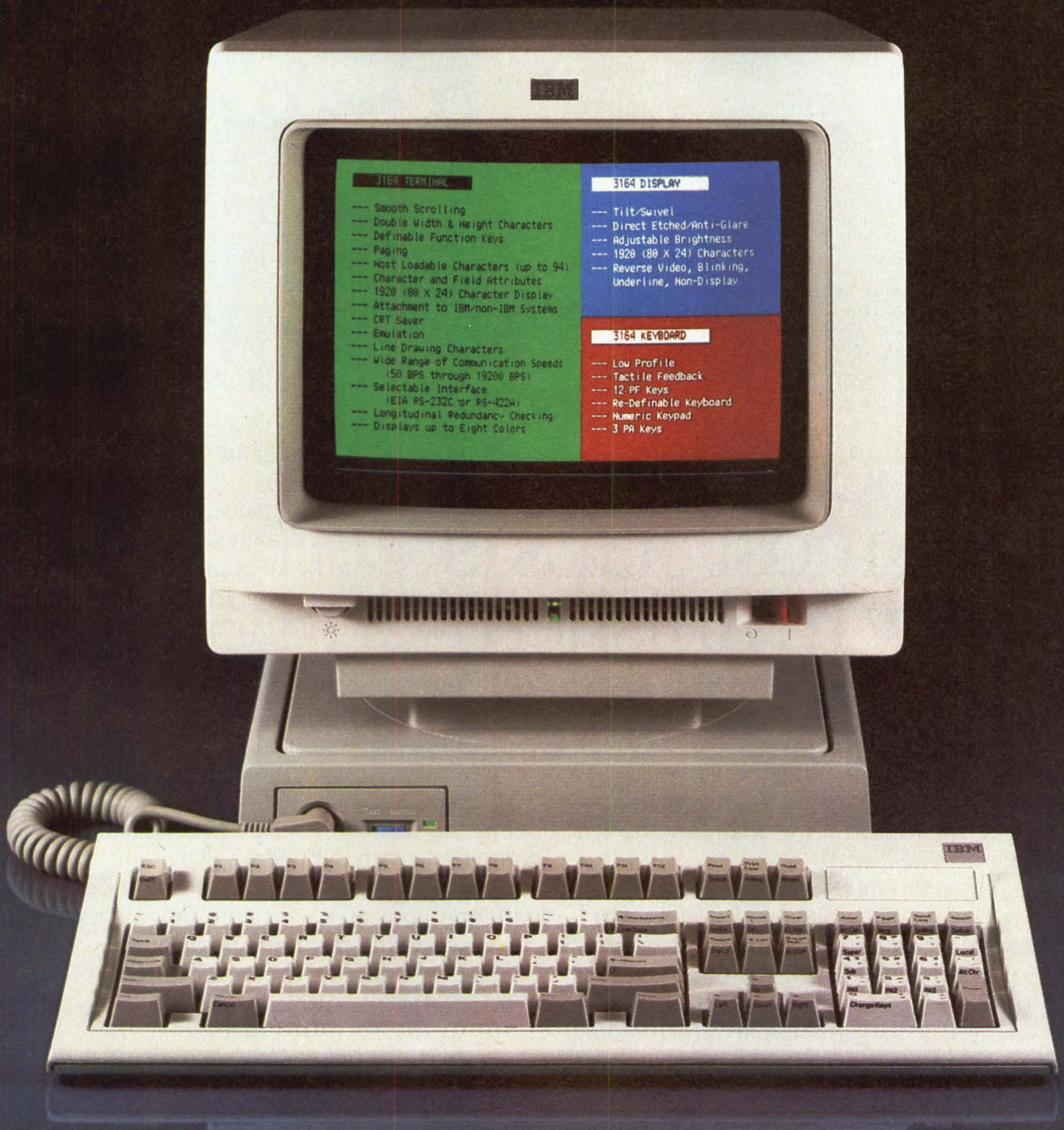
The case in color.



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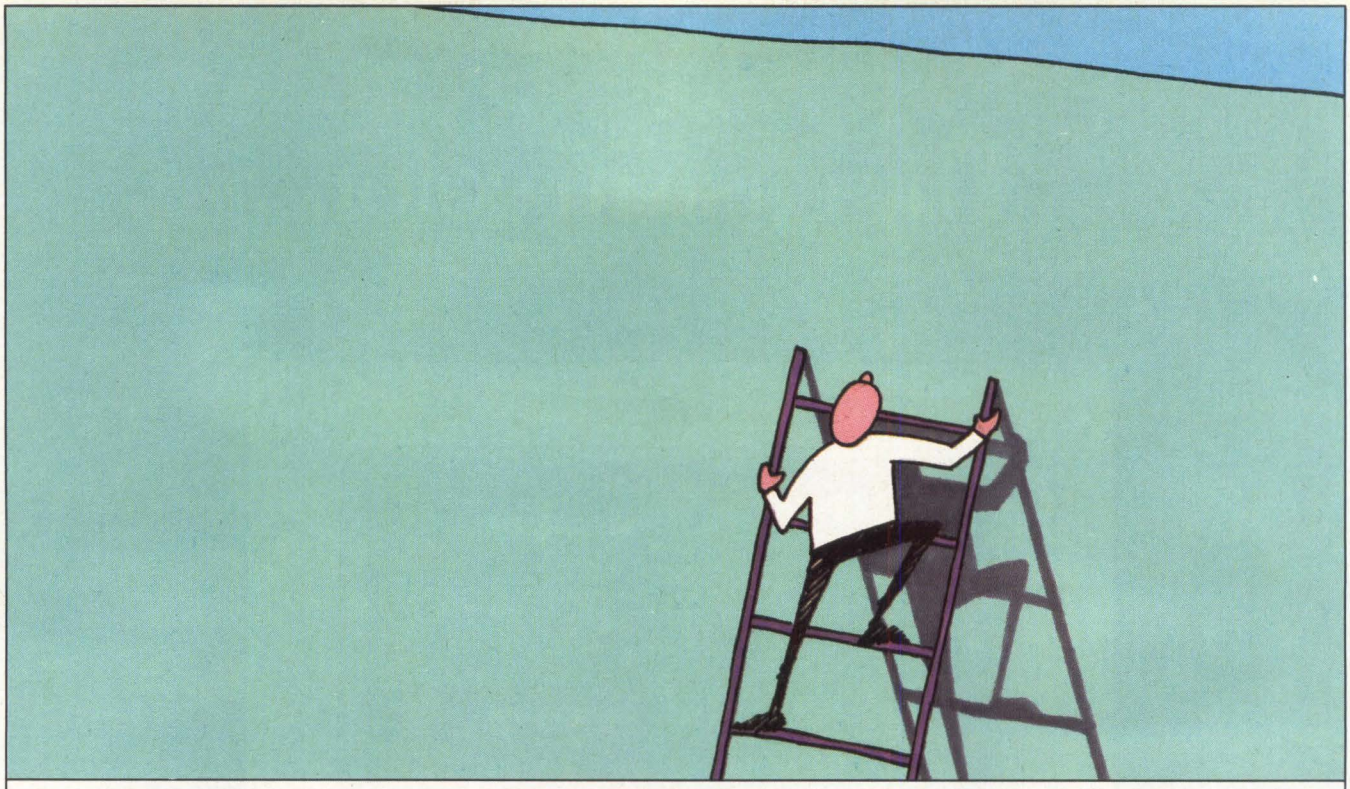

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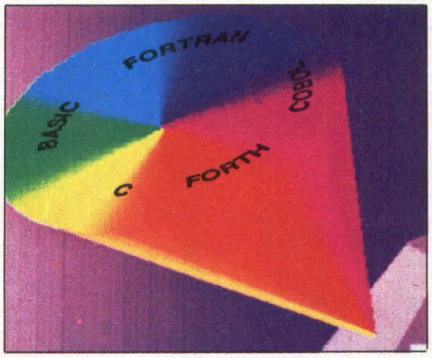
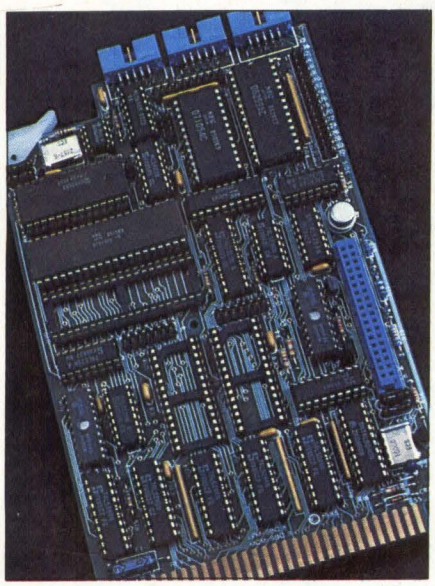




Despite the hype and hoopla surrounding artificial intelligence, the technology continues to evolve at a normal pace. And now AI is stepping out of the research closet into the real-life world. The major forces behind AI's mainstream acceptance are new workstations, standardized languages such as Common LISP and Prolog, and affordable prices. Perhaps most importantly, system integrators and value-added resellers are developing precisely targeted AI applications. This article is the first of a two-part special report on artificial intelligence.

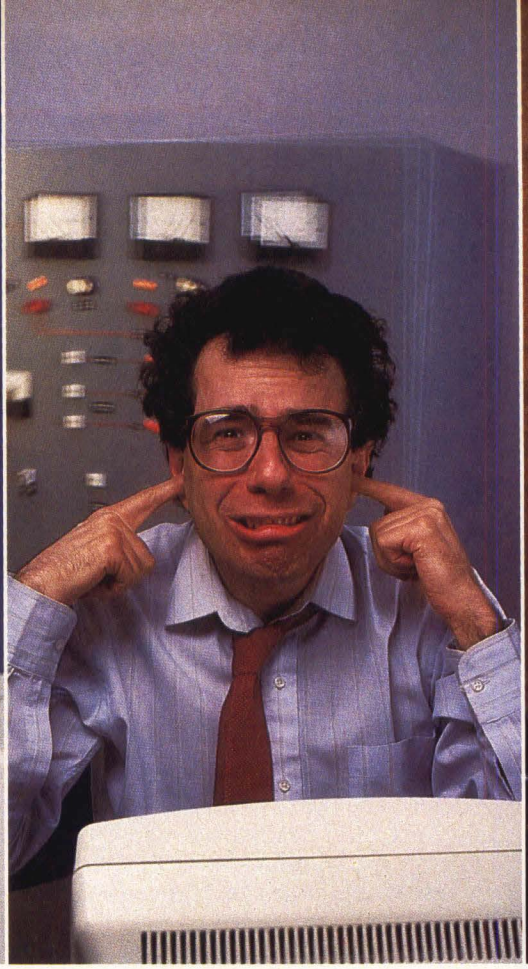
Although they rarely enjoy the limelight, compilers—programs that turn source code into machine language—remain a dynamic technology. Where they used to be mills that merely churned out binary code, compilers now often come with large assortments of integrated software-engineering tools, highly modular designs, interactive debugging facilities and even integrated databases to keep track of code modifications.

If the original IBM PC/AT doesn't have enough bang-per-buck for your applications, take a look at what AT-compatible manufacturers are up to. Cranking up the capabilities of the AT and compatibles, vendors are offering faster machines, larger capacity rigid disk drives, add-in and add-on boards, expansion buses, alternative motherboards and new chips and software.

The STDbus has long been the workhorse of the low-cost industrial-control market. But recently, the old standby has encountered increased competition from PC/AT, Multibus and VMEbus single-board computers. To meet the opposition, STDbus board vendors are upgrading in a variety of ways, including adding new 16- and 16/32-bit microprocessors, CMOS technology, multitasking and multiprocessing support and SCSI interfaces.

Mini-Micro Systems' annual survey of single-board microcomputers lists over 50 companies and more than 120 products. The table also identifies key characteristics, such as the CPU type, bus, operating system, software and programming language support, memory capacities, dimensions and price.

Too big.



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AI SHAPES UP FOR MAINSTREAM USE

Commercial AI is evolving, not exploding. But new platforms, standardized languages, lower prices and targeted applications are beginning to spur usage

Wendy Rauch-Hindin
Special Features Editor

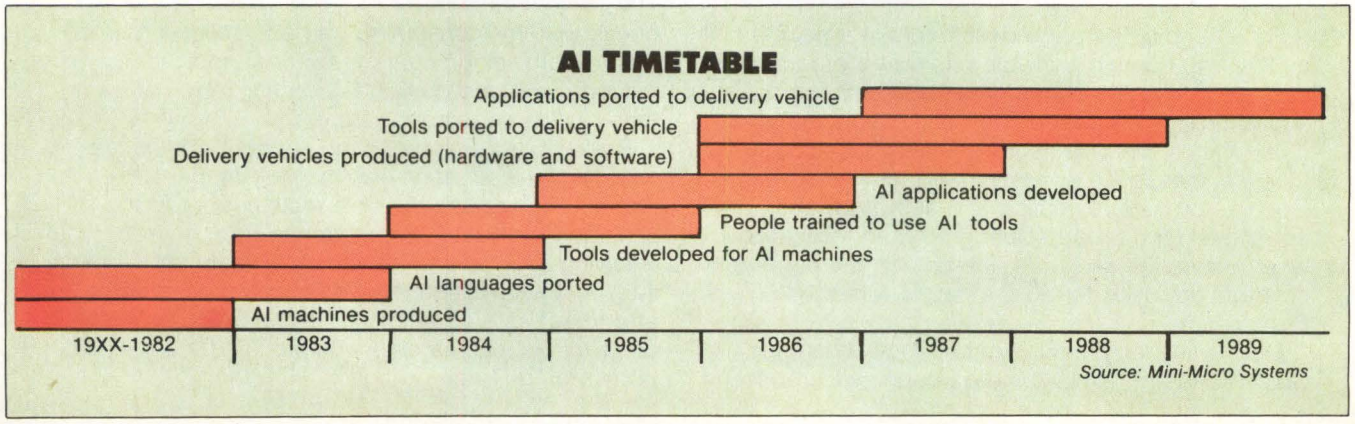
Perhaps because of hype, just a few years ago many people expected artificial intelligence (AI) to burst into the business scene. Now it is becoming the "in thing" to criticize AI for not developing a market fast enough.

The truth is that AI demonstrated commercial feasibility a few years back, but the time expectations were unrealistic. Solving the problems necessary to field a new technology is usually an evolutionary, not revolutionary, process.

Fielding a knowledge system depends on a number of technical and non-technical factors. These include corporate-management attitudes, perceived risk, cost, training, hardware, language, portability, tools, integration with traditional hardware and software systems and the demonstration of application success stories.

One hardware barrier, related to risk and cost, is dissolving because major computer companies are entering the field. For example, Texas Instruments Inc. and Xerox Corp. are players in the LISP machine market. Apollo Computer Inc., Digital Equipment Corp., Hewlett-Packard Co., IBM Corp., Sun Microsystems Inc. and Tektronix Inc. have made AI a major focus. Of these, Apollo, HP, IBM, Sun, Tektronix and Xerox offer relatively inexpensive AI workstations. Some of these workstations are based on the Motorola Inc. MC68020 microprocessor—a processor that has become popular for AI. Intel Corp. has also designed features specifically suited to AI pro-

Part II of Mini-Micro Systems' *special report on artificial intelligence, to be published later this year, will cover AI software trends, integration with standard systems and knowledge-system tools.*



gramming into its 80386 microprocessor, and it is working with third parties to develop an 80386-based machine that hosts Common LISP and Prolog environments as well as support the major knowledge-system development tools (see "The 386 enters the fray," below).

These may or may not be the most innovative companies. But most of them are large. And large companies, which are likely to be AI users, prefer to deal with other large, familiar companies. Management tends to feel that, if they go out on a limb and make a $20,000 investment in an AI computer and have to write it off later, at least they haven't bought themselves an expensive white elephant. They can creep into AI sidewise, with inexpensive machines that are capable of doing substantial AI jobs and are from familiar vendors that, they feel, understand the tradition of service.

A key barrier to AI acceptance is programming languages. Most AI systems are programmed in LISP. A large number of LISP versions exist.

With an eye toward avoiding the incompatibility problems rampant in the computer industry, the major AI players banded together to standardize and support a version of LISP called Common LISP. An ANSI subcommittee is working on a formal standard. LISP experts in commercial companies, universities, government and research organizations are participating in the ANSI efforts. Common LISP is now appearing on all LISP machines and on some conventional computers.

Common LISP means AI portability with minimal grief. If programmers write a large software package in Common LISP, and take reasonable care not to use too many machine-dependent features, they can salvage more than 90 percent of the code when they transport the program to other Common LISP machines.

Associated with the programming language obstacle is the lack of available programmers. However, many universities are teaching LISP and AI in their computer science courses. Several AI books for the non-researcher have been published. And programmers who want to learn LISP or Prolog—the other major AI language—can obtain these languages, with usable documentation, for PCs and compatibles.

One example is Golden Common LISP, an enhanced subset of Common LISP from Gold Hill Computers Inc., that includes a fairly complete LISP development system and an organized computerized LISP tutorial. Another example is the recently introduced Prolog compiler, from Borland International Inc., which includes an interactive development system and has the added attraction of a $99.95 price tag. Digitalk Inc. has a comparable offering—language, graphical environment and readable documentation for a PC implementation of the object-oriented Smalltalk language.

A number of companies have designed large-scale AI toolkits for developing large knowledge systems on LISP machines, conventional computers and workstations. Increasingly, these companies are basing their tools on Common LISP, and some are translating the tools into C.

The 386 enters the fray

Paging, dynamic memory management and "garbage collection" are three bottlenecks in LISP program execution. The Intel Corp. 80386 microprocessor is designed to attack them and speed AI performance.

For example, the page descriptors in a paging unit on the chip contain available bits that a programmer can use to classify pages on a page-by-page basis and to facilitate garbage collection (cleaning out old data). Pages typically might be classified according to their lifetimes, such as static (lives forever), dynamic (such as procedures called and activated) and ephemeral (short-lived). During program execution, when pages are allocated, the bits on the page descriptors are used to tag the pages with these classifications.

During any incremental garbage collection run, which frees up memory, the garbage collector scans the page descriptor table to look for the most likely areas of memory that have become garbage. The trick is to scan the short-lived ephemeral objects 10 times before scanning any of the dynamic objects. The static area is never scanned. This scheme reduces the time-consuming garbage collection procedure by providing some hardware support for memory management and garbage collection, and narrowing the areas to search for garbage.

Besides garbage collection support, certain features in the instruction set, memory model and—particularly—the permissible register-addressing schemes allow fast access to and from memory when following LISP pointers across LISP data structures. Intel is now investigating a symbolic process accelerator to act as a coprocessor to the 80386. Among other things, such a chip would offload a significant portion of garbage collection from the CPU.

The combination of tools, academic training and available languages means that the supply of people who can develop knowledge systems is expanding. It is still smaller than the market needs. But engineers and application experts exist who can do the job, and people who are good conventional-application programmers are slowly being turned into good AI programmers.

All things considered, it is no longer harebrained to suggest that a large, stable, conservative company use AI technology in its routine operations. So encouraging are the signs that Dataquest Inc., a San Jose, Calif., market-research concern, predicts that world purchases of AI hardware, software and services will grow from $335 million last year to $2.7 billion in 1990. Most of this market will be oriented toward large-scale knowledge systems.

The fastest growth will be in conventional computers purchased primarily for symbolic processing. Until now, most AI hardware and software has been purchased primarily for AI research, and most AI systems have been developed and run on LISP machines. Symbolics Inc. currently has the lion's share of the LISP-machine market. But commercialization of AI is likely to require the purchase of many LISP computers instead of just a few, and so cost will become a greater factor. The changing AI hardware requirements mean that by 1988 purchase of conventional computers dedicated to AI will outstrip LISP machine purchases. Many experts believe, however, that LISP machines will have a place in niche markets as specialized hardware.

Approaches to AI

In AI, there are turnkey applications, vertical-market tools, generic application-development tools and AI-specific languages like LISP and Prolog. Knowledge systems are computer programs that contain people's opinions, experiences and judgements, all of which can change. Thus, it seems that a turnkey application would be difficult to build. However, there are some routine judgments and decisions that are made in certain types of application areas, like assessing a corporation's financial future. If the potential user agrees with the quality of knowledge in such a knowledge system, then a turnkey system is possible.

PlanPower, from Applied Expert Systems Inc. (APEX), is an example of a turnkey knowledge system. PlanPower performs comprehensive personal financial planning. It is designed for use by financial planners who can control it, interact with it or run it in an automated mode.

Three artificial intelligence workstations *from Tektronix run Smalltalk, LISP and Prolog. They are the 4406 (foreground), 4405 (back left) and 4404 (back right).*

A large system, PlanPower runs on Xerox LISP machines and uses a variety of AI techniques. It differs primarily in scope from a number of similar, but smaller, systems, including some which run on IBM PCs and compatibles. Its developers claim that PlanPower covers the details and analyses necessary for comprehensive financial planning. Most smaller systems bite off only a small part of the problem.

A subsidiary of APEX, APEX Advisory Services, provided the staff and expertise to source the knowledge for PlanPower. But the APEX subsidiary, itself a registered investment advisor, is also committed to servicing and supporting the knowledge base as knowledge changes or as new situations arise.

Turnkey systems are less likely to be found in manufacturing domains because factories are not generic. A compromise—customized turnkey systems—is finding favor for these domains. Such systems are essentially AI application-development tools that also contain some generic knowledge applicable to particular application domains.

Users can add the remaining knowledge that is specific to a company's problem. Generally, the user of such a system is a non-programmer and can add the specific knowledge by picking choices from a menu.

The best known examples are off-the-shelf knowledge-based simulation systems from IntelliCorp Inc. and Carnegie Group Inc., and Picon from LISP Machine Inc. (LMI). IntelliCorp's simulation system is built on top of the company's KEE package; Carnegie Group's is built on top of its Knowledge Craft package. They are visually oriented, frame-based systems that contain knowledge of components of a factory, networks or of other systems that

users want to model. The simulation system uses its knowledge of manufacturing to ask users about applications.

When the simulation system runs, it displays events and performs knowledge-based analyses of the simulation, compares alternative models, generates reports and recommends changes.

Picon is a similar type of semicustom vertical tool. The first version contains knowledge about process control plants; a second Picon version contains knowledge about discrete manufacturing and materials handling.

Picon users develop specific applications through a menu-driven, interactive graphics system and a schematic capture system. Engineers combine plant component icons to construct a schematic that represents their plant. Picon captures the component/icon information, its type and connections, and determines its relationship to the overall process or to the materials-handling system. Users can add further knowledge by selecting and combining words and phrases from a menu to form knowledge-system rules. Picon has been used to develop applications that are operational at Exxon Corp., Johnson Controls Inc., Leeds & Northrup Co. and Texaco Inc.

In the materials-handling area, Picon has been used to build an Automated Guided Vehicle (AGV) system in use at the Oak Ridge National Laboratory. Called Hermies II, the AGV not only carries and retrieves materials in hazardous environments, but also navigates and dodges obstacles and still figures out how to reach its goal.

Another approach to building and using AI systems is through knowledge-system application-development tools. These tools are composed of a template to hold knowledge, an inference mechanism that reasons with the knowledge and an easy-to-use interface. Large-scale tools also support multiple ways to represent knowledge, multiple reasoning methods, a control mechanism to efficiently control the order of a consultation and an explanation facility, used more by developers debugging a system than by users.

Application-development tools can be used by application experts, but most often they are used by programmers and engineers. The most well known of the large-scale tools are S.1 from Teknowledge Inc., KEE from IntelliCorp, ART from Inference Corp. and Knowledge Craft from Carnegie Group. These tools are similar, but different. For example, they vary in complexity and ease of use in the order listed, with S.1 being the simplest to use and Knowledge Craft, at the high end, being the hardest. A variety of other knowledge-system tools exist for minicomputers, UNIX-based workstations and IBM PCs and compatibles.

Still another approach to developing knowledge systems is to develop the system in a low-level AI language like LISP, Prolog or even OPS5, which is a slightly higher level rule-based language. This requires much more programming and AI knowledge than does using an application-development tool. On the other

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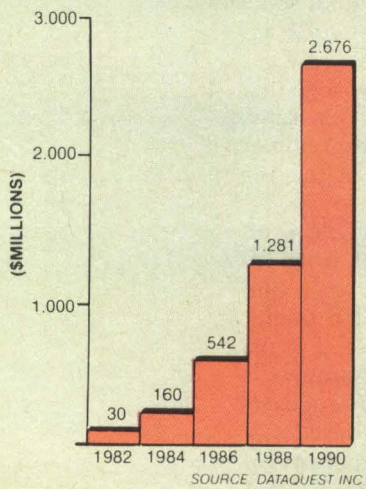
TOTAL WORLDWIDE REVENUES



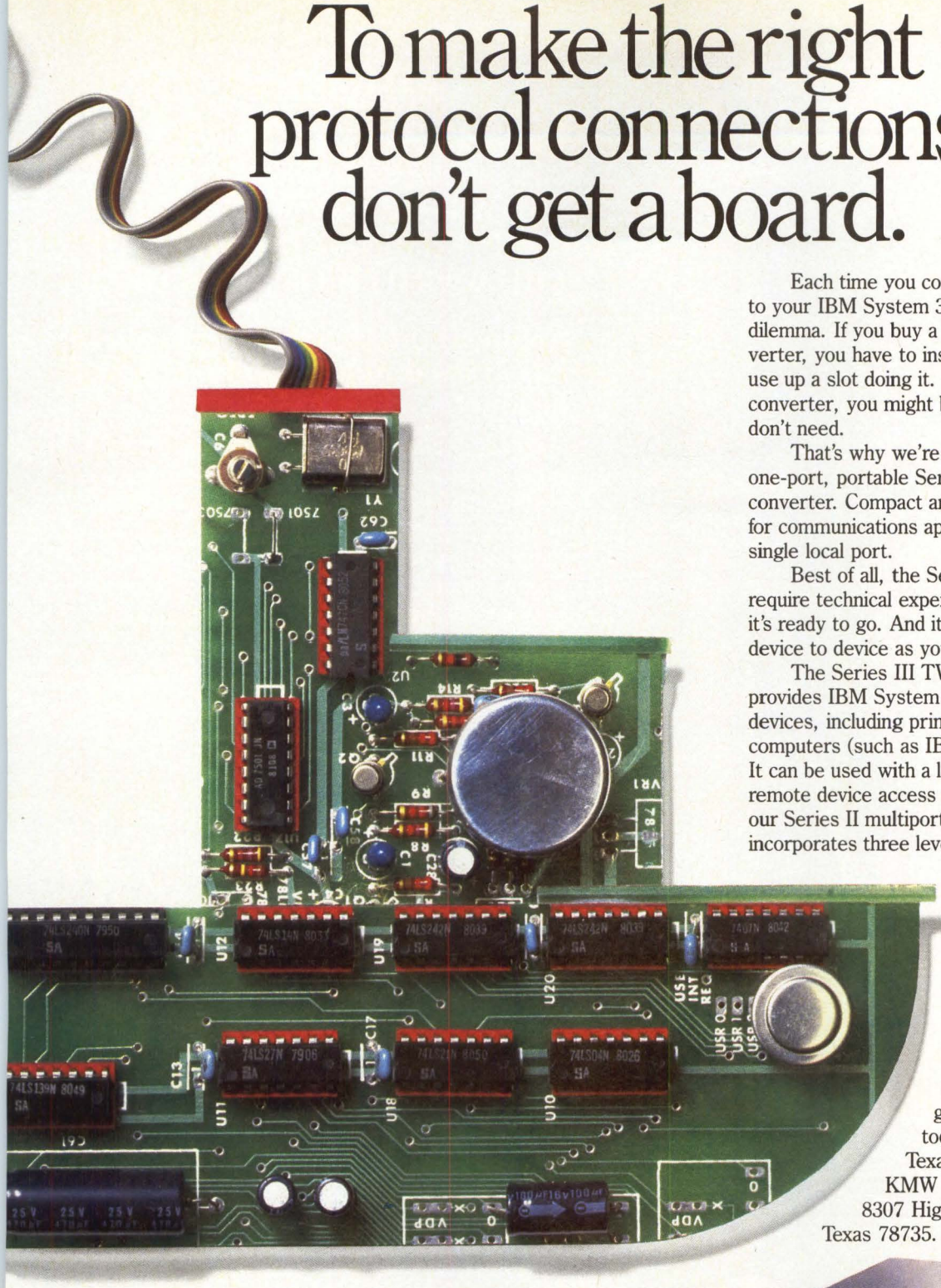
(Worldwide revenues, $ millions)

	1982	1984	1986	1988	1990	% CAGR* 81-85	% CAGR* 86-90	%Total market 1985	%Total market 1990
Hardware:									
Conventional hardware	14	37	143	403	953	72	61	24	36
Symbolic processors	9	70	185	389	736	159	41	40	28
Hardware subtotal	23	107	328	792	1,689	105	51	64	63
Systems software:									
System development tools	0	7	55	132	284	N/A	51	8	11
System processing languages	0	5	36	80	147	N/A	42	5	5
Natural language	0	11	29	69	141	N/A	49	5	5
Systems software subtotal	0	22	120	281	572	N/A	48	19	21
Services:									
Contract services	5	26	84	181	355	124	44	15	13
Education and training	2	5	10	27	60	58	55	2	2
Services subtotal	7	31	94	208	415	109	45	17	16

Note: Numbers may not total due to rounding

* Compound annual growth rate

To make the right protocol connections, don't get a board.



Each time you connect a PC or peripheral to your IBM System 34, 36 or 38, you face a dilemma. If you buy a board level protocol converter, you have to install it yourself — and use up a slot doing it. If you buy a multiport converter, you might be paying for ports you don't need.

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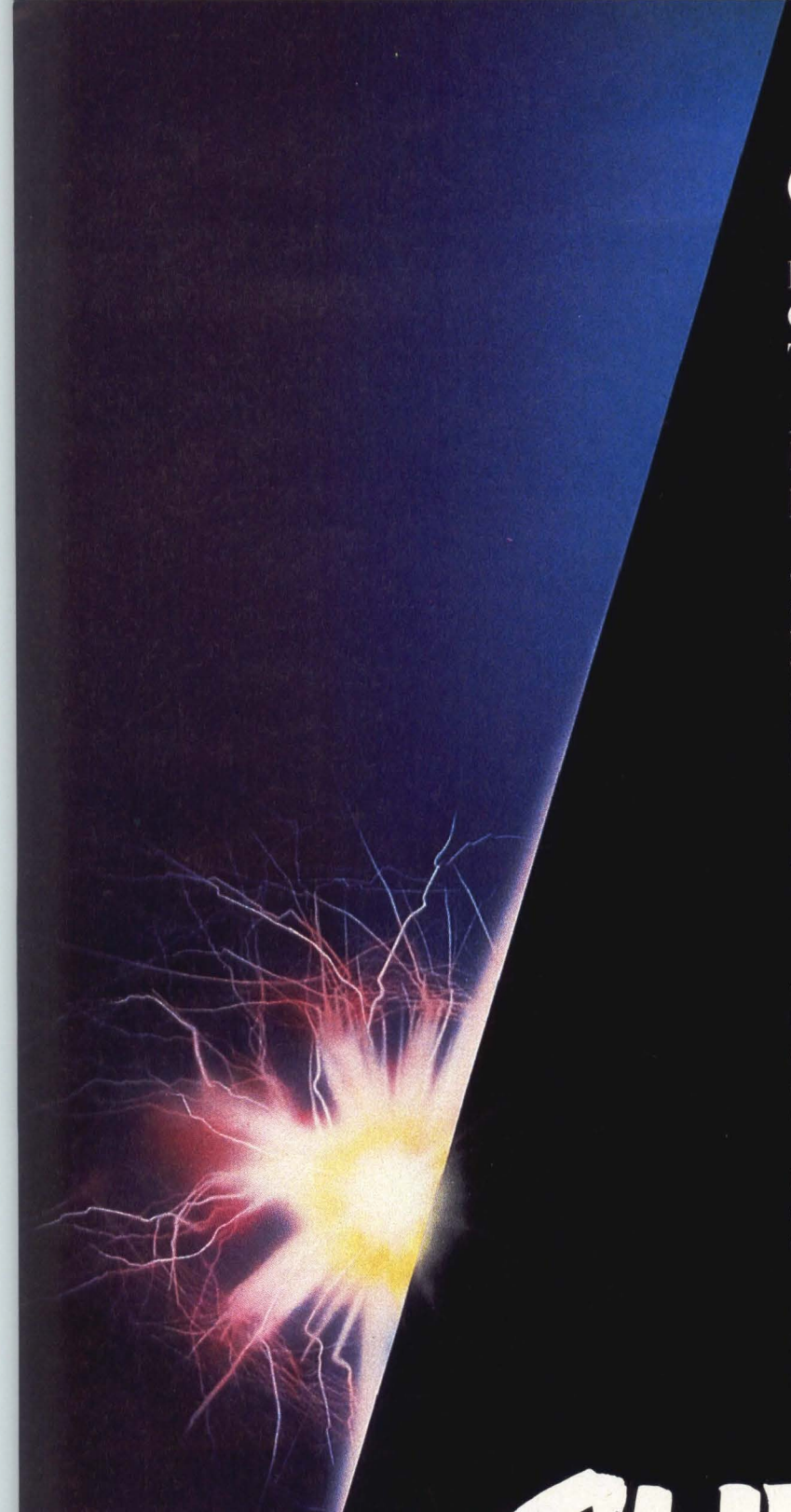

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CIRCLE NO. 34 ON INQUIRY CARD

hand, working in these languages provides the maximum amount of functionality.

IntelliCorp surveyed 50 of its customers in 1985 and asked them, in some detail, what they needed to deliver their applications. They found a spectrum of answers.

At one end of the spectrum were users who wanted to use the development system as a delivery system as well. These were mostly people whose applications were a moving target. They needed the use of the development machine so that, over time, they could continue to make significant modifications and add major new functionality rather than just perform normal maintenance. Many of these customers were in the scientific or real-time areas. Typically, they have a knowledge-based meteorological or pattern-recognition system. Generally, they did not need production quantities of either the system or of the AI computers.

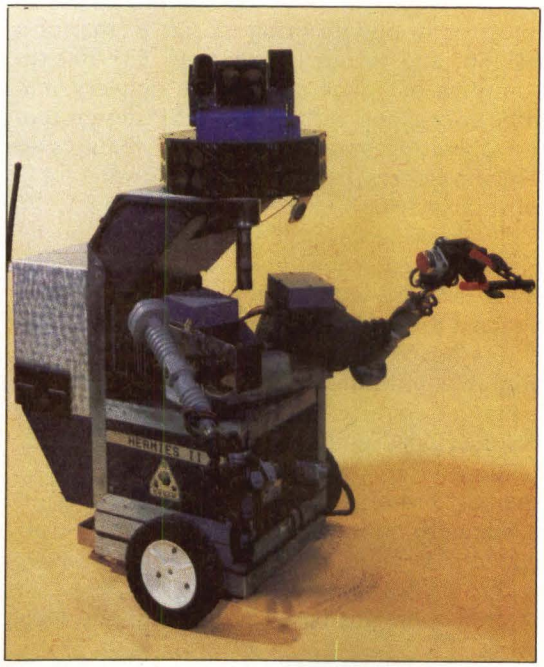
The ability to develop programs incrementally was particularly valuable to these people. There are no metrics to measure productivity for incremental program development, but few people who have used it want to return to conventional methods.

At the other end of the spectrum were users who wanted applications embedded within existing software or hardware systems so they were invisible to the end users. The same two issues appeared in most survey answers: cost and integration with existing software. A third significant issue, the ability to run on existing hardware, relates both to cost and integration.

Choosing run-time systems

There are five classes of hardware that can be used as run-time vehicles for knowledge systems: delivery versions of LISP machines, engineering workstations, RISC (reduced instruction set computers) machines, timesharing computers and personal computers. Run-time machines are usually characterized by features such as low cost, ease-of-use by non-programmers and maintenance support.

APEX cites low price and the national support provided by a large company as the reason for buying 1,000 run-time versions of the Xerox LISP machine to deliver PlanPower. The Xerox delivery machine, model 1185, sells for $10,000; the 1186 development machine costs $25,000. Xerox attributes its low price to economy of scale that stems from using the same hardware for its 1185 and 1186 LISP machines and its 6085 office products machines. The only differences are the microcode, which the 1185 and 1186 use to execute LISP instructions, and the machines' configurations.



An Automated Guided Vehicle (AGV), *called Hermies II, was built using LISP Machines' Picon AI application-development software. The AGVs carry and retrieve materials in hazardous environments. They can also navigate and dodge obstacles.*

Because of this commonality, the 1185 and 1186 lack specialized LISP machine hardware, such as hardware memory tags and hardware assists for garbage collection. "Garbage" is obsolete data residing in main memory. Hardware memory tags provide hardware support for run-time data-type checking. Xerox does its run-time data-type checking in microcode.

Xerox says this design does not give its machines the fastest LISP-function execution speed. But real applications also involve I/O, graphics, windows, menus and moving things on the screen. Benchmarks tend to merely measure computational time for performing simple operations on data structures. The fast graphics of the 1185 and 1186 deliver zippy performance for real world applications.

Direct comparisons between LISP machines like the 1185 or 1186—or conventional workstations running Common LISP—and the TI, Symbolics, and LMI LISP machines are misleading. These latter LISP machines are bundled with expensive peripherals, including huge amounts of main memory, mass storage, digital signal processors and array boards. When these are added to the smaller scale LISP machines and workstations, price differences begin to fade. In any case, LISP machine prices are decreasing.

For example, earlier this year, Symbolics introduced a delivery version of its model 3600 LISP machine. The 3610 AE (Application Engine) uses VLSI semicustom, gate-array technology, and CMOS for low power consumption, to reduce the 3600's three-board

processor to one, to bring its size to that of a desktop, and to cut the price to $31,500 (in quantities of 76 or more). The delivery machine goes along with a new LISP design tool and operating system, which has features to help developers package their software for a delivery system.

TI is looking toward commercial versions of its compact LISP machine, which is essentially a plug-in board-level version of the Explorer, its regular LISP machine. The central component of this board is a VLSI CMOS sub-2-micron chip that contains about 60 percent of the Explorer's circuits. The compact LISP machine was developed under contract for the Defense Advanced Research Projects Agency (DARPA). The first prototype, built for very high performance with military specifications, will be delivered next month.

This prototype will be followed by some lower cost designs based on the chip. To meet cost goals, the chip's performance will probably be downgraded. The chip will be designed into a board-level LISP processor that can be used as an inexpensive standalone LISP machine or as a board that plugs into non-LISP machines.

TI estimates that the price of a commercial version of the compact LISP machine will be about $25,000, for which the user gets the same performance, memory and mass storage as with today's Explorer. Initially, the LISP board aims at machines such as the TI Business Systems 1500—a multiuser UNIX-based minicomputer —and the TI Business Pro. The boards will also be available to other computer manufacturers. But the architecture and memory handling methods of a LISP processor and of a conventional computer are too different to allow the LISP boards to work directly as a plug-in board. TI believes that some customizing of the boards will be necessary for most computers.

Porting and customizing, however, take time.

Companies mentioned in this article

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RISC machines, which are considered a new AI delivery vehicle, are characterized by instructions that are designed to execute in one machine cycle.

TI estimates it will be one to two years before the boards turn up in TI end-user environments, and two to three years before other companies have similar boards.

LMI espouses a different delivery-system strategy. For users who need the development machine as a delivery vehicle, LMI offers two-, three- and four-user LISP machines. Each user has a dedicated LISP processor. But the processors are in one cabinet. This approach divides the cost among users who share the cabinet, power supply and peripherals.

However, LMI maintains that many AI applications can be delivered on conventional machines. For those cases, LMI supports tools that allow the automatic port of applications to other machines, including DEC's VAX, IBM's PC/AT and Sun machines.

The viability of AI on time-shared minicomputers and mainframes is controversial. Time-shared machines that support AI include the VAX and MicroVAX, Data General Corp.'s Eclipse and DS series, and IBM 370s and 4300s. The DEC and DG machines run Common LISP and several standard AI application tools. The VAX also runs OPS5, a high-level rule-based language. IBM machines run their own LISP and an IBM AI tool called ESDE/VM (Expert System Development Environment/VM).

Minicomputers as run-time systems

The problem with AI on time-shared machines is other users. Experts say that neither the hardware nor the instruction sets of these machines were designed for LISP. Users say LISP on a time-shared machine is instantly visible to other users, and degrades the machine's performance. Developers at Delco Products did their initial knowledge-system development in the middle of the night so they could get a dedicated VAX. For reasons like these, many developers advocate LISP development on the MicroVAX or AI VAXstation, rather than the VAX.

Arnold Kraft, manager of solutions marketing for the intelligent-systems technologies group at DEC, says users running knowledge systems that only occasionally need to consult other files often opt for a standalone machine. But other customers have knowledge systems that access data from attached manufacturing systems. And the accesses in this environment are often as intensive as those in many MIS shops. These users frequently prefer to have the two systems coresident on the VAX.

Coresidency makes application integration and database access easier. It reduces file, disk, and integrity maintenance problems. And some applications are served best by the VAX processors' I/O and data transfer rates.

Kraft claims that performance degradation problems due to VAX LISP may often be solved by adding more physical memory. Moreover, he points out that many VAX knowledge systems are written in OPS5. Kraft adds, "OPS5 is as invisible in a time-shared environment as FORTRAN." In addition, some knowledge-system development tools, such as S.1 and ART, have been translated to C.

Engineering workstations serve AI

Engineering workstations represent a major class of machines being touted for AI delivery. They are generally based on the Motorola 680X0 and Intel 80X86 families, the National Semiconductor Corp. NS32032, or on a proprietary RISC chip. The manufacturers include Apollo, HP, Sun Microsystems, Tektronix and IBM with the RT PC workstation. The machines run Common LISP, which gives them an entry to many of the standard AI application tools, and often Prolog. Tektronix workstations also run Smalltalk.

Unlike minicomputers, workstations are dedicated machines with graphical interfaces. They have the advantages of lower cost ($20,000 to $50,000) and compatibility with existing programs. The HP 300 series workstations, for example, run Common LISP as a process under HP-UX (HP's version of UNIX). From LISP, users can call HP-UX commands or software written in any UNIX-supported language, edit a Pascal program, spawn a Pascal compile and create programs that are hybrids of conventional and AI languages, without ever leaving the LISP editor.

Workstations had been deemed deficient because they were not microcoded for LISP execution. But now fast LISP compilers are being written for 32-bit workstations. Lucid Inc., for example, has written such compilers for several engineering workstations. Scott Fahlman, senior research scientist at Carnegie Mellon University reports that, with the Lucid compiler, the 68020-based Sun-3 performs considerably faster than the Symbolics 3600 on most of the benchmarks. He says Apollo machines will do as well.

There are some differences, however. To get maximum speed on the Sun machine, it is necessary to program carefully and to make sure of the declarations. Data type checking, which helps ensure program correctness, slows speed. In contrast, sloppy programs run just fine on Symbolics machines, which have hard-

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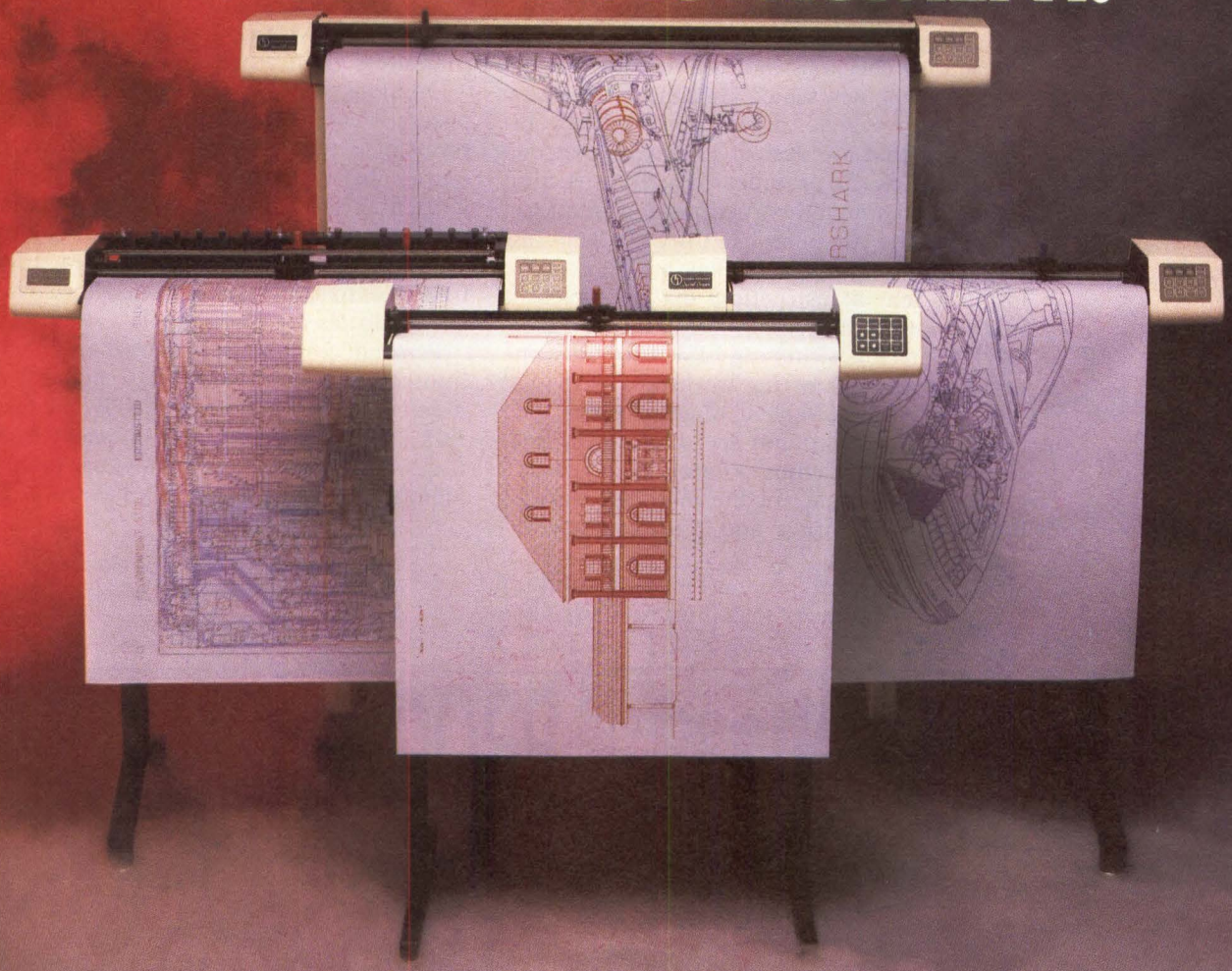

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Opinions about the value of PCs for AI applications are divided.

ware support for run-time type checking. A way around this drawback is for programmers to use the run-time type checking on the Sun machine just for program development. When they are sure their code is correct, they can turn off the type checking and compile for speed.

RISC machines, which are considered a new AI delivery vehicle, are characterized by instructions that are designed to execute in one machine cycle. To provide this high instruction throughput, simple instructions are necessary, otherwise the computer can't decode them fast enough. Such throughput may not be possible for more general instructions that are typical of traditional machines.

RISC machines running LISP have the same problems as engineering workstations in that they cannot simultaneously achieve run-time checking and maximum speed. However, machines with RISC chips, a lot of memory and a good compiler may, in the long run, surpass both LISP machines and traditional workstations.

MIPS Computer Systems Inc. has a family of RISC-based products that illustrates what the RISC future might hold. The RISC products include either VMEbus or Multibus CPU boards and a development system for building minicomputers, supermicrocomputers and workstations (MMS, May, Page 33). The MIPS computers will run Common LISP.

Opinions about the value of personal computers for AI applications are divided. The problem is that most serious AI programs require substantial memory. Programmers have written and fielded small, but useful, systems on personal computers. Personal computers also make inexpensive entry vehicles, front-end interfaces to host-based knowledge systems and good vehicles for learning AI.

Personal computers, however, are inherently limited because of their lack of memory. Their memory is even further limited by the fact that PCs do not support virtual-memory capabilities, which would allow them to use more main memory than they physically have. □

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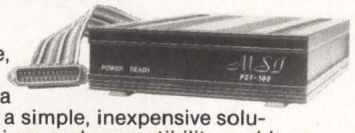

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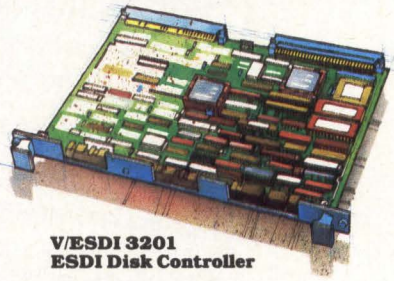
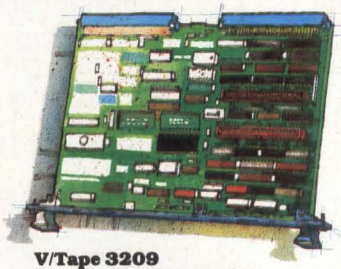


V/ESDI 3201
ESDI Disk Controller



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COMPILERS COMBINE MATURITY, INNOVATION

Despite being one of the oldest software technologies, compilers continue to develop as software-development tools and as databases to monitor code modification

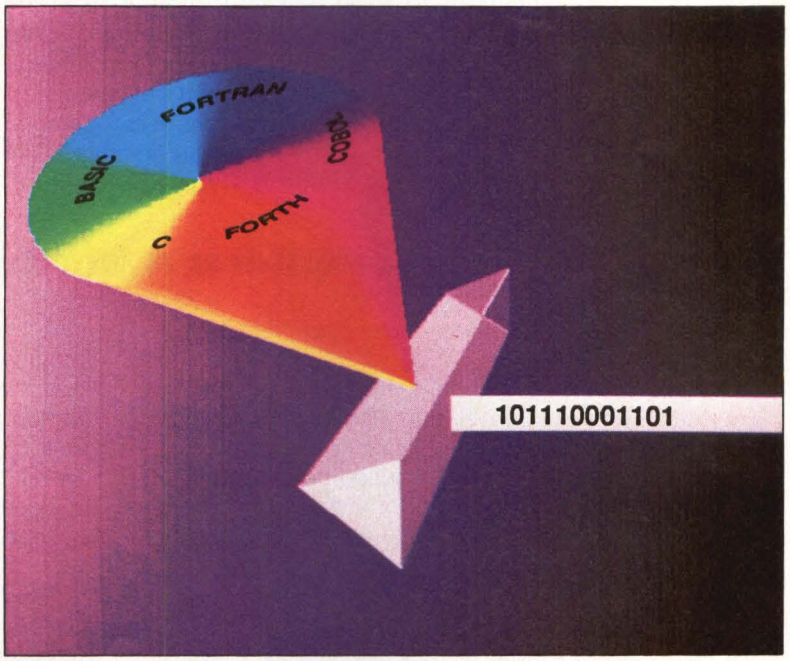
Michael Tucker, Associate Editor

Compilers are almost 30 years old. Yet, despite their age, they are by no means a perfected or a static technology, and still less do they represent a static market. Increasingly, compilers for a host of languages resemble complete software-development environments. Where once compilers were little more than mills to churn out binary code, now they may come with large assortments of integrated software-engineering tools, highly modular designs, interactive debugging facilities and even integrated databases to keep track of code modifications.

Morever, compiler vendors are adapting rapidly to the new realities of microcomputing. Instead of being relegated to a kind of mainframe ghetto, compilers can now fit easily into 32-bit workstations and personal computers. Compiler vendors see their products taking a starring role in remote software development: coding tasks performed by teams of programmers, each programmer at a workstation producing software for target machines ranging from supercomputers to embedded systems.

Even the most basic rules of the compiler business have begun to change. Where at one time compilers only randomly appeared on individual computers, now hardware makers include compilers as basic elements in their machines' design. Microprocessor vendors have begun to line up strategic alliances with compiler makers even before their own products come to market.

Compilers are programs that turn source code—software written in such languages as BASIC, FORTRAN, C and FORTH, which humans can understand—into binary code, which machines can understand. They differ from, say, interpreters, in that they perform this translation in a single pass. This makes them very fast and very demanding of computer resources.



Compilers *are software programs that turn high-level languages like COBOL and FORTRAN into machine code.*

The first compilers appeared with some of the first commercial computers in the 1950s.

They've undergone considerable refinement since then, and some observers regard them as having reached the limits of their development potential. "We don't even follow them," says one market reseacher. "When you've had a product around for 30 years or so, whatever big advances are going to be made have been made."

To a certain extent, the manufacturers themselves agree, though less for technical reasons than for marketing ones. "As languages mature," says John Hurd, vice president for marketing at compiler maker Language Processors Inc. (LPI), "it becomes less and less an issue of what features a compiler will have, as how closely it adheres to whatever standard has been set for the language." While compilation speed never really goes away as an issue, says Hurd, portability and standards gradually become more important.

However, if the technology of compilers tends to be fixed, the tools around them are not. Over the last decade, the business of compiler making has become the business of manufacturing software-development environments. LPI, for instance, markets compilers for several languages for computer systems based on UNIX and the Motorola Corp. MC68000 microprocessor. While Hurd may argue that the languages thus supported—LPI's COBOL, RPG II, Pascal, PL/1, BASIC, C and FORTRAN—are remarkable only in their conformance to standards, the underlying structure supporting the compilers is extremely unusual. The compilers are, in fact, merely modules within a much larger collection of code.

Each compiler sits on top of a code optimizer common to them all. The optimizer, in turn, is atop a common code generator. The code generator, which functions as the compilers' "back end" and their link to the computer, is the only part of the structure that isn't machine-independent. "What we have is basically seven different front ends," says Hurd. "These front ends, the compilers, are machine-independent. When we want to put our languages on a new computer, we just write a new back end and marry it to seven different compilers."

For programmers, this means software can be developed in several languages and then run as a single application—something which would be particularly useful in addressing vertical markets. For example, if developers wanted to sell an application to small engineering shops, they could write a program that would do computer aided design and computer aided

Compilers: A hardware vendor's perspective

Tom Miller, Fairchild Semiconductor Corp.

Microprocessors that have evolved, often painfully, to the 32-bit level from 8- and 16-bit forebears are burdened with performance-limiting architectures. However, new precision instruction processors (PIP) bring superminicomputer performance to desktop machines. They do this through streamlined instruction sets tuned to architectures that foster concurrent operations in hardware. While only in their first generation, PIPs in advanced systems such as the IBM Corp. RT PC and the Hewlett-Packard Co. Spectrum have broken price, performance, power and size barriers that had seemed to permanently threaten the evolution of CPUs.

Not surprisingly, the most popular PIPs draw from both the commercial experience of supercomputer architecture and academia's research in reduced instruction set computers. Inputs from both worlds helped develop balanced architectures that meld intimately with appropriate high-level language (HLL) compilers and mate with operating systems like the de facto standard UNIX System V.

Fortunately, much of the software that OEMs need to port to high-performance PIPs has been written in HLLs; and just about all ongoing software development is in HLLs. Though, of course, for time-critical operations there is usually some hand-crafted assembly-language code that can be returned after the port. To facilitate the switch to PIPs, system designers and integrators need high-quality development tools for generating new applications and for converting existing programs to run efficiently on the new-generation processors. Central to such tool sets are compilers. These translators join software written in easily produced, easily maintained HLLs to speedy hardware, resulting in efficient computing systems.

Compilers, of course, convert HLL instructions into machine code. This code can and does vary from compiler to compiler in two important aspects—program length (number of bytes) and execution speed (algorithm run time). The quality of the code it generates depends on the level of intelligence (the optimizing capabilities) programmed into the compiler. This intelligence handles five operations:

- Eliminating or reducing redundant jumps, unreachable code, run-time computation and so forth.
- Mapping data structures onto the memory hierarchy of the architecture. PIP class processors generally support main, cache and register memory levels.

manufacturing in C and bookkeeping in COBOL. The C and COBOL would be processed by their relative compilers and then, using tags provided by the programmers, linked into a single binary program at the code generator.

This also has advantages in team programming. An organization working on a large project requiring different capabilities in different modules of code could have individual programmers working at individual workstations in whatever language each was expert. The results could then be assembled and coordinated at some larger departmental machine.

To support both kinds of development, LPI is investing heavily in programmers' tools. The company currently markets LPI-Debug, an interactive souce-level debugger that allows programmers to test code without having to reduce it to machine language.

Another compiler maker, Philon Inc., takes a very similar approach. Philon too produces compilers for 68000-based UNIX systems. Specifically, the company supports C, COBOL, BASIC, FORTRAN, RPG and Pascal. However, Philon is noted for the extraordinary speed of its product. The company can produce benchmarks showing that its products are among the fastest on the market. For this reason, hardware vendors have been eager to put Philon compilers on their machines (the faster the compiler, the better a machine looks to would-be customers), and the company's products now run on over 30 different brands of computer.

Philon can give its customers the ability to work in several languages on the same project. The company's compilers are also modular in design. In fact, Philon argues that it was one of the first software vendors to successfully produce modular compilers. The compilers have a device-independent front end sitting atop a device-dependent back end. They are linked by Philon's proprietary intermediate code known as "Phi-code." The front end translates a programming language into Phi-code and then drops it to the back end, where it's turned into machine code.

Philon also offers a highly interactive, powerful debugger called "Phi-Analyzer." Like LPI's LPI-Debug, Phi-Analyzer could almost be sold as an interpreter. It allows programmers to test code and locate errors while performing development. Indeed, if there is a common theme to the compiler market of 1986, it's the emerging eminence of tools.

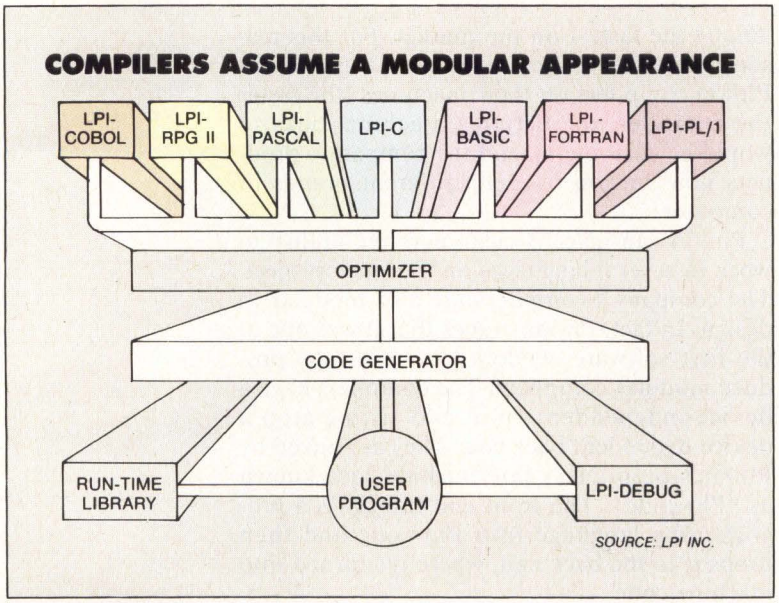
- Reorganizing compiled code in accord with system pipelining. Non-synchronized code sequences can force what would otherwise be pipelined processes to wait for the completion of a calculation.
- Parameter passing in subroutines. Allocating parameters to registers whose use is in turn controlled during subroutine execution saves many push/pop operations otherwise needed for calling and returning subroutines.
- Selecting cache strategy. PIPs, like their mainframe forebears, usually allow compilers to choose between copy-back and write-through modes or to bypass caching completely.

In addition to the compiler, advanced processor programmers must be supplied with quality run-time environments such as a library of FORTRAN computational subroutines. Here again, as in the compiler, a run-time library's quality is measured by code length and execution time of the routines. The library's completeness is critical.

Completing the support environment crowned by the HLL compiler are the system-development and debugging utilities provided by the operating system. These facilitate the code-verification process. Sort, Merge and comparison routines; HLL debuggers; and configuration managers are musts for programming and for porting to and maintaining modern high-performance 32-bit processor-based systems. Here, the UNIX environment saves the day. Software developed in virtually any popular HLL ports easily to PIPs under UNIX, once the appropriate compilers are in place.

Developing the appropriate compiler for a particular PIP under UNIX is an exercise of the processor vendor's determination. UNIX is written in C. Most good third-party compilers, however, are written in Pascal. By generating dedicated code generators for the target processor, first the compilers and then the derived UNIX port can execute on the new system. With the UNIX "pcc" compiler, however, code generation is frequently not optimum. But, processor suppliers can choose compiler vendors such as Green Hills Software Inc., Glendale, Calif., whose packages for each HLL merge to a common intermediate format. With the Green Hills package, one optimization covers the C, FORTRAN and Pascal.

Tom Miller is the director of marketing for Fairchild Semiconductor Corp. He works particularly with the Clipper Chip.



The seven interlocking compilers *from Language Processors Inc. sit atop a common code generator. This means programmers can work with different languages in the same application.*

Partly, the sudden dominance of software tools is the product of elementary market forces. Lattice Inc., for example, sells a selection of popular C compilers. Lattice has, however, recently brought out several tools to support those compilers. Steve Hersee, Lattice's vice president of marketing, says bluntly, "We're diversifying. We've been in this business long enough to know that any market can go down the drain."

In addition, compiler vendors are beginning to feel that software support and maintenance are part and parcel of software development. Ryan-McFarland Corp., for instance, is one of the leading names in compilers. Its FORTRAN and COBOL compilers have become very close to being standards. Recently, Ryan-McFarland began incorporating a debugger into its compiler. The company also has a licensed third-party software-vendor community of 300 members, most of whom are selling tools. "When you think of a language, you don't normally think of a debugger or linker," explains Chuck Runge, Ryan-McFarland's vice president of marketing. "But, for developers, such support software is very much an issue."

This trend shows up most clearly in the case of Ada—the programming language developed to the specifications of the Department of Defense in the late 1970s. Ada is a young and complex language, still struggling with quite basic issues of compiler technology. While FORTRAN and BASIC may have reached their development limits, Ada compilers are very much in their infancy. Only recently have any Ada compilers been validated by the DOD as being genuinely Ada. And they're still comparatively rare on microcomputers. Only in the last year have validated Ada compilers appeared on even the largest personal computers, such as the IBM Corp. PC/AT.

Gradually, however, Ada compilers are becoming more sophisticated. Telesoft released the first commercial Ada compiler in the early 1980s. It was, says Bruce Sherman, Telesoft's director of marketing, "Very bad. I'll admit that." However, this year Telesoft introduced Telegen 2, which the company calls an "Ada development system." It features a much-improved compiler. "It is truly one of the first second-generation Ada compilers," says Sherman. "We've spent three years taking care of the problems in the first one."

The rub in Telegen 2 is the software around the compiler. Ada is immensely capable, doing almost anything a programming language can do. In addition, because it is used by the civil government, the military and their contractors, it frequently shows up in vast projects, involving hundreds of programmers and hundreds of thousands or, even, millions of lines of code. The result is that Ada's single biggest problem is its own complexity. Projects get lost in themselves.

Telegen 2 addresses the problem with several tools, among them a complete database management system integrated directly with the compiler. "Ada encourages the use of separately compiled modules of code," explains Sherman. "The problem is in maintaining consistency among updates of those modules. In our compiler, we've included a library-management function, actually a complete database management system, specifically to let the programmer keep track of all those adjustments in the software."

Enter embedded systems

Another Ada vendor facing the same issues is Verdix Corp., whose presence in the compiler business is something of a surprise to Verdix itself. The company was formed in July 1982 with no intention of being involved with compilers. Verdix's founders were interested in making secure local area networks for military and government installations. "But, when they took a look at the commercial Ada compilers available, they found most of them were pretty awful," says Jack Crosby, Verdix's director of marketing. "So, they wrote one of their own."

The compiler they wrote, plus an extended collection of tools, is known as the Verdix Ada Development System (VADS). It includes the compiler itself, a symbolic debugger and assorted support software. VADS has been popu-

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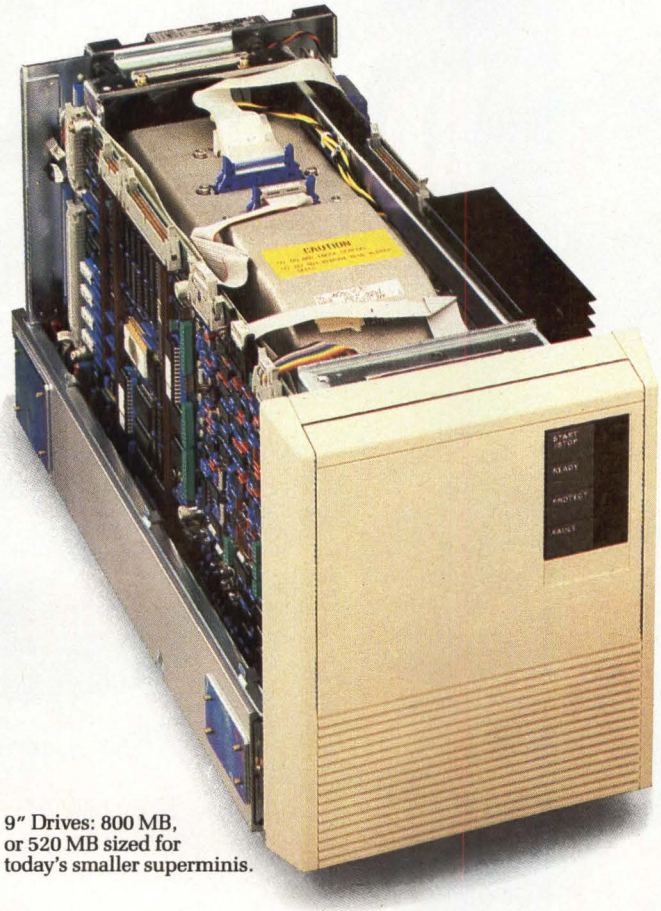

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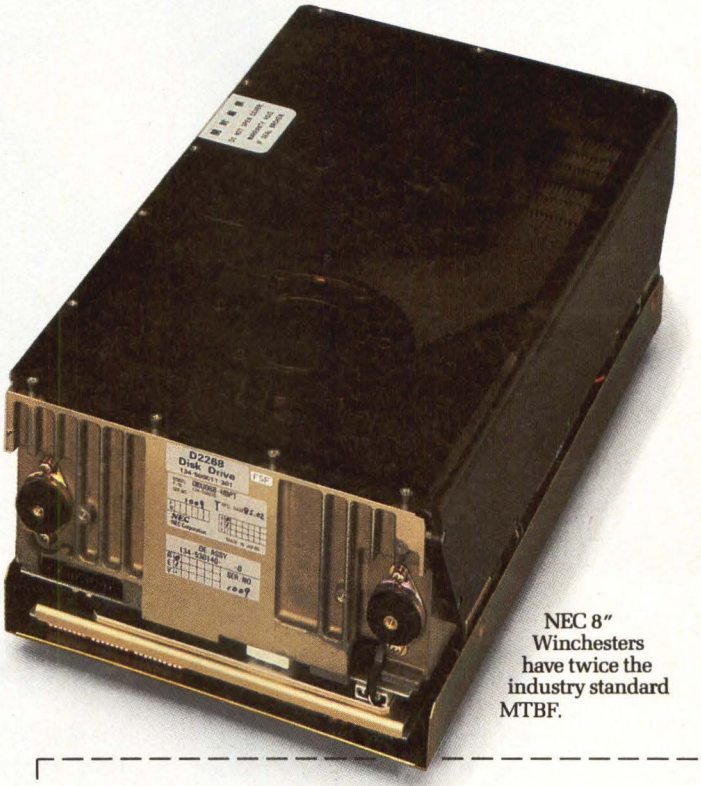

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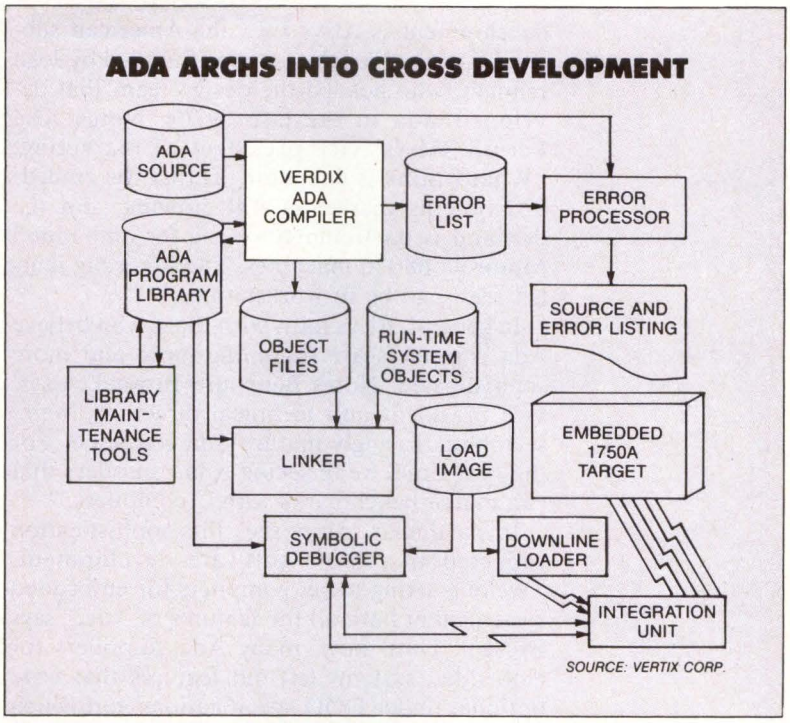
lar on minicomputers and high-end microcomputers and, most recently, on workstations, such as the Digital Equipment Corp. MicroVAX II, the Harris Corp. MCX and the Sun Microsystems Inc. Sun-2 and Sun-3.

This is significant because it reflects a new reality of programming—the remote development of software. Increasingly, software vendors are producing their code on machines different from those on which it's meant to run. Instead, programmers are doing their work on 32-bit workstations, and then downloading their code to target systems that are either too big or too small to be their own development environments. These targets might be anything from supercomputers, whose time is just too expensive to waste in software development, to a toaster oven's 4-bit microcontroller, which simply hasn't got the brains for it.

Ada is tailor-made for both kinds of remote development. For one thing, it is so biased toward modular, structured programming that projects automatically break up into neat components, easily farmed out to the desktops of individual programmers. For another, Ada was originally meant for the military market, which is to say it was designed for embedded systems.

What has prevented the language from being more broadly used in remote development has been a lack of cross-compilers—that is, compilers on one machine that can produce binary code for another machine. This summer, Verdix announced it was working on just such an Ada cross-compiler, the "VADS/VAX VMS-to-1750A cross-compiler," meant to drop code from VADS running on a DEC VAX to the military-standard microprocessor, MIL-STD-1750A, currently produced by several vendors.

Another Ada compiler vendor eying remote



An Ada cross development system *from Verdix; the VMS to MIL-STD-1750A cross compiler allows code developed on a DEC VAX to be downloaded to a 1750A processor.*

Are compilers obsolete?

Meanwhile, at least for some applications, compilers are coming under pressure to go away and stop bothering everyone.

Compilers will, of course, always be with us—at least so long as programmers need a means of accessing computers at a level above machine code and below natural language. But, gradually, non-compilable fourth-generation languages (4GL) are making serious inroads wherever non-programmers develop their own applications. The production and refinement of 4GLs seems to be something of a growth industry.

The following are just a few of the 4GLs that have made news lately:

- **Accell,** from Unify Corp., Lake Oswego, Ore., is a combined 4GL and applications generator built on the Unify database manager for UNIX machines. Accell makes particular use of forms-based programming.
- **Informix-4GL,** from Relational Database Systems Inc., Menlo Park, Calif., is built on the company's UNIX-oriented database management system. Informix-4GL offers a quick and easy entrance to SQL-applications.
- **Progress,** from Data Language Corp., Billerica, Mass., is meant for MS-DOS-, XENIX- and UNIX-based machines. Progress provides a 4GL, a DBMS and associated support utilities for both programmers and non-programmers in the commercial field.
- **Smart*Star,** from Signal Technologies Inc., Goleta, Calif., is a 4GL and applications generator for the Digital Equipment Corp. world. Smart*Star allows developers to link 4GL applications with applications in standard third-generation languages, like COBOL.
- **Mach 1,** from Tominy Inc., Cincinnati, Ohio, is a 4GL for IBM machines. It is capable of producing code for the entire spectrum of IBM Corp. computers, from mainframes to the PC.

development is Alsys Inc., the American subsidiary of the French company founded by Jean Ichbiah, who headed the design team that developed Ada in the late 1970s. Notes José Leruth, Alsys' vice president of marketing, "What I think is happening is that the embedded-systems market is still growing, and the demand is particularly strong for embedded Motorola 68020 machines. The other big market seems to be in workstations."

In general, Alsys joins with those who believe Ada compilers are becoming more and more sophisticated. Notes Benjamin Brosgol, Alsys' vice president and technical director, "We're seeing increasingly mature Ada compilers. For the first time, we're seeing Ada compilers that can match benchmarks with C compilers."

In particular, Alsys sees this sophistication reflected in remote software development. "We're starting to get compilers for embedded systems that have all the features of Ada," says Brosgol. Until now, many Ada compilers for embedded systems left out features that were optional under DOD specifications, but which were also extremely useful.

And, Alsys is getting into the cross-compiler business. In September, the company announced an agreement with Hunter & Ready Inc., Palo Alto, Calif., makers of VRTX, a real-time operating system (RTOS) for embedded applications. Under the terms of the agreement, the two companies will work together to produce a cross-compiler that will drop Alsys' Ada code from a DEC VAX or MicroVAX II to a 68020 running on VRTX.

PCs play a role

Like most compiler vendors, Alsys sees remote development on workstations as the wave of the future. "I think, very soon, the majority of programmers in the world will have workstations on their desk," says Alsys' Leruth. What is unusual is that among the workstations they see on those desks are IBM PCs, or at least PC/ATs, for which Alsys recently introduced an Ada compiler. "Increasingly, you are going to see the PC/AT used as a developmental environment," says Brosgol.

Pursuing that logic, a few compiler makers feel the ever-present PC, PC/XT, PC/AT and compatibles may be the best possible platform for remote but inexpensive software development. Forth Inc., for example, makes a PC-based compiler for the FORTH language, which is frequently used for real-time applications. The company recently introduced PolyFORTH ISD-4, a development environment for the PC consisting of the compiler, the PolyFORTH operating system, an editor and assorted utilities.

PolyFORTH ISD-4 is meant expressly for the embedded-systems world. "The glamour market for the last few years has been personal computer software," says Elizabeth Rather, president of Forth. "But if you really look at what's going on in industrial automation, and at the fact that you virtually can't buy a chair anymore without finding a microcontroller in it, then you realize embedded systems are a very, very important market."

The PolyFORTH operating system is an extremely fast RTOS that may be downloaded to an embedded system along with a completed application. Most development environments require that users do their programming on a fully featured, but relatively slow operating system, such as UNIX. They then must download the resulting code to a target processor running a real-time executive—that is, a small, streamlined, fast operating system that may have strikingly different features from the host operating system. "With PolyFORTH ISD-4," says Rather, "you do your development and your execution on the same software." □

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ALREADY POTENT PC/ATs GAIN POWER, VERSATILITY

Manufacturers of PC/AT-compatibles are increasing clock speeds, adding higher capacity disks and providing alternative motherboards, as well as bringing out new chips and software

Carl Warren, Western Editor

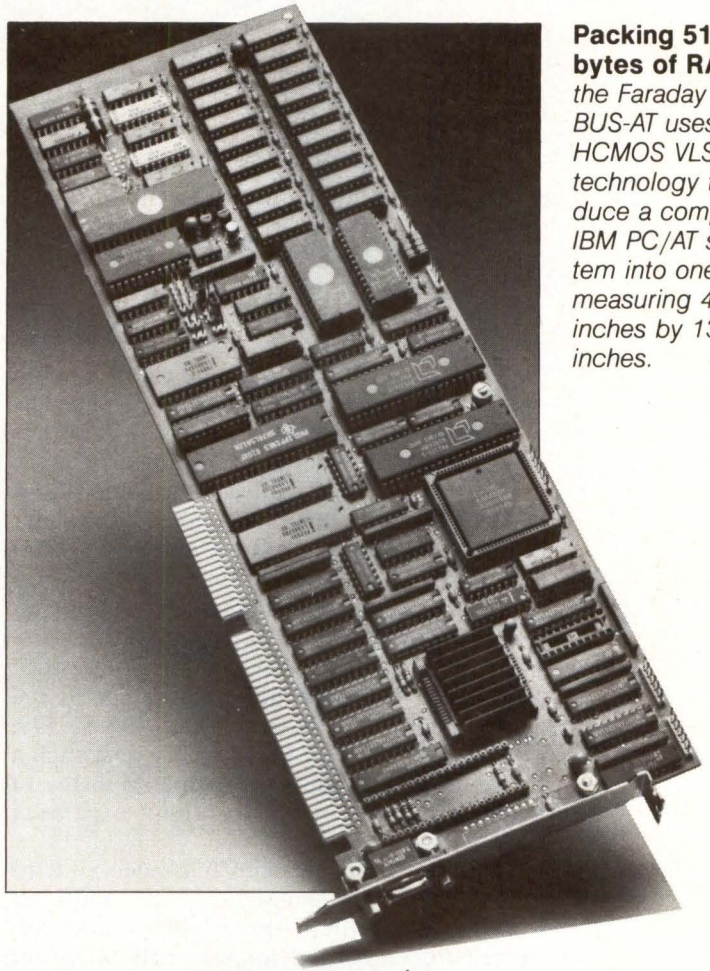
The IBM Corp. PC has evolved from the original, relatively slow pseudo-16-bit machine to a powerhouse system capable of supporting multiple displays and handling a veritable warehouse of peripherals. This more powerful architecture, dubbed Advanced Technology (AT) by IBM, provides true 16-bit data and address paths, and replaces the PC's Intel Corp. 8088 with the more powerful 80286 microprocessor.

But, as capable as the original PC/AT was, the demand for greater processing power made changes in the basic machine inevitable. IBM and PC-compatible manufacturers have thus beefed up the PC/AT into a machine for the multiuser environment and as a powerful single-user workstation that supports a variety of concurrent applications.

Indeed, the goal of IBM, and virtually all the manufacturers of PC/AT-compatible products, is to drive as many display devices and to handle as much information as possible. To this end, vendors offer faster machines, larger capacity rigid-disk drives, add-on and add-in boards and chassis, expansion buses, alternative motherboards and new chip sets and software.

To exploit the last ounce of processing power, IBM boosted the PC/AT clock rate to 8 MHz, and one vendor's version offers a 10-MHz clock—although 6 MHz or 8 MHz is still the norm for most implementations.

For example, Intelligent Data Systems Inc. (IDS) provides 4.77-MHz to 10-MHz speeds on its PC-286. But IDS has added more to its machines than clock speed. Because the company also views the IBM PC/AT as being a powerful workstation engine, they include a large Winchester disk drive, which starts at 30M bytes in the $3,360 basic model. To meet the



Packing 512K bytes of RAM, *the Faraday BUS-AT uses HCMOS VLSI technology to reduce a complete IBM PC/AT system into one card measuring 4.8 inches by 13.2 inches.*

Capable of functioning *as a stand-alone single-user system, or a file, print or communications server, TeleVideo's TeleCAT-286 serves as a multiuser UNIX engine.*

need of large Winchesters for more power, IDS supplies a 200W supply.

Epson America Inc.'s Equity III PC/AT-compatible machine allows users to switch between 6 MHz and 8 MHz. It also provides up to 15.5M bytes of RAM with expansion cards and optional support for the Intel 80287 math coprocessor. Epson, however, isn't simply relying on sheer clock power. It provides a 200W switched power supply with the ability to hold up the system when AC power drops to as low as 90V, and a software setup system that lets users tailor the system's I/O to add peripherals.

The company that really set the standard for 80286-based systems is Compaq Computer Corp. The original IBM PC/AT has several limitations, including comparatively sluggish processing speed, and Compaq elected to overcome this limitation with its 8-MHz Deskpro. The company's goal, however, wasn't necessarily to sell a display engine, but rather to sell many single-user systems, and its $3,599, 6-MHz, 80286-based Portable II is just such a machine. It can support up to 4M bytes of RAM, using one of its two 16-bit expansion slots.

Zenith Data Systems and TeleVideo Systems Inc. have also set their sights on the multiuser world. Zenith offers the $3,499 Z-200 Advanced PC, suggested for use with Microsoft Corp.'s XENIX for multiuser functions. TeleVideo's TeleCAT-286 functions as a multiuser UNIX engine. It is capable of working as a single-user system, or as a file, printer or communications server driving many displays.

Kaypro Corp. is also getting on the AT-compatible bandwagon with the $3,995 model 286i, which comes with a 30M-byte Winchester disk drive. It uses the same DOS 3.2 software as does the IBM PC-Convertible, and the company plans to eventually offer drives for 5¼- and 3½-inch disks.

Software in short supply

Full utilization of the power of the AT's 80286 processor, however, has been hampered by lack of software. Because the chip can address as much as 16M bytes of memory and integrates memory-management functions, associated software becomes complex, especially to accommodate protected-mode operation.

Protected mode, which makes use of the memory-management scheme, allows tasks to operate concurrently while preventing overlapping of application- or system-level software. George Alexi, Intel's microprocessor marketing manager, contends, however, that Digital Research Inc.'s Concurrent DOS-286 and Microsoft's XENIX are providing the tools necessary to ensure adequate use of the processor's capabilities.

The PC/AT and its look-alikes can run under a variety of operating systems including UNIX and its derivatives. Wyse Technology's $4,199 WYSEpc 286, for example, which sports a 40M-byte Winchester disk drive, maximizes UNIX's abilities to run multiple terminals and to link up to other attached PCs. Wyse thus expects to see a growing use of dependent displays—nonintelligent terminals—connected to a departmental system like IBM's System/36 minicomputer via PC/AT clusters.

Structuring the use of the PC/AT around larger systems to drive as many display devices as possible is a concept endorsed by IBM. Connecting the company's three distinct architectures—the PC, the System/3X minicomputers and the System 370 mainframe—is thus a key issue, according to Allison Lowrie, manager of advanced information systems planning at IBM in Rochester, Minn.

Part of the challenge of PC/AT software is getting applications to run properly on the hardware—especially on the clones. To assist system integrators in this effort, Control-C Software Inc. has developed the Softcloning technique. It allows misbehaving IBM PC applications (such as those that make direct calls to ROM, the basic input/output system, the video memory or a screen controller) to run on systems that aren't totally compatible with the IBM PC or its derivatives. It also permits PC/AT vendors who want to increase the per-

formance or functionality of their version of the PC/AT architecture to do so, without their machines' losing the ability to run the large store of available applications.

Tatung Company of America Inc.'s model TCS-7000 is an engine capable of supporting applications such as computer-aided design. Aimed at OEMs, its prices depend on what you decide to add on. The company also makes an enhanced-graphics adapter board and the high-bandwidth display to support it.

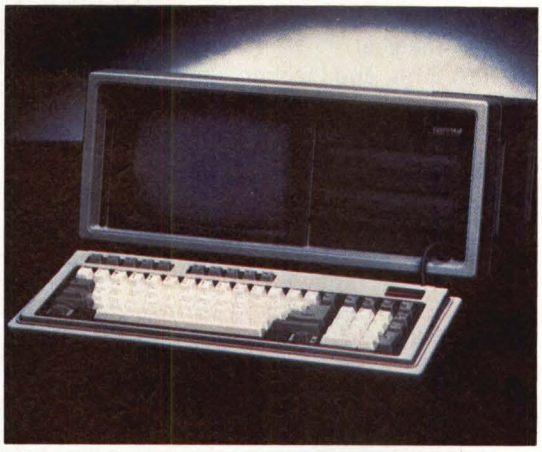
Cordata Inc., on the other hand, offers VARs the ability to drive multiple displays with its ATD-8-Q40 $6,995 desktop system. It also offers the ATP-8-Q single-user transportable workstation for $2,995.

Along with adding power, PC/AT-compatible vendors are making the computers smaller by shrinking the box itself or by reducing the electronics to a board-level system.

Taking the latter approach, Datavue Technology Systems's model 8612 is packaged on a full-sized PC expansion card and uses the NEC Semiconductor Corp. V30 processor or an Intel 8086-1 chip operating at 10 MHz. The $626 single-board computer includes 512K bytes of RAM and serves as the bus master.

Faraday Electronics is taking a similar approach with its BUS-AT. This board includes the Faraday FE3000 very large-scale integration (VLSI) chip that shrinks all the functions of an AT motherboard down to a 4.8-inch-by-13.2-inch configuration. The system is priced at $1,195 for the 6-MHz version and $1,395 for the 8-MHz model.

Although the board can slip into an open slot on an existing machine, Faraday expects that OEMs will consider it more for industry applications that are currently served by STDbus-level boards. With the BUS-AT, "you get a higher level of power, a wider range of software and more system flexibility than you do with boards designed for other buses," claims Faraday's vice president for marketing, Ron Mazza.



Supporting up to 4M bytes *of internal RAM memory, the Compaq Portable II uses a 6-MHz 80286 and operates as a single-user workstation.*

Faraday and Chips and Technologies Inc. are taking leading roles in shrinking the AT system. Both are squeezing the support electronics, comprising bus drives, real-time clocks, and memory managers, into gate arrays—an approach that frees up board real estate to designers who want to add interfaces or additional RAM.

Moreover, because the high-speed CMOS gate arrays take the place of about nine large-scale integrated (LSI) circuits and 11 small-scale integrated (SSI) circuits, overall power needs are reduced by about 2.5A. "This alone," says Ira J. Perlow, hardware product manager at Phoenix Technologies Ltd. in Norwood, Mass., "helps resolve power issues when porta-

A look at the PC processor hierarchy

There are some major differences in the microprocessors used on the various IBM Corp. PC architectures. The PC's Intel Corp. 8088 chip is a 16-bit processor internally, but it masquerades as an 8-bit processor to the outside world. The processor's cousin, the 8086, on the other hand, is a full-fledged 16-bit device both internally and externally. The 8086 can operate as fast as 10 MHz and address 1M byte of memory.

Despite both chips' 16-bit capability, the original IBM PC implemented them on an 8-bit bus structure, thus limiting them to byte-wide transfers.

The 80286, also a 16-bit processor, is currently being shipped as a 10-MHz part; volume shipments of 12.5-MHz units are expected to start this fall. When properly implemented on a 16-bit-wide bus, such as the PC/AT's, it manages up to 16M bytes of RAM and another 16M bytes of virtual memory.

The 32-bit 80386 processor sits at the top of the performance scale. Capable of addressing up to 4G bytes of physical memory, the 16-MHz part can manage another 64 terabytes of virtual memory.

Both the 80286 and 80386 integrate memory management and memory protection, which handle arrays of memory and implement concurrent, multitasking and multiuser functions.

"We developed the 80386 as a UNIX engine," says Intel's microprocessor-marketing manager, George Alexi. He sees the 80386 as being a good platform for the next generation of office-automation products.

bility is the goal."

The Chips and Technologies CS-8220 PC/AT-compatible chip set is priced at $50 each in quantities of 1,000 and currently includes five chips. However, the company plans to soon add another array that picks up a real-time clock and peripheral drivers such as serial- and parallel-port support chips.

Similarly, Faraday Electronics' FE3000 integrates 53 components and shrinks the size of the AT motherboard by 62 percent. The device supports 6-, 8- and 10-MHz clock speeds with zero wait states and can accommodate 256K-bit and 1M-bit dynamic RAMs. The FE3000 is priced at $45 in quantities of 100.

Even though the 80286 microprocessor used on IBM's and other vendors' AT systems offers a significant increase in computer power over the PC, companies such as Definicon Systems Inc. and Opus Systems are tackling yet more-demanding processing needs with 32-bit add-on subsystems.

Definicon claims its DSI-32 coprocessor board provides performance equivalent to that of the Digital Equipment Corp. VAX-11/750. Using the National Semiconductor Corp. NS32032 microprocessor, the NS32081 floating-point math processor and the NS32082

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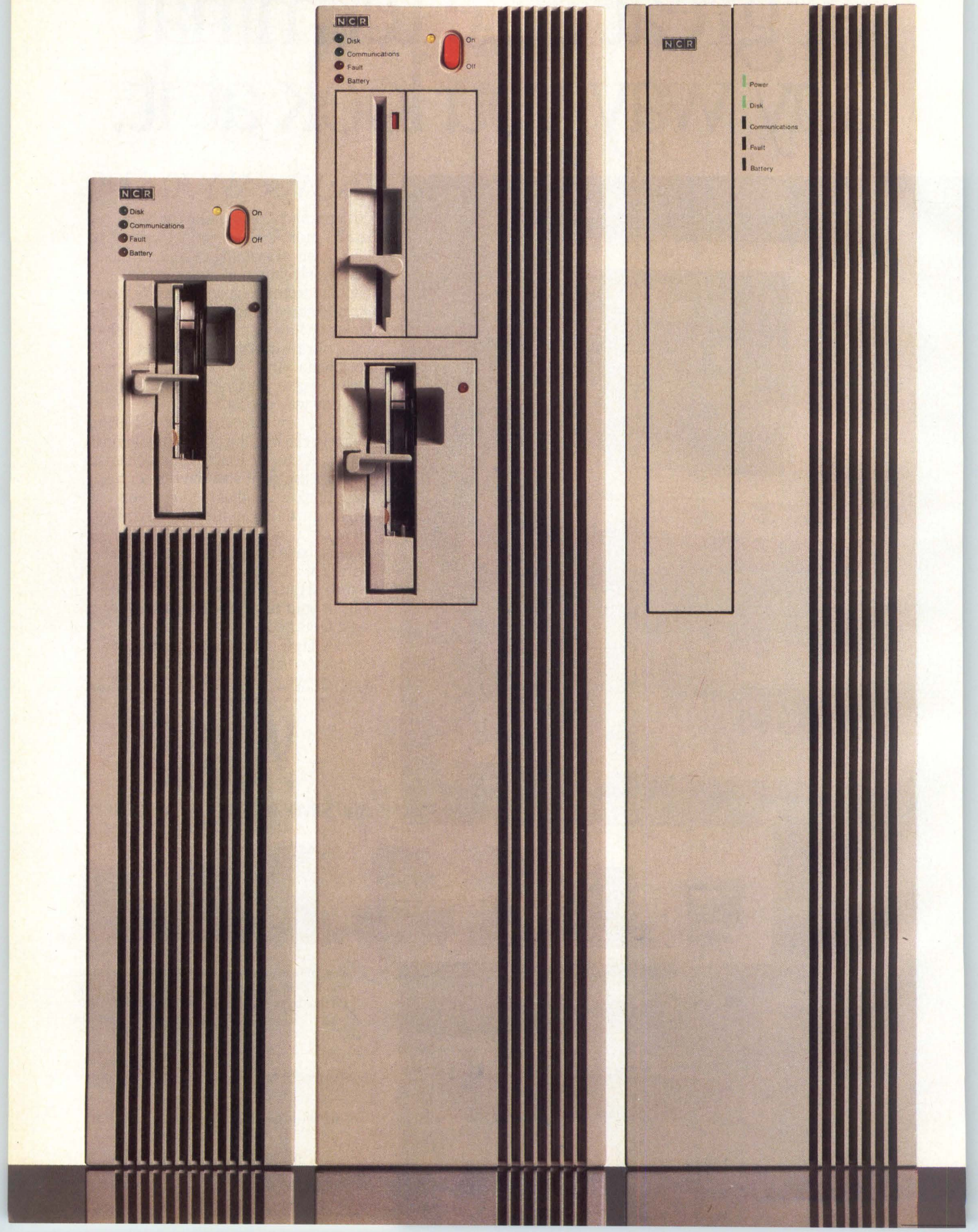
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memory-management unit, the board operates at a minimum clock rate of 10 MHz and includes 2M bytes of dual-ported RAM. According to Definicon, the system, which starts at $1,495 depending on configuration, supports multiuser tasks under UNIX System V.

Opus Systems' president Ted Atlee likes to refer to his company's AT implementation, the Opus board, as a "personal mainframe." A multiuser and multitasking UNIX engine, the board costs about the same as the DSI-32 and uses the same processors. It operates at 10 MHz without wait states and treats all the on-board memory (up to 4M bytes) as being local to the National processor.

Although Atlee sees the board being used primarily with PC/AT-type architectures, the design is optimized for the PC/XT—an 8-bit bus machine. Thus transfers are done 1 byte at a time. However, Atlee says that, to improve performance, the board affords direct-memory access directly to an I/O device.

Other computer vendors take a different approach to PC/AT compatibility by providing board-level coprocessors that allow their machines to run MS-DOS applications. Hewlett-Packard Co.'s 80286-based coprocessor, interface card and software allow the company's HP 9000 Series of technical workstations to integrate MS-DOS applications under the multitasking HP-UX operating system.

Because a major trend with AT architectures is to pack most of the power on plug-in cards, there is an attendant need for backplane boards as well. One of the companies that is stepping forward to solve this problem is I-Bus Systems. It offers a PC/AT expansion chassis board as well as a rack-mount version. Both backplanes have 12 slots: one has three 16-bit slots and nine 8-bit slots; the other has 12 16-bit slots.

To ensure proper power distribution, I-Bus provides four sets of power connectors. Although IBM has elected not to terminate the PC/AT backplane bus, the I-Bus board can add active or passive termination.

Adding extra slots to the PC/AT backplane is also the motive behind Micro Computer Technologies' $250 Expansion Box. It provides four slots, for a net gain of three: The host-adapter board requires use of one of the main backplane slots.

PC/AT systems that are inexpensive

There are PC/AT compatibles awaiting cost-conscious buyers. For example, Micro Distribution Center offers a 640K motherboard that operates at 8 MHz for $175. From Taiwan comes First International Computer Inc.'s 8-MHz 80186 system, dubbed the Turbo Leo, for less than $500, depending on the options and configuration. K.S. Brotherbox Co. Ltd., also in Taiwan, offers the Kingtech 80286 machine and a full line of add-in boards for under $2,000, depending on configurations and quantities. An American newcomer to the AT neighborhood, AMQ Computer Corp., offers its 8-MHz AMQ AT 286. With 2.7M bytes of RAM and a 20M-byte hard disk, the system costs $3,995.

Other companies, such as Avant Industries Inc. of Santa Fe, Calif., King Yee Industries Co. Ltd. of Taiwan, and Tokyo Electric Co. Ltd., provide all the components to build IBM PC-compatible systems, including PC/AT compatibles. Parts range from graphics display cards to power supplies and keyboards. In fact, Tokyo Electric's FB-506-AT2 is offered as an OEM product complete with chassis, power supply, disk controllers and a complete choice of add-in cards.

Assembling your own PC/AT-compatible machine may have some pitfalls, however. VARs are cautioned to look closely at the workmanship and the quality of the material, because a cheap part may end up being an expensive problem.

Vendors aim for 32-bit performance

Although the 80286 microprocessor-based machines haven't gotten into full swing, computer developers are already eyeing the Intel 80386 processor to increase data transfers to 32 bits. Intel, in order to encourage development, has created an extension for the PC/AT bus that accommodates the 32-bit chip.

Trying to dam the stream of information leaks about Intel's so-called 386 Turbo enhancement, William Lattin, senior vice president for Intel's System Group, has put a "No Comment" sign on the desk of anyone who is even remotely associated with the design.

But members of the industry's Personal Computer Extended Technology (PCET) bus committee, which includes representatives from over 40 companies, are going beyond the Intel design in their deliberations. They expect to provide a short-range solution that allows the PC/AT to handle 32-bit memory mapping over its 16-bit bus and then to define a fully workable 32-bit design for later standards consideration. □

Along with adding power, AT-compatible vendors are making the computers smaller by shrinking the box or reducing the electronics to a board-level system.

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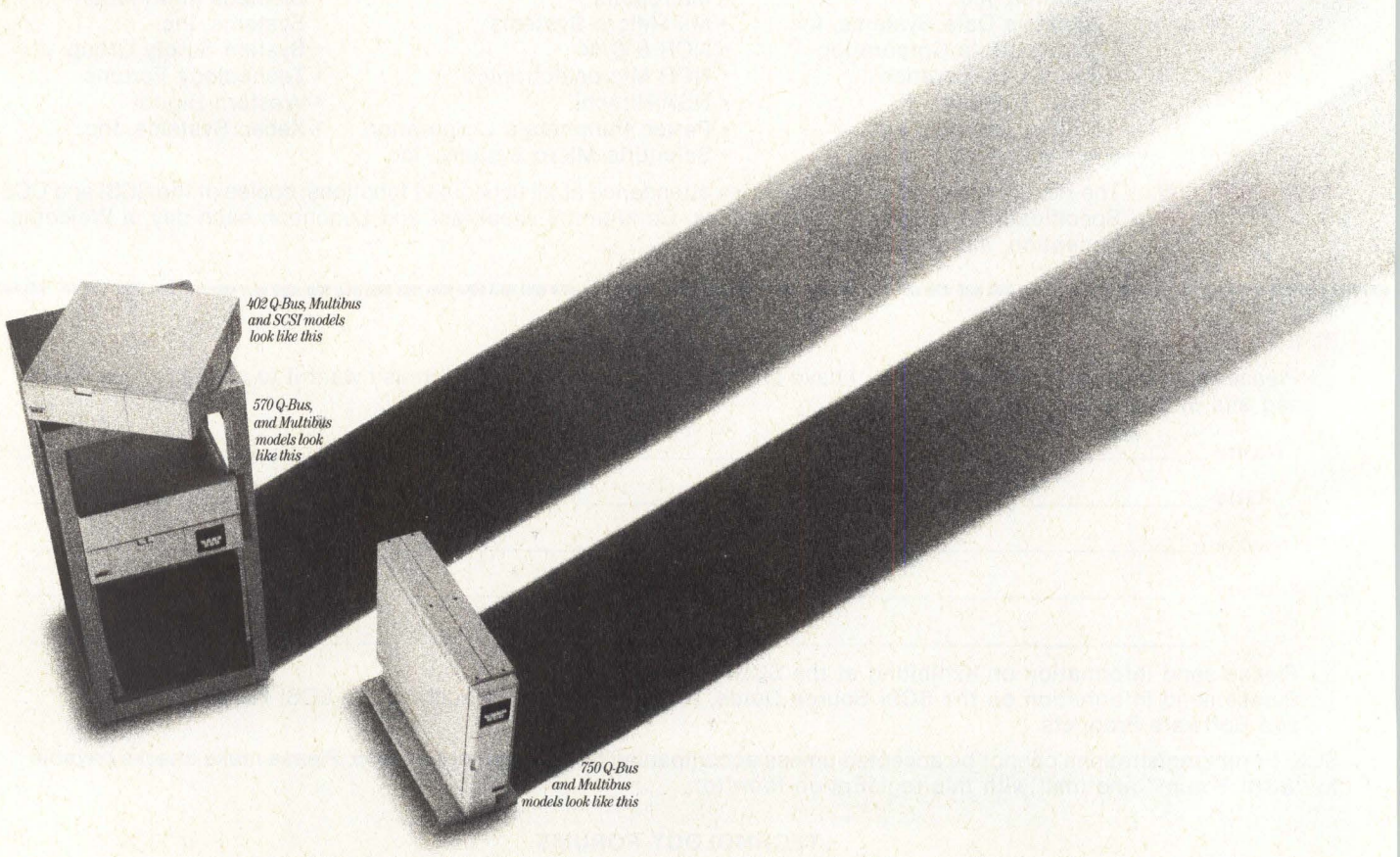

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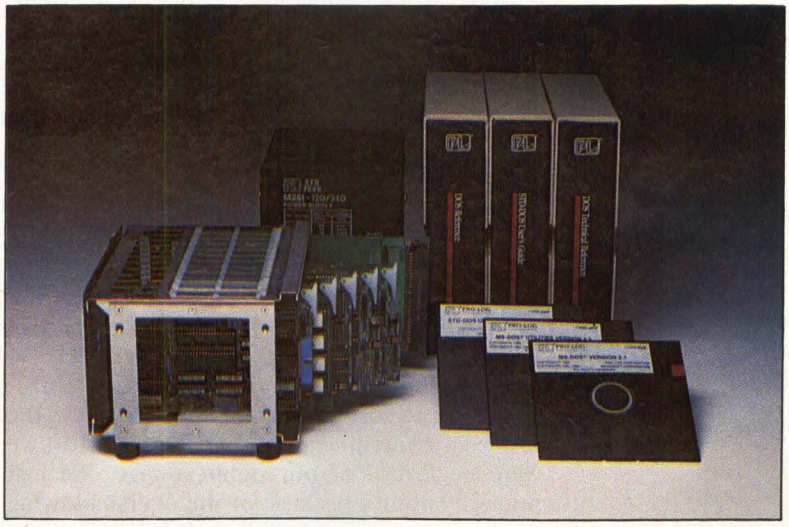
Jesse Victor, Associate Editor

Vendors of Standard Bus (STDbus) products are attempting to dispel what they regard as an unjustified image of a dormant 8-bit bus technology unsuited to the challenges of the '80s and '90s. In fact, this workhorse of the low-cost industrial-control market is alive and kicking. The 8-year-old bus has quietly and steadily added new 16- and 16/32-bit processors, advanced operating systems and programming languages, multitasking or multiprocessing support, CMOS single-board computers and I/O cards, small computer systems interfaces (SCSI), compatible rigid disks and semiconductor disk storage.

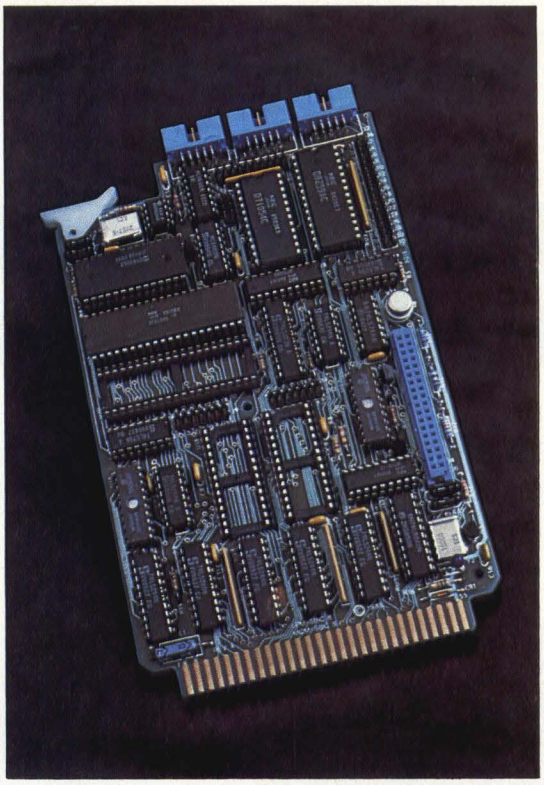
Armed with these enhancements—plus new 16-bit data-transfer and Intel Corp. 8088 microprocessor standards—STDbus vendors are vigorously working to protect the bus's large installed base of industrial applications against assaults by IBM Corp. PC and PC/AT bus single-board computers and VMEbus and Multibus products.

In addition, STDbus vendors are looking ahead to double-byte-wide memory boards and a new generation of networks to link STDbus systems both to one another and to single-board computers adhering to other bus standards. With all this activity, vendors are engaged in another crucial endeavor: pitching STD's advantages to system integrators and end users so that it can continue to win "design-ins" for industrial applications. Although it's a major-league bus in every way—with over 150 vendors, scores of single-board computers and more than 1,000 I/O cards—STDbus has lost its image in the glare of publicity given to "bus wars" between the glamorous, high-end buses.



The PS1.1 prototyping system *from Pro-Log furnishes a built-in editor and debugger, an 8088 CPU card with an RS232C port, two RAM disks, 384K bytes of system RAM and 128K bytes of ROM for the resident STD-DOS version of the MS-DOS 3.1 operating system.*

"Originally, STDbus was an 8-bit single-processor bus relying mainly on the [Zilog Inc.] Z80 microprocessor, which limited it," asserts Paul Virgo, marketing manager at STDbus vendor Pro-Log Corp. "However, multiple-processor schemes using the 8088 CPU for real-time I/O-intensive applications, full 16-bit specifications, which allow processors on the bus like



This CMOS 8088-based 16-bit single-board computer *from WinSystems is typical of the increased processing power now appearing on the STDbus. Onboard functions include an 8259A interrupt controller, three 16-bit counter/timers, an RS232/RS422 serial port and a watchdog timer.*

the [Intel] 80286 or the [Motorola Inc.] MC68000, and a full CMOS specification have geared the bus up to go forward into the 1990s."

"STDbus is here to stay," contends Jim Eckford, vice president of sales and marketing at Ziatech Corp., San Luis Obispo, Calif. "There is no cost-effective solution like it in the low-cost control-system marketplace. But we were neglectful of our public image. We lost public visibility because of the overshadowing publicity given to Multibus, VMEbus and the PC bus."

Underestimates market share

The bus's momentum has also been blunted, STDbus vendors charge, because market-research companies have consistently underestimated STDbus' market share, relative to other computer buses, for several reasons. For instance, since STDbus cards generally cost much less than VMEbus or Multibus boards, market-share figures based solely on shipment values make it appear as if the STDbus had a much smaller installed base than it does. Also, STDbus boards are unique in that a large number of them are user-designed and thus not counted by market-share estimates.

"STDbus is holding its own in design-ins; there's no question about it," asserts Chuck Cech, president of ElectroTech Marketing Consultants, Monterey, Calif.

Cech says that, although STDbus product sales were essentially flat last year, the bus will show a 20 percent to 25 percent growth rate this year and at least a 20 percent growth rate through 1990. This year's total sales of boards and hardware support products such as card racks should reach $65 million to $75 million, he estimates.

Cech attributes the "revitalization" of the STDbus to the availability of both STD-DOS, the STDbus version of MS-DOS, and to the 8088 processor standard, but he sees the integration of more software as the key to future growth.

For its part, STD-DOS allows STDbus users to utilize IBM PC application software in industrial environments with the PC as a software-development machine on the bus.

"Industrial process-control people are reluctant to put IBM PC cards in the factory," claims Robert A. Burckle, vice president of WinSystems Inc. "[But,] with the 8088 on the bus, you can develop applications on a development machine or IBM PC and move them directly to a target application."

STDbus vendors Ziatech and Pro-Log follow different approaches to STD-DOS implementation. Ziatech's is based on IBM's PC-DOS; Pro-Log's, on Microsoft Inc.'s MS-DOS. Ziatech also offers STD Multi-DOS, an extension of PC-DOS comprising a multitasking virtual real-time executive (VRTX) kernel, a Virtual System Console, a global file system and the TRACER real-time debugger, developed by Hunter & Ready Inc. Both STD Multi-DOS and Ziatech's STD-DOS allow concurrent and independent operation of both the PC and the STD system and program development on either a PC or an STDbus computer. "The Multi-DOS multitasking kernel takes over the system and uses the resources of the PC as a background utility set," comments Eckford.

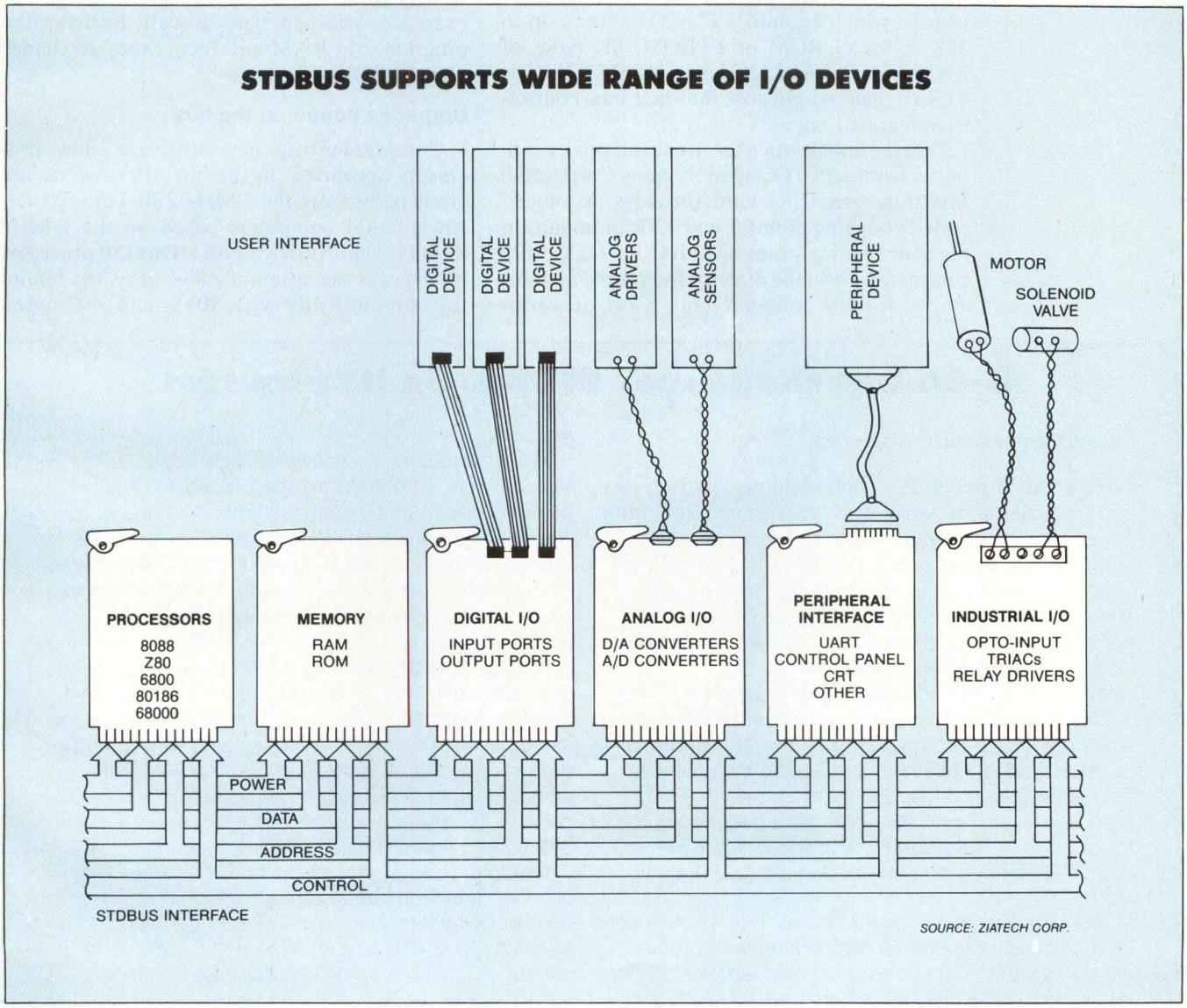
Pro-Log supplies the PS 1.1 STD-DOS prototyping system and three-card (OS 1.1) and two-card (OD 1.2) versions of its STD-DOS OEM system, all based on MS-DOS 3.1. The prototyping system furnishes a built-in editor and debugger, MS-DOS in ROM, an RS232C port, 8088 CPU card, plus semiconductor disk storage. In addition, the company's new STD LIB 1.1 library of initialization and driver routines permits application programs written in assembly language, BASIC or C to control STDbus I/O cards.

Software support by the STDbus is not confined to PC-DOS or MS-DOS or the BASIC offered by most vendors. Languages, develop-

ment systems and boards with resident high-level languages are proliferating on the bus, enabling programs to be developed on a PC or on a standalone module and downloaded for execution from ROM in the STDbus system.

"Sophisticated operating and development systems are appearing on STD that cut the costs of development by an order of magnitude," asserts Eckford. "Our customers spend 10 times more on software than they do on hardware. If we can halve that, we have made a major contribution."

FORTH language programs, which can execute code 50 times faster than BASIC programs, are supplied by several vendors. Ziatech, for example, offers STD PolyFORTH combining a multitasking operating system, the PolyFORTH high-level language, a PolyFORTH assembler for the 8088 CPU, an editor, database support, utilities and a math package for the 8087 coprocessor. The company also offers STD VRTX with a VRTX development system and the STD PDS IBM PC-based development system for its 8088 and



A synchronous bus structure *using a 56-pin edge connector and separate buses for power, data, address and control signals, STDbus supports a wide variety of I/O cards for data acquisition, motor and valve control, robot guidance and other industrial applications. Analog interfaces handle A/D and D/A converters and sensors; peripheral cards function with CRTs and UARTs; and industrial I/O connections control relays and valves through opto-isolated inputs and other inputs.*

80188 computers.

Vesta Technology Inc.'s STD88 board provides a FORTH board with an editor in ROM, allowing software development via a terminal and a power supply or via a PC. HiTech Equipment Corp., San Diego, provides ForthCard, which also allows integrators to develop FORTH or alternative assembly language programs. The board includes an EPROM-EEPROM programmer (electrically programmable-electrically erasable programmable ROM), development firmware and serial and parallel I/O. Finally, Mitchell Electronics, Athens, Ohio, offers the M/E200 and M/E300 boards, which contain a FORTH kernel, up to 32K bytes of ROM or EPROM, 8K bytes of RAM and dual RS232C ports. The M/E200 has a GPIB (general-purpose interface bus) controller integrated circuit.

Programmable via a terminal and power supply or from a PC, Octagon Systems Corp.'s 890 Multifunction CPU card provides an object-code-debugging monitor and 120 commands in resident floating-point STD BASIC. Of the 120 commands, 44 talk directly to control systems at bit, binary code-decimal, 8-bit or 16-bit levels. Statistical and math functions are included, and special commands ease control tasks. "Tach," for example, enables the board to measure the revolutions per minute of a rotating shaft via an optical encoder.

John McKown, the Westminster, Colo., company's technical marketing manager, notes that ROM-based systems, such as the 890, have many advantages in factory-floor applications. "Our experience is that most users have to change the software frequently. If you are having a problem with your robot arm, for example, you can take a programmer out on the factory floor and easily change the code. For example, you can type 'Recall' to bring the program into RAM and then 'Store' to change your EPROM."

Upgrades speed up the bus

Complementing new software, new processors appearing on the bus offer several upgrade paths from the 4-MHz Z80. For instance, single-board computers based on the 6-MHz 8-bit Hitachi America Ltd. HD64180 processor offer faster execution of Z80 code while retaining compatibility with 8085- and Z80-based

G-64 bus challenges STDbus on its own turf

Cosma Pabouctsidis, Gespac Inc.

Buses such as VMEbus and Multibus II, which target the high-performance end of the board spectrum, are usually implemented on large and expensive boards, have complex bus-arbitration schemes and often represent overkill for most simpler 8-bit and 16-bit applications. In contrast, the G-64 bus offers compact, simple, inexpensive but powerful, industrial-grade microcomputer boards.

A second-generation, processor-independent, nonmultiplexed, 16-bit-microprocessor synchronous or asynchronous bus, G-64 aims for low-end and mid-range industrial applications. Gespac Inc., Geneva, Switzerland, first defined G-64 in Europe in 1979. France's Thompson-CSF acted as a second source for the bus in 1980. Since its introduction, over 250,000 G-64 boards have been sold to European users.

The bus's compact board format, high-performance level and low cost suit factory-automation, process-control, robotic, data-acquisition and remote-monitoring applications. The bus's Eurocard/DIN form factor is a worldwide standard supported by many card-cage manufacturers. G-64's pin-in-socket connector provides two points of contact on each pin in a virtually gas-sealed environment, making it corrosion-resistant.

Processors such as the Intel Corp. 80286 or the Motorola Inc.. MC68000 can be utilized to their full power on the bus. Gespac's 80286 CPU board, for example, contains an 8-MHz 80286 CPU, a socket for the 80287 math coprocessor, four timers, a real-time clock/calendar, a serial port and a socket for up to 128K bytes of electrically programmable ROM (EPROM).

A large pool of hardware and software support is available, including advanced graphics display and network controllers. Gespac's GESNET-1A board, for instance, allows several G-64 systems to exchange data over a coaxial cable and CSMA/CA (carrier sense multiple access with collision avoidance) protocol at 800K bytes per second. CMOS and 32-bit-processor boards will soon be introduced.

Operating systems such as MS-DOS and CP/M allow access to a large number of high-level-language compilers. Multitasking kernels and operating systems such as OS-9, PDOS and FORTH suit the bus for a variety of real-time process-control applications.

Cosma Pabouctsidis is president of Gespac Inc., Mesa, Ariz.

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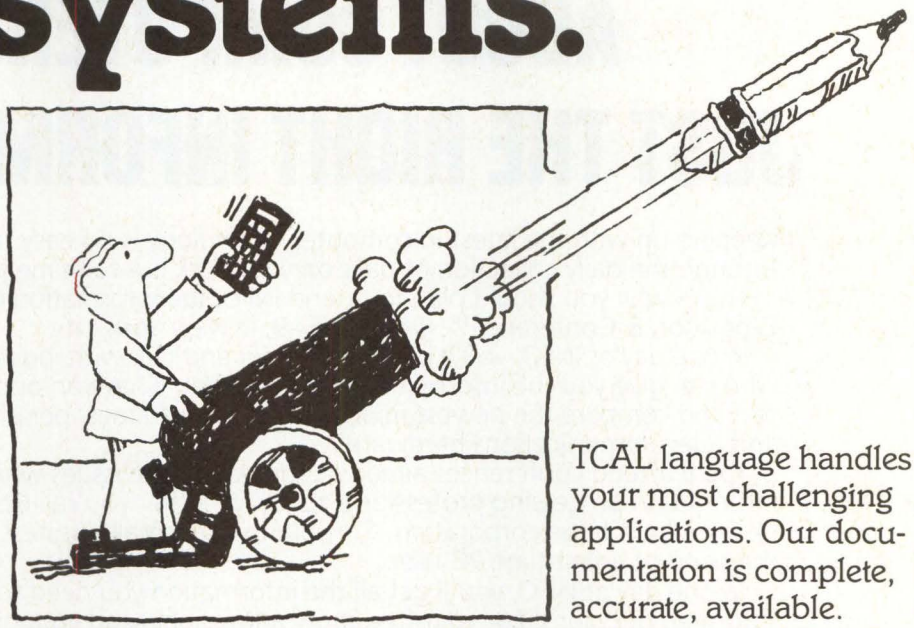

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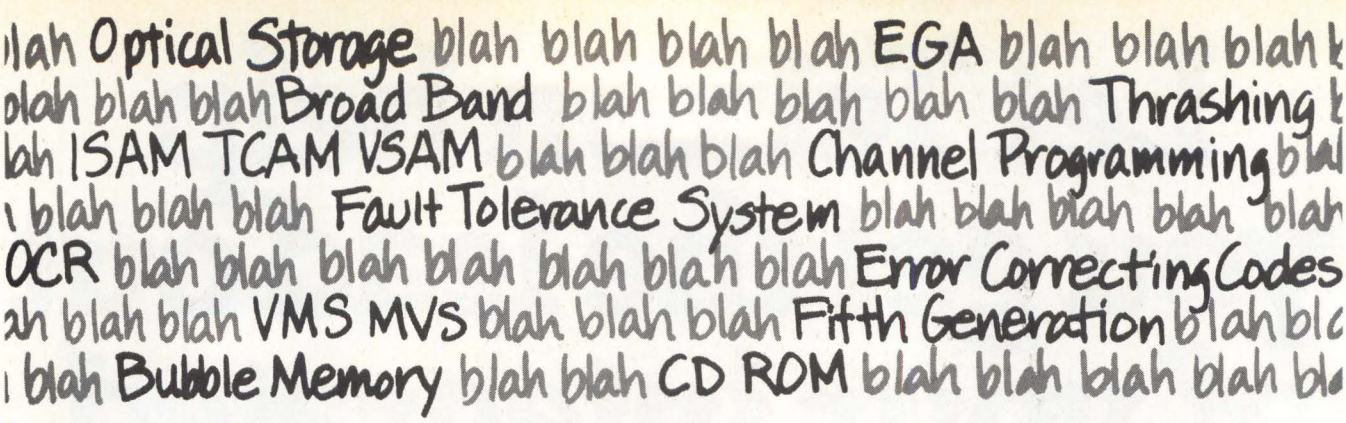

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applications. They provide memory management for 512K-byte addressing, a high-speed multiply circuit and up to 25 percent faster throughput. WinSystems Inc. and the Cubit division of Proteus Industries, Mountain View, Calif., both offer NMOS (N-channel metal-oxide semiconductor) and CMOS versions of 64180 boards.

CMOS processor and I/O boards are emerging as important selling points for STDbus systems, enabling remote and factory-floor applications to take advantage of the technology's low power dissipation, wide operating temperature range (minus 40 C to 85 C) and high noise immunity.

"CMOS allows STDbus systems to be totally embedded in controllers," explains Pro-Log's Virgo. "We are well into providing a critical mass of support on the bus for CMOS systems. Ten or 12 vendors now offer five or six CMOS cards."

Most new STDbus 8088-based boards are implemented in CMOS or come in CMOS or NMOS versions. WinSystems' LPM-SBC-8 board, for example, uses a NEC America Inc. CMOS V20 processor, but is also available in an NMOS version. It packs three 16-bit counter/timers, an 8087 math coprocessor, an 8259A interrupt controller and a watchdog timer, which monitors and automatically reinitializes the system in the event of failure. It also has a power-fail-detect circuit, sockets for 128K bytes of EPROM or 64K of RAM, RS232C and RS422 ports, and an iSBX connector in a 4½-by-6½-inch card.

The 8-MHz 8810-C8 CMOS board from Systek also uses the V20 chip. Capable of addressing 1M byte of memory, the board includes three 16-bit programmable counter/timers, an interrupt controller, 48K bytes of memory, a serial interface with crystal-controlled baud rate, power-fail-detect circuitry and an iSBX expansion connector.

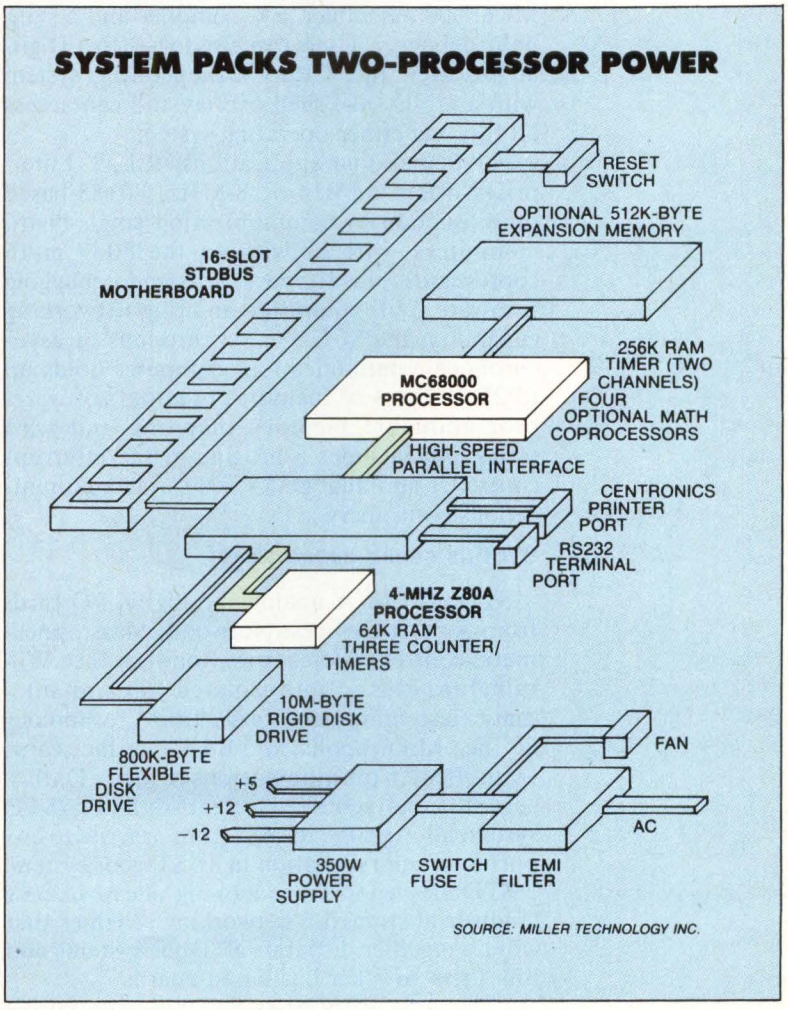
Pro-Log offers 12 CMOS boards in its 7000 Series, including four CPU and five I/O cards. The 80C88-processor-based 78C61 has an on-board interrupt vector generator, up to 136K bytes of memory and an I/O wait-state generator.

The STDbus 16-bit data-transfer standard provides up to 24 bits of addressing by multiplexing eight address lines on the data bus. It redefines only the infrequently used "Memex" signal on the bus, easing upgrades to 16-bit applications, and it clears the way for the emerging 80186, 80286 and 68000 processors that are generating the most excitement about the bus.

Several STDbus vendors, including WinSystems, Cubit, Miller Technology Inc., R.L.C. Enterprises and Ziatech, offer or will soon offer 16/32-bit processor boards.

WinSystems' 80186 board uses the NEC America V50 chip and is available in both CMOS and NMOS versions. It furnishes an 8259 interrupt controller, four direct-memory-access (DMA) channels, a real-time clock, battery backup and three 16-bit counter/timers. The company's MC68000-based CMOS board will be available by the end of the year.

Cubit's model 8500 8-MHz, 80186-based STDbus board sports one RS232 serial port and two 8-bit parallel ports controlled by an 8256 chip. Soft-emulator firmware supports software development and debugging via a PC. An iSBX connector allows the addition of the



Taking a different approach *to 16-bit upgrades, Miller Technology's MTI-1000 STDbus system board combines a Z80 processor and a 6-MHz 68000 coprocessor communicating via a high-speed parallel port.*

STD-DOS allows STDbus users to utilize IBM PC application software in industrial environments.

model 3810 EPROM programmer and a serial-expansion board or the 3830 programmable interrupt-controller module. The 8087 math coprocessor can be added with the model 8590 board replacing the 80186 chip. Ziatech's CMOS 80186 board will debut in the third quarter.

Miller Technology takes a different approach to 16-bit upgrades with its MTI-1000 STDbus single-board computer. It combines a conventional Zilog Z80A with a 6-MHz 68000 coprocessor, communicating through a high-speed parallel port. The 68000 addresses its own memory, timer and arithmetic coprocessors on a 16-bit data, 24-bit address bus. The Z80 controls I/O mass storage and the STDbus controller.

Software support includes the CP/M 68K operating system for the 68000 with an MC68000 assembler, a C compiler and a symbolic debugger. Users can also toggle to a Digital Research Inc. CP/M 2.2 operating system with a UNIX-like shell overlay and can access all files via either operating system.

For demanding applications, R.L.C. Enterprises offers 5-MHz or 8-MHz, 80188-based multifunction or communication single-board computers, with or without the 8087 math coprocessor, plus support cards and debugging firmware. With multidrop and ring-networking capability, the SCC-188 synchronous or asynchronous communications computer holds up to 256K bytes of memory, provides software-programmable memory mapping and wait states and includes a programmable interrupt controller and dual DMA and serial communications controllers.

STDbus seeks networking

STDbus CMOS analog and digital I/O cards from Analog Devices, Norwood, Mass., pneumatic-control systems from Robitech Inc., Wilmington, Mass.; opto-isolated I/O and automatic test-equipment cards from Technology 80 Inc., Minneapolis, and LAN interface cards from Beal Communications Corp., Dallas, serve specialized needs. Beal's NETPC/STD system allows a PC to read from or write to any port or memory location in an STDbus system.

STDbus vendors are looking ahead to new "industrial-strength" networking schemes that will tie together disparate STDbus systems and link them to other bus-based boards.

"The next frontier is STDbus-compatible smart networks that will be able to handle program downloading and remote-file access," maintains Ziatech's Eckford. "Some kind of general-purpose, widely accepted networking is very much in demand. The type of network is up in the air. The Manufacturing Automation Protocol (MAP) is too expensive and too much in flux right now. It is also overkill for the kinds of low-cost applications STDbus controllers perform."

The network that will become the standard, Eckford contends, will cost $350 to $400 a node, will be multidropped and will be environmentally robust. "It will be able to be strung around in a tough environment outdoors or in a factory. We are in a waiting mode with some intermediate approaches until IBM, Intel or some [other] major force comes forward with something that everyone salutes," Eckford adds.

STDbus vendors are confident that such added functionality on the bus, plus STD's traditional strengths—a small card, ruggedness, simplicity of design, low bus overhead, favorable cost/performance ratio and wealth of I/O cards—will enable it to weather the challenges of PC bus systems, Multibus, VMEbus and the emerging G-64 bus (see "G-64 challenges STDbus on its own turf," Page 94).

Although STDbus products are not competing directly against VMEbus and Multibus for high-end applications, the 32-bit buses are having an impact on the industrial-control market where, observes ElectroTech Marketing's Cech, "STDbus will move up to midrange applications through 16-bit systems. VMEbus and Multibus will retain the high-mid and the high-end portions."

The industry movement from 8-bit to 16-bit and, ultimately, to 32-bit applications will affect the sales of STDbus products, but the migration might be slower in the industrial than in the business arena. It may not be economical to link a fast 32-bit processor to an 8-bit analog-to-digital card for the relatively simple control applications that are STDbus' strong suit. In any case, STDbus vendors think they are well-positioned for demanding control tasks with the emerging 16/32-bit processors, 16-bit data transfers and multiprocessor implementations.

"Our motto is, 'Here today, here tomorrow,'" insists WinSystems' Burckle. "We serve people in the industrial environment with products that have life spans to 15 years. If I were an industrial-control person, I would be relieved to know that the STDbus has been around for awhile." □

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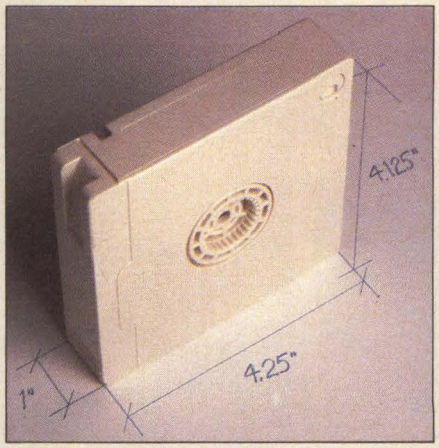

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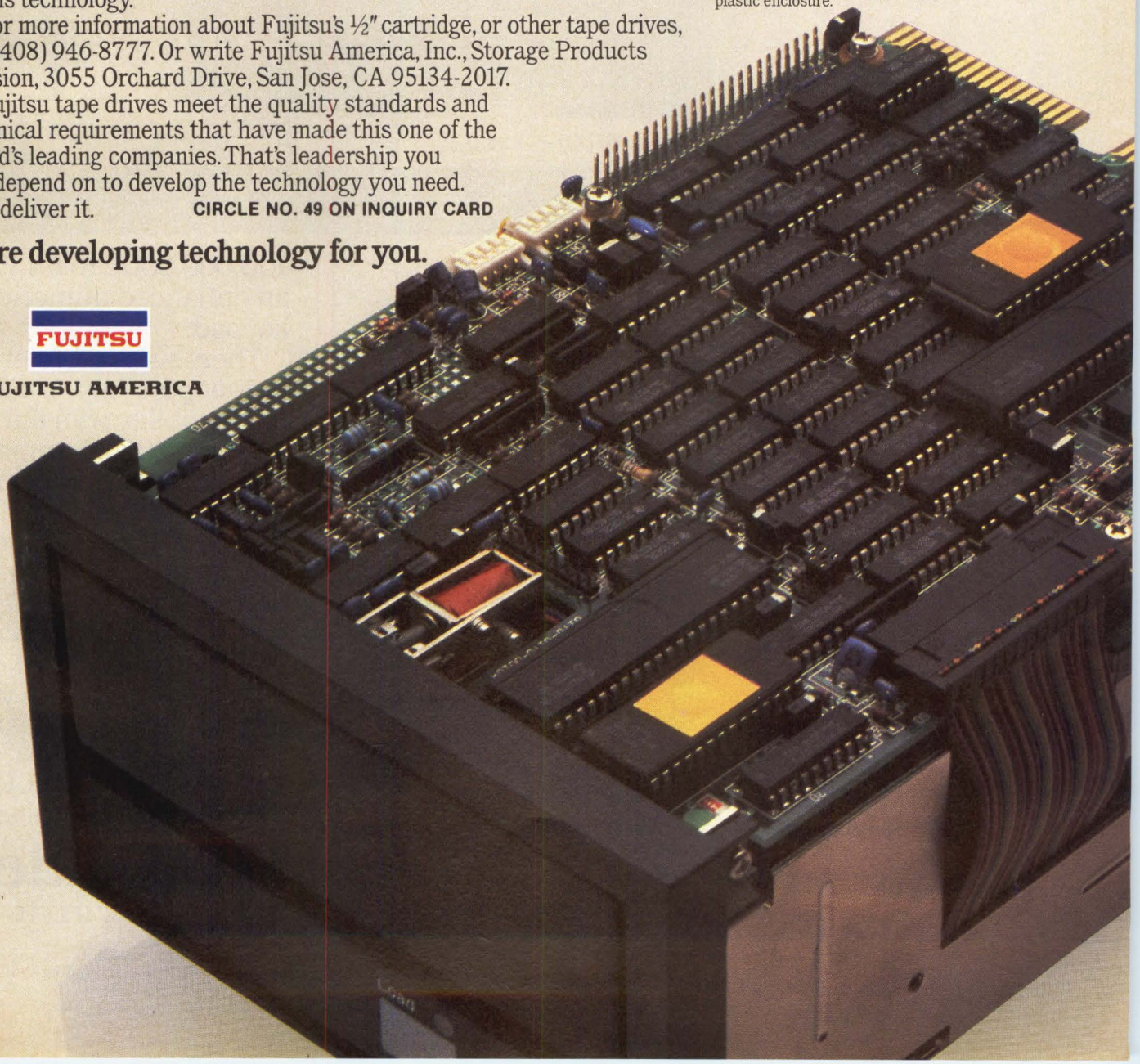

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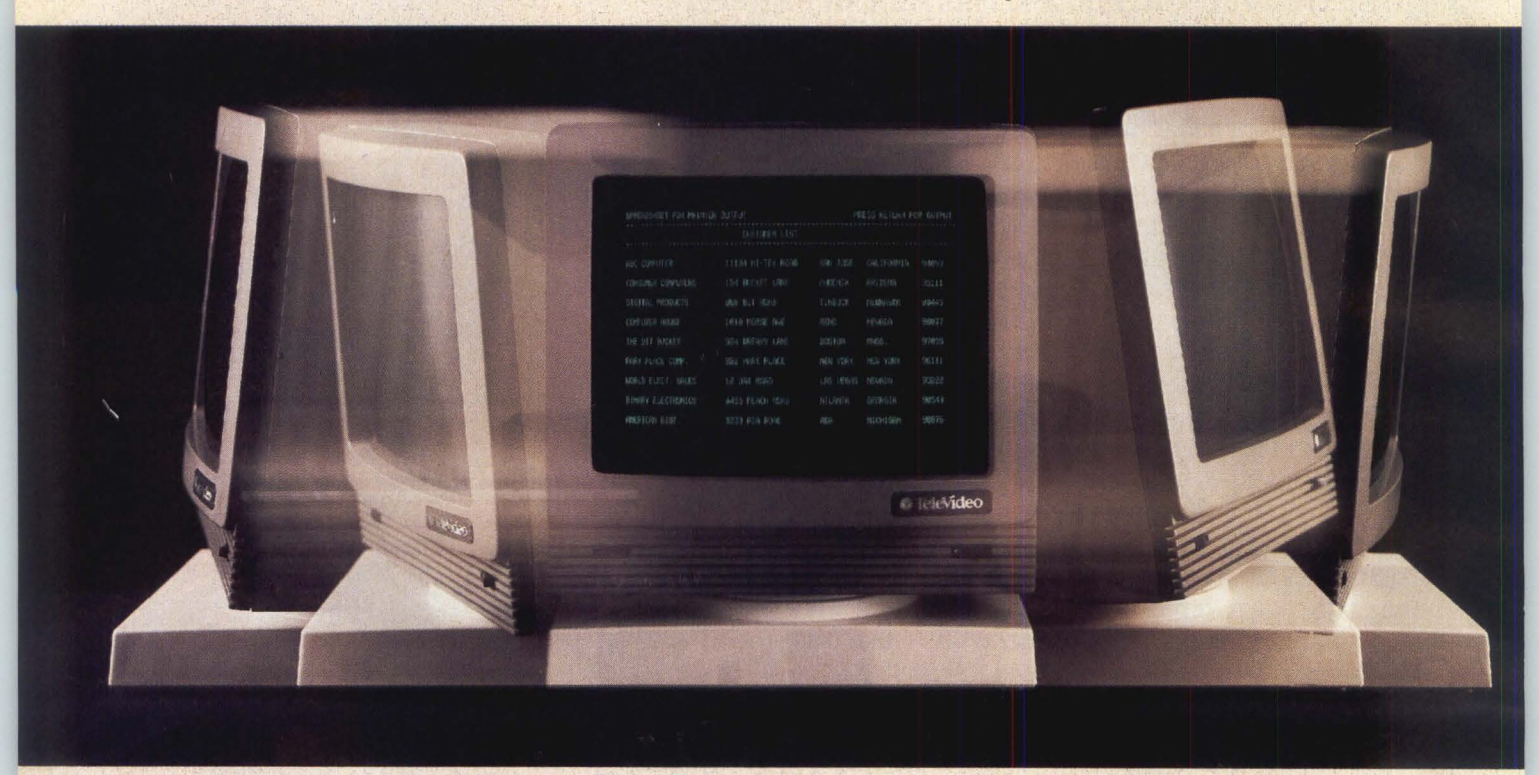

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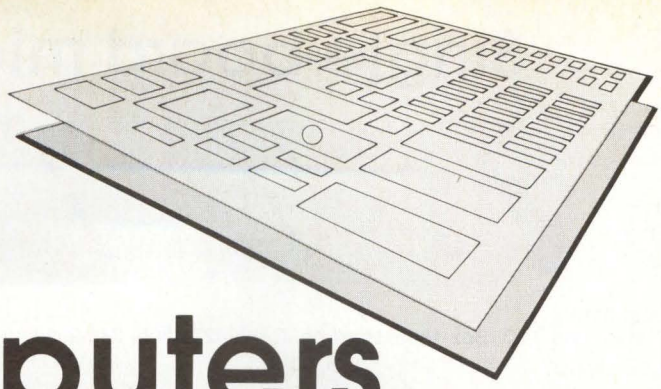
Single-board microcomputers



Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
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A68 KPM	68000, 68010 (32)	Q-bus	REGULUS	debugger	C, FORTRAN, Pascal	512K (64K)	10.4×8.7		clock/calendar, memory management, four asynch communication ports
A68 VME	68000, 68010 (32)	VMEbus	REGULUS, pSOS	debugger, editor, graphics generators	C, FORTRAN, Pascal	1M (128K)	6.4×9.32		memory management, clock/calendar, two asynch serial communication ports
ALLOY COMPUTER PRODUCTS INC. 100 Pennsylvania Ave., Framingham, MA 01701, (617) 875-6100									**Circle 341**
PC-PLUS	NEC V20 (16)		MS-DOS			512K (1M)		4,895(Q1)	math coprocessor
AMPRO COMPUTERS INC. 67 E. Evelyn Ave., Mountain View, CA 94041, (415) 962-0230									**Circle 342**
Little Board	Z80A	SCSI	CP/M 2.2, Turbo-DOS, ZRDOS			64K (64K)	5.75×7.75 ×0.75	249(Q1)	two serial and one parallel port(s)
Little Board 186	80186	SCSI	Concurrent DOS, PC-DOS, Turbo-DOS			128K (1M)	5.75×7.75 ×0.75	549(Q1)	two serial and one parallel port(s)
APPLIED BUSINESS COMPUTER CO. 1509 N. Kraemer Blvd., Suite E, Anaheim, CA 92806, (714) 666-2604									**Circle 343**
65-8	6502, 6809 (8)	EXORciser bus	ADOS	debugger, editor	Assembly, BASIC, FORTH	8K (24K)	6.5×9.75 ×0.5	295(Q1)	one RS232C port, battery backup
65-64	6502, 6809 (8)	EXORciser bus	ADOS	debugger, editor	Assembly, BASIC, FORTH	64K (64K)	6.5×9.75 ×0.5	325(Q1)	two RS232C ports, real-time clock, battery backup
CENTRAL DATA CORP. 1602 Newton Dr., Champaign, IL 61821, (217) 359-8010									**Circle 344**
CD21/ 1680	68000 (8, 16)	Multibus	UNIX	UNIX boot monitor	C	(128K)	6.75×12 ×0.5	1,400(Q1); 975(Q100)	memory management, three programmable timers
CD21/ 8630	8086 (8, 16)	Multibus	RMX-86	system debugger, monitor	ASM-86, FORTRAN, Pascal, PL/M-86	128K-256K (4K-256K)	6.75×12 ×0.5	1,500-1,680(Q1); 1,000-1,125(Q100)	one serial I/O port
CD21/ 8635	8086 (8, 16)	Multibus	RMX-86	system debugger, monitor	ASM-86, FORTRAN, Pascal, PL/M-86	512K-1M (4K-256K)	6.75×12 ×0.5	1,740-2,135(Q1); 1,160-1,425(Q100)	one serial I/O port
COMPUTER DYNAMICS INC. 105 S. Main St., Greer, SC 29651, (803) 877-7471									**Circle 345**
CPU-9	Z80, Z80A, Z80B, Z80H (8)	STD	CP/M-80, Turbo-DOS	debugger, monitor	Assembly, BASIC, C, FORTRAN, COBOL	64K (32K)	4.5×6.5 ×0.5	250(Q1); 200(Q100)	two serial and one Centronics parallel port(s), real-time clock, two timers, memory mapping

Single-board microcomputers

Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
DAVIDGE CORP. 292 E. Hwy. 246, P.O. Box 1869, Buellton, CA 93427, (805) 688-9598									**Circle 346**
DSB-4000	Z80A, Z80B (8)		CP/M-80			64K (4K)	0.5×10 ×5.75	315(Q1); 235(Q100)	flexible disk controller, SASI port, up to four RS232C and one Centronics port(s), DMA
DSB-6000	Z80B (8)		CP/M-80			256K (32K)	0.5×10 ×5.75	570(Q1); 415(Q100)	flexible disk controller, SASI port, two RS232C and one Centronics port(s), DMA
DSB-8000	HD64180 (8)		CP/M-80, MP/M-II			512K (64K)	0.5×10 ×5.75	480(Q1); 375(Q100)	flexible disk controller, SCSI port, up to six RS232C and one Centronics port(s), DMA
DIVERSIFIED TECHNOLOGY INC. P.O. Box 748, Ridgeland, MS 39158, (601) 856-4142									**Circle 347**
CBC 86C/05	80C86 (16)	Multibus				16K (128K)	6.75×12 ×0.5	1,395(Q1); 1,116(Q100)	one RS232C port, 24 parallel I/O lines, three 16-bit counter/timers
CBC 86C/14	80C86 (16)	Multibus				128K (128K)	6.75×12 ×0.5	1,795(Q1); 1,436(Q100)	one RS232C port, 24 parallel I/O lines, three 16-bit counter/timers
CBC 88C/25	80C88 (8)	Multibus				16K (128K)	6.75×12 ×0.5	1,095(Q1); 876(Q100)	one RS232C port, 24 parallel I/O lines, three 16-bit counter/timers
DUAL SYSTEMS CORP. 2530 San Pablo Ave., Berkeley, CA 94702, (415) 549-3834									**Circle 348**
VIOP	68000 (16, 32)	VMEbus		downloading		512K (64K)	2.4×9.36 ×0.8	1,495(Q1)	three interrupts
VMPU	68020, 68881 (32)	VMEbus	UNIX System V 2.2	downloading	BASIC, C, COBOL, FORTRAN, LISP	1M (32K)	2.4×9.36 ×0.8	5,250(Q1)	battery-backed clock, mailbox interrupt
FARADAY ELECTRONICS INC. 749 N. Mary Ave., Sunnyvale, CA 94086, (408) 749-1900									**Circle 349**
Bus AT	(16)	PC/AT bus	MS-DOS	debugger; editor; loader; character, graphics generators	BASIC, C, FORTH, Pascal	512K (64K)	13.5×4.8	1,190-1,325(Q1); 1,012-1,126(Q100)	two DMA controllers, 15 vectored interrupts, CMOS clock/calendar
Bus PC 256	8088 (8)	PC bus	MS-DOS	debugger; editor; loader; character, graphics generators	BASIC, C, FORTH, Pascal	256K (64K)	13.5×4.2	495(Q1); 421(Q100)	eight interrupts, one parallel port, coprocessor
CMOS Micro PC/256	80C88 (8)	PC bus	MS-DOS	debugger; editor; loader; character, graphics generators	BASIC, C, FORTH, Pascal	256K (64K)	6.2×4.2	550(Q1); 468(Q100)	eight interrupts, one serial port, coprocessor
FORCE COMPUTERS INC. 727 University Ave., Los Gatos, CA 95030, (408) 354-3410									**Circle 350**
CPU-1/2/3	68000, 68010 (8, 16)	VMEbus	P-DOS, pSOS	assembler, disassembler, montior	BASIC, C, FORTRAN 77, Pascal	512K/1M/128K (128K/32K/128K)	9.2×6.3 ×0.8	1,295/1,895/2,195(Q1)	real-time clock, CPU-2: flexible drive controller, CPU-3: UNIX engine, MMU
CPU-5	68000, 68010 (8, 16)	VMEbus	P-DOS, pSOS	assembler, disassembler, monitor	BASIC, C, FORTRAN 77, Pascal	128K (25.6K)	9.2×6.3 ×0.8		coprocessor, two RS232C ports
CPU-21	68020 (8, 16, 24, 32)	VMEbus	P-DOS	assembler, disassembler, monitor	BASIC, C, FORTRAN 77, Pascal	512K (512K)	9.2×6.3 ×0.8	6,995(Q1)	coprocessor, two RS232C ports
GENERAL MICRO SYSTEMS INC. 4740 Brooks St., Montclair, CA 91763, (714) 625-5475									**Circle 351**
GMS6506	6809, 6502 (8)	EXORbus	CP/M 2.2, OS9	debugger, loader, file manager	BASIC, C, FORTRAN	4K (32K)	9.75×6 ×0.7	536(Q1); 429(Q100)	serial and parallel port

Single-board microcomputers

Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
GMS6507	68008, 6809 (8)	EXORbus	CP/M 2.2, OS9	debugger, loader, file manager	BASIC, C, FORTRAN, Pascal	65K (65K)	9.75×6 ×0.7	799(Q1); 539(Q100)	two serial and one parallel port(s)
GMS V06/V07	68010/ 68020 (16/32)	VMEbus	P-DOS, UNIFLEX	debugger, self-test, I/O drivers	BASIC, C, FORTRAN, Pascal	2M/512K (128K/ 128K)	9.2×6.3 ×0.4	2,995/ 4,195(Q1); 2,396/ 3,356(Q100)	SCSI controller; battery-backed, real-time clock; coprocessor; two serial ports
GESPAC INC. 100 W. Hoover, Suite 11, Mesa, AZ 85202, (602) 962-5559									**Circle 352**
MPU-4A	68000 (16)	G-64	CP/M-68, OS9	debugger, graphic plotter, loader, macro assembler, screen editor,	Extended BASIC, C, COBOL, FORTRAN 77, Pascal	16K (64K)	0.625×3.9 ×6.3	395(Q1); 315(Q100)	three 16-bit timers, RS232C port
MPU-18	80286 (16)	G-64	MS-DOS	debugger	Extended BASIC, C, COBOL, FORTRAN, Pascal	(128K)	0.625×3.9 ×6.3	1,350(Q1); 1,080(Q100)	coprocessor, RS232C port
SBS-5	8088 (8)	G-64	CP/M-88	assembler, editor, graphic plotter	CBASIC, PBASIC, C Compiler, COBOL, Pascal	64K (64K)	0.625×3.9 ×6.3	595(Q1); 485(100)	two RS232C ports, multi-memory mapping, ten 8-bit and four 16-bit timers, real-time clock/calendar
GIMIX INC. 1337 W. 37th Place, Chicago, IL 60609, (312) 927-5510									**Circle 353**
SBC-20	68020 (32)		OS9		BASIC, C, Pascal	1M		2,750(Q1)	battery-backed clock/ calendar, MMU, floating point coprocessor
GOODSPEED SYSTEMS INC. 23 Main St., P.O. Box 29, East Haddam, CT 06423, (203) 873-1481									**Circle 354**
GS-32	32032 (32)		C-Executive, CP/M, UNIX	debugger, disassembler, editor, loader	BASIC, C, FORTRAN, Pascal	2K (16K)	1×15×13	5,500(Q1); 3,575(Q100)	SCSI port, six RS232C and one parallel port(s)
68020 UNI-SYSTEM	68020 (32)	VMEbus	Berkeley UNIX Version 4.2, UNIX System V	debugger, disassembler, editor, loader	BASIC, C, FORTRAN, Pascal	8K (128K)	1×14.4 ×11.1	7,500(Q1); 6,000(Q100)	SCSI port, one RS422 and up to 16 RS232C port(s)
GRANT TECHNOLOGY DIVISION OF COMPUTER PRODUCTS INC. 321 Billerica Rd., Chelmsford, MA 01824, (617) 256-8881									**Circle 355**
309	8X305 (8)	Q-bus				0.5K (4K)	8.9×5.2 ×0.5	995(Q1); 696(Q100)	16 serial ports
312	68000 (16)	Q-bus				4K (16K)	8.9×5.2 ×0.5	795(Q1); 556(Q100)	eight serial ports
1301	Z80H (8)	VMEbus				2K (8K)	10×6 ×0.6	795(Q1); 556(Q100)	eight serial ports
HEURIKON CORP. 3201 Latham Dr., Madison, WI 53713, (608) 271-8700									**Circle 356**
HK68/ME	68000 (16)	Multibus	VRTX		Ada, BASIC, C, COBOL, FORTRAN, Pascal	1M (128K)	12.2×6.88	1,395(Q1); 975(Q100)	two RS232C and RS422 ports, mailbox interrupt, six counter/timers
HK68/M10	68010 (16)	Multibus	UNIX System V 2.2, VRTX		Ada, BASIC, C, COBOL, FORTRAN, Pascal	1M (128K)	12.2×6.88	2,895(Q1); 2,000(Q100)	four RS232C and RS422 ports, mailbox interrupt, three counter/timers
HK68/V10	68010 (16)	VMEbus	UNIX System V 2.2, VRTX		Ada, BASIC, C, COBOL, FORTRAN, Pascal	1M (128K)	9.4×6.4	2,595(Q1); 1,800(Q100)	two RS232C and RS422 ports, mailbox interrupt, six counter/timers
INDOCOMP INC. 5409 Perry Dr., P.O. Box 157, Drayton Plains, MI 48020, (313) 674-2294									**Circle 357**
68001/ 68011	68010 (16, 32)		MTOS-68K, MTOS-UX68K	application programs, debugger, editor	C, Pascal	128K (128K)	15×1.5 ×9.5	942/ 2,894(Q1); 785/2,411 (Q100)	

Single-board microcomputers

Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
68021/ 68031	68010 (16, 32)		MTOS-68K, MTOS-UX68K	application programs, debugger, editor	C, Pascal	128K (128K)	15×1.5 ×9.5	2,312/ 1,650(Q1); 1,927/ 1,375(Q100)	32 digital I/O lines/ eight serial ports
68041	69010 (16, 32)		MTOS-68K, MTOS-UX68K	application programs, debugger, editor	C, Pascal	128K (128K)	15×1.5 ×9.5	2,100(Q1); 1,774(Q100)	40 digital I/O lines

INNER ACCESS CORP. **Circle 358**
3206 E. Laurel Creek Rd., Belmont, CA 94002, (415) 591-8295

68K-P	68000 (16)	S-100	AMOS/L, DOS, Mirage	debugger, editor	APL, BASIC, C, FORTRAN, FORTH, Pascal	32K	5×10 ×0.5	695(Q1)	

INTEGRATED SOLUTIONS **Circle 359**
1140 Ringwood Ct., San Jose, CA 95131, (408) 943-1902

V8/V16/ V24	68020 (32)	VMEbus	Berkeley UNIX Version 4.2	debugger; editor; loader; character, graphics generators	Assembly, C, FORTRAN, LISP, Pascal		25.5×9.5 ×19.5/ 26.4×12.5 ×28.4/ 62×21.5 ×30		

INTERCONTINENTAL MICRO SYSTEMS CORP. **Circle 360**
4015 Leaverton Ct., Anaheim, CA 92807, (714) 630-0964

CPS-B6A	Z80B (8)	S-100	Turbo-DOS	debugger; editor; loader; character, graphics generators	BASIC, C, FORTH, Pascal	64K-128K	5.5×10 ×0.5	650-750(Q1); 422- 487(Q100)	interrupt controllers, two RS232C ports
CPS-16	8086 (16)	S-100	Turbo-DOS, MS-DOS	debugger; editor; loader; character, graphics generators	BASIC, C, FORTH, Pascal	256K	5.5×10 ×0.5	995- 1,595(Q1); 646- 1,037(Q100)	interrupt controllers, two RS232C ports
NET-82	Z80A (8)	S-100	Turbo-DOS	debugger; editor; loader; character, graphics generators	BASIC, C, FORTH, Pascal	64K-128K (2K)	5.5×10 ×0.5	600-700(Q1); 390- 455(Q100)	interrupt controllers, two RS232C ports

IRONICS INC. **Circle 361**
798 Cascadilla St., Ithaca, NY 14850, (607) 277-4060

IV-1600/ IV-1602	68010 (16, 32)	VMEbus	UNIX System V 2, pSOS, UNIFLEX	debugger, monitor		1M (320K/64K)		3,395/ 2,295(Q1)	

ISOTRON INC. **Circle 362**
140 Sherman St., Fairfield, CT 06430, (203) 255-7443

712G	68010 (32)	VMEbus	UNIX System V, XENIX V compatible	UNIX/XENIX utilities	APL, C, COBOL, FORTRAN, Pascal, OSI BASIC	2M	1×15 ×12	2,000(Q100)	two SCSI interfaces, four RS232C ports, battery-backed clock/calendar, floating point processor

JF MICROSYSTEMS **Circle 363**
3641 Frontier Rd., Pasco, WA 99301, (509) 297-4294

4188	8088 (16)	STD				2K (16K)	4.5×6.5 ×0.4	400(Q1); 300(Q100)	four parallel ports, three timers, interrupt controller
8759	8088 (16)	STD	CP/M-86	debugger		(32K)	4.5×6.5 ×0.4	500(Q1); 375(Q100)	memory and I/O mapping, three timers, interrupt controller
8800	8088 (16)	STD		debugger		(8K)	4.5×6.5 ×0.4	250(Q1); 187(Q100)	

LAMAR MICRO **Circle 364**
2107 Artesia Blvd., Redondo Beach, CA 90278, (213) 374-1673

Super- kim	6502, 65C02 (8)	KIM-1	KIM-1	cross assembler	Assembly, BASIC, C	48K (16K)	11.5×11.5 ×1	545(Q1); 345(Q100)	priority interrupts, eight counter/timers

LAPOLE SYSTEMS INC. **Circle 365**
Link Consulting Associates-New York, 575 5th Ave., New York, NY 10021 (212) 744-4423

LPU 68-K	68000 (16)	Multibus	CP/M-68K, OS9, REGULUS			512K (8K-128K)	12×6.76 ×0.55	1,750- 1,950(Q1); 1,120- 1,250(Q100)	

Single-board microcomputers

Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
LITTLE MACHINES INC. 4241 Jutland Dr., Suite 103, San Diego, CA 92117, (619) 483-3606									**Circle 366**
DPX86/ME	80286, 80186 (16)	Multibus	RMX-286, VRTX 86, XENIX	RMX, XENIX utilities	BASIC, C, FORTRAN, Pascal	1M (384K)	6.75×12 ×0.6	3,950(Q1); 2,370(Q100)	three serial and one parallel port(s)
MATROX ELECTRONIC SYSTEMS LTD. 1055 St. Regis Blvd., Dorval, Quebec, H9P 2T4, Canada, (514) 685-2630									**Circle 367**
MAP-2000	68020 (32)	Multibus		ROM monitor		256K (512K)	12×6.75 ×0.5	2,995(Q1)	two serial ports
MBC-86/ 512	8086 (16)	Multibus		ROM monitor		512K (128K)	12×6.75 ×0.5		one serial port, 24 programmable parallel lines
NAP-2000	32032 (32)	Multibus		ROM monitor		128K (512K)	12×6.75 ×0.5	2,995(Q1)	two serial ports
MICRO-AIDE INC. 685 Arrow Grand Circle, Covina, CA 91723, (818) 915-5502									**Circle 368**
80-0027	Z80 (8)	STD				128K (128K)	0.5×4.5 ×6.5	250(Q1); 212(Q100)	CMOS version available
80-0033	6809E (8)	STD	OS9 compatible	monitor		128K (128K)	0.5×4.5 ×6.5	300(Q1); 250(Q100)	one RS232C port, 16 I/O lines
80-0038	8088 (8)	STD		monitor		256K (256K)	0.5×4.5 ×6.5	170(Q1); 144(Q100)	
MILLER TECHNOLOGY INC. 647 N. Santa Cruz Ave., Los Gatos, CA 95030, (408) 395-2032									**Circle 369**
MCPU-800/ MCPU-900	Z80A (8, 16)	STD	CP/M	monitor	BASIC, C	64K (32K/16K)	4.5×7 ×0.5	645/795(Q1); 535/ 675(Q100)	memory mapping/ flexible drive controller, counter/timer
MIZAR INC. 20 Yorkton Ct., St. Paul, MN 55117, (612) 224-8941									**Circle 370**
VME 7100	68000, 68010 (16)	VMEbus	CP/M-68K, P-DOS, polyFORTH, OS9-68K	debugger, monitor	BASIC, C, FORTH, FORTRAN 77, Pascal	512K (128K)	9.1×.54 ×6.2	1,595-2,345(Q1); 1,215-1,785(Q100)	two RS232C and parallel ports, seven interrupts
VME 7120	68020 (32)	VMEbus	polyFORTH, P-DOS, OS9	debugger, monitor	BASIC, C, FORTH, FORTRAN 77, Pascal	1M (256K)	9.1×.54 ×6.2	2,995(Q1); 2,280(Q100)	controller, seven interrupts, timer
VME 8115	68000, 68010 (16)	VMEbus	CP/M-86, polyFORTH, P-DOS, OS9-68K	debugger, monitor	BASIC, C, FORTH, FORTRAN 77	512K (128K)	3.9×0.54 ×6.2	1,195-1,595(Q1); 910-1,215(Q100)	seven interrupts, two RS232C ports
MODULAR COMPUTER SYSTEMS (MODCOMP) 1650 W. McNab Rd., Ft. Lauderdale, FL 33310, (305) 977-1823									**Circle 371**
CLASSIC	custom (16)	proprietary	MAX IV		C, COBOL, CORAL, FORTRAN, Pascal		1.25×14.5 ×19.6	9,500(Q1)	
MONOLITHIC SYSTEMS CORP. 84 Inverness Circle East, Englewood, CO 80112, (303) 790-7400									**Circle 372**
MSC8009	Z80A (8)	Multibus	CP/M, ZRDOS		Assembly, BASIC, C	64K (32K)	12×6.75 ×0.5	1,219(Q1); 750(Q100)	two serial ports, CP/M engine
MSC8019	HD64180 (8)	Multibus	CP/M, ZRDOS		Assembly, BASIC, C	512K (128K)	12×6.75 ×0.5	1,190(Q1); 790(Q100)	two serial and one SCSI port(s)
MSC8186	80186 (16)	Multibus	CP/M, iRMX, MS-DOS	SDM-186 debugger, monitor	Assembly, BASIC, C, FORTRAN, Pascal, PL/M	1M (256K)	12×6.75 ×0.5	1,990(Q1); 1,200(Q100)	coprocessor, one serial port, 24 parallel I/O lines
OMNIBYTE CORP. 245 W. Roosevelt Rd., Bldg. 1-5, West Chicago, IL 60185 (312) 231-6880									**Circle 373**
OB68-K1A	68000 (16)	Multibus	polyFORTH, IDRIS	Versabug, Macsbug	C, FORTH, FORTRAN 77, Pascal	32K, 128K, 512K, (up to 192K)	6.75×12 ×0.062	1,250(Q1); 842(Q100)	two 16-bit parallel and two serial ports, three 16-bit timers

Single-board microcomputers

Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
OB68K/ MSBC1	68000, 68010 (16)	Multibus	polyFORTH, IDRIS		C, FORTH, FORTRAN 77, Pascal	256K/2M (256K)	6.75×12 ×0.062	1,895(Q1); 1,232(Q100)	four serial ports, iSBX port, one 24-bit timer
VME-1	68000 (16)	VMEbus				4K-112K (8K-448K)	6.3×9.19 ×0.062	995(Q1); 647(Q100)	two serial and two 8-bit parallel ports, one 16-bit and one 24-bit timer

ONSET COMPUTER CORP. **Circle 374**
199 Main St., North Falmouth, MA 02556, (617) 563-2267

CPU-801	NSC800 (8)	C-44	monitor			0.12K (6K)	5.25×4.5 ×0.5	445(Q1); 350(Q100)	real-time clock, 22 I/O lines
CPU-8085	80C85 (8)	C-44	monitor			8K (8K)	5.25×4.5 ×0.5	275(Q1); 200(Q100)	22 I/O lines
CPU-8088	80C88 (8)	C-44	monitor			0.25K (8K)	5.25×4.5 ×0.5	550(Q1); 400(Q100)	real-time clock, 22 I/O lines

PERFORMANCE TECHNOLOGIES INC. **Circle 375**
300 Main St., East Rochester, NY 14445, (716) 586-6727

PT-VME-100	68010 (16, 32)	VMEbus	UNIX System V	debugger, loader	Ada, BASIC, C, COBOL, FORTRAN, Pascal	64K (64K)	9.2×0.8 ×6.3	2,800(Q1); 2,000(Q100)	dual MMU, VME system controller
PT-VME-102	68010 (16, 32)	VMEbus	P-DOS	debugger, loader	BASIC, C, FORTRAN 77, Pascal	2M (256K)	9.2×0.8 ×6.3	2,195(Q1); 1,700(Q100)	floating point processor, VME controller
PT-VME 103 PT-VBS 104	68010/ 68020 (16, 32/32)	VMEbus/ Versabus		debugger, loader		128K/64K (64K/128K)	9.2×0.8 ×6.3 9.25×0.4 ×14.5	2,950/ 6,500(Q1); 2,100/ 5,000(Q100)	floating point processor/two serial ports, real-time clock

PERIPHERAL TECHNOLOGY **Circle 376**
1480 Terrell Mill Rd., Suite 870, Marietta, GA 30067, (404) 984-0742

PT-68K-1	68008 (8, 16)		OS9-68K, STAR-DOS	assembler, debugger, editor	BASIC, C, Pascal	768K (64K)	8×5.75 ×0.5	500(Q1); 350(Q100)	two serial and parallel ports, flexible disk controller, real-time clock
PT-69-3	6809 (8)		FLEX, OS9, STAR-DOS	assembler, debugger, editor	BASIC, C, Pascal	59K (4K)	6.5×5.5 ×0.5	279(Q1); 185(Q100)	two serial and parallel ports, flexible disk controller, real-time clock
PT-69-5	6809 (8)		FLEX, OS9, STAR-DOS	assembler, debugger, editor	BASIC, C, Pascal	60K (4K)	7×5.75 ×0.5	450(Q1); 325(Q100)	four serial and two parallel ports, flexible disk controller, real-time clock

PERSONAL MICRO COMPUTERS INC. **Circle 377**
275 Santa Ana Ct., Sunnyvale, CA 94086, (408) 737-8444

PC-101	Z80A (8)		CP/M 3.0		CBASIC	128K (4K)	11.65×5.7	325(Q1)	

PLESSEY MICROSYSTEMS **Circle 378**
One Blue Hill Plaza, Pearl River, NY 10965, (914) 735-4661

PME 68-1B	68000, 68010 (16)	VMEbus	P-DOS, pSOS, VDOS	assembler, debugger	BASIC, C, FORTH, FORTRAN, IDEAL, Pascal	512K (128K)		1,037(Q1); 835(Q100)	battery-backed, real-time clock; three RS232C and one parallel port(s)
PME 68-2	68000, 68010 (16)	VMEbus	P-DOS, pSOS	assembler, debugger	BASIC, C, FORTRAN, Pascal	1M (64K)		1,609(Q1); 1,295(Q100)	one RS232C port, seven interrupts, flexible drive controller
PME 68-2D	68000, 68010 (16)	VMEbus	P-DOS, pSOS	assembler, debugger	BASIC, C, FORTRAN, Pascal	512K (64K)		1,188(Q1); 956(Q100)	one RS232C port, seven interrupts

POWER SOLUTIONS INC. **Circle 379**
25 Main St., P.O. Box 878, Kennebunk, ME 04043, (207) 985-2926

IOP-1	Z80A (8)	STD		line editor, cassette download	MBASIC	32K (24K)	11×13 ×0.5	1,495(Q1); 1,125(Q100)	math coprocessor; two RS232C ports

The VME BUS and OS-9:

Ultimate Software for the Ultimate Bus.

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When you're working with VME you must have access to every part of the system. Unlike other operating systems that literally scream KEEP OUT!, OS-9's open architecture invites you to create, adapt, customize and expand. Thanks to its unique modular design, OS-9 naturally fits virtually any system, from simple ROM-based controllers up to large multiuser systems.

And that's just the beginning of the story. OS-9 gives you a complete UNIX-application compatible environment. It is multitasking, real time, and extremely fast. And if you're still not impressed, consider that a complete OS-9 executive and I/O driver package typically fits in less than 24K of RAM or ROM.

Software tools abound for OS-9, including outstanding Microware C, Basic, Fortran, and Pascal compilers. In addition, cross C compilers and cross assemblers are available for VAX systems under Unix or VMS. You can also plug in other advanced options, such as the GSS-DRIVERS™ Virtual Device Interface for industry-standard graphics support, or the OS-9 Network File Manager for high level, hardware-independent networking.

Designed for the most demanding OEM requirements, OS-9's performance and reliability has been proven in an incredible variety of applications. There's nothing like a track record as proof: to date, over 200 OEMs have shipped more than 100,000 OS-9-based systems.

Ask your VME system supplier about OS-9. Or you can install and evaluate OS-9 on **your own** custom system with a reasonably priced Microware PortPak™. Contact Microware today. We'll send you complete information about OS-9 and a list of quality manufacturers who offer off-the-shelf VME/OS-9 packages.

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Box 1309 S-751 43 Uppsala
Sweden
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Porphyrstrasse 15
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Telex: 465025 keil d
Phone: 06203-6741

Elsoft AG
Bankstrasse 9
CH-5432 Neuenhof
Switzerland
Telex: 57136 elso ch
Phone: 056-862724

Vivaway, Ltd.
36-38 John Street, Luton
Bedfordshire LU1 2JE
England
Telex: 825115
Phone: 0582-423425

Microprocessor Consultants, Ltd.
16 Bandera Avenue
Waga Waga, 2650
NSW Australia
Phone: (069) 312331

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CIRCLE NO. 52 ON INQUIRY CARD

Single-board microcomputers

Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
PRO-LOG CORP. 2560 Garden Rd., Monterey, CA 93940, (408) 646-3603									**Circle 380**
7806	Z80A (8)	STD		editor	BASIC interpreter	32K (128K)	4.5×6.5 ×0.5	345(Q1)	two serial ports, clock, two counter/timers, power reset circuit
7863	8088 (8)	STD	MS-DOS				4.5×6.5 ×0.5	395(Q1)	coprocessor, two serial ports, clock
QUICKWARE ENGINEERING & DESIGN INC. 139 Brighton Ave., Suite 5, Allston, MA 02134, (617) 782-8330									**Circle 381**
QED 11/85 CPU	J-11 (16)	UNIbus	RT-11, RSX-11, RSTS, UNIX	all DEC software	all PDP-11 languages		9×16 ×0.5	6,000(Q1); 4,000(Q100)	16K-byte cache memory, two serial lines, line clock
R.L.C. ENTERPRISES 1117 Hillview Dr., Milpitas, CA 95035, (408) 946-7471									**Circle 382**
SBC-188/ SBC-1885L	80188 (16)	STD	MS-DOS	debugger, symbolic monitor	Assembly, C, FORTRAN, Pascal, PL/M	96K (256K)	6.5×4.5 ×0.062	549(Q1); 357(Q100)	RS232C port, real-time clock, interrupt and DMA controller
SBC-100	Z80, Z80A (8)	STD	CP/M	debugger, monitor	Assembly, BASIC, C, FORTRAN	16K (16K)	6.5×4.5 ×0.062	249(Q1); 179(Q100)	real-time clock, two RS232C ports, parallel port
SPURRIER PERIPHERALS CORP. 10513 LeMarie Dr., Cincinnati, OH 45241, (513) 563-2625									**Circle 383**
STD 68008	68008 (16, 32)	STD	CP/M-68K	debugger	BASIC, C, FORTRAN	128K	4.5×6.5	399(Q1); 349(Q100)	
STD 68020	68020 (32)		OS9	debugger	BASIC, C, FORTRAN	512K (32K)	10×10	7,000(Q1)	flexible and rigid drive controller
Z80-II	Z80 (8)	STD	CP/M	debugger	BASIC, C, FORTRAN	64K	4.5×6.5	379(Q1); 329(Q100)	serial port
SYSTEK 1027 N. Kellogg St., Kennewick, WA 99336, (509) 735-1200									**Circle 384**
8810/ 8810-C	8088/ 80C88 (8, 16)	STD	CP/M-86, MS-DOS	debugger	BASIC, C, FORTH, Pascal	32K (48K)	4.5×6.5 ×0.5	395/475(Q1); 260/ 356(Q100)	interrupt controller, three 16-bit counters
8887	8088 (8, 16)	STD	CP/M-86, MS-DOS	debugger	BASIC, C, FORTH, Pascal	(64K)	4.5×6.5 ×0.5	425(Q1); 319(Q100)	coprocessor
TELETEK ENTERPRISES INC. 4600 Pell Dr., Sacramento, CA 95838, (916) 920-4600									**Circle 385**
SBC 86/87	8086 (16)	S-100	CP/M-86, Turbo-DOS			512K (4K-64K)	5×10	1,770(Q1); 1,079(Q100)	two serial and parallel ports
Syste-master	Z80A (8)	S-100	CP/M, Turbo-DOS			64K (2K-8K)	5×10	795(Q1); 499(Q100)	flexible disk controller, two serial and one parallel port(s)
Syste-master II	Z80H (8)	S-100	Turbo-DOS			128K (2K-32K)	5×10	1,074(Q1); 754(Q100)	
TEXAS INSTRUMENTS INC. (INDUSTRIAL SYSTEMS DIV.) P.O. Box 1255, Johnson City, TN 37605-1255, (615) 461-2500									**Circle 386**
990/101-MB1	TMS 9900 (16)	TM 990	P-DOS	debugger, graphics	BASIC, FORTH, Pascal	4K (60K)	7.5×11	743(Q1)	two RS232C and one parallel port(s)
990/102-3	TMS 9900 (16)	TM 990	P-DOS	debugger, graphics	BASIC, Pascal	128K (16K)	7.5×11	1,125(Q1)	one RS232C port
990/103-1	TMS 99105 (16)	TM 990	P-DOS	debugger, graphics	BASIC, Pascal	64K (32K)	7.5×11	1,674(Q1)	two RS232C and one parallel port(s)
VESTA TECHNOLOGY INC. 7100 W. 44th Ave., Suite 101, Wheatridge, CO 80033, (303) 422-8088									**Circle 387**
OEM 188	80188 (8, 16)	IBM PC bus	MS-DOS		MS-DOS languages	256K (64K)	7×8 ×0.5	329(Q1); 269(Q100)	disk controller, printer port

Single-board microcomputers

Company Model	CPU type (word size/bits)	Bus	Operating system	Software support	Programming languages supported	Memory/bytes RAM(ROM)	Dimensions (H×W×D/inches)	Price $ (quantity)	Notes and features
SBC88	8088 (8, 16)				BASIC, FORTH	32K (32K)	5×6 ×0.5	199(Q1); 139(Q100)	

WAVE MATE INC. **Circle 388**
14009 S. Crenshaw Blvd., Hawthorne, CA 90250, (213) 978-8600

Bullet 286	80286 (16)	IBM PC bus	Concurrent CP/M, PC-DOS, Pascal, SMC, UNIX	assembler, debugger, editor, linker	BASIC, C, COBOL, FORTRAN, Pascal, PL/1	1M (32K)	8.5×12 ×0.75	995(Q1); 398(Q100)	custom bus controller
Bullet SBC	Z80A (8)	proprietary	CP/M 3.0, MP/M, THEOS 8			128K (16K)	8×10 ×0.5	495(Q1); 198(Q100)	flexible disk controller, two RS232C ports
Super-bullet SBC	Z80A (8)	proprietary	CP/M 3.0, MP/M, THEOS 8	assembler, debugger, editor, linker	BASIC, C, COBOL, FORTRAN, Pascal, PL/1	256K (16K)	8×10 ×0.5	795(Q1); 318(Q100)	flexible disk controller, four RS232C ports

WINSYSTEMS INC. **Circle 389**
P.O. Box 121361, Arlington, TX 76012, (817) 274-7553

MCM-CPU2A	Z80A (8)	STD, CMOS STD	CP/M	debugger, loader	BASIC, C, FORTH, Pascal	64K (64K)	4.5×6.5 ×0.5	185(Q1)	four counter/timers
MCM-SBC3	Z80A (8)	STD, CMOS STD	CP/M	debugger, loader	BASIC, C, FORTH, Pascal	64K (64K)	4.5×6.5 ×0.5	295(Q1)	two RS232C, RS422 ports; two 8-bit parallel I/O ports; four counter/timers
MCM-SBC5	HD64180 (8, 16)	STD, CMOS STD	CP/M	debugger, loader	BASIC, C, FORTH, Pascal	64K (128K)	4.5×6.5 ×0.5	395(Q1)	four RS232C ports, two 16-bit timers

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Unit price $249.

TRANSTERM 6
Two line 40 character display
Unit price $299.

TRANSTERM 7
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CIRCLE NO. 54 ON INQUIRY CARD

MicroPDP-11/53

The Entry-Level 16-bit Q-bus Supermicrosystem

digital

The MicroPDP-11/53 is the entry-level, 16-bit supermicrosystem with an attractive price and performance combination that will meet the best of your computing requirements. The MicroPDP-11/53, with approximately twice the system performance of the MicroPDP-11/23, offers just the extra boost of power you may need to solve your realtime or multitasking problems.

At the center of the MicroPDP-11/53 is a 15-megahertz, J-11 single-board computer that contains 0.5 Mbytes of onboard memory. This computing engine can easily devote itself to your dedicated process control program or become a shared resource for your department's multiuser workload. Whatever the job, the MicroPDP-11/53 demonstrates superlative performance.

As is the standard with all PDP-11 systems, the MicroPDP-11/53 is fully compatible with the proven 16-bit PDP-11 architecture and the thousands of PDP-11 software tools and applications in existence today. Along with this compatibility is support for a wide variety of Q22-bus mass-storage devices and communications interfaces, including two new half-height disk drives. Its trim size is small enough to fit comfortably and quietly into your personal work area. And with DECnet and Ethernet networking capability, the MicroPDP-11/53 can send, share, and store files from other systems in your department or organization.

With improved performance at an appealing price, the MicroPDP-11/53 enhances 16-bit computing to help you meet your business goals. And better yet, Digital has it now.

Literature Distribution

For additional copies of this information sheet write: PDP-11 ED-28903-41, 200 Baker Avenue, Concord, Massachusetts 01742.

Current PDP-11 users: If you would like to be added to our PDP-11 mailing list please indicate the CPUs you are currently using on the back of your business card and send it to the above address.

Highlights

- Features a high-performance, single-board computer with 0.5 Mbytes of onboard memory.
- Allows for memory expansion for up to 4 Mbytes with parity MOS memory in increments of 0.5, 1, or 2 Mbytes.
- Has complete MicroPDP-11/73 instruction set, including the Extended Instruction Set (EIS) for compatibility with the full line of MicroPDP-11 processors.
- Includes floating-point instructions for increased instruction execution.
- Supports a comprehensive set of communications interfaces and mass-storage devices, including two new half-height disk drives.
- Supported by an extensive number of operating systems, high-level languages, development tools, and application packages.
- Easily integrates into networking environments or into local area networks with DECnet and Ethernet.

The Single-board Computer – A First for MicroPDP-11 Systems

The MicroPDP-11/53 is based on the high-speed, 15-megahertz J-11 chip set. Accompanying this microprocessor on the same quad-height module is 0.5 Mbyte of dynamic RAM, parity MOS memory. This economical combination of CPU and onboard memory saves on module space and input power and, more importantly, increases the basic system performance to approximately twice that of the MicroPDP-11/23.

The MicroPDP-11/53 single-board computer comprises:

- A J-11 chipset, including 16-bit I/O, addressing capability up to 4 Mbytes, maximum clock rate of 15 megahertz, and onboard memory management.
- Complete MicroPDP-11/73 instruction set, including floating-point instructions and the Extended Instruction Set (EIS).
- Q22-bus interface that supports block-mode DMA and up to 4 Mbytes of physical memory.
- One console serial-line unit and one printer serial-line unit.
- 32-Kbyte, erasable read-only memory (ROM) for bootstraps and diagnostics.

Half-height Storage Can Increase Your Storage Capacity

The Q-bus links the MicroPDP-11/53 with a compatible set of mass-storage devices. Two new half-height disk drives, the RD31 and the RX33, are available for the first time on a supermicrosystem. At half the height of their predecessors, their size allows more storage devices to be housed directly in the system chassis. There is now room for three integrated mass-storage devices, as opposed to two full-height devices.

Offered as integrated storage devices, the RD31 is a 20-Mbyte Winchester fixed-disk subsystem, and the RX33 is a 1.2-Mbyte single-diskette subsystem. And the following full-height storage devices can be added externally to your MicroPDP-11/53:

- 71-Mbyte RD53 Winchester fixed-disk subsystem.
- 31-Mbyte RD52 Winchester fixed-disk subsystem.
- 95-Mbyte TK50 cartridge-tape subsystem.

The Q-bus also has a wealth of peripherals developed for it by Digital. You can select from a wide range of communications interfaces, videodisplay terminals, hardcopy terminals, and system printers.

Flexible Packaging for Your Style of Working

The MicroPDP-11/53 is packaged in a trim, versatile enclosure that can fit underneath, beside, or on top of your desk. It is also available in a rack-mount model for cabinet integration. This package features an eight-slot backplane and space for three half-height storage devices or for two full-height storage devices. Ample space exists for memory and communications options and room for connecting as many as 26 I/O devices.

Software That Is Proven and Available

The MicroPDP-11/53 runs Digital's leadership 16-bit operating systems.

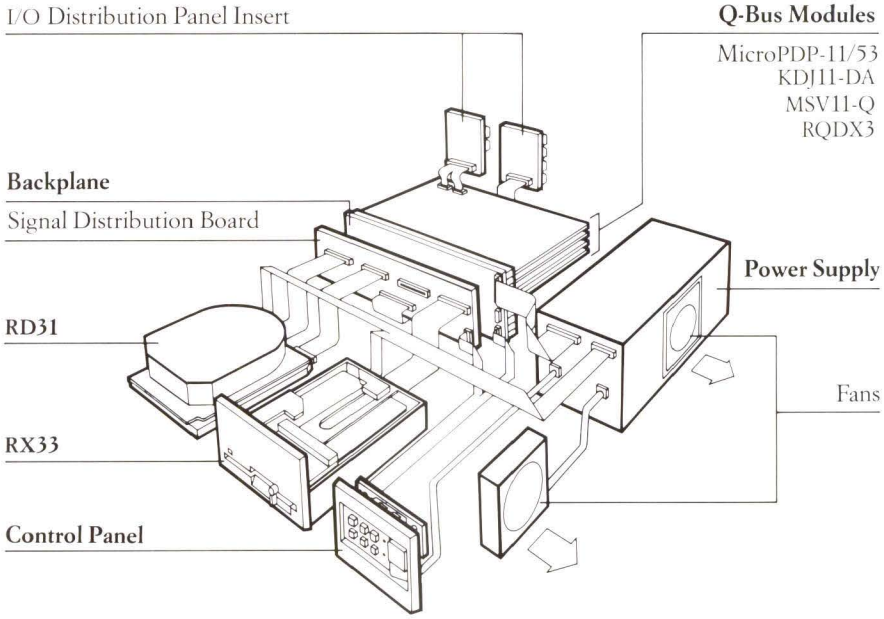
These are proven operating systems that efficiently and effectively meet a variety of demands – from small, dedicated laboratory and industrial control systems to larger, multiuser information management systems.

Micro/RSX and Micro/RSTS are tailored specifically for the MicroPDP-11 family. Micro/RSX is a low-cost version of Digital's larger RSX-11M-PLUS. It combines the multiuser, realtime capability of RSX with refined commercial capabilities. And Micro/RSTS is a subset of the RSTS/E system that is a multiuser, timesharing system environment.

Also available is RT-11, a single-user, realtime system; RSX-11M-PLUS, RSX-11M, and RSX-11S, three multiuser, realtime systems; RSTS/E, a multiuser, timesharing system; CTS-300, for small business timesharing; ULTRIX-11, Digital's enhanced native-mode UNIX* software; MicroPower/Pascal, an advanced development tool kit; and DSM-11, a multiuser operating system with high-performance, data management capability.

Digital's own layered software includes a wide variety of high-level languages and data management tools. Supported high-level languages include BASIC, C, COBOL, DIBOL-83, FORTRAN-77, FORTRAN IV, MUMPS,* and Pascal. Data management tools include DATATRIEVE-11, a query report-writing and data-maintenance system; RMS-11, a record management system; and FMS-11, a forms management system.

And thousands of application software products already exist for the MicroPDP-11/53 in virtually every area of science, education, government, business, and industry. These products have been developed both by Digital and third-party software developers. Ask your sales representative for a copy of the *PDP-11 Software Source Book,* a guide to the more than 2,000 applications packages that are available today.



Tie Together Your System, Department, and Organization

A wide variety of communications hardware and software is available to make the MicroPDP-11/53 supermicrosystem interface with the widest possible range of communications and networking applications. Digital's powerful DECnet software supports communications between Digital systems, and between Digital systems and other manufacturers' systems. The MicroPDP-11/53 is also supported by Ethernet local area networking. Ethernet allows large amounts of data to be exchanged at high rates among various departments of an organization, within one building or within a complex of buildings.

Digital's Commitment To Service

Like all of Digital's products, the MicroPDP-11/53 and its system software have been designed for reliability. And Digital's customer services organization is ready to provide quality support. Digital is the complete service vendor and has the products and tools to back its commitment to customer satisfaction.

If You Would Like To Know More

Find out just what the MicroPDP-11/53 can do for you. Call your local Digital sales office, Digital OEM, or Authorized Digital Distributor for an indepth discussion of the MicroPDP-11/53 solution.

digital

Specifications

Power Requirements		
Line voltage	120 Vac	240 Vac
System power	4.4 amperes	2.2 amperes
Power source phasing	Single	Single
Voltage tolerance	90-128 VRMS	176-256 VRMS
Line frequency tolerance	47-63 Hz	47-63 Hz
Input power	345 watts	345 watts
Operating Environment		
Temperature range	15-32°C (59-90°F)	
Relative humidity	20-80% noncondensing	
Maximum operating altitude	2.4 km (8,000 ft)	
Physical Characteristics		
Pedestal Model		
Height	62.2 cm (24.5 in)	
Width	25.4 cm (10.0 in)	
Depth	72.4 cm (28.5 in)	
Weight	32 kg (70 lb)	
Tabletop Model		
Height	15.2 cm (6.0 in)	
Width	56.5 cm (22.25 in)	
Depth	72.4 cm (28.5 in)	
Weight	32 kg (70 lb)	
Rackmount Model		
Height	13.3 cm (5.25 in)	
Width	48.3 cm (19.0 in)	
Depth	64.8 cm (25.5 in)	
Weight	25 kg (55 lb)	

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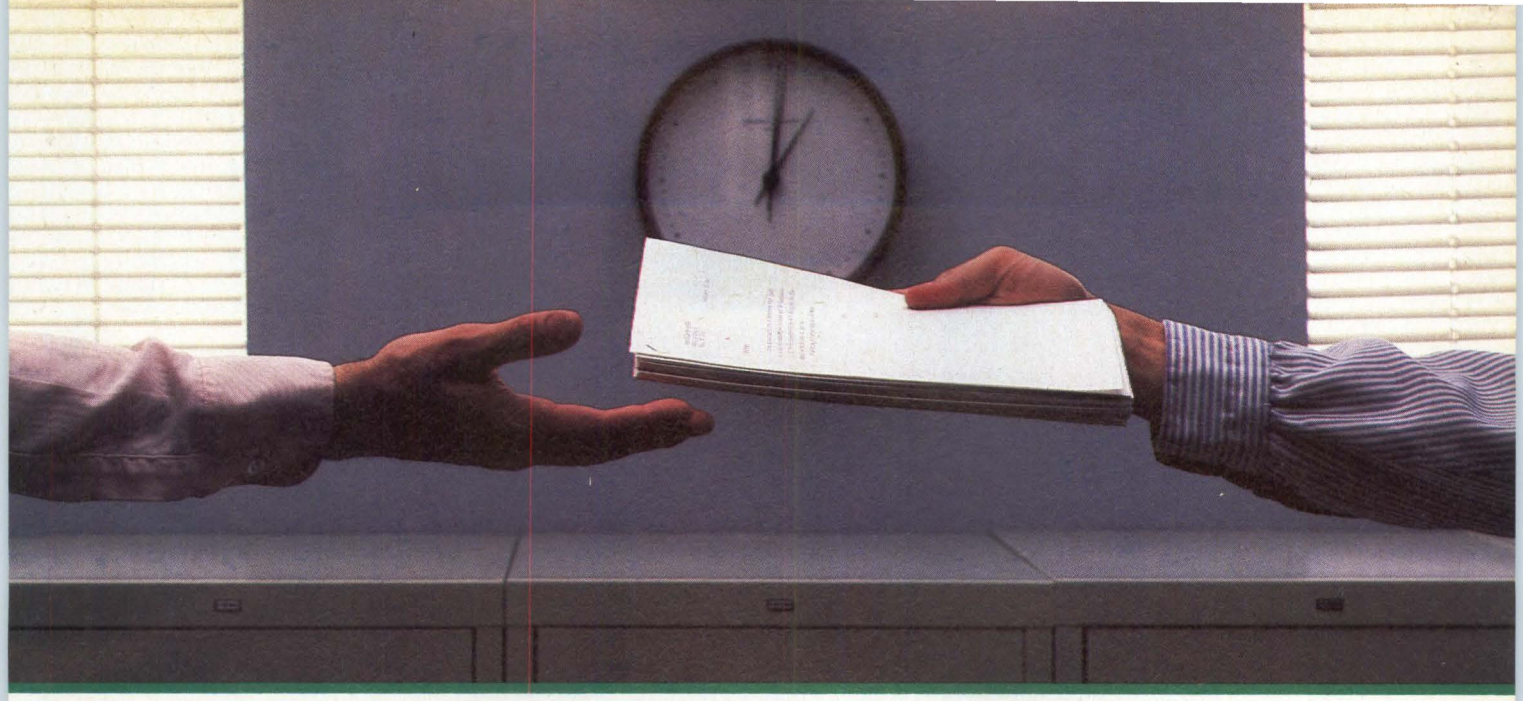
*Third-party trademarks: UNIX is a registered trademark of AT&T Bell Laboratories; MUMPS is a registered trademark of Massachusetts General Hospital.



2400 bps modems: Do you Really need another speed?

- Is the shift from 300 to 1200 bps going to repeat itself at 2400 bps? The answer is both yes and no. There certainly are applications for 2400 bps asynch dial-up modems, but we shouldn't expect 1200 bps to die overnight.
- 2400 bps modems can improve throughput, thereby getting tasks done quicker and more economically. However, 1200 bps has become the virtual standard for professional dial-up communications, and most users are satisfied with it. So why consider a 2400 bps modem at all?
- One reason is flexibility. If the modem you select operates at all three speeds (300, 1200 & 2400) in accordance with accepted industry standards, it will serve virtually all dial-up applications now and in the foreseeable future.
- The modem you select should be the MultiModem224. It is Bell 212A and 103 compatible at 1200 and 300 bps, and CCITT V.22bis compatible at 2400. It is also 100% compatible with the Hayes command set, meaning that it will work with virtually all communications software packages, at all three speeds. Other features include both synchronous and asynchronous operation, full intelligence and a phone number memory.
- The MultiModem224 is available in both desktop and IBM PC™ internal card versions. (There is also a rack-mounted version for central sites.) And as a bonus, we provide free offers from ten of the most popular on-line information services, including CompuServe™, Dow Jones™ and The Source.™
- A 2400/1200/300 bps modem is just a plain good investment. Why not let the MultiModem224 provide your communications for both today and tomorrow?

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CIRCLE NO. 66 ON INQUIRY CARD

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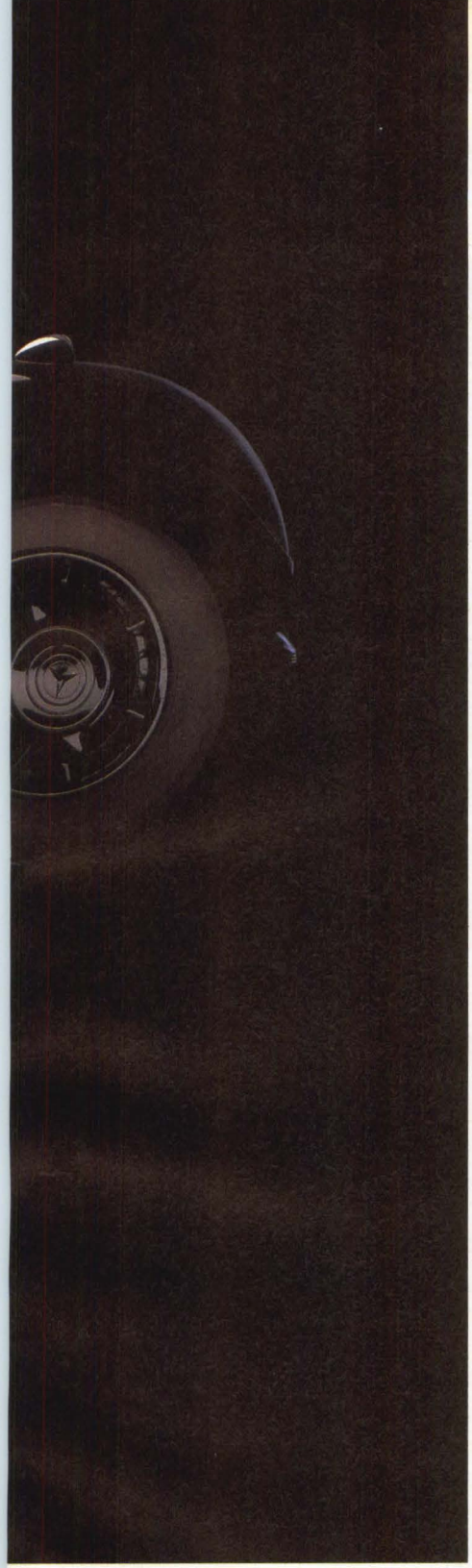

Call it a manifestation of German pride, but we took our time to introduce the MT330 for good reason: We wanted to think it through to a superior conclusion.

The result is not just an idle entry into the burgeoning class of 24-needle machines. But a printing plant that some have even suggested is overbuilt.

In contrast to hurriedly stamped frames of sheet metal, the superstructure of the MT330 is solid cast. All of which creates a more substantial, shock-absorbing work platform.

Likewise, the power train is a product of serious deliberation; a push-fed tractor driven by surge resistant DC motors.

Then our engineers went to work on the print head.

For increased speed and resolution, they staggered the 24-needle matrix into two perfect vertical-plane columns.

In addition, they developed a magnetic head assembly that actually requires less power during printing. So long after our counterparts have overheated, or beaten themselves into obsolescence, the MT330 continues to spew out mountains of data.

Up to 10,000 pages per month at 300 characters per second.

Characters that remain crisp and dense from a ribbon rated at more than 15 million impressions.

So if it seems we were exceedingly patient in our introduction of the MT330, the results of German perfectionism are a justifiable reward.

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NEW PRODUCTS

SYSTEMS

Megan Nields, Assistant Editor

Business system suits IBM PC/AT

- 10 expansion slots
- 512K bytes of RAM
- 80286 processor

Supplying 10 expansion slots, the Business Partner 286 computer accommodates five IBM PC/AT-compatible and five IBM PC-compatible boards. The unit's 80286 microprocessor offers 512K bytes of RAM, expandable to 1M byte. It is available in two configurations. The system operates under MS-DOS 3.1 and GW BASIC. $2,795 to $2,995. **Panasonic Industrial Co.,** 1 Panasonic Way, Secaucus, N.J. 07094, (201) 348-7000.

Circle 301

Supermicrocomputer features dual bus

- MC68000 processor
- 256K bytes of RAM
- 18 RS232C ports

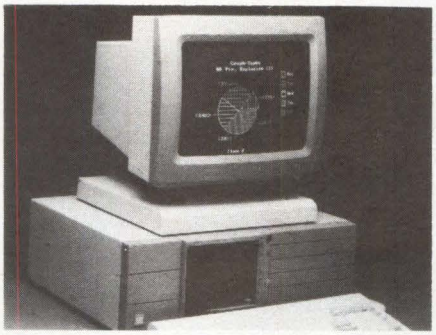
Incorporating an MC68000 processor, the XF/300 supermicrocomputer features dual-bus architecture and 256K bytes of RAM. The system supplies 18 RS232C ports, 1M byte to 4M bytes of memory and up to 177M bytes of formatted disk storage. Options include a floating-point processor and an Ethernet data controller. $14,000 and higher. **Concurrent Computer Corp.,** 197 Hance Ave., Tinton Falls, N.J. 07724, (201) 758-7000.

Circle 302

Supermicro runs DOS, XENIX

- Four configurations
- 80286 processor
- 1.6M bytes of RAM

Available in four configurations, the XTRA XL supermicrocomputer runs both DOS and XENIX. The system utilizes an 80286 processor. It provides 640K bytes or 1.6M bytes of RAM, a 1.2M-byte flexible disk drive and a



40M-byte or 72M-byte rigid disk drive. Disk storage is expandable to 144M bytes. The multiuser models include 60M bytes of streaming tape backup. $5,299 to $12,299. **ITT Information Systems,** 2350 Qume Drive, San Jose, Calif. 95131, (408) 945-8950.

Circle 303

Personal computer suits IBM PC/AT

- 40M-byte disk drive
- 640K bytes of RAM
- Five internal slots

Compatible with the IBM PC/AT, the APC IV personal computer is geared toward CAD/CAM, engineering and data-processing applications. The unit provides a 40M-byte rigid disk drive, a 1.2M-byte flexible disk drive and five internal storage slots. It utilizes an 80286 microprocessor. Up to 640K bytes of RAM is standard. Features include a color monitor and two RS232C ports. $5,045 and higher. **NEC Information Systems Inc.,** 1414 Massachusetts Ave., Boxborough, Mass. 01719, (617) 264-8000.

Circle 304

Microcomputer suits OEMs

Addressing OEMs, the 32-bit Universe 2600 microcomputer is built around the 68000 microprocessor. It supports over 100 simultaneous users or 1,064 serial communication devices, 10M bytes of main memory and 1G byte of disk storage. The system supplies 20 VMEbus-board slots for user configuration. A 4K-byte data and instruction cache enables it to execute 1.25 million instructions per second with no-wait states. The base configuration is equipped with a 45M-byte streaming tape unit, a 140M-byte Winchester disk drive and four serial ports. $29,000 and higher. **Charles River Data Systems Inc.,** 983 Concord St., Framingham, Mass. 01701, (617) 626-1000.

Circle 305

Computer achieves IBM compatibility

- 80286 processor
- 1M bytes of RAM
- Five-drive capacity

The AT286i is an IBM PC/AT-compatible computer equipped with an 80286 microprocessor. It provides 512K bytes to 1M byte of RAM, eight expansion slots, a five-drive capacity and a 1.2M-byte flexible disk drive. The unit runs all IBM PC, PC/XT and PC/AT software. MS-DOS 3.1 and GW BASIC 3.1 operating systems are provided. Options include an 80287 numeric coprocessor. $2,995. **PGI Corp.,** 1635 W. 12th Place, Tempe, Ariz. 85281, (602) 967-1421.

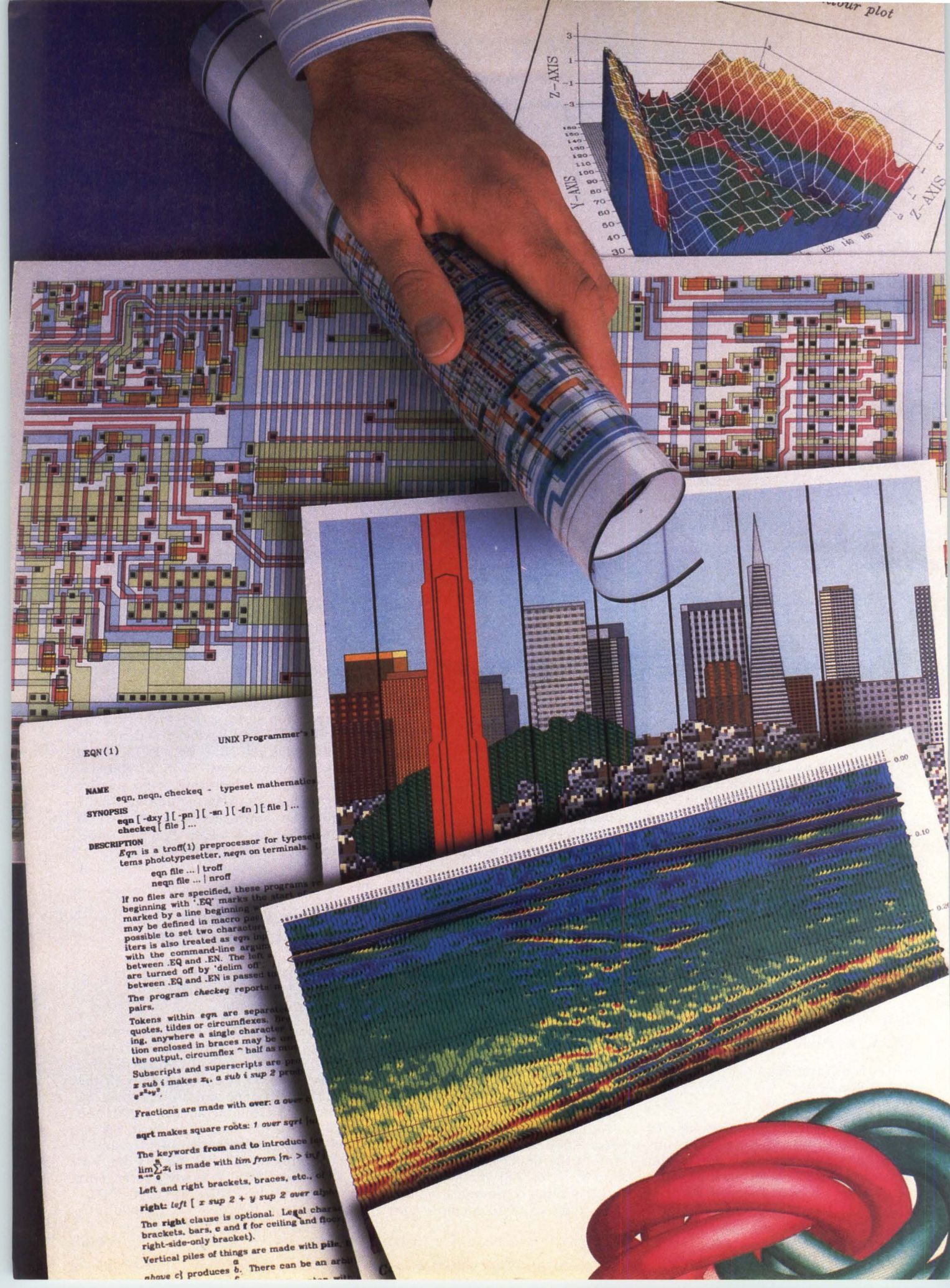
Circle 306

Computer offers 640K bytes of RAM

- 35M-byte disk drive
- IBM PC/AT compatible
- 80286 processor

The Tandy 3000 35MB HD computer offers 640K bytes of RAM, a 35M-byte rigid disk drive and a 1.2M-byte flexible disk drive. It is compatible with the IBM PC/AT. The unit utilizes an 80286 microprocessor operating at 8 MHz and 10 expansion card slots. Features include a serial/parallel adapter and a color monitor. $4,499. **Tandy Corp./Radio Shack,** 1800 1 Tandy Center, Fort Worth, Texas. 76102, (817) 390-3700.

Circle 307



EQN(1) UNIX Programmer's

NAME
eqn, neqn, checkeq - typeset mathematics

SYNOPSIS
eqn [-dxy] [-pn] [-sn] [-fn] [file] ...
checkeq [file] ...

DESCRIPTION
Eqn is a troff(1) preprocessor for typeset
terms phototypesetter, *neqn* on terminals.
eqn file ... | troff
neqn file ... | nroff
If no files are specified, these programs r
beginning with '.EQ' marks the start
marked by a line beginning
may be defined in macro pa
possible to set two characte
iters is also treated as *eqn* in
with the command-line argu
between .EQ and .EN. The left
are turned off by 'delim off'
between .EQ and .EN is passed
The program *checkeq* reports
pairs.
Tokens within *eqn* are separat
quotes, tildes or circumflexes.
ing, anywhere a single character
tion enclosed in braces may be
the output, circumflex ^ half as
Subscripts and superscripts are
x sub i makes x_i, *a sub i sup 2* pro
$e^{x^2+y^2}$.
Fractions are made with **over**: *a over*
sqrt makes square roots: *1 over sqrt*
The keywords **from** and **to** introduce
$\lim_{n\to\infty}\sum_{0}^{n} x_i$ is made with *lim from* {*n* -> inf
Left and right brackets, braces, etc., c
right: *left* [*x sup 2 + y sup 2 over a*
The **right** clause is optional. Legal char
brackets, bars, **c** and **f** for ceiling and flo
right-side-only bracket).
Vertical piles of things are made with **pile**
$\binom{a}{b}$ produces *above c*. There can be an arb

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The Versatec Spectrum electrostatic plotter/printer does it all. Plots A (11" x 8½") and B (11" x 17") page drawings. Plots in full color or black and white. Prints software listings, parts lists, reports, or other alphanumeric printing with a built-in character generator at 1000 lines per minute. Produces hard copies direct from monochrome or color displays with an optional video interface that includes a frame-buffer. And all at a lower cost per copy than other technologies.

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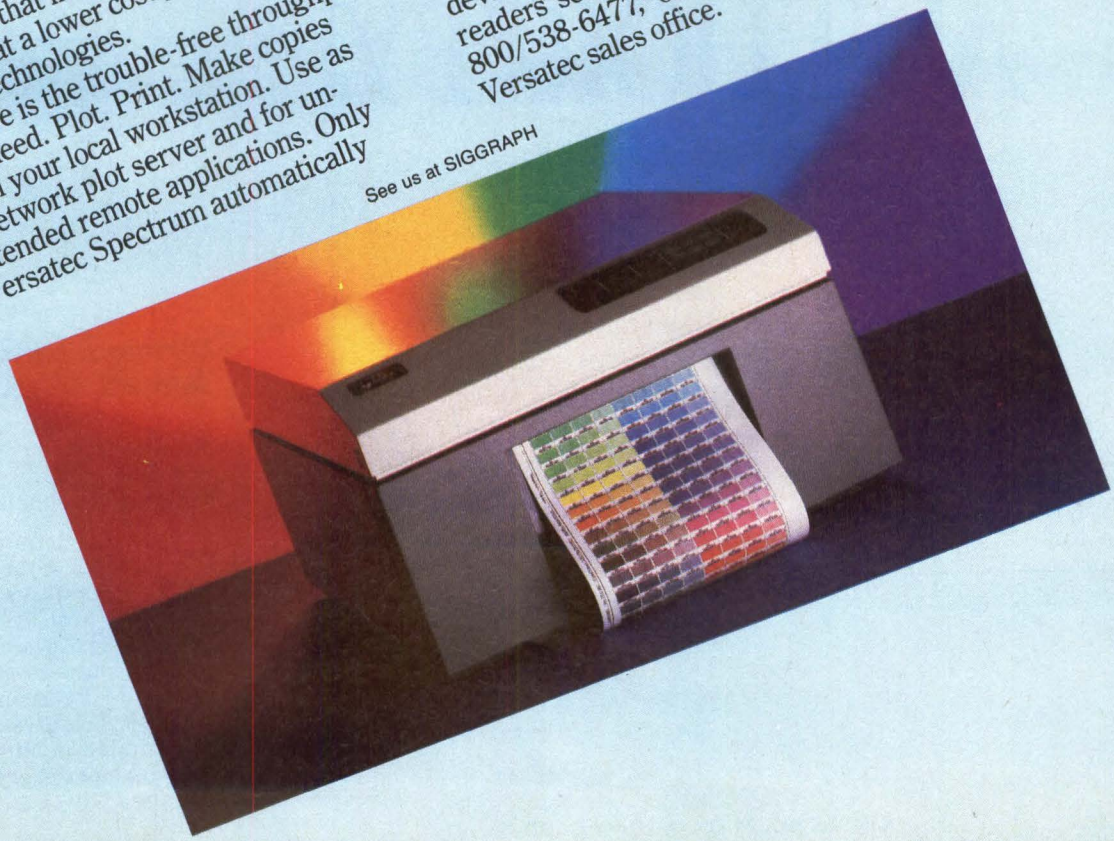

Plot data courtesy of UNIRAS.

CIRCLE NO. 70 ON INQUIRY CARD

Graphics monitor combines with card

The Definition 895 DU color graphics monitor and the Ultragraph 800 graphics-and-text card combine to execute personal computer-based CAD/CAM applications. The 14-inch monitor displays 800 by 400 pixels in 16 colors. Automatic mode selection allows all IBM PC and compatible software to be run.
$895, monitor. **Microvitec, Inc.,** 1943 Providence Court, Airport Perimeter Business Center, College Park, Ga. 30337, (404) 991-2246. **Circle 454**
$995, card. **Ultragraphics Corp.,** 37 S. Franklin St., Chagrin Falls, Ohio. 44022, (216) 247-6600.

Circle 308

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CIRCLE NO. 71 ON INQUIRY CARD

RGB monitor offers 16 colors

The CM 2000 RGB monitor displays a 640-dot-by-240-line resolution on a 13-inch screen. It features a 16-color chromatic mode. The unit is plug-compatible with the IBM PC, /XT and /AT. $599. **C. Itoh Digital Products,** Suite 220, 19750 S. Vermont, Torrance, Calif. 90502, (213) 327-2110.

Circle 309

Monitor suits OEMs, VARs

- 14-inch screen
- 256 by 256 dpi
- IBM PC compatible

Suiting OEMs and VARs, the Touch-Monitor 14 is the lowest priced monochrome touch screen monitor available. The unit is compatible with the IBM PC, PC/XT and PC/AT. It displays 256 by 256 dpi on a 14-inch screen. Analog ports and RS232C ports are standard. $398. **Personal Touch,** 4320-290 Stevens Creek Blvd., San Jose, Calif. 95129, (408) 246-8822.

Circle 310

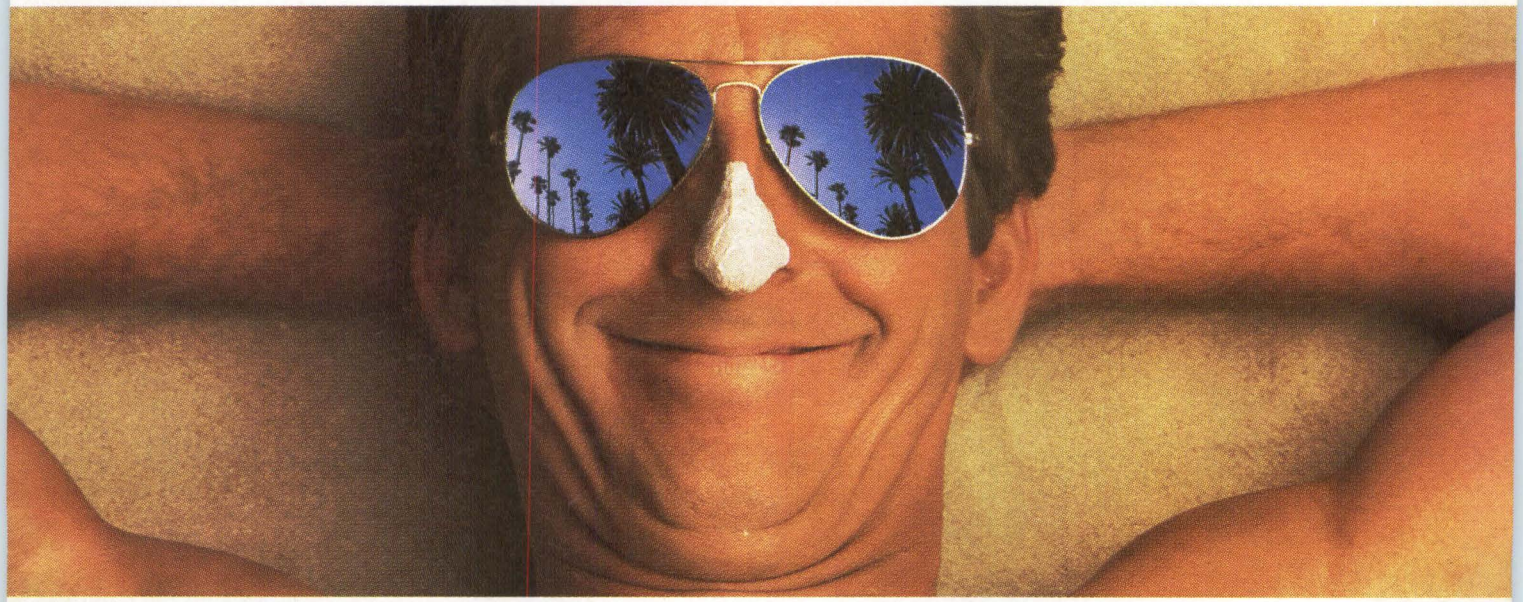
Terminal suits IBM PC, PC/XT, PC/AT

- 14-inch screen
- 25 lines
- 80 or 132 columns

An ASCII terminal, the model 232 functions in either single IBM PC, PC/AT or multiuser PC/AT environments via host PC software. The unit displays 25 lines at either 80 or 132 columns on a 14-inch screen. It emulates IBM PC scan-codes and screen displays. Features include TeleVideo 925 emulation and a serial interface. $649. **Ampex Corp.,** 401 Broadway, Redwood City, Calif. 94063-3199.

Circle 311

We have 2400 feet to stick in the door. So you can put yours in the sand.



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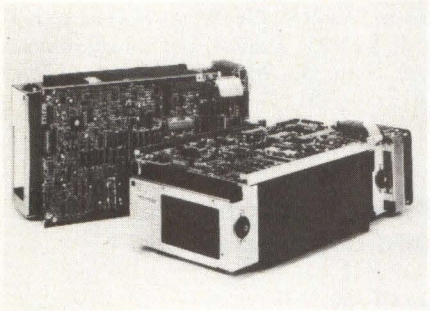
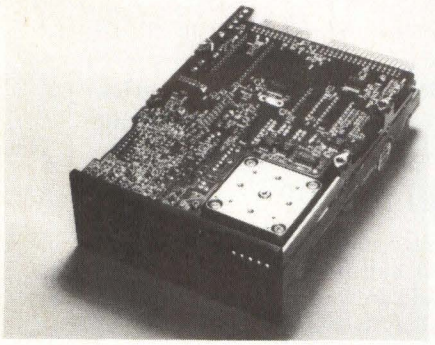


Eight-inch Winchester holds 510M bytes

- SMD interface
- 18-msec access time
- 2.4M bytes per second

Utilizing an SMD interface, the MK-288FC 8-inch Winchester disk drive offers 510M bytes of memory. The device has an average access time of 18 msec and a data transfer rate of 2.4M bytes per second. Track capacity is 40,000 bytes per track. The unit accommodates eight disks. $4,315. **Toshiba America Inc.,** Disk Products Division, 3910 Freedom Circle, #103, Santa Clara, Calif. 95054, (408) 727-3939.

Circle 312



OEMs targeted by 3½-inch drives

- 910 tpi
- 20M-byte capacity
- 69-msec access time

The HMD-710 and HMD-720 Winchester disk drives provide 10M bytes and 20M bytes of formatted storage capacity, respectively. The 3½-inch, half-height units are aimed at OEMs. Average access time is 69 msec and data transfer rate is 5M bps. The devices utilize an ST506/412 interface. Rotary postioning supports storage densities of 910 tpi. $300 to $400. **Epson America Inc.,** OEM Product Division, 23600 Telo Ave., Torrance, Calif. 90505, (213) 534-4500.

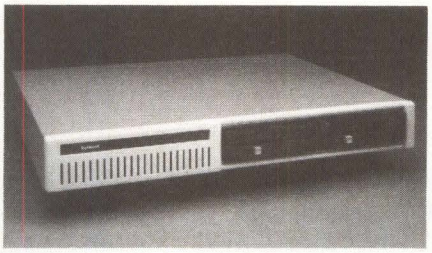
Circle 313

Subsystem targets IBM PC and compatibles

- Two disk drives
- Host adapter cards
- 35-msec access time

The Bernoulli Box Plus combines two removable-cartridge 20M-byte disk drives with an 80M-byte formatted rigid disk drive in an external subsystem. The unit is compatible with the IBM PC. Fixed-disk hardware allows the rigid disk to store files larger than 32M bytes. Data access rate is 35 msec. Features include a SCSI interface, two host adapter cards and a file-management software package. $5,995 to $6,095. **Iomega Corp.,** 1821 W. 4000 South, Roy, Utah 84067, (801) 778-1000.

Circle 314

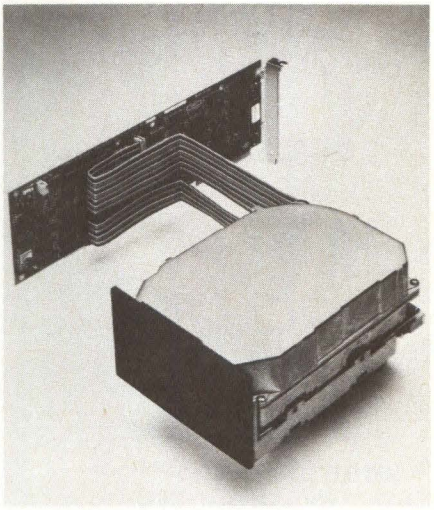


Subsystems suit IBM PC, PC/XT, PC/AT

- Four models
- 7.5M-bps transfer rate
- 45M-byte fixed drive

The SQ1500 subsystem comes in four models. The single- and dual-drive configurations, models SQ15 and SQ15x15, feature 15M-byte removable rigid disk drives. The model SQ15x45 provides a 15M-byte removable and a 45M-byte fixed drive; the SQ45x45 offers dual 45M-byte fixed drives. Data transfer rate is 7.5M bps. Features include a chassis, a controller and utility software. The units are geared toward OEMs and system integrators. $2,499 to $3,695. **SyQuest Technology,** 47923 Warm Springs Blvd., Fremont, Calif. 94539, (415) 490-7511.

Circle 315



Subsystem includes tape controller

- IBM compatible
- 70M-byte capacity
- 28-msec access time

The Matched Pair Winchester disk drive subsystem is available in 40M-byte or 70M-byte capacities with an average access time of 28 msec. The IBM PC-and PC/XT-compatible systems incorporate the SC6000 Turbo Controller to control up to two self-booting rigid disk drives. A 1-to-1 interleave-factor ratio is used. $250, Turbo Controller; $1,795 to $2,995, Matched Pair. **Sysgen Inc.,** 47853 Warm Springs Blvd., Fremont, Calif. 94539, (415) 490-6770.

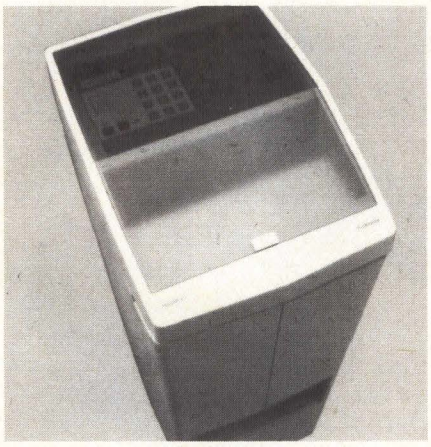
Circle 457

Optical disk subsystem targets VARs

- IBM PC compatible
- SCSI controller
- 1G byte of storage

A write-once optical disk drive subsytem, the Optimem 1000/S suits the IBM PC, PC/XT, PC/AT and compatibles operating under DOS 3.0 or 3.1. The 12-inch unit provides 1G byte of storage, a SCSI-standard controller and a host adapter. It is geared toward VARs. Features include an installable device driver. $20,000. **Optimem,** 435 Oakmead Parkway, Sunnyvale, Calif. 94086, (408) 737-7373.

Circle 458



Printer produces near-offset quality

- 32 ink jets
- 240 by 240 dpi
- Two ppm

The Pixelmaster printer uses 32 ink jets to produce near-offset quality images. Generating text at two ppm and running at four minutes per page for full-color graphics, the unit provides a 240-by-240-dpi resolution. The printer's Thermo-Jet system offers over 250,000 shades of color and raised printing. It accommodates standard office paper. $2,995. **Howtek Inc.,** 21 Park Ave., Hudson, N.H. 03051, (603) 882-5200.

Circle 451

Laser printer generates 8 ppm

- 300 by 300 dpi
- 1M-byte bit map
- 56 dB(a)

A desktop laser printer, the LN03 PLUS achieves a resolution of 300 by 300 dpi and a speed of 8 ppm. Graphics are generated via 1M byte of bit-mapped memory. Plug-in RAM is expandable to 256K bytes. The unit offers Tektronix compatibility, 18 resident fonts and a noise level of less than 56 dB(a). An RS232C serial port is standard. $4,995. **Digital Equipment Corp.,** 146 Main St., Maynard, Mass. 01754, (617) 897-5111.

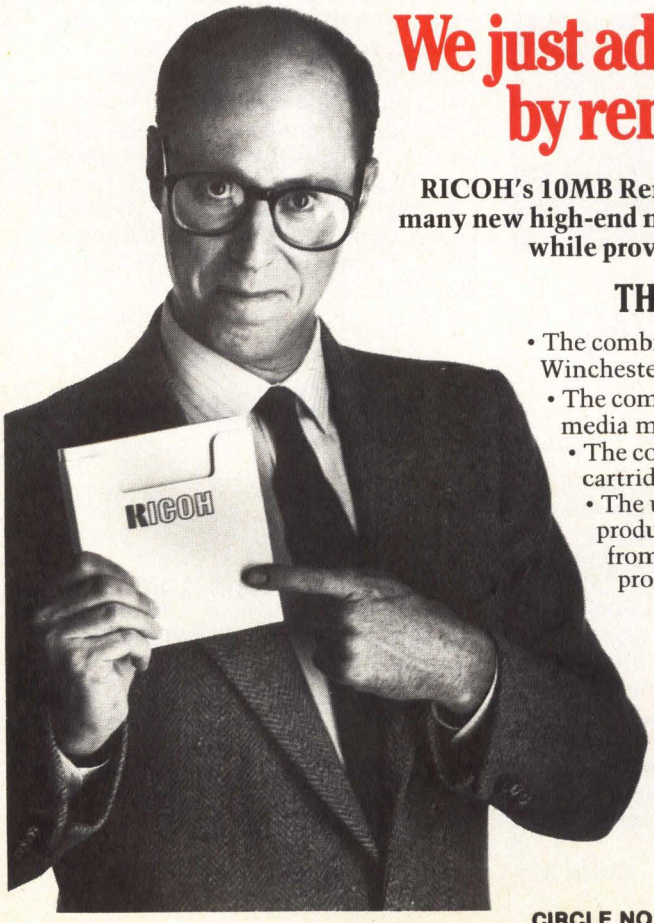
Circle 452

Printer weighs under four pounds

- 150 cps
- Battery powered
- Centronics interface

The Diconix 150 portable ink-jet printer weighs less than four pounds and measures 2 by 6.5 by 10.8 inches. It prints 150 cps, draft, on single sheets of letterhead or continuous-feed computer paper. Emulating the IBM Proprinter or the Epson FX printer, the battery-powered unit connects to computers via a Centronics 8-bit parallel interface. $479. **Diconix Inc.,** 3100 Research Blvd., P.O. Box 3100, Dayton, Ohio 45420, (513) 259-3100.

Circle 453



We just added to your opportunities by removing our cartridge.

RICOH's 10MB Removable Cartridge Disk Drive offers OEMs and VARs many new high-end marketing opportunities in additional market segments while providing the potential for greater profit margins.

THE BENEFITS OF RICOH ADD UP

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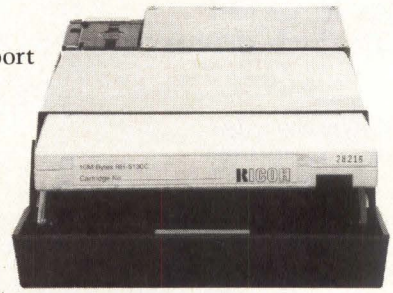
- The confidence of data security made simple. Lock up your cartridges, not your system.
- The unquestionable reliability, production capabilities and support from an international leader in product quality control.



RICOH

RICOH SYSTEMS, INC., Marketing Department, 2071 Concourse Drive, San Jose, CA 95131-1887 TEL: 408-946-6200 FAX: 408-262-0662

CIRCLE NO. 75 ON INQUIRY CARD

Jon Garman, Director of Product Engineering
Workstation Division,
Sun Microsystems, Inc.

XYLOGICS SUPPORTS THE POWER OF THE SUN.

When Sun Microsystems began looking at Multibus disk and tape controllers for their high performance engineering workstations, they demanded a lot.

"We needed a fast Multibus SMD disk controller, one that could read fast drives, like the Fujitsu Eagle, at full speed," says Sun Director Jon Garman. *"The boards we were evaluating simply couldn't measure up."*

That's when Sun discovered Xylogics.

"Getting Xylogics' 440 controllers operational with Sun's workstations was a positive experience," Garman remembers. *"What the manual said, the Xylogics boards did, and the software interface was simple to use.*

"We had our first Xylogics board up and running with UNIX in just four hours. It was quite phenomenal," he says.

Next, Sun integrated the Xylogics 450 in its second-generation family of workstations because it was the fastest, most reliable Multibus board they could find.

"From the start, our number one concern has been performance," says Garman. *"But just as important is the support Xylogics gives us. They've always been very responsive. They listen. And take us seriously. We have a close working relationship: engineering to engineering and management to management. They've always delivered on their promises."*

Xylogics' newest product, the 751 VME controller, is now being integrated into Sun's third generation of workstations, The Sun-3 Series.

Little wonder that Xylogics is the secret behind virtually every supermicro and workstation company. Or that nearly half of all high performance Multibus disk and tape controllers in use today are Xylogics.

Find out how Xylogics performance, reliability and support can be part of *your* success story. Call or write for information about our complete line of Multibus and VME bus products.

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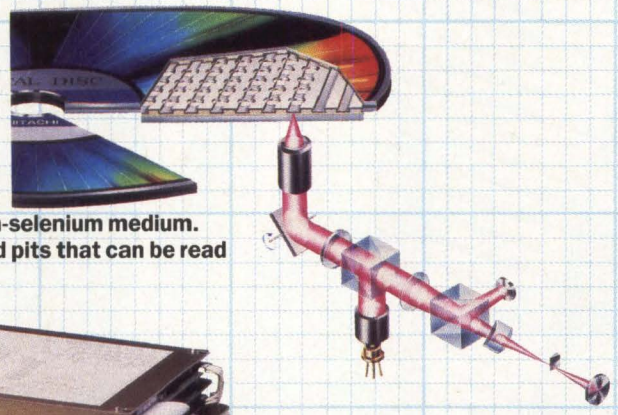
Kevin Gonor, Xylogics and Jon Garman, Sun Microsystems, with Sun-3/160 C Color Workstation

CIRCLE NO. 76 ON INQUIRY CARD

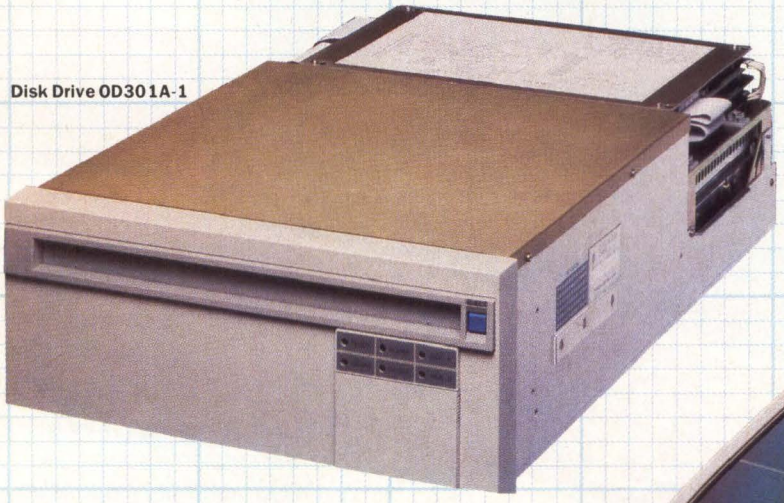
SPEEDING INFORMATION ACCESS THROUGH OPTICAL DISK TECHNOLOGY

THE 301 SERIES OPTICAL DISK SUBSYSTEM

■ Hitachi's 301 Series optical disk subsystem enables a computer to access as much as 5.2 gigabytes of on-line information. The 301 Series optical disk subsystem consists of a formatter/controller that handles as many as four disk drives, each having a write-once storage capacity of 2.6 gigabytes. The drives record data by employing a semiconductor laser to score microscopic pits on a 12-inch disk coated with a photosensitive tellurium-selenium medium. This proprietary technique produces sharply defined pits that can be read back with high accuracy and reliability.



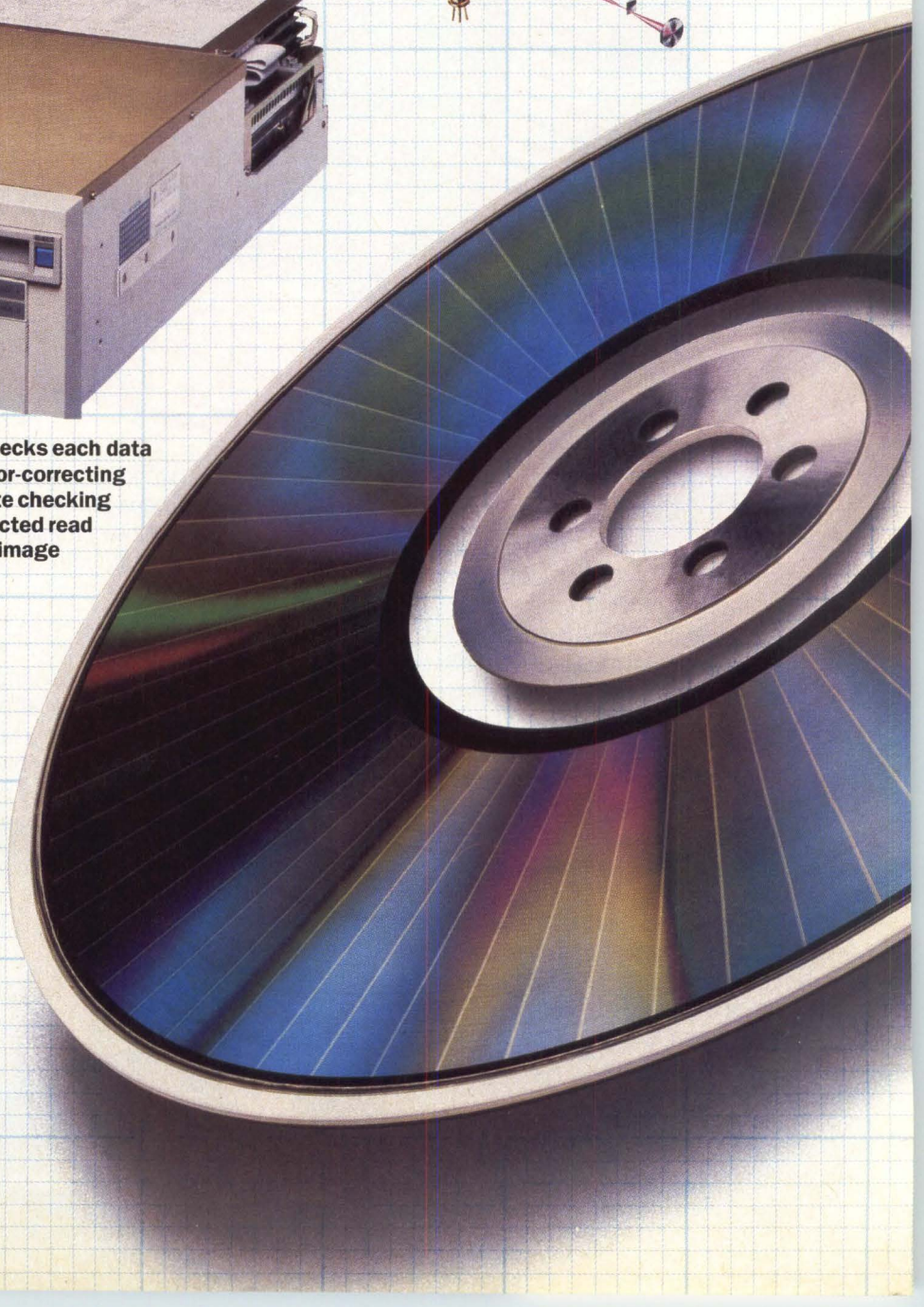
Disk Drive OD301A-1



■ The 301 Series drive automatically checks each data bit after it is written and also records error-correcting bits. The combined use of read-after-write checking and error-correction codes reduces expected read errors to 10^{-12}, allowing storage of both image and encoded data.

Disk Cartridge OC301

■ To assure data retention, the 301's disks are sealed in a glass envelope and then encased in an easy-to-handle plastic cartridge. The predicted data life of the doubly sealed disk is more than 10 years.



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How Hitachi's 301 Series Facilitate Information Storage and Retrieval

With the introduction of its 301 Series optical disk system, Hitachi has taken a giant step forward in speeding information access. Unlike conventional disk units, which record information magnetically, the model 301 stores data optically—by using a laser to inscribe microscopic pits on a specially coated disk surface and subsequently read them.

The results: a big leap in storage capacity per disk. A 301 Series system can store 2.6 gigabytes of information on a 12-inch disk. The 301 Series library unit, which combines an automatic disk changer with one or two drives, can store and retrieve 83 gigabytes of information—yet occupies no more space in an office than would a large filing cabinet.

The ability to record so much information so compactly opens vast new applications for on-line information storage and retrieval. For example, with the 301 Series, it becomes economically feasible to create extremely compact electronic archives for storing and retireving copies of medical records, engineering drawings, and other documents, much faster than with conventional microfilm or magnetic tape storage. Other applications include electronic publishing and backup of volatile databases in large-scale information processing systems. For more information, contact:

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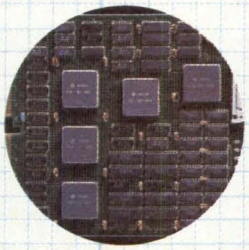
Peripheral Systems Marketing Department
950 Elm Avenue, San Bruno, CA 94066
Tel: 415/872-1902
or: 313 Speen Street, Natick, MA 01760
Tel: 617/655-5501

The 301's formatter/controller implements either the industry-standard SCSI interface or a GP-IB (IEEE-488) interface, which enables the disk subsystem to be used with a wide range of computers. The unit includes its own memory buffer to speed data transfer between a host computer and the disk drive, which has a 250 millisecond average access time.

Formatter Controller OF301S-1/2



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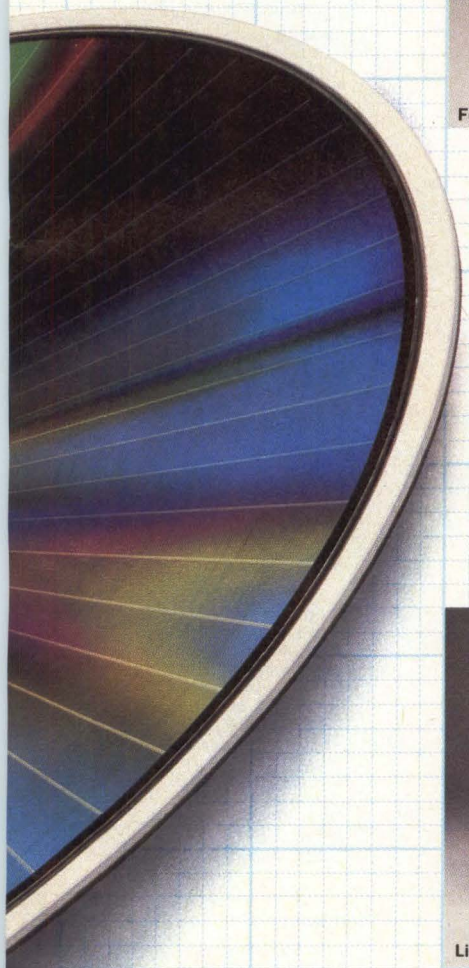

This 12-inch optical disk can store 2.6 gigabytes of images or encoded data.

Library Unit OL301S-11

The 301 Series library unit provides as much as 83 gigabytes of on-line storage capacity. It incorporates a formatter/controller, one or two disk units, and an automatic changer for as many as 32 disk cartridges.

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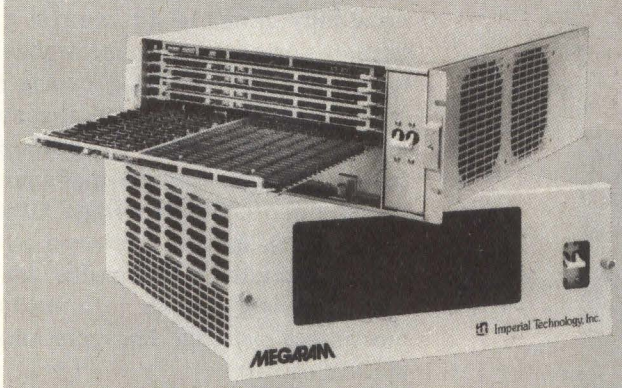

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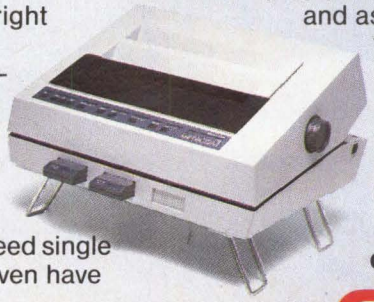

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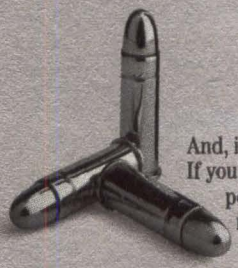

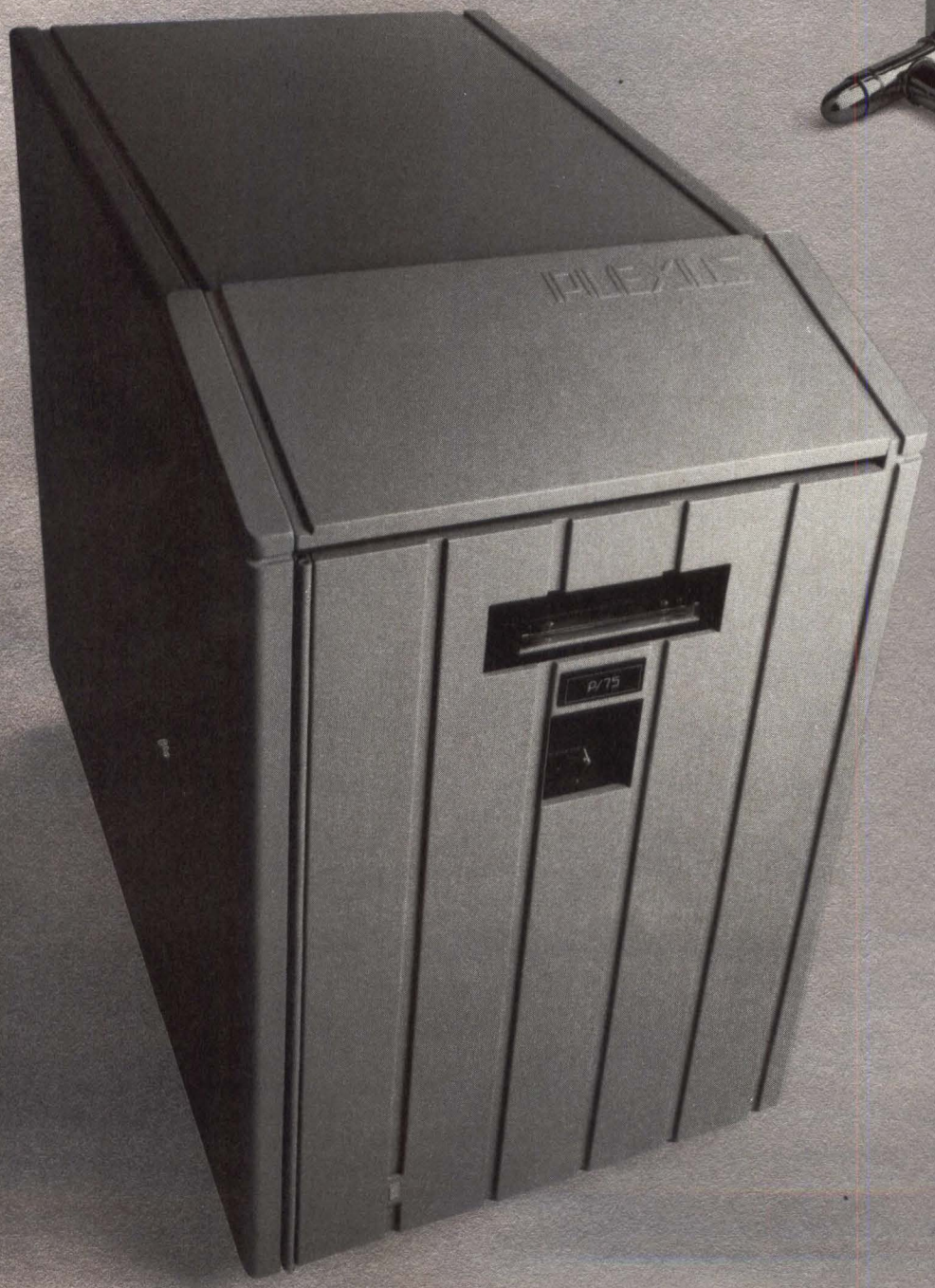

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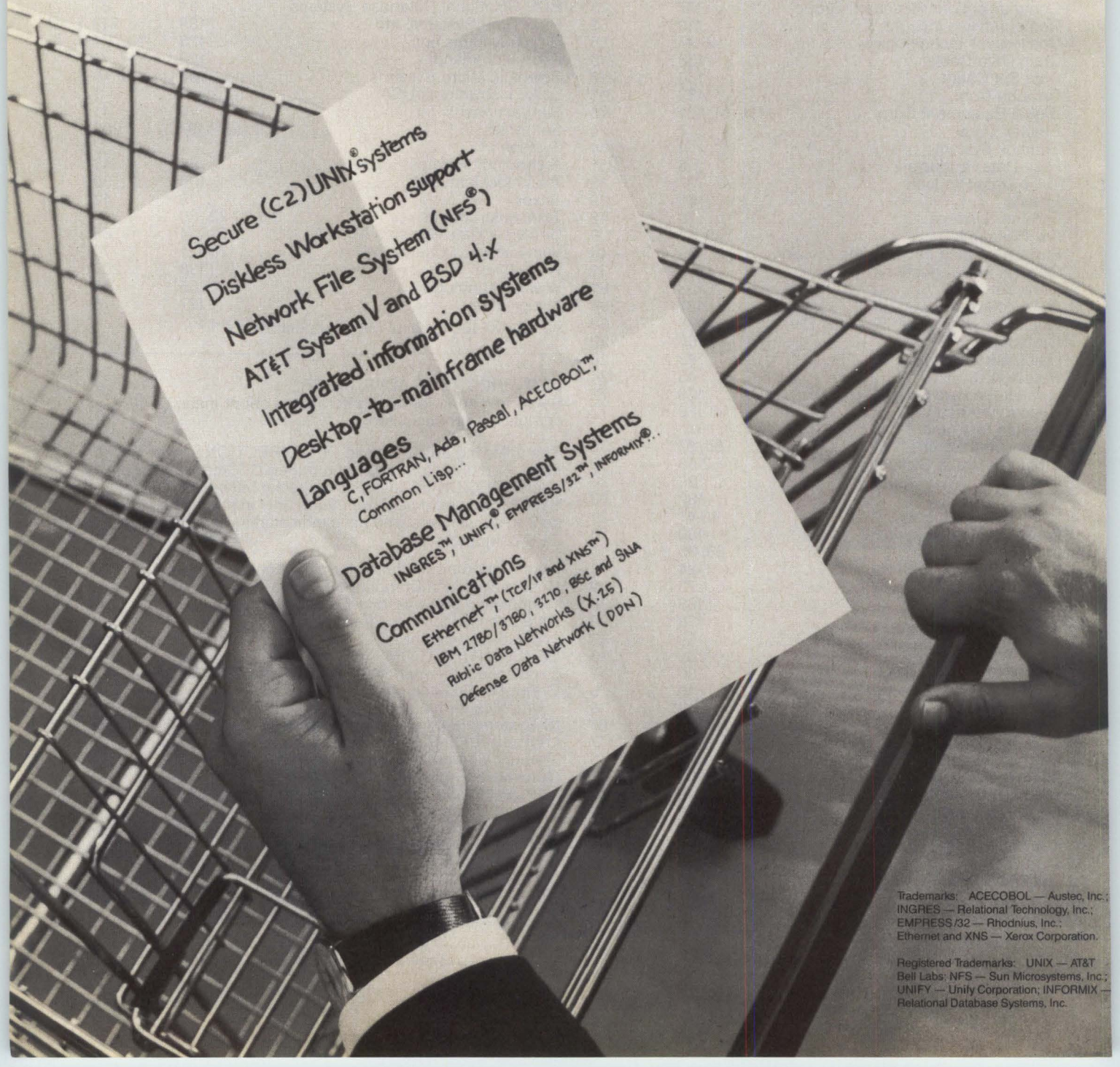

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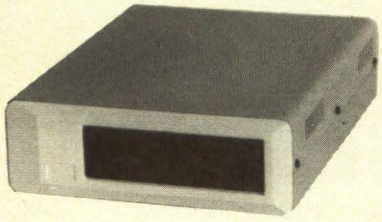

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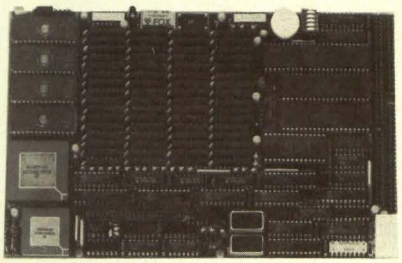

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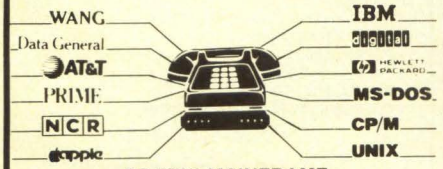

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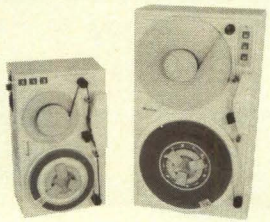

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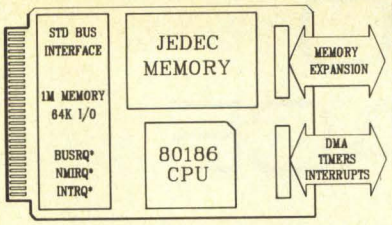

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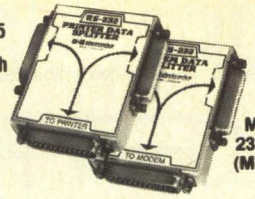

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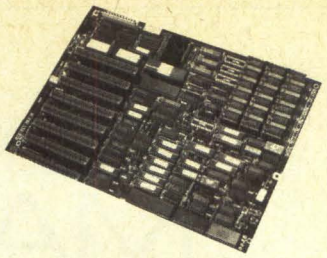

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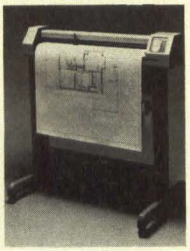

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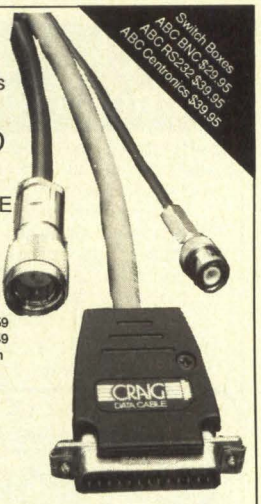

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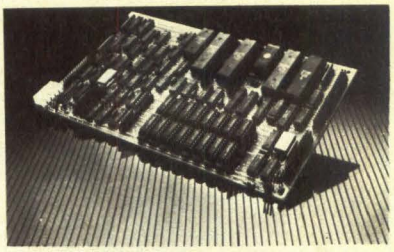

HIGH PERFORMANCE Z-80 SINGLE BOARD COMPUTERS

Available with either Z-80A or Z-80B CPU, 64-256K RAM, 2-64K ROM or EPROM, 2 or 4 RS-232 serial ports, high speed bi-directional parallel port or an I/O expansion bus. All models have 5¼" & 8" disk controller and Centronics parallel printer port. SCSI port and RS-422 ports are also available. Private label systems available.

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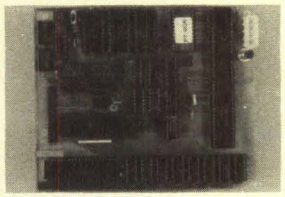

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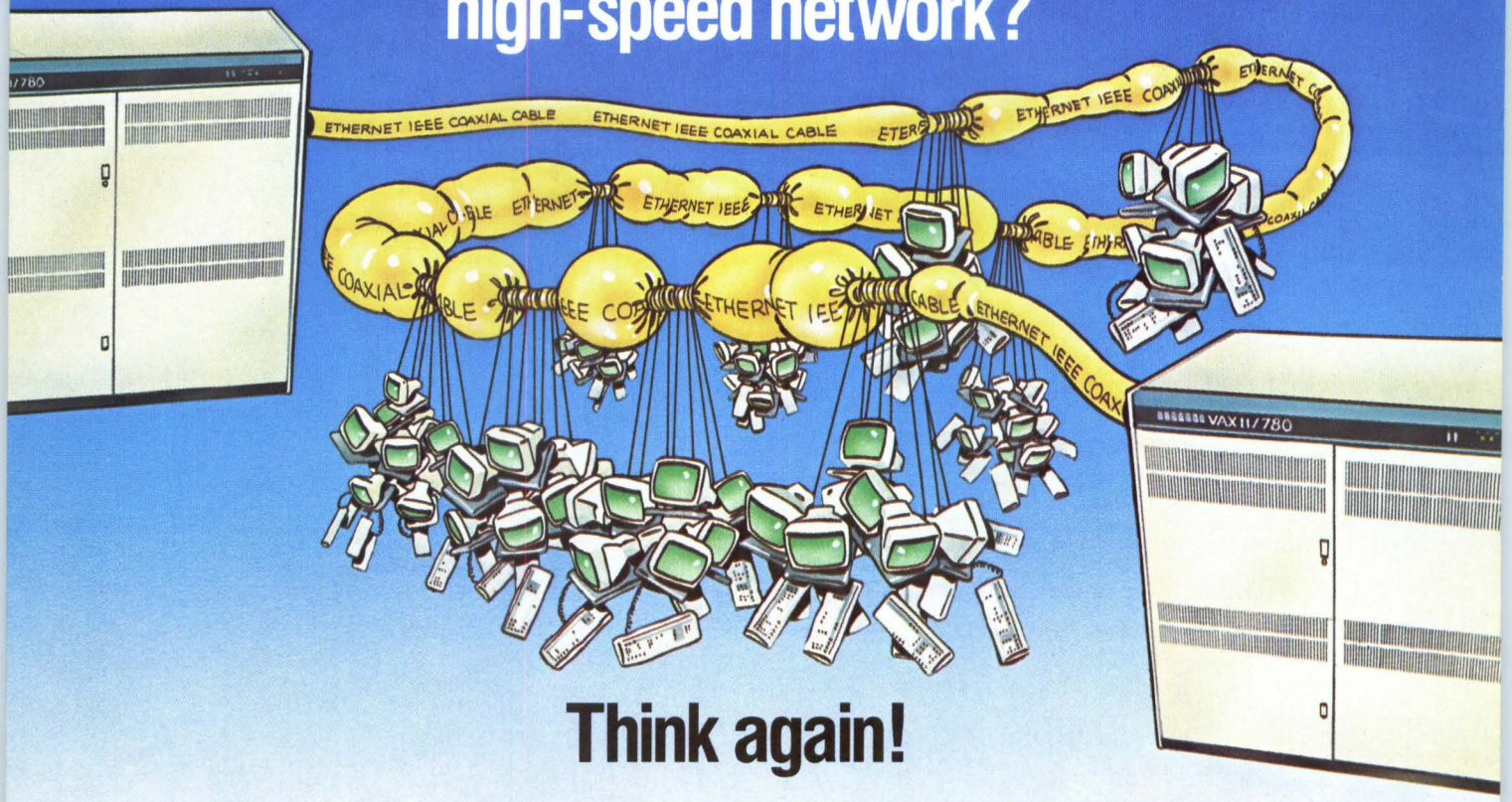
CIRCLE NO. 214 ON INQUIRY CARD

Thinking of tying low-speed terminals onto a high-speed network?



Think again!

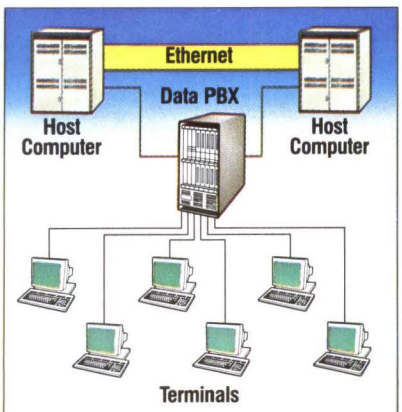
A high-speed LAN is ideal for file transfer, distributed processing and CPU-to-CPU communications. But using it for terminal traffic can cause problems.

You may be tying up bandwidth.
Low-speed terminal traffic on a high-speed network can rob bandwidth where it's needed most. That means slow file transfers and sluggish response for all network users. The protocol overhead required for a terminal to send small data packets across an Ethernet® link can mean that only 10% of the 10 Mbps bandwidth is available.

By connecting your terminals through an Equinox® Data PBX and connecting your computers together with Ethernet, your LAN runs at top efficiency. An Equinox Data PBX dedicates a full 12 Mbps to terminal data traffic. More than 1300 devices can run continuous 9600 bps data at the same time, providing the best possible response through the network.

You'll tie up about $500 per terminal.
When you consider the cost of Ethernet Terminal Servers, Taps, and Cable, Ethernet can cost between $300 and $800 per terminal. An equivalent solution using an Equinox Data PBX with our 8-channel Terminal Servers and twisted pair wiring is about $100 per terminal.

You could tie up your computer.
Some Ethernet LANs handle terminal switching by running special software in your computer. So adding terminal traffic means your computer spends more time running the network and less time running applications. An Equinox Data PBX requires no special software and handles all terminal network processing without disturbing the host. It even allows you to monitor the network load and provides additional security for access control.



We won't tie you down.
Putting your terminals on an Equinox Data PBX provides more terminal switching features for less money with greater efficiency, so you can get the most out of your LAN. And because it works with all types of computers and terminals you're not tied to a one-vendor solution.

Don't think twice. Call Equinox.
1-800-DATA-PBX
In Florida Call (305) 255-3500

Equinox Systems Inc.
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Push this, once

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It has all the advantages of our original 224, including V.22bis compliance at 2400 bps and Bell-compatible fallback rates of 1200 and 300 bps. In addition, it offers battery-backed memory storage for 10 numbers and their log-on sequences, keyboard or automatic dialing (pulse or tone), call progress monitoring and an impressive array of built-in test functions.

For detailed specifications, contact Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35805.
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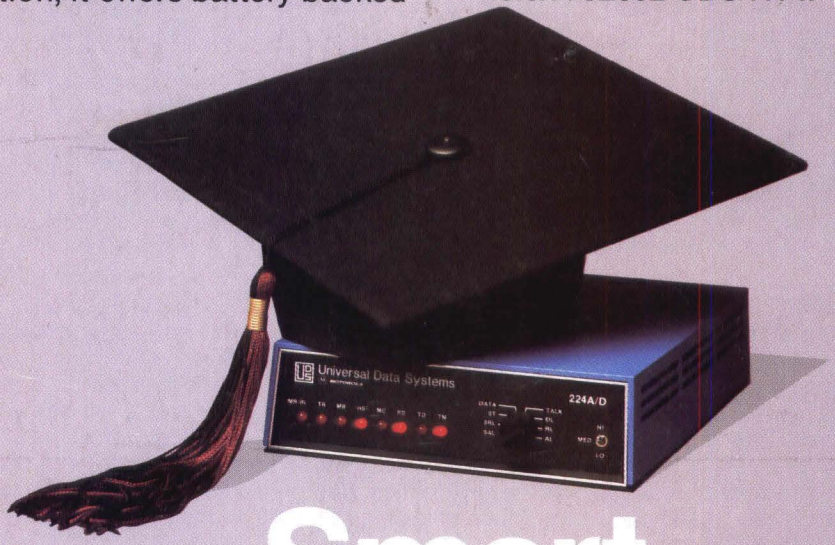

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