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the small systems journal

16-BIT DESIGNS

Inside Apple

Apple Computer Inc., 20525 Mariani Avenue, Cupertino, California 95014 Vol. 1 No. 2

For the authorized Apple dealer nearest you, call 800-538-9696 (800-662-9238 in California.)

Fruitful Connections.

There are more people in more places making more accessories and peripherals for Apples than for any other personal computer in the world.

Thanks to those people – in hundreds of independent companies – you can make the humblest 1978 Apple II turn tricks that are still on IBM's Wish List for 1984.

But now we're coming out with our very own line of peripherals and accessories for Apple® Personal Computers.

For two very good reasons.

First, compatibility. We've created a totally kluge-free family of products designed to take full advantage of all the advantages built into every Apple.

Second, service and support.

Now the same kindly dealer who keeps your Apple PC in the pink can do the same competent job for your Apple hard-disk and your Apple daisywheel printer.

So if you're looking to expand the capabilities of your Apple II or III, remember:

Now you can add Apples to Apples.

A joy to behold.

The new Apple Joystick II is the ultimate hand control device for the Apple II.

Why is it such a joy to use?

With two firing buttons, it's the first ambidextrous joystick – just as comfortable for lefties as righties.

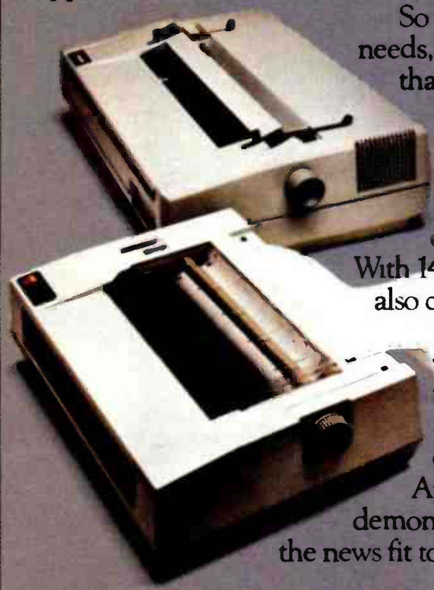
Of course, it gives you 360° cursor control (not just 8-way like some game-oriented devices) and full X/Y coordinate control.

And the Joystick II contains high-quality components and switches tested to over 1,000,000 life cycles.

Which makes it a thing of beauty. And a joystick forever.

Gutenberg would be proud.

Old Faithful Silentype® has now been joined by New Faithfuls, the Apple Dot Matrix Printer and the Apple Letter Quality Printer.



So now, whatever your budget and your needs, you can hook your Apple to a printer that's specifically designed to take advantage of all the features built into your Apple. With no compromises.

The 7x9 Apple Dot Matrix Printer is redefining "correspondence quality" with exceptional legibility. With 144x160 dots per square inch, it can also create high resolution graphics.

The Apple Letter Quality Printer, which gets the words out about 33% faster than other daisywheel printers in its price range, also offers graphics capabilities. See your authorized Apple dealer for more information and demonstrations. Because, unfortunately, all the news fit to print simply doesn't fit.

Up the creek without a paddle?

Or lost in space? Or down in the dungeons?

Whatever your games, you'll be happy to know that someone has finally come out with game paddles built to hold up under blistering fire. Without giving you blisters.

Apple Hand Controller II game paddles were designed with one recent discovery in mind:

People playing games get excited and can squeeze very, very hard.

So we made the cases extra rugged. We used switches tested to 3,000,000 life cycles. We shaped them for holding hands and placed the firing button on the right rear side for maximum comfort.

So you'll never miss a shot.

A storehouse of knowledge.

If you work with so much data or so many programs that you find yourself shuffling diskettes constantly, you should take a look at Apple's ProFile,™ the personal mass storage system for the Apple III Personal Computer.

This Winchester-based 5-megabyte hard disk can handle as much data as 35 floppies. Even more important for some, it can access that data about 10-times faster than a standard floppy drive.

So now your Apple III can handle jobs once reserved for computers costing thousands more.

As for quality and reliability, you need only store one word of wisdom:

Apple.

Launching pad for numeric data.

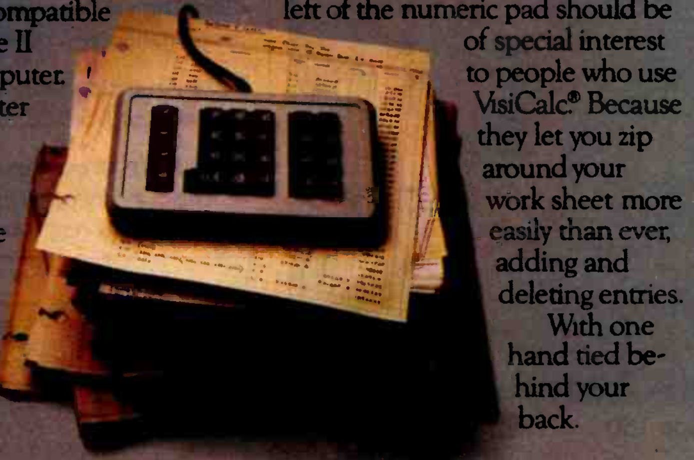
Good tidings for crunchers of numerous numbers:

Apple now offers a numeric keypad that's electronically and aesthetically compatible with the Apple II Personal Computer. So you can enter numeric data faster than ever before.

The Apple Numeric Keypad II has a standard calculator-style layout. Appropriate, because unlike some other keypads, it can actually function as a calculator.

The four function keys to the left of the numeric pad should be of special interest to people who use VisiCalc.® Because they let you zip around your work sheet more easily than ever, adding and deleting entries.

With one hand tied behind your back.



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In The Queue

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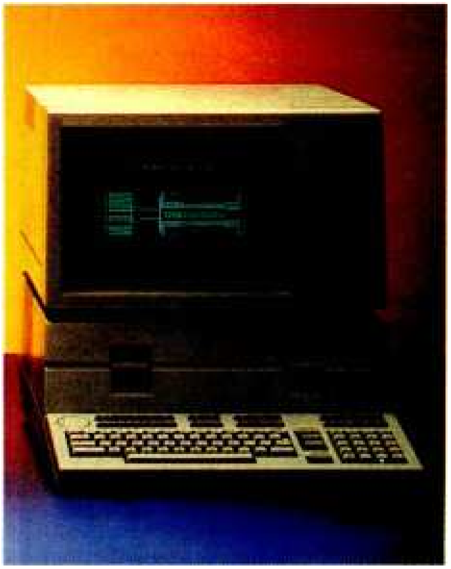

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96 Digital's Professional 300 Series by Wesley Melling / Owning a 325 or 350 is almost like having a personal minicomputer. They both share the PDP-11 instruction set and memory management and provide about 90 percent of the throughput of a PDP-11/24.

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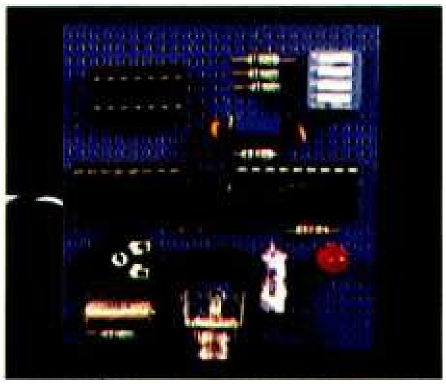

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Editorial

High-Tech Morrill Act

Lawrence J. Curran, Editor in Chief

The U.S. Senate has begun deliberations on a bill that would create a highly desirable partnership whose goal is the revitalization of high-technology education in this country. The bill, S.631, would join the federal government, state governments, and educational institutions with high-tech companies in an effort to ensure that the human resources required for this nation to compete in worldwide high-tech markets will be available. Sen. Paul Tsongas (D., Mass.) is the primary sponsor of the initiative, which he calls "the high-technology Morrill Act."

The Morrill Act established the federal land-grant college system in 1862 and is credited with revolutionizing U.S. agriculture education and, eventually, agricultural production. It helped foster an industrialization that led to global agricultural leadership for the U.S., a position we still maintain. Sen. Tsongas' bill could do the same for high-tech education by providing $500 million per year over five years. Half the money would come from the federal government, state governments would be asked to contribute 30 percent, and industry 20 percent. We heartily support this legislation, and urge you to support it by contacting your representatives.

Among other things, the money would be used to establish computer literacy programs in elementary and secondary schools; make the teaching of math, science, and engineering more attractive as a career; modernize university lab equipment and establish university research and education centers; expand technician training programs at community colleges; and develop programs to teach the management of technological innovation.

The education grants established by the bill would be administered by the director of the National Science Foundation, who would be authorized to establish an advisory committee representing industry, education, state government, professional societies, and labor organizations. We think that such an advisory committee can be effective, but we also believe it's critical that it receive strong direction from high-tech industries that compete globally so that it is responsive to real-world competitive considerations.

Sen. Tsongas is to be commended for his astuteness in seeking counsel from people who should be especially well qualified to understand global competition and education in high-technology industries. Those assisting with the legislation include the authors of a recent book that we think is an enlightening contribution to the literature: Ray Stata, president of Analog Devices Inc., Norwood, Massachusetts; and James Botkin and Dan Dimancescu, consultants in high technology from Cambridge, Massachusetts. The book is *Global Stakes, The Future of High Technology in America* (written with John McClellan. Ballinger Publishing Co., Cambridge, MA, 1982).

It's time that this nation started to deal more effectively with global competition. Through its emphasis on education, S.631 seeks to keep U.S. high-tech industry on the leading edge. Education is the long-fallow ground that must be fertilized so that the engineers, scientists, and technicians it produces are prepared for ever more formidable competition in future decades. ■

How to buy a computer by the numbers.

Introducing the Cromemco C-10 Personal Computer. Only $1785, including software, and you get more professional features and performance for the price than with any other personal computer on the market. We've got the numbers to prove it.

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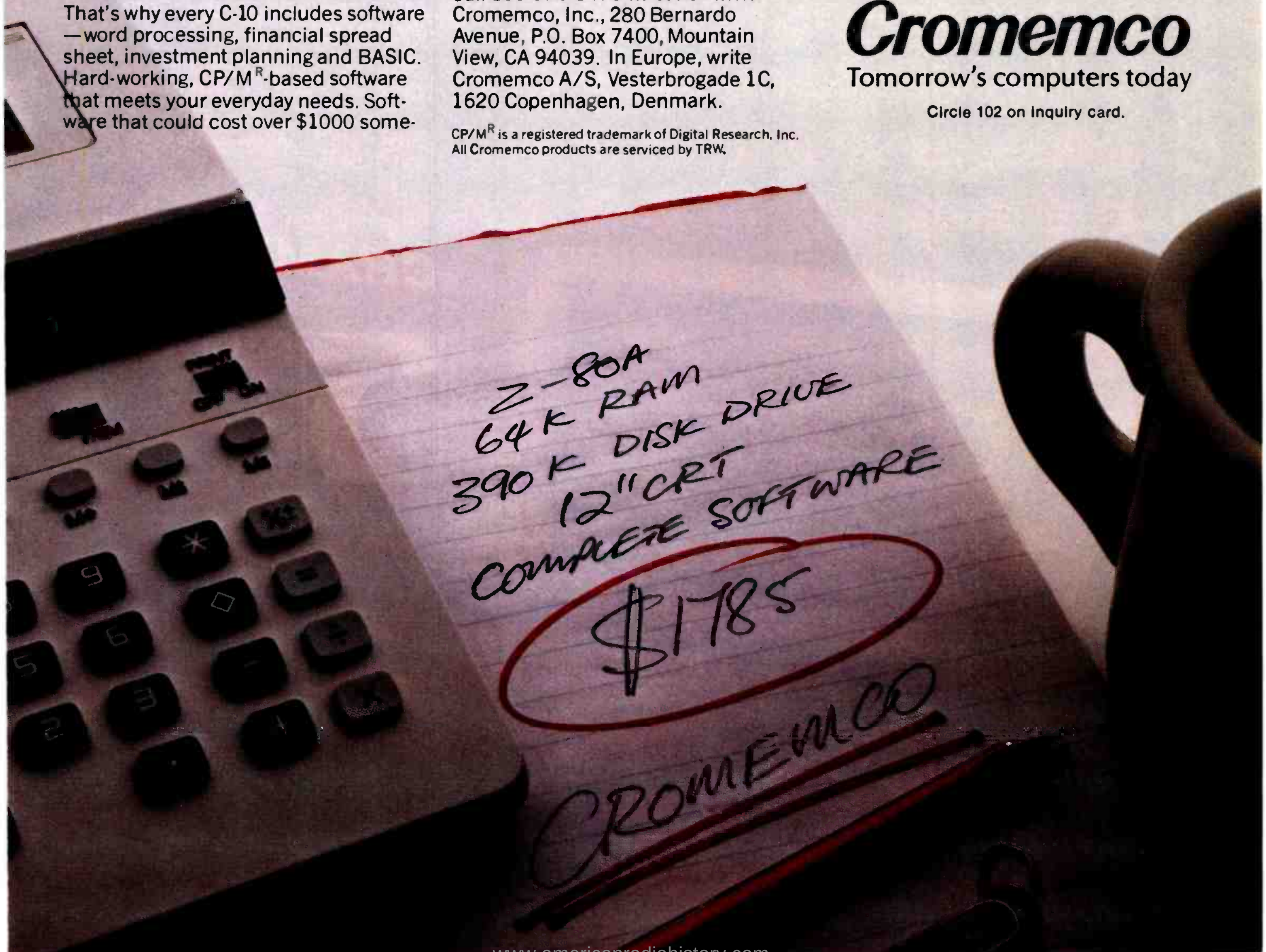

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MICROBYTES

Staff-written highlights of late developments in the microcomputer industry.

OPERATING SYSTEMS BATTLE LINES INVOLVE IBM, DEC, AMERICAN BELL

International Business Machines, Digital Equipment Corporation, and American Bell will make separate moves that together could reshape the world of microcomputer operating systems. IBM is believed ready to make available more operating systems for the IBM PC and may emphasize for the business market an operating system other than PC-DOS. One account says that IBM sees the need for a multitasking operating system with more flexible data structures. Another account says IBM is developing its own operating system for the IBM PC to be compatible with the CPIX version of Unix that runs on the IBM Series 1. IBM's alternate channels marketing department has also arranged for CDI in Bellevue, WA, to install the Pick operating system on the PC late this year. A Microsoft spokesman, however, says,"We have a long-term relationship with IBM and have solid plans involving PC-DOS."

Microsoft has strengthened its position elsewhere by reaching a large OEM agreement with American Bell. At least some of American Bell's computers will run Microsoft's Multi-Tool application programs and some version of the Unix operating system. Other American Bell microcomputers, however, will run well-known application programs from a variety of major software houses. Meanwhile, Digital Equipment Corporation is working closely with Digital Research and Visicorp. DEC's low-end microcomputers such as the Rainbow 100 will run Concurrent CP/M-86 and Visicorp's Visi On operating environment.

DIGITAL RESEARCH INTRODUCES PERSONAL BASIC AND MARKETS LANGUAGES FOR IBM PC-DOS

Digital Research has introduced Personal BASIC, an interpretive BASIC designed to compete with Microsoft BASIC but to sell for only $150, compared to MBASIC's $350, and at OEM prices far below that. Personal BASIC checks syntax as statements are entered and reports syntax errors before the program is run. It has advanced error trapping, informative error messages, and debugging aids such as statement-number tracing, variable tracing, and breakpoints with single-step operation. Version 1.0 of Personal BASIC runs source code written in Microsoft BASIC or IBM PC BASIC except for PC BASIC's graphics commands. Version 2.0 will support fully integrated graphics statements through the GSX implementation of the graphics kernel standard.

Digital Research's Language Division has broadened its marketing strategy and is selling all DR languages in versions to run under IBM PC-DOS. These include CBASIC-86, CB-86, Pascal/MT + -86, PL/I-86, C-8086, Microfocus COBOL, and the programming aids Display Manager and Access Manager. CB-80 and CB-86 have been enhanced to include some graphics support. Digital Research says its languages will provide portability of applications programs across microprocessors and operating systems.

SYDIS SYSTEM INTEGRATES VOICE AND VISIWORD

Sydis Inc., a startup company in San Jose, CA, has introduced the Voicestation System, a 68000-based system with desktop-manager software that incorporates the functions of a personal computer, a telephone, a dictating machine, a card file, and a calendar. Each terminal has its own 68008 microprocessor, 128K bytes of graphics RAM, and 832 by 608 resolution. The combination of voice input, mouse, and programmable-function keys may greatly reduce or eliminate the need for many users to have a keyboard. While the Sydis system does not provide voice recognition, it does provide voice memos and voice annotation of text documents generated with Visicorp's Visiword. The central Sydis Information Processor uses multiple 68000s and manages a shared 160-megabyte hard disk. Price of a 16-user system is less than $7000 per user.

MICROSOFT ANNOUNCES MULTI-TOOL WORD, MOUSE

Microsoft has introduced Multi-Tool Word, the second of the company's planned series of productivity tools. Developed under the guidance of Charles Simonyi, formerly of Xerox PARC, Multi-Tool Word provides sophisticated printer support and text-editing. Use of the new Microsoft mouse for the IBM Personal Computer is optional. The two-button mouse and three programs that demonstrate its use cost $195.

SOFTOFFICE TO OFFER IBM PC INTEGRATED SOFTWARE

The Softoffice Co., San Rafael, CA, is developing both networking and stand-alone versions of an integrated software system for the IBM PC. President Bruce Van Natta describes the product, also called Softoffice, as an object-oriented structure and says it will provide fully integrated applications, electronic mail, and videotex, all accessible through a pictorial desktop manager for professional and administrative users.

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OCTAGON 80286 SUPPORTS THREE OPERATING SYSTEMS SIMULTANEOUSLY

Octagon Computer Systems will announce the first 80286/Z80-based dual-processor multiuser system at PC '83 in San Francisco June 17. Software will allow users to run PC-DOS, Concurrent CP/M-86, and CP/M-80 applications software at the same time on different terminals. The system's standard equipment includes a 5¼-inch IBM-PC-format floppy disk, an 8-inch floppy disk, and a 5¼-inch Winchester hard disk. As a result, the system supports convenient transfer of files between the two sizes. Other hardware features include up to 4 megabytes of onboard memory, 8 high-speed serial ports, 8 video-display controllers, 6 parallel ports, 64K bytes of PROM, and a calendar/clock with battery backup. The system, including the 15-megabyte formatted hard disk, is priced at $8750.

PFS:WRITE COMING THIS MONTH FROM SOFTWARE PUBLISHING

PFS:WRITE, a what-you-see-is-what-you-get word processor, will be available this month for $140. Developed by Software Publishing for the IBM PC, PFS:WRITE works with PFS:File to do mailing lists and can print data tables from PFS:Report, bar charts from PFS:Graph, and spreadsheets from Visicalc.

MICROPRO IMPROVES WORDSTAR AND INTRODUCES PLANSTAR, STARBURST, STARINDEX

Micropro International, San Rafael, CA, recently announced three new products and an updated version of Wordstar. Wordstar (3.30) for the IBM PC has user-definable function keys, faster screen updating through memory-mapped video, a new install program, and support for color displays.

Planstar, a financial modeling tool that runs on PC-DOS or any microcomputer with CP/M version 2.2 or later, includes bar charts and line graphs and can build large multidimensional models and consolidate worksheets. With Starburst, users create menus for their own office "script" to link Micropro or other programs and automate a series of tasks. Starburst performs repeat sequences and conditional logic. The program runs on CP/M version 2.0 or later, an Apple with a CP/M board, PC-DOS 2.0, MS-DOS, and CP/M-86. Starindex works with any version of Wordstar to create alphabetized indexes with subentries and a four-level table of contents.

ASHTON-TATE INTRODUCES FRIDAY

Ashton-Tate of Culver City, CA, publisher of dBASE II, is offering a new user-friendly personal filing system called Friday that permits adding, deleting, and changing of fields and creating and changing of files from anywhere in the system. Every screen display shows a reference to a related section in the user's manual. Data from Friday and dBASE II can be combined. Friday costs $295 and is available now.

SHARP ENTERS PORTABLE-COMPUTER MARKET

Sharp Electronics has introduced the Super Portable Computer, an IBM-PC data-compatible unit. The SPC has a flip-up liquid-crystal display providing 8 lines by 80 characters and a full-size keyboard. It uses the 8088 microprocessor and comes with 128K bytes of CMOS RAM expandable to 256K bytes, MS-DOS and BASIC in ROM, and two slots for ROM cartridges (64K to 128K bytes), RAM cartridges (64K bytes), or bubble memory cartridges (128K bytes). The unit is powered by rechargeable batteries. The SPC is expected to be bundled with word-processing, electronic spreadsheet, communications, and executive planner programs. Suggested retail price for the SPC with one bubble memory cartridge will be in the $2495 to $2995 range.

NANOBYTES

American Bell may market Apple computers through its 461 Phone Center stores. . . . **The Hewlett-Packard** 85B and 86B are the first micros to have built-in semiconductor virtual disks as standard equipment. . . . **Quarterdeck of Santa Monica,** CA, showed a desktop manager that integrates existing PC-DOS and CP/M-86 applications programs. . . . **Schuchardt Software Systems** will offer applications-oriented database-modeling systems that "take advantage of recently developed artificial-intelligence techniques to simplify the user/machine interface," according to Frederick H. Schuchardt, president and founder of the new San Rafael, CA, company. A software hotline service will be available by subscription to end users, dealers, and OEMs. Schuchardt was formerly president of Micropro's World Trade division and before that managed applications development for the American Airlines Sabre System. . . . **Fujitsu's $2400** 1-megabyte RAM board for its Micro 16s uses 256K-bit RAM chips. . . . **3Com Corp. has reached agreement** with 25 retail stores to distribute the company's Ether/Series Ethernet products. Businessland and independent Computerland stores are among those handling the 3Com products. 3Com reports selling 1000 Etherlinks for the IBM Personal Computer since the beginning of 1983.

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5 meg — $1595. 10 meg — $1995.
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Letters

Vox Populi

The recent issue on standards missed an important new trend in the standards-making process. It is all the more significant because it is the result of the proliferation of microcomputers, where the BYTE readership is strongest. The trend is the democratization of standards.

Ten years ago the ANSI (American National Standards Institute) rule for a balanced representation of committee members between users, implementers, and general-interest members was easily satisfied from the large corporations willing to ante up the high membership fees required by CBEMA because only large companies could afford computers.

With the advent of microcomputers this is no longer true. Consider Chuck Card's new working group for a standard floppy-disk format. To be a member of this committee costs you $150 per year for three to five years, plus travel and lodging costs four times a year to the other side of the country. For a large company with a vested interest, this is not too much. But users like you and me cannot afford $1000 or so each year for this kind of activity. The result is that ANSI activities are going to be increasingly biased away from the users toward the manufacturers. Note that CBEMA (the official secretariat) stands for Computer and Business Equipment Manufacturers' Association, which is hardly likely to encourage participation of independent users.

But I mentioned a new trend; it is developing within the IEEE Computer Society. The Computer Society, through the IEEE (Institute of Electrical and Electronics Engineers), is a member of ANSI, and thus a full-fledged standards-making body. But there is no $150 membership fee, and many of the active working groups stay in one place so that there is a possibility for participation by users. True, a committee meeting in Silicon Valley is still out of the budget for East Coast participants, but at least West Coast participants are not locked out also. Furthermore, the Microprocessor Standards Committee rules permit membership by correspondence, so everyone has the opportunity to have a say in the formation of these far-reaching standards. Finally, unlike the traditional ANSI procedures, the Microprocessor Standards Committee has a policy of publishing full drafts for public review and comment in widely read trade journals, so you can see what is going on and have the opportunity to participate.

As with any new trend, there are reactionary forces. Even within the Computer Society there are those who want to inhibit the democratization by squelching publication or insisting on peripatetic meeting places. You, the readers of BYTE, can put in your vote for democracy. Write ANSI and/or the Governing Board of the Computer Society and demand to be a part of the standards process. Insist on public review of work in process (i.e., publication of drafts) and working groups that stay in one place long enough to permit the participation of unfunded users like you. Remind them of the success of IEEE-696 (S-100 bus) and the soon-to-be standard P754 (Binary Floating Point) that benefited from this open process. Your voice counts.

Some organizations to write to are the American National Standards Institute (1430 Broadway, New York, NY 10018), the IEEE Computer Society (POB 80452, Worldway Postal Center, Los Angeles, CA 90080), and the Microprocessor Standards Committee, Michael Smolin, Chair (Synertek Inc. MS61, POB 552, Santa Clara, CA 95051).

Please don't everybody write to me expecting replies. I am another unfunded user trying to get some work done to pay the bills.

Tom Pittman
POB 6539
San Jose, CA 95150

Another Standards Organization

The February articles on standards were excellent. Richard S. Shuford's editorial, "Standards, The Love/Hate Relationship" (page 6), and especially his analysis of forces hindering standardization were right on target.

Your readers may be interested in a standards organization that was not mentioned in the issue, ASTM Committee E-31 on computerized systems. ASTM (American Society for Testing and Materials) was founded in 1898. It is the oldest voluntary consensus standards organization in the United States. It is also among the most prolific, with over 6500 separate standards in the 64-volume *An-*

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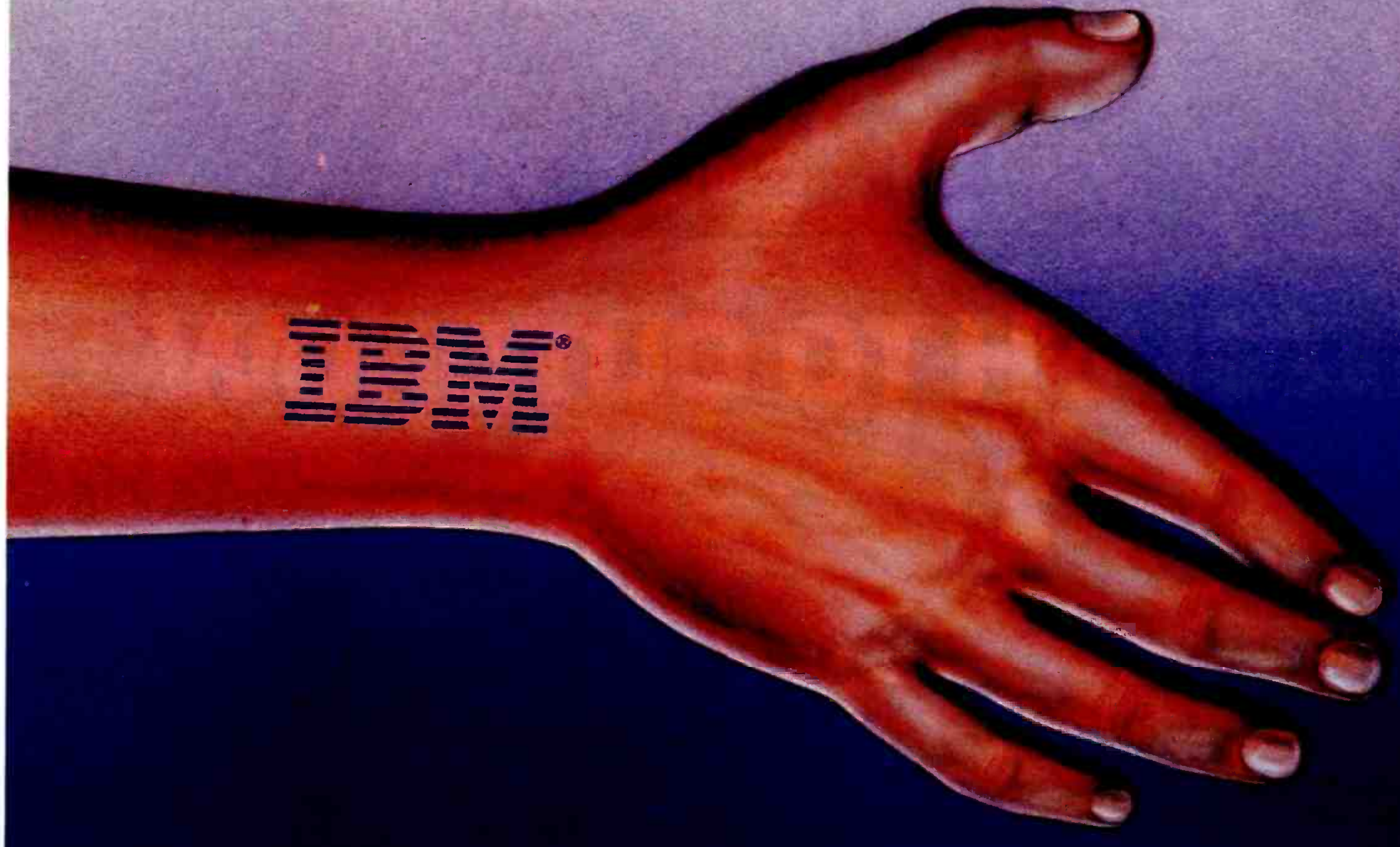

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nual Book of ASTM Standards. ASTM was one of the four organizations that, in 1918, founded what has become the American National Standards Institute.

Committee E-31 on computerized systems was organized in 1970. E-31's standards focus on the needs of people who *use* computerized systems. (A computerized system is one in which a digital computer is a significant part.) There are draft or approved standards for computerizing clinical laboratories, manufacturing operations, hospital pharmacies, and scientific laboratories, as well as more general standards to guide any computerization project. A standard specification for software documentation is now in the final stages of approval.

All meetings of Committee E-31 and its subcommittees are open. Anyone is welcome who wants to learn, to participate, and to join in the work of developing standards. Many of us learned a good deal of what we know about computerized systems with Committee E-31. We are all still learning.

People can contact me for more information or they can write directly to ASTM at 1916 Race St., Philadelphia, PA 19103.

Peter E. Schilling, Chairman
ASTM Committee E-31 on Computerized Systems
Aluminum Company of America
Alcoa Technical Center
Alcoa Center, PA 15069

More on the Proposed ANSI BASIC Standard

Ronald Anderson's "The Proposed ANSI BASIC Standard" (February, page 194) raised some questions to which I would like to respond.

First, it should be pointed out that the ANSI (American National Standards Institute) public review period is indeed open to the public; any interested party may submit comments directly to ANSI/X3 committee (X3 Secretariat, CBEMA, 311 First St., NW, Washington, DC 20001). It is also possible to channel these comments through the Association for Computing Machinery (ACM).

The standard is organized in the form of a core specification plus some independently optional modules (e.g., real-time and graphics). This was done to provide standardization for a given well-demarcated functional area without forcing it on all implementations. In the case of real-time operations, for instance, there is widespread use and implementation, and so the need for standardization exists. At the same time, it doesn't seem reasonable to require all vendors to implement this rather ambitious module because their users may have no need of it.

The article implied that the standard did not provide data typing. In fact, the standard does specify a DECLARE statement for the typing of variables. Variables need not be declared explicitly, but they are still typed, according to the usual BASIC convention of a trailing dollar sign for strings and no such dollar sign for numerics. Assignments and comparisons between incompatible types are not allowed. Furthermore, the standard even guarantees type-checking for I/O (input/output) to so-called INTERNAL files; no other language of which I am aware provides this protection.

Finally, I take exception to the statement that "the new standard appears to be more loosely defined than most other language standards." This certainly was not the intention nor, I believe, the result of X3J2's efforts. There are indeed a number of instances in which a result is explicitly implementation-defined; such is the case in all language standards. But I believe the clarity of the specification compares favorably with that of other recent and proposed standards, e.g., for FORTRAN, Pascal, or Ada. X3J2 would certainly welcome hearing about any specific aspect of the standard that is vague or ambiguous and will, I'm sure, do its best to remedy such lapses.

John V. Cugini
Programming Languages Group
Data Management and Programming Languages Division
United States Department of Commerce
National Bureau of Standards
Washington, DC 20234

Standard Priorities

Thank you for the informative articles on standards in February. However, I was wondering if there is a standards committee on documentation. If there is anything the computer industry needs today it is a set of standards for documentation. Much of the software and hardware produced today is of good quality, yet the documentation is so poor that these pro-

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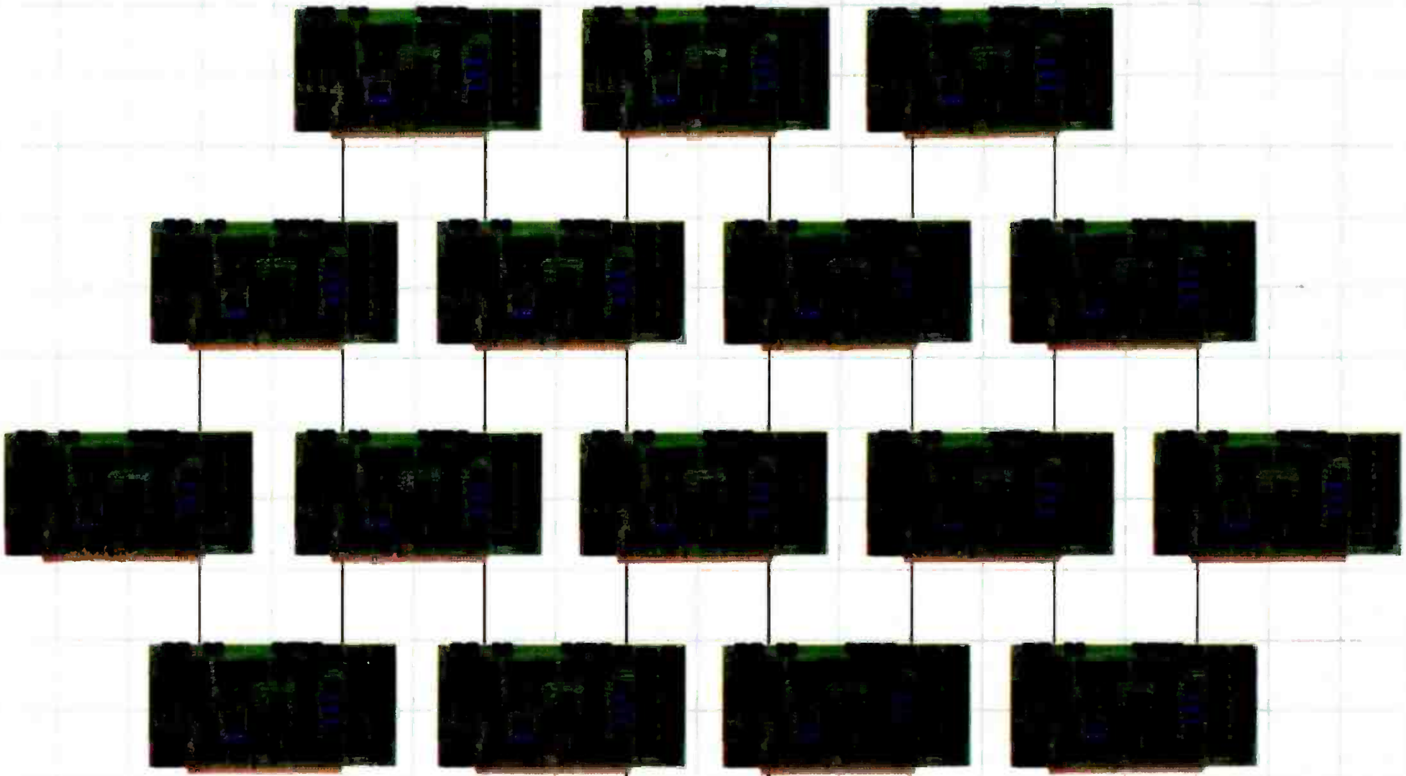
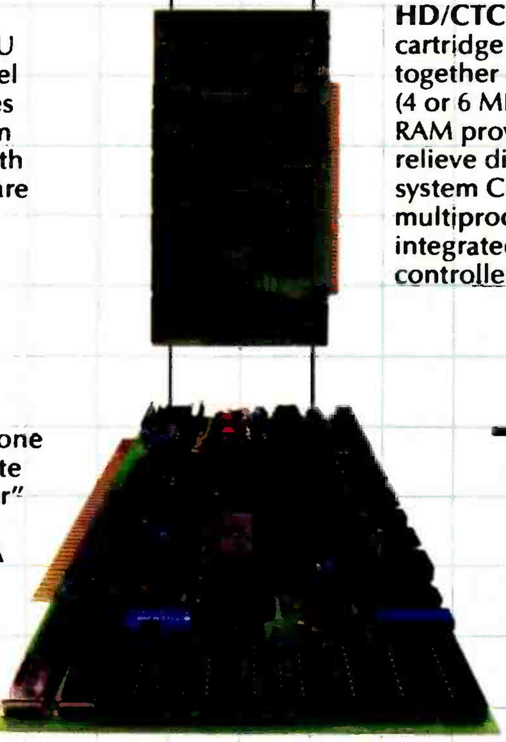


SBC-1 (Above) A multiprocessing slave board computer with Z-80 CPU (4 or 6 MHz), 2 serial ports, 2 parallel ports, and up to 128K RAM. Provides unique 2K FIFO buffering for system block data transfers. When used with TurboDOS or MDZ/OS the results are phenomenal!



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ducts are under-used or not used at all. My word-processor program, for example, does not have an index. A book of over 100 pages without an index is all but ludicrous, not to mention the fact that one page of the table of contents is missing. If standards for documentation are developed, they should include both a table of contents and an index for each volume of the document.

Most of the standards dealt with by the articles in your February issue seem to be long overdue and should be implemented. Yet, somehow I feel that some of these standards may become too restrictive and burdensome, such as the proposed floppy-disk-format standard. Even more critical is that program languages such as BASIC, Pascal, COBOL, and others undergo further needed standardization. Take, for example, Visicalc. It can be used with relative ease on any of the computers for which it is designed, provided users have the appropriate copy of Visicalc for each computer they wish to use. Visicalc is not a program language; yet its virtue of commands that are similar if not identical for the various computers for which it is designed should be the goal for program-language standardization. Standardization of program languages is much more important than the standardization of floppy-disk formatting or of operating systems.

John H. A. Deal
RFD 2, Box 77
Malta Bend, MO 65339

Lisa Feedback

Like everyone else, I awaited with great anticipation Gregg Williams' in-depth review of Apple's new Lisa machine (February, page 33). However, upon completing the article, I found myself wishing that the author had provided more searching analysis and less parroting of the manufacturer's promotional fog and vague promises.

As a longtime admirer of Apple's corporate verve, I've hoped that the Lisa would provide the transfusion of fresh blood necessary to keep the company from otherwise inevitable crushing under the IBM juggernaut. From the article, I'm not sure this is the case. Maybe Williams just missed some fundamental points, but I'm sure that the corporate purchasing agents who will be making searching evaluations of this very expensive machine will not miss such points as these:

The microprocessor: The 68000 is more or less current state-of-the-art, but what's the point if the multiuser, multitasking, networked operating systems aren't in place? Trying to separate promises from deliverable hardware, it seems that quite a bit of such support has yet to be implemented.

Drives: What's so "revolutionary" about an 860K-byte variable speed drive? Chuck Peddle put 1.2-megabyte variable-speed drives (double-sided version) in the Sirius I (Victor 9000) two years ago.

Display: It's hard to tell from the photos, but the display seems to be just black on white or pale blue. If so, it may be a serious mistake. While such a display may be necessary for logic implementation of the desktop-with-icons metaphor, it sacrifices the utility and pizazz of the full-color graphics rapidly becoming industry standard with Apple's competition. And black on white is just hopeless for long-term word processing; even executives must sometimes draft long reports.

Input Devices: People doing any serious spreadsheet work will surely long for cursor movement keys and curse the need to remove hands from the keyboard to use the mouse. The mouse itself seems pointless; why replace a device you're afraid the executive is afraid of (the keyboard) with another unfamiliar device? If Apple was seriously interested in the psychology involved it would have given said executive a light pen.

Software-Bundle Concept: Certainly Apple must be applauded for its willingness to take the software-bundle concept to new heights. However, I wonder whether in some areas it goes too far. For example, while the desktop-with-icons metaphor may be useful, were I a Fortune 500 company vice-president, I would be mortally insulted that a designer felt my computer had to show me a picture of a wastebasket to direct me to the delete-file function. Such offensive condescension shows up throughout the design, even in the hardware (e.g., labeling the disk release button "Disk Request").

The individual programs seem well thought out, except for the word processor. If this machine is really aimed at executives, it probably ought to trade

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some of the sophisticated manipulation and formatting for a spelling check (they probably aren't much as typists), grammar checker (they want their reports to be readable and articulate), style manual, and thesaurus. They'll want to be able to creat sharp, lucid *drafts*; they'll expect their stenographers to take care of formatting and printing with the right margins and other details.

Image: I'd hoped (apparently in vain) that Apple finally understood how badly its cutesy, whimsical image hurts its chances of executive-suite penetration. This image crops up in too many ways in the Lisa: the Apple (control) key, the mouse, and on and on. Please, guys, the next time you're in the executive-suite waiting room, flip through the magazines on the table. You'll find *Fortune*, *Barron's*, *Forbes*, etc., but certainly not *Nibble*. There's a lesson there.

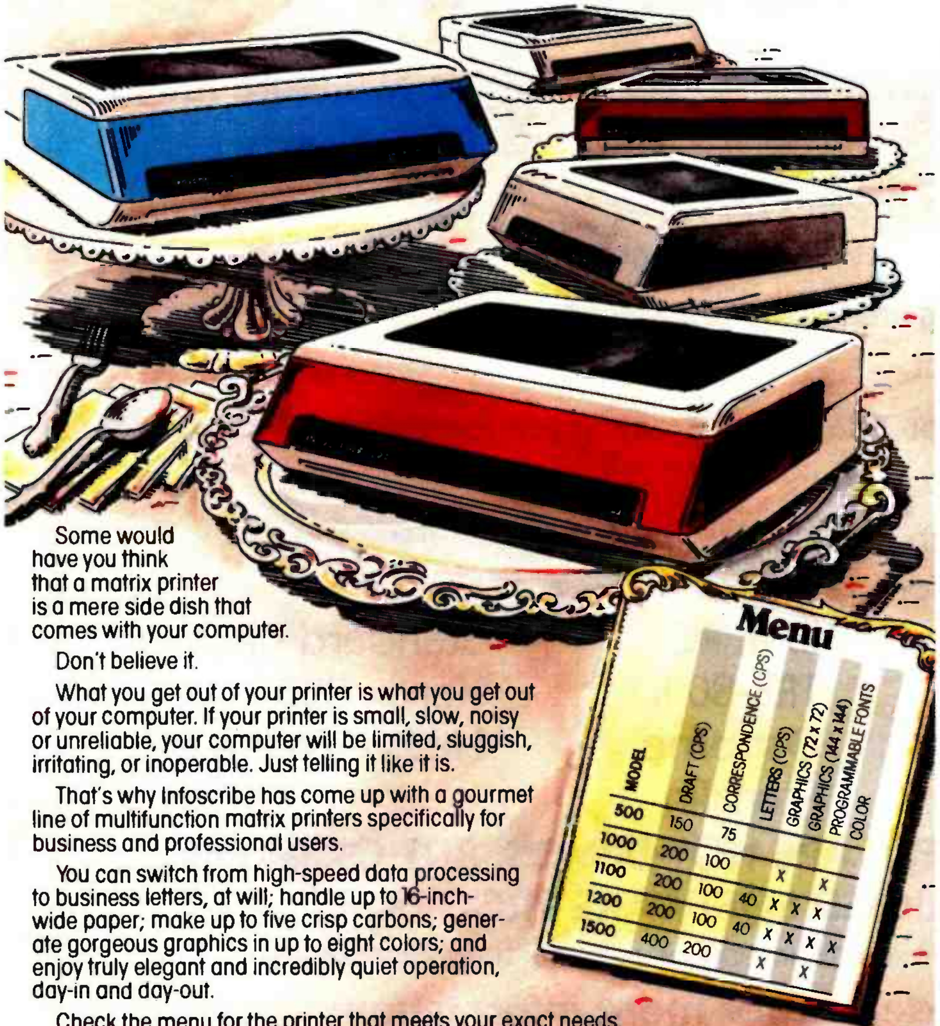
Price: $10,000 is ludicrous. Most customers may feel that with existing competitive hardware and other software bundles that will reach the market before the Lisa, they can get good enough performance. Why pay $2000 to $3000 more to be condescended to by a machine? And it becomes hopelessly worse if Apple goes through with the imbecility of locking machine and software together with electronic serial numbers. What company in its right mind is going to spend $4000 many times over for repetitive bundles of software? Times are gettin' hard, boys. Money's gettin' scarce, in case you didn't realize it already. It would be far more sensible to license the package to a network of stations.

Don't get me wrong. I vigorously applaud the effort, initiative, and obviously deep consideration that Apple has given to the Lisa. I really hope it succeeds. My remarks are not a debunking diatribe, but an earnest effort to point out that there are still some significant bugs in a generally pretty snazzy machine.

Del Palmieri
3 Maple Ridge
Ballston Lake, NY 12019

Thank you for your comments on the Lisa system and my review of it. I think you summed it up when you said that the Lisa is the result of "effort," initiative, and obviously deep consideration." Of course, no project of such complexity can satisfy everyone, and many of your criticisms are valid personal objections. I particularly agree with you that the $10,000 price is regrettably high (although I would not call it ludicrous) and that the capabilities of Lisa Write do not mesh well with Apple's intended audience of corporate executives. I also thank you for pointing out that the Victor 9000 (as it's called in the U.S.) disk drives do outperform the Lisa's; I was dead wrong on that, although I still think that other aspects of the drives (like the redundant directory and the Disk Request button) are very valuable.

At this point, however, we part company. Your opinions as a potential Lisa customer have the utmost validity but may not be widely shared. For example, I don't think that most people are "mortally insulted" by icons that give them visual clues about the machine's operation, nor do I think they find a Disk Request button, which keeps them from taking a disk out and losing data, to be "offensive condescension." You imply that Apple's use of the mouse is perhaps not the best pointing device for the typewriter-shy executive; maybe so, but Apple spent a lot of money on research that caused them to



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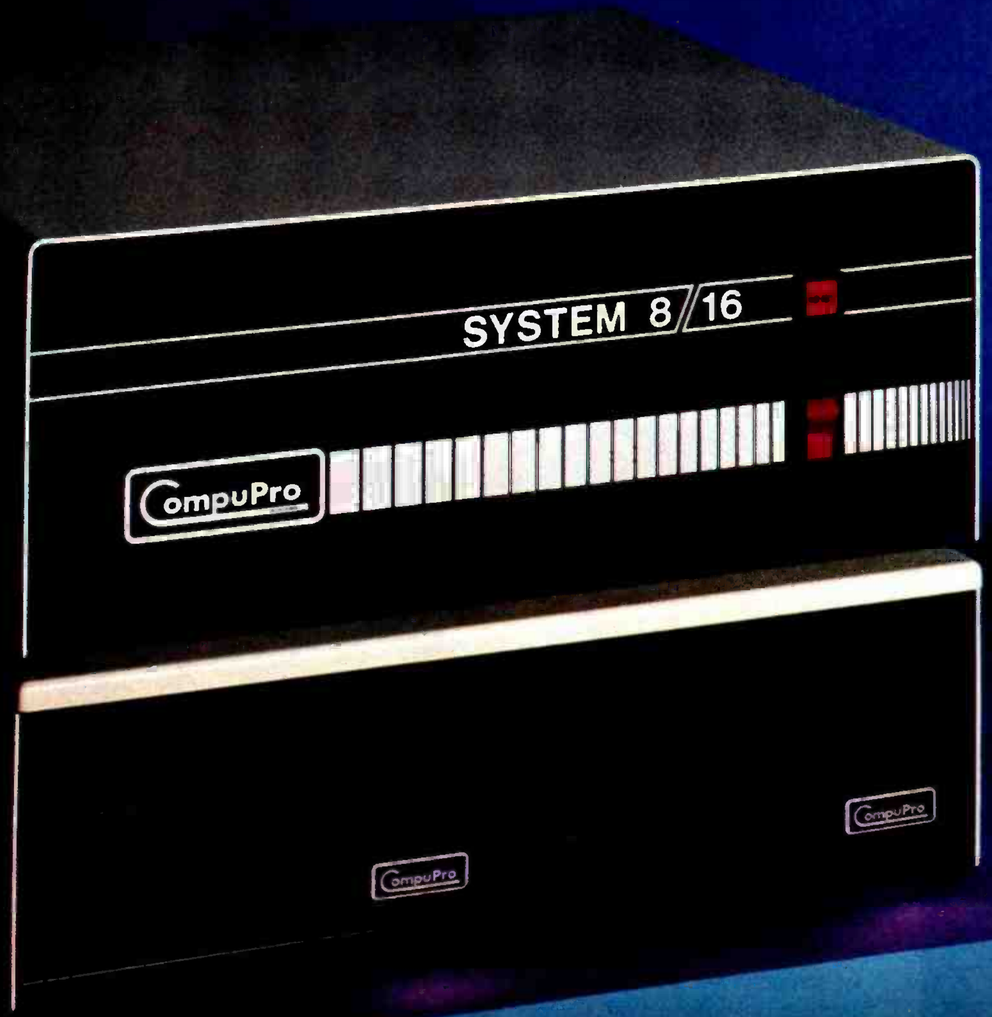

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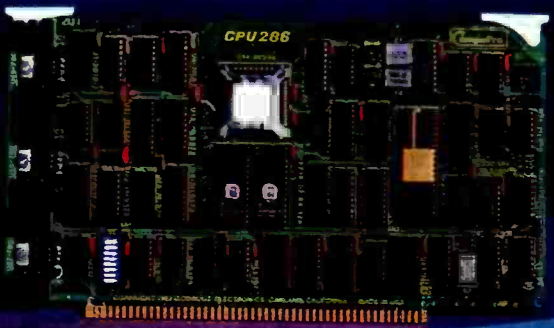

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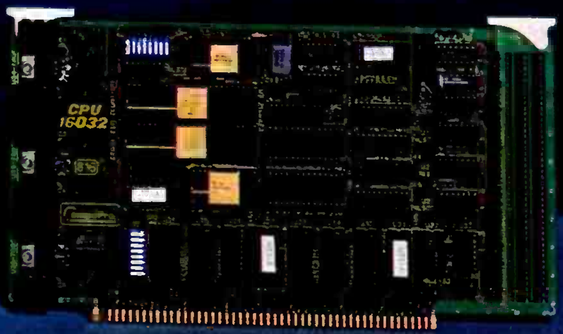

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choose a mouse over light pens and other input devices. Such research also recommended a black-text-on-white-background video display, which you call "hopeless for long-term word processing."

Finally, you make several misleading statements. You say that the Lisa is at fault for not having color graphics, which are "rapidly becoming industry standard." This is simply not the case. Machines like the IBM Personal Computer and the Texas Instruments Professional Computer have color, but most business software does not make routine use of it. The reason for this is simple: software vendors, attempting to maintain product portability to other computers, shy away from implementation-dependent features like color graphics. Also, the "imbecility of locking machine and software together" does not exist because the Lisa is sold only with legal copies of its software. The idea of Apple licensing the software to a network of Lisa machines does have merit and is a good compromise between paying for each copy and pirating multiple copies from one legal one.

I agree with you that "there are still some significant bugs" in this "pretty snazzy machine," but I think that Apple (or other companies) will iron them out as the price of such technology decreases and more variations of it become available to suit more people's needs. As it turns out, you are not alone in your dissatisfaction, as you will see from the next letter. . . . G. W.

I read "The Lisa Computer System" by Gregg Williams and "An Interview with Wayne Rosing, Bruce Daniels, and Larry Tesler" by Chris Morgan, Gregg Williams, and Phil Lemmons (February, pages 33 and 90) with hopes that I would learn some of the shortcomings of the Lisa. Instead, these articles, like so many others, read like they were written by Apple's marketing department.

I have not set eyes on a Lisa, but from what I know about the Star and the Worm (remember the Worm that was going to eat the Apple?), and from what I have read about the Lisa, I do not think that the Lisa will be the success that the media have presented.

I dislike being negative because the Lisa does have many marvelous features, which were well presented in your article. However, I think the mistakes made in designing the Lisa and its predecessors should be pointed out by someone.

Mistake #1: The philosophy that computer designers know what users need is arrogant and usually wrong. Every computer user has different desires and needs. The Apple II successfully caters to this market by allowing users to select a machine configuration to meet basic start-up requirements. Users can later purchase additional hardware and software from numerous sources. Users can also customize their machines or software, attaching all sorts of devices and making all kinds of modifications to both hardware and software.

It appears there is one configuration of hardware and software available to potential Lisa users. The Lisa software has six application programs for what appear to be basically word-processing applications. The graphics are excellent, but what if I am offended by the garbage-can concept? How do I change the graphics symbols to ones I prefer? How do I change the commands to ones I like?

What language was this all written in anyway, and why isn't it available to the user? These questions and their answers are missing from all the articles I've read about the Lisa and imply to me that its designers do not believe purchasers of the machine should modify what they have bought.

Mistake #2: The mouse. The mouse is an inexpensive graphics input device that is beloved by graduates of Stanford's computer science program. It has been around for about 15 years in a variety of forms. The Lisa's designers have improved upon the mouse by reducing the number of buttons on it to one. Whether they have removed the other problems with the mouse—poor reliability, intermittent behavior, and inability to move in a natural direction—remains to be seen.

The poor reliability and the intermittent behavior both result from the fact that mice get dirty rolling around on a table. Dirt gets into the potentiometers, which then have "bad spots" and eventually do not work at all. A bad spot is a spot on the display which you cannot point to. You can work around this by lifting the mouse and moving it so the bad spot moves too, but this rapidly becomes annoying.

The unnatural direction results from two wheels mounted perpendicularly to each other. To move diagonally, you need to move along the x-axis and then the y-axis rather than along a diagonal as you can with a joystick.

Because I have no experience with Lisa's mouse, these comments may be unfair. My experience is based on Star's mouse, which had these problems. Gregg Williams' article only pointed out the button improvement, so I assume the rest remains the same.

Mistake #3: The disk. Why the designers of Lisa needed a nonstandard disk package is beyond me. This will make the disks far more expensive with no great improvement in performance. That is, there is no great improvement in the amount of information being stored or in the speed of access. The reliability claim is nice, but in terms of reliability, floppy disks are not a weak link in a system. If anything, the mechanics of the disk need looking at, not the recording technique. The method of storing two directories is a good redundancy technique that can be done in standard packages.

Mistake #4: Performance. This is a difficult issue to evaluate by reading glowing articles about the Lisa. This is mostly a worry because of the size of the programs mentioned in the article and because of the lack of a display processor, not because of the chip chosen for the Lisa. I have seen old PDP-8 word processors with a tiny memory outperform 16-bit word processors with large memories, so it is a matter of software, not hardware.

If I were to check a Lisa, I would type in a page of text. Then I would block copy the page to create 2 pages of text, then block copy the 2 pages to create 4 pages and so forth until I had 128 pages. This would require only seven block copies and should be done relatively fast if the machine performs well. I would then go to page 50 and cut out a paragraph and insert it in page 1. I have done this on a variety of word processors. Some will not even allow a small number of block copies.

We will be seeing more small computers that use the Motorola 68000. I hope we will someday see one that shares Apple's original philosophy of letting users decide what they need.

Sabina Saib
1500 Holiday Hill
Goleta, CA 93117

Thank you for raising concerns that I have not heard elsewhere. You bring up some important points: why doesn't the Lisa allow you a choice of ways to do things? Is the mouse reliable enough and easy enough to use? Why did Apple choose an expensive, nonstandard floppy disk? Will the computer be responsive enough when dealing with large, "real-world" tasks? Let me respond to each of these in turn.

You say that the Lisa does not have the protean nature of the Apple II. That opinion is not quite fair to the Lisa computer; after all, it does have three expansion slots for extra hardware, and Apple will be releasing a "programmer's toolkit" that will allow third-party vendors to create whatever software they feel is best. Aren't these the very features you applaud the Apple II for? I grant that you will never have the wide variety of hardware and software add-ons for the Lisa that you have for the Apple II, but that is because of three factors. First, the Lisa doesn't need them—many Apple II add-ons correct deficiencies in that computer's design. Second, nobody has had time yet to develop new software and hardware for the Lisa. (Remember, when the Apple II was first introduced, nothing was available for it, either.) Third, the Lisa is a more expensive machine that will not sell as widely as the Apple II; this will significantly influence the number of vendors who will consider creating products for it.

Your criticism about the Lisa coming in only one configuration is certainly a valid one. Probably the only customization you will be able to do is what Apple allows you to do; the software is written in 68000 machine language and is too complex to be modified by the user. The Lisa computer is the first of an entirely new kind of computer. The computers that follow it will improve on the first design; if people like you convince the designers that they must include more customization to satisfy the potential user, they will probably do so.

I think your fears about possible unreliability in the mouse pointing device are unfounded. Of the many details I didn't have time to put in my product description of the Lisa (please note that the article was a description, not a review), one was that Apple designed a new kind of mouse that is meant to be cleaned by the user. The design also isolates the rolling ball from the decoding mechanism as much as possible so that dust and eraser shavings entering the mouse have little effect on the performance of the device. Also, the mouse I tested rolled equally well in all directions; I did not have any difficulty making diagonal movements with it.

I agree with you that the Lisa floppy disks will be more expensive than similar disks because of their nonstandard design. However, I disagree with your opinion that software enhancements such as redundant directories "can be done in

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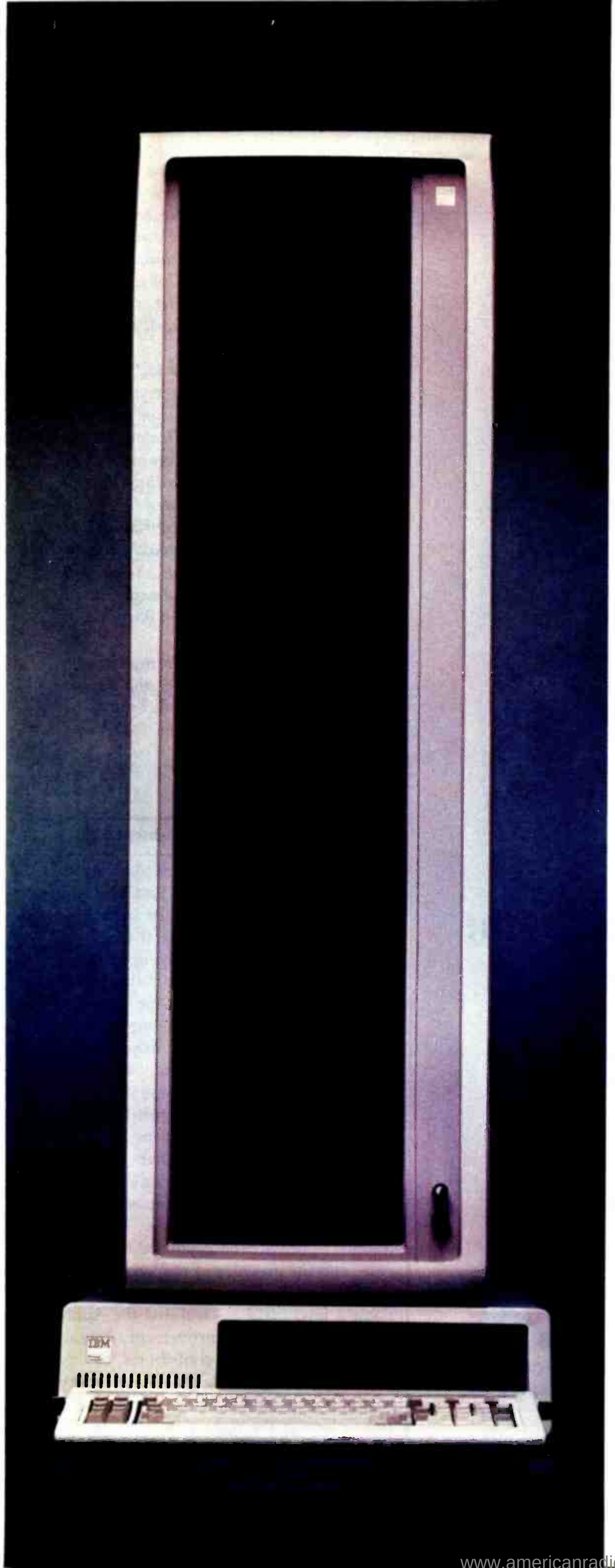

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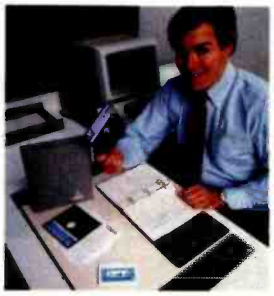

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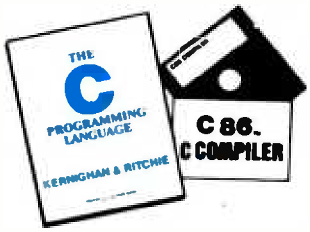

standard packages." The place to put such enhancements is in the operating system, so they will be there regardless of the opinions of individual software designers who will either reinvent the wheel and charge you for it or leave it out. Redundant directories take up relatively little space and will save you a lot of grief if they are ever needed; other operating system designers would do well to follow Apple's example.

I like your word-processor test and will keep it in mind for future evaluations. However, I'm not sure you can fault the Lisa for not having a dedicated video-display processor. As I said on page 43 of the description, ". . . according to the designers, the use of a dedicated hardware graphics chip would limit itself and slow down the system. . . ." It would be hard to check this point directly, so we will have to rely on the technical explanation given by the Lisa designers on page 106 of the February BYTE.

I hope you find some merit in my opinions. Thank you for writing; the quality of future microcomputers will, I think, be influenced by discussions such as ours. . . . G. W.

A Slight Improvement

It was ironic that the reviews of the two new Apple products, the Lisa and the Apple IIe, both appeared in the same issue (February, pages 33 and 68). It was hard for me to believe that both computers are made by the same company. In the case of the Lisa, it sounds like Apple did a superior job of design and implementation. The modular approach displayed by both the hardware and software demonstrates a mature, serious product.

On the other hand, the Apple IIe seems like only a slight improvement over the engineering hodge-podge that was the Apple II. For example, checking a game-paddle port to see if a shift key is pressed, pressing Control-R (unless between quotes) to restrict the keyboard to uppercase, and the presence of numerous seemingly incompatible graphic modes (to name a few) make me feel that the Apple IIe isn't much of an improvement. Actually, the whole thing contributes to my suspicion that the Apple II's primary reason for success was its being at the right place at the right time. The design errors (or perhaps oversights) in the Apple II were serious enough to make the inventors of replacement processor cards, 80 column boards, and the like rich. While there's no doubt that the Apple IIe is an attempt to rectify some of the most serious difficulties, further repackaging and advertising hype don't contribute to a solution.

Jon Forrest, Computer System Manager
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Monte Carlo Fix

Roger C. Millikan's article "The Magic of the Monte Carlo Method" (February, page 371) leaves out a very important ingredient in the program for finding the area under a curve. The author should have made it clear that the given program will work only for functions that are evaluated in an area of one square unit (as was the example). For all other examples line 2115 of listing 2 should be changed to:

```
2115 PRINT" the integral is ";A*U/N
```

where A is the area over which the function is being evaluated. This must be done because U/N is an approximation of the ratio of the area under the curve to the total area A. For example, to find the area under the example curve Y=X*X when X varies from 0 to 2, the value of A would be 8 because the area over which the function is being evaluated is a rectangle of width 2 (X varies from 0 to 2) and length 4 (Y varies from 0 to 4). Of course, the corresponding RND functions must also be changed.

I believe this added bit of information would make the program much easier for the average user to adapt to his or her application.

Ronald W. Guffin
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Bethel, AK 99559

Alternatives to the Monte Carlo Method

I agree with Roger C. Millikan that the Monte Carlo Method is an important statistical tool (February, page 371). That said, I object to a number of suggestions in his article.

It should be clearly understood that the Monte Carlo method is a shotgun technique, one that tends to converge slowly compared to methods derived analytically from the specific parameters of the problem in question. It is also a statistical technique, meaning that any Monte Carlo simulation should generate a sample standard deviation and/or a distribution histogram where feasible. Clearly both results should have been generated in the problem of the staggering drunk.

Millikan's example of finding the area under a parabola is as badly chosen as possible—rather like demonstrating recursion through the use of the factorial function. Any textbook on numerical methods is full of simple techniques to find areas under curves—a process known as numerical integration or numerical quadrature. Simpson's Rule, for example, would converge more rapidly in almost every case and would have a lower margin of error.

Finally, Millikan's area example does not even converge properly, probably because of a lack of refinement in assigning areas to points where the point is on the curve or is very close to it.

In any case, there is no point in using a random-number generator where you are going to use as many as 10,000 trials. It would be simpler to cover the unit square with 10,000 evenly spaced points.

William J. Sohn
293 Crest Dr.
Tarrytown, NY 10591

Apple-Cat Changes

When I read James A. Pope's review of the Apple-Cat II (January, page 110) my initial reaction was akin to that of a parent listening intently to a guidance counselor's evaluation of a precocious child. I adored the overall favorable findings and wanted to interrupt with a rebuttal every time a negative comment was made.

However, after carefully rereading Pope's article, I must admit it is both fair in its evaluation and constructive in its recommendations. In fact, most of the changes he suggested for the Apple-Cat II have already been included in the product available today.

Let me get specific. The review is based on an early version of our software (ComWare II 3.2), which was current through mid-1982. Since then we have updated the software three times and revised the docu-

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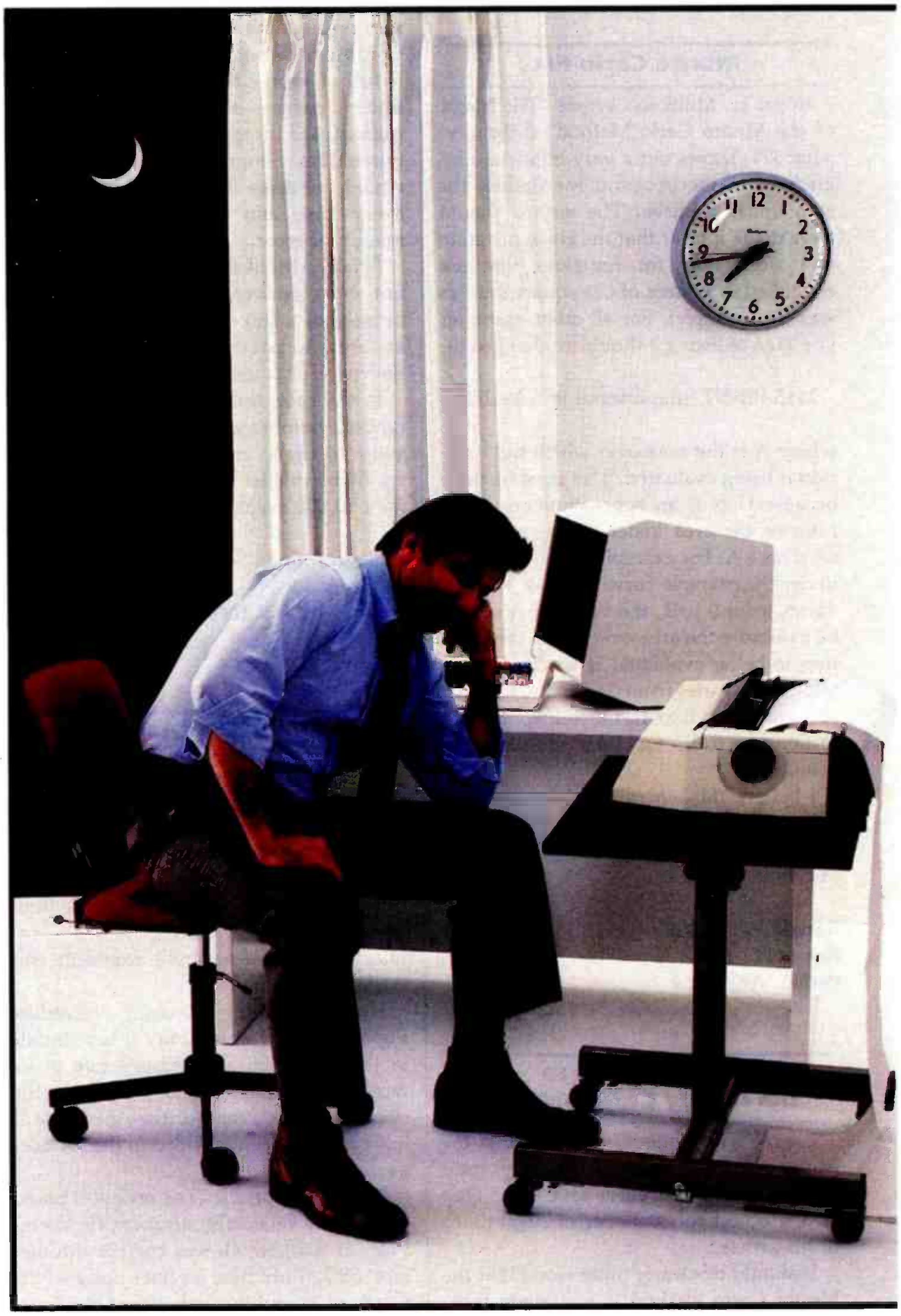

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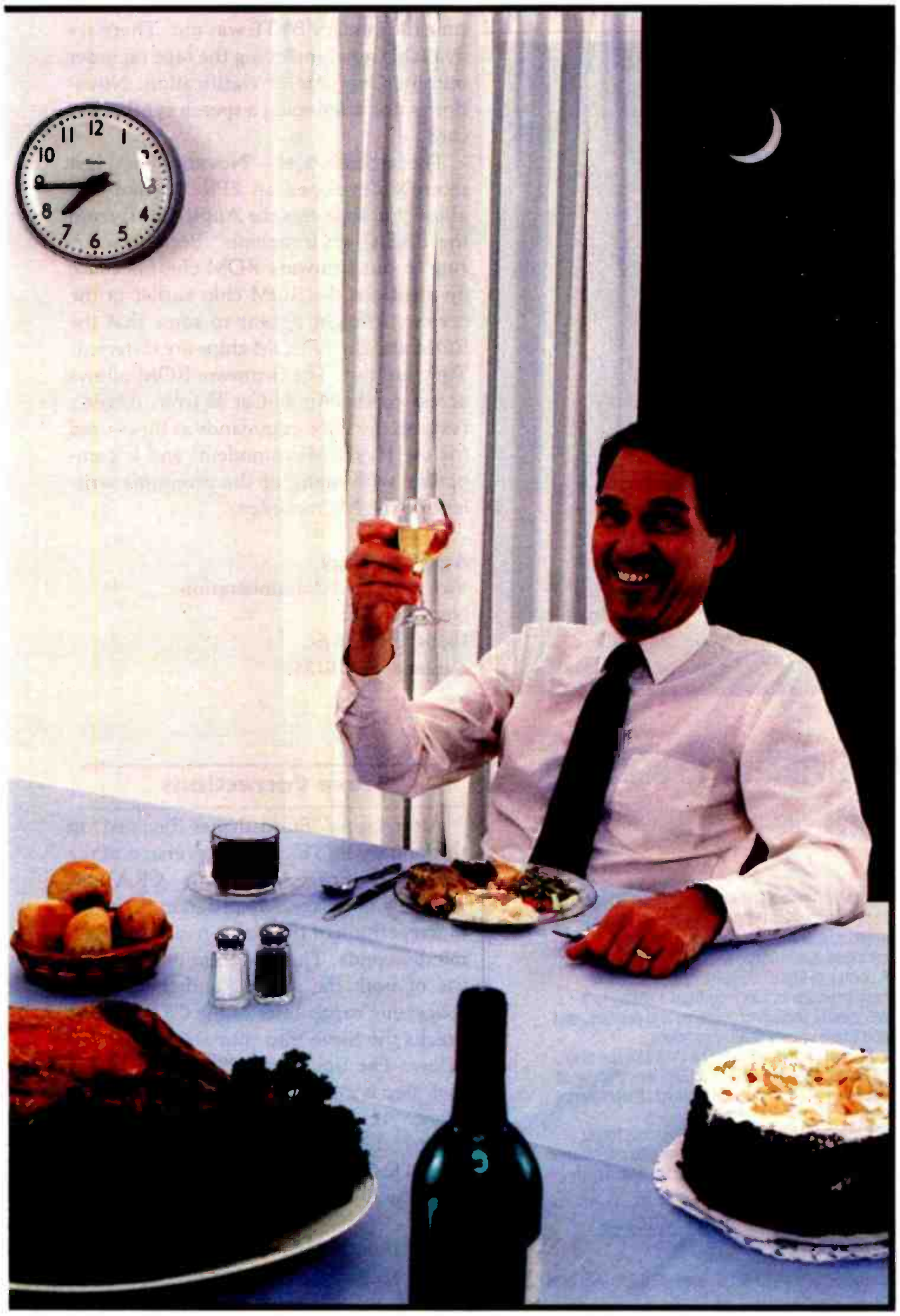

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mentation. For example, the review's "At a Glance" box designates the software as DOS 3.2. Since June of last year the system has been formatted in the more widely used DOS 3.3 system. The "At a Glance" box also indicates that the Apple-Cat II is designed for the Apple II Plus. This could be misleading because the system is engineered for the Apple II as well.

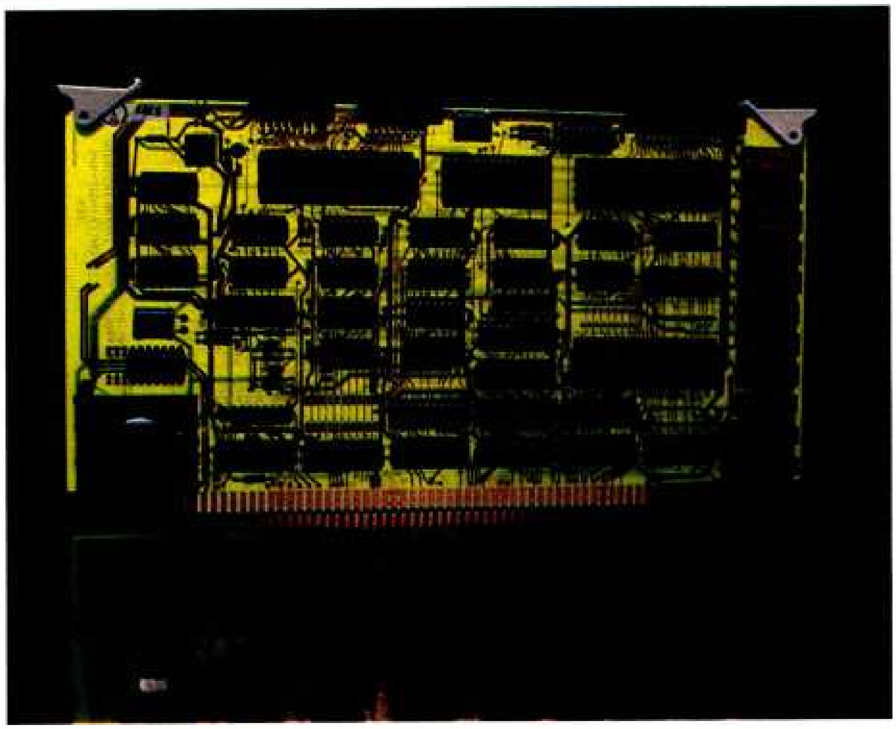
Pope wasn't thrilled by our documentation. Frankly, neither were we. We've published a new owner's manual and Com-Ware II operating instructions booklet. We've done our best in this new literature to state instructions and descriptions clearly, to organize the content in the most logical manner and to represent exactly what is included with the unit and what are optional features or equipment. With regard to optional equipment, Pope felt that the expansion module should have been part of the basic system rather than a $39 add-on. Here we disagree. The expansion module provides for features not all customers want or need, particularly to start up. To include it in the basic system would force customers to pay for something they might not use.

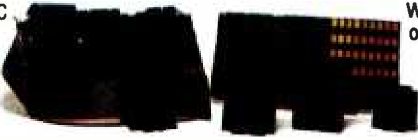
The table of Com-Ware II features used in the article is accurate but outdated. Our newest revision (5.0) includes an additional four functions. All Apple-Cat II buyers are given the opportunity to obtain each new Com-Ware revision free of charge. They just send us their old disk and we send them an updated one.

The article listed a number of expansion capabilities and conjectured that they would probably all be available by the time the January BYTE was out. These are available now, including the tape recorder output. One note of clarification: Novation is not developing a speech synthesizer card.

The article states, "Novation has just recently developed an EPROM that will allow you to access the Apple-Cat II from the BASIC environment." Pope is referring to our firmware ROM chip. Because he mentions the ROM chip earlier in the review, it might appear to some that the ROM and the EPROM chips are different. They are not. The firmware ROM allows access to the Apple-Cat II from BASIC, features the same commands as those used for the Hayes Micromodem, and is compatible with many of the programs written for the Micromodem.

Agnes A. Nagy
Vice President-Administration
Novation Inc.
18664 Oxnard St.
Tarzana, CA 91356





Sieve Corrections

After seeing "Eratosthenes Revisted" in the January BYTE, I wrote a version of the Sieve of Eratosthenes in CRAY-1S assembly language. My program performs one repetition of the Sieve in exactly 385.7 microseconds. This program makes good use of both the scalar- and the vector-processing capabilities of the CRAY-1S. It breaks the Sieve into four steps, as given below. The timing (in microseconds) for each step is interesting: initializing the flag array, 111.3; unflagging multiples of primes, 156.9; counting the number of primes found, 117.1; and searching for the last prime found, 0.4. The times total 385.7.

Of this 385.7 microseconds, the CRAY-1S's memory is fully occupied for at least 361.375 microseconds. Thus, at

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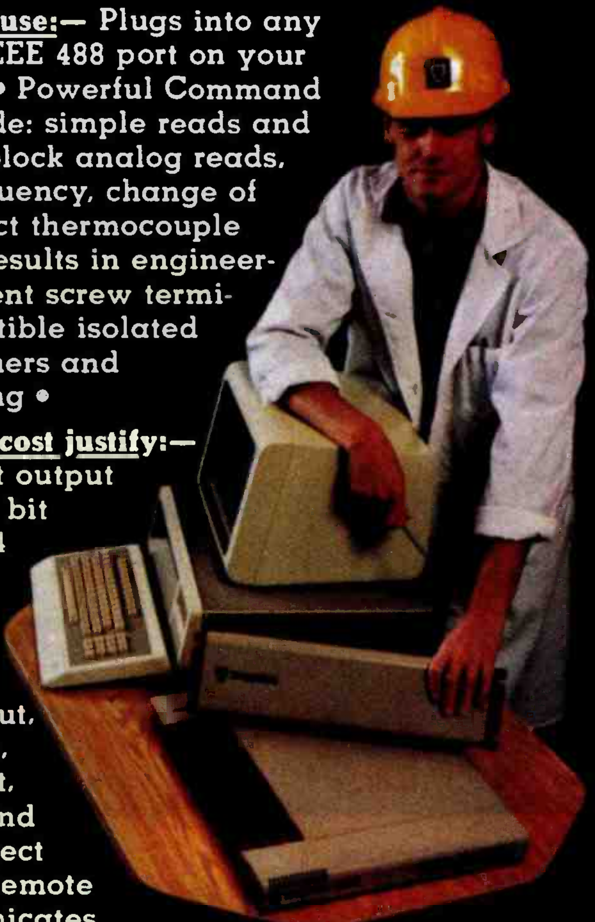

best, the program could be improved by only a few percent. I believe it is unlikely that more than one or two microseconds of processing time could actually be eliminated.

For 10 repetitions of the Sieve, multiply by 10 and add 1.275 microseconds for loop counting, giving 3859 microseconds. This number is about one-half the fastest time reported in the article, and returns the CRAY-1S to its rightful position as the world's fastest computer.

David S. Dodson
3824 South 255th Place
Kent, WA 98032

I have just seen Jim Gilbreath and Gary Gilbreath's article, "Eratosthenes Revisited: Once More Through the Sieve" (January, page 283).

I was dismayed to find that my contributions for the Prime 300 computer and the PRIMOS operating system were printed incorrectly. The numbers printed were *per iteration*. They have *not* been "adjusted for . . . 10 iterations." Also the times for BASIC and COBOL are reversed. My contributions to table 1, adjusted, should read: assembly language, 4.5; FORTRAN, 7.8; FORTH (RLM), 104.0; BASIC, 504.0; and COBOL, 6707.0.

This gives PRIME 300 COBOL the dubious distinction of being the slowest computer/language combination in the article.

Richard L. Maurer
National Life and Accident Insurance Company
National Life Center
Nashville, TN 37250 ■

BYTE's Bits

Z100 Software Directory Being Compiled

Zenith Data Systems is compiling a directory of available software for its Z100 desktop computer. The Z100, a dual 16/32-bit computer, uses Digital Research's CP/M as its 8-bit operating system. Z-DOS, marketed by Microsoft as MS-DOS, is used for 16-bit processing. Software vendors with Z100-compatible packages are asked to contact Victoria M. Lerner, Zenith Data Systems Corp., 1900 North Austin Ave., Chicago, IL 60639. ■

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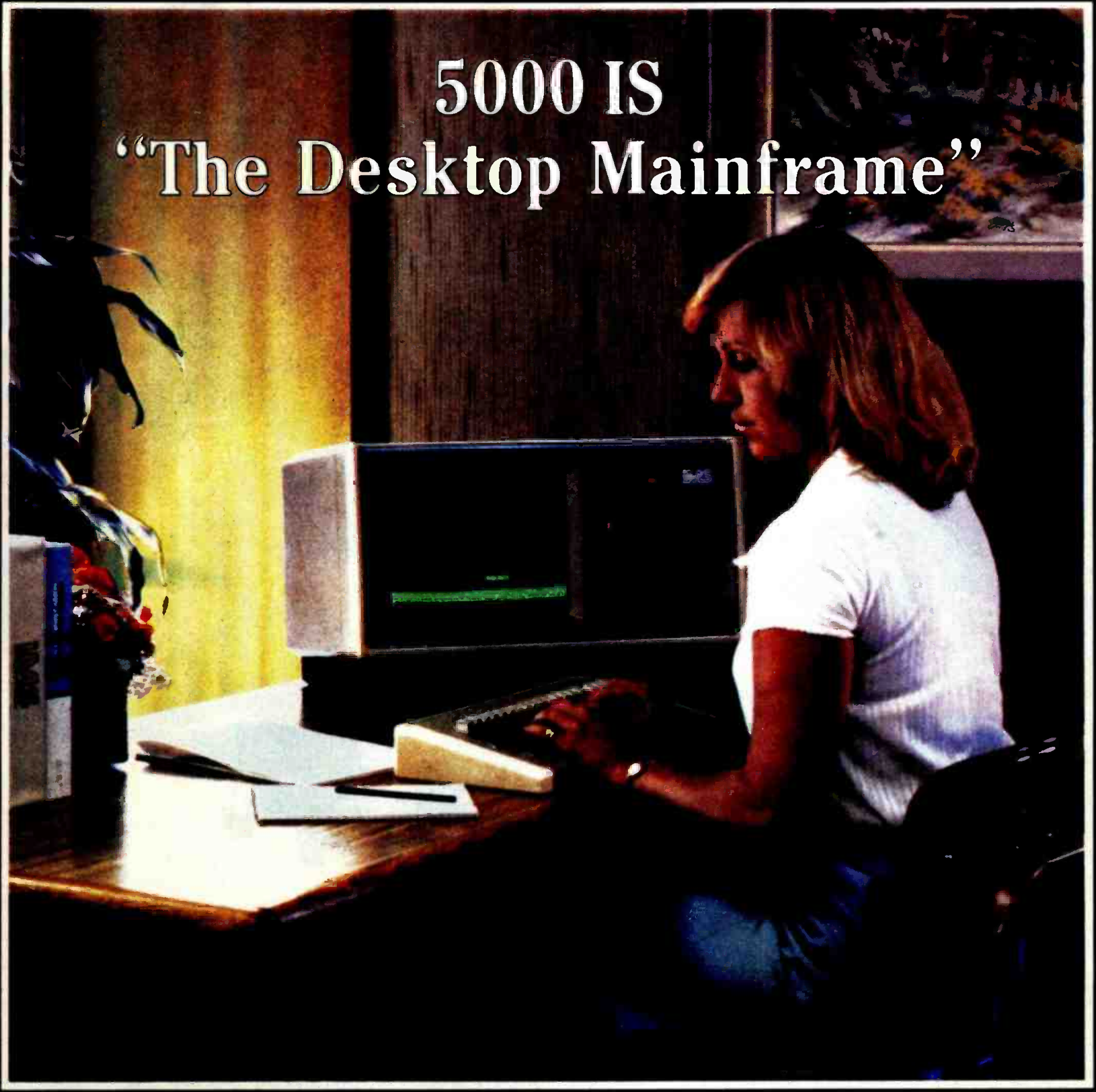

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Steve Ciarcia
POB 582
Glastonbury, CT 06033

During the past few years I have presented four different computer speech-synthesizer projects (see references). With each article I have tried to present the latest technology and describe successively more cost-effective synthesis methods. This month I'd like to describe a new variation on digitized speech that uses adaptive differential pulse-code modulation.

What Is Digitized Speech?

Computers communicate in a digital language, but the language of humans is analog. If computers are to speak as we do, this obvious barrier must be overcome. Fortunately for us, a number of techniques have been devised to allow a computer to synthesize a human voice, some of them quite effective.

Some synthesized voices employ electronic circuitry to simulate the throat and vocal tract, but the purest form of machine-generated speech is simply a digital recording of an actual human voice, using digital circuitry to mimic the action of a tape recorder. For example, in most parts of the United States you can dial a telephone number and hear a recorded voice saying something like, 'The number you have reached has been changed. The new number is 924-9281." The voice is distinctly human in quality, highly intelligible, and machine-generated—an excellent example of digitized speech. Although it uses a lot of memory, digitized speech is the most intelligible machine-generated speech currently possible.

Photo 1: *You use a microphone to record words in high-intelligibility ADPCM speech synthesis. The stored vocabulary retains the inflection, accents, and intonation of the human speaker. If you need your computer to speak a low-pitched, mid-Connecticut drawl, let me know.*

The basic concepts of producing stored digital speech are fairly simple. The process begins with data acquisition. A voice waveform can be treated like any other fluctuating voltage input; the computer can record the waveform by periodically taking a sample of the signal's voltage through an analog-to-digital (A/D) converter and storing it as a binary value. (The number of samples needed per second depends upon the frequency of the input signal.) Once the samples have been stored, the computer can recreate the original waveform by sequentially sending the stored values to a digital-to-analog (D/A) converter at the same rate as the original sampling.

Pulse-Code Modulation

A common method of representing continuous analog values in digital form is pulse-code modulation, or PCM. In PCM, distinct binary representations (pulse codes) are chosen for a finite number of points along the continuum of possible states. Whenever the value is being measured and it falls between two encoded points, the code for the closer point is used.

Special thanks to Bill Curlew for his software expertise.

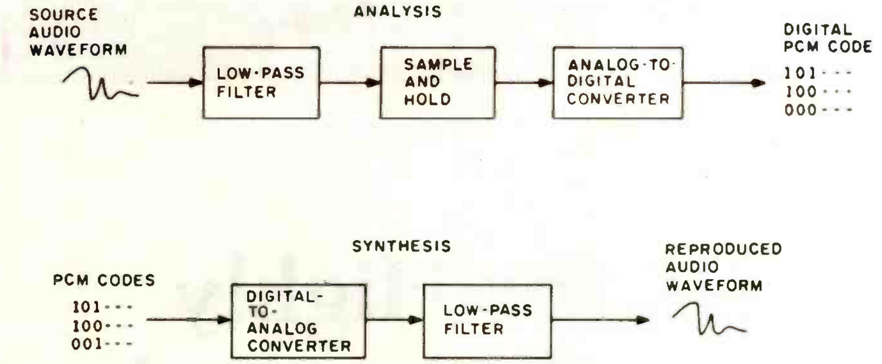


Figure 1: *Functional block diagram of a digitized speech-reproduction system that employs pulse-code modulation.*

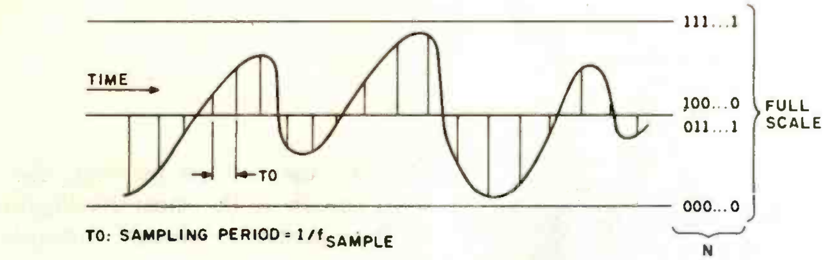


Figure 2: *Waveform sampling by pulse-code modulation (PCM). The interval between samples is T0; the sampling frequency is the reciprocal of the interval. Each sample of PCM data consists of N bits; the leftmost is the most significant bit and the rightmost is the least significant bit.*

(This process is called *quantization*: the dividing of the range of values of a wave into subranges, each of which is represented by an assigned value.) A series of these pulse codes can be transmitted in a pulse train, resulting in a pulse-code modulated signal.

Because the samples of digitized speech referred to above are stored in the form of digital pulses, the stored speech waveform can be thought of as an example of pulse-code modulation. Figure 1 shows a block diagram of a speech synthesizer that reproduces speech stored in pulse-code-modulated form.

Sampling Rates and Other Messy Stuff

The sampling rate you use in recording any signal must be chosen with awareness of a theoretical limit called the *Nyquist interval*. At the very minimum, the sampling rate must be at least twice the highest frequency found in the input signal. With an input bandwidth of 2 kHz (kilohertz), adequate for intelligible speech, the sampling frequency would have to be at least 4 kHz.

This rule holds strictly true only when an ideal low-pass filter is used on the output of the D/A converter.

The ear is sensitive, and too coarse a reproduction will sound unnatural or even unintelligible.

In real equipment, sampling rates of 3 or 4 times the input bandwidth are sometimes necessary. So for speech reproduction, a sampling rate around 6 or 8 kHz is good. (Optical digitized-music recordings, which are just now coming to market, use 16-bit A/D conversion at a 50-kHz sample rate to achieve high fidelity. The resulting data rate is 800,000 bps—bits per second.)

Other technical limitations crop up. Once you have determined the sampling rate, you must consider the resolution of the analog-to-digital converter. A/D converters operate in discrete steps (quanta) rather than continuous levels, as shown in figure 2. If a 4-bit A/D converter is used, then only 16 values are available to define the signal. Any reading could potentially be in error by ±1/16, or about 6 percent. A 12-bit converter, which has 4096 potential levels, would have a possible quantization error of only 0.02 percent.

Achieving Fidelity

In dealing with analog voice signals, we must accurately reproduce the input signal for it to be understood. The ear is sensitive, and too coarse a reproduction will sound unnatural or even unintelligible.

A direct relationship exists between the PCM data rate and reproduced speech quality. Let's consider a case in which we have an 8-kHz sampling rate. If we use 12-bit A/D conversion, then the data rate (in bits per second) is found using the following equation:

$$\begin{aligned}\text{bit rate} &= \text{sample rate} \times \text{conversion bits}\\ &= 8000\ \text{Hz} \times 12\ \text{bits}\\ &= 96{,}000\ \text{bits/second}\end{aligned}$$

Using standard PCM on a voice signal with a 4-kHz bandwidth would require a 96,000-bps data rate. The average personal computer could store only about 8 seconds of speech in its 64K-byte memory.

The data rate can be reduced somewhat by using an 8-bit A/D converter rather than a 12-bit unit. The raw data rate now becomes 8000 × 8 or 64,000 bps. (This reduces the signal-to-noise ratio from 66 to 42 dB (decibels), but the sound quality is more than adequate for experimentation. For commercial applications, however, I recommend a 12-bit converter.)

Delta Modulation

The pulse-code modulation we

have been examining uses no data compression. In playback, the data bits representing the absolute values of each successive signal sample are sent to a full-resolution D/A converter and reproduced at the same rate at which they were recorded: 96,000 bps in, 96,000 bps out. The circuit can operate with no assumptions made about the signal it is to process.

On the other hand, voice waveforms contain much redundant data. Long periods of silence are interspersed with sounds that vary in pitch slowly. If you take some time to analyze the A/D samples, you will notice that the changes are, for the most part, gradual and that the variations in the signal between adjacent samples are a limited portion of the full dynamic range.

One method of reducing the data rate used in PCM voice reproduction is called *delta modulation*. This process assumes that the input signal's waveform has a fairly uniform and predictable slope (rate of rising and falling). Rather than storing an 8- or 12-bit quantity for each sample, a delta modulator stores only a single bit. When the computer samples the input signal from the A/D converter, it compares the current reading to the preceding sample. If amplitude of the new sample is greater, then the computer stores a bit value of 1. Conversely, if the new sample is less, then a 0 will be stored. Figure 3 shows how this works. Reproduction of the waveform is accomplished by sending the stored bits in sequence to the output, where their values are integrated.

But, like other techniques, delta modulation has limitations, one of them the familiar sampling-rate restriction. Because only a single bit changes between samples, the rate at which samples are taken must be sufficiently fast that no significant information is lost from the input signal. Furthermore, if the slope of the input waveform varies a lot, the reproduced waveform may be audibly distorted. So using delta modulation may not reduce the data rate much, although there are many different variant schemes, and it's difficult to

(3a)

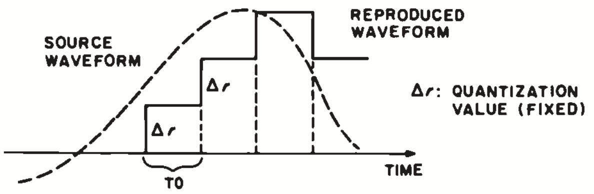


Figure 3a: *Waveform sampling by delta modulation. Each sample of the source waveform is tested to see if its amplitude is higher or lower (within the resolution of a fixed quantization value Δr—delta-r) than that of the previous sample. If the amplitude is higher, the single-bit delta-modulated encoding value is set to 1; if lower, the encoding value is set to 0.*

(3b)

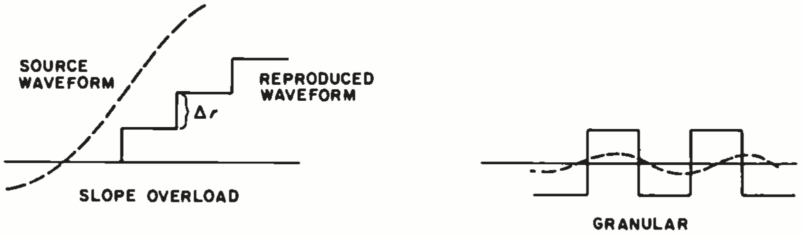


Figure 3b: *Two potential problems occurring in delta modulation. When the source waveform changes too rapidly, the fixed quantization value may be too small to express the full change in the input; this slope overload causes a compliance error. Or when there is little change in the input waveform (at the extreme, a DC signal), vertical deflection in the quantization value results in granular noise in the output.*

Competing Digitizing Methods

By the time you read this, you may have heard the results of a standardization proceeding that put two of the speech-digitizing methods discussed here in competition. (See reference 7.)

American Telephone and Telegraph (AT & T), in the throes of beginning its divestiture of its 22 local Bell operating companies (BOCs), submitted a proposal to the CCITT (Comité Consultatif International Téléphonique et Télégraphique) to standardize a certain form of adaptive differential pulse-code modulation as the worldwide preferred method of digitizing voice telephone signals for long-distance transmission. The proposed CCITT scheme uses a 4-bit sampling size with an 8-kHz sampling rate, for a 32,000-bps overall data rate. This would be a change from the two different 64,000-bps digitizing systems now in use.

A competing digitizing scheme, developed by Satellite Business Systems (SBS—a company jointly owned by IBM, Comsat, and Aetna Life & Casualty), employs delta modulation: 1-bit samples taken at a rate of 32 kHz, arriving at the same 32,000-bps data rate by a completely different route.

Standards published by the CCITT are called "recommendations," but they are quite strictly followed in most regions of the globe.

Telecommunication experts outside of AT & T have expressed concerns that the local BOCs and the independent long-distance common carriers will face both financial and technical problems in upgrading equipment to interface with the proposed CCITT 32,000-bps ADPCM circuits. At this writing, it is not known when AT & T will begin installing the new system. . . . **R. S. S.**

predict which is optimal in a given situation.

The most effective application of delta modulation that I have observed is the technique developed by Dr. Forest Moser at the University of California and implemented in the National Semiconductor Digitalker voice-synthesis chip set (see reference 1). However, while the Digitalker's process is definitely a variant of delta modulation, the data-compression and zero-phase-encoding algorithms that produce the stored bit patterns take hours of processing per word; it's very difficult for you to program your own custom vocabulary.

Differential PCM

We can actually reduce the amount of data stored for reproduction of speech by using a concept related to delta modulation as follows. When the speech waveform is being sampled, for each sample a value is stored that represents the amplitude difference between samples. This scheme, called *differential pulse-code modulation*, or DPCM, allows more that a single bit of difference between stored samples, accommodating more variation in the input waveform before severe distortion sets in. The DPCM value can be expressed as a fraction of the allowed input range or the absolute difference between samples (see figure 4).

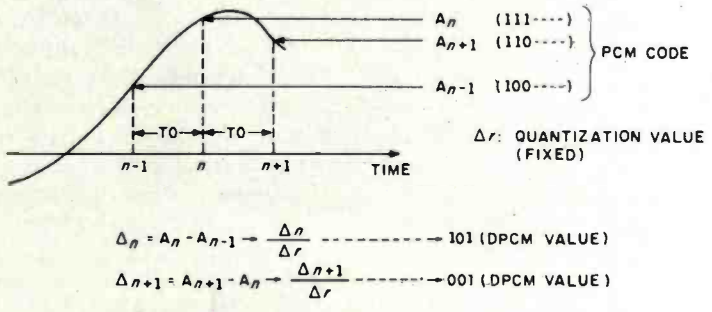


Figure 4: *Differential pulse-code modulation (DPCM) is an attempt to reduce the amount of data stored or transmitted, as compared with regular PCM. For each sample, the difference between the previous PCM code and the current code is expressed in terms of a fixed quantization value Δr (delta-r), which must be chosen with attention to the characteristics of the source waveform. If too large or small a quantization value is used, compliance errors occur.*

DPCM exhibits some of the same limitations as simple delta modulation but to a lesser degree. Only when the difference between samples is greater than the maximum DPCM-encoding value will distortion (called a *compliance error*) occur. Then the only solution is to reduce the input bandwidth or raise the sampling frequency.

ADPCM is a specialized form of PCM that offers significantly improved intelligibility at lower data rates.

Adaptive Differential PCM

The real breakthrough in digitized speech is the technique known as *adaptive differential pulse-code modulation* (ADPCM), a specialized form of PCM that offers significantly improved intelligibility at lower data rates. This system was devised to overcome the defects of the delta-modulation techniques described thus far while still reducing the overall data rate and improving the output's compliance with the source waveform.

ADPCM improves upon DPCM by dynamically varying the quantization between samples depending upon their rate of change while maintaining a low bit rate, condensing 12-bit PCM samples into only 3 or 4 bits. (The variations in the quantization value are regulated with regard to the characteristic complex sine waves that occur in voice. The technique is therefore not applicable to other kinds of signals, such as square waves.)

In ADPCM, each sample's encoding is derived by a complicated procedure that includes the following steps: a PCM-value differential *dn* is obtained by subtracting the previous PCM-code value from the current value; the quantization value Δ*n* (delta-*n*) is obtained by multiplying the previous quantization value times a coefficient times the absolute value of the previous PCM-code value; the PCM-value differential is then expressed in terms of the quantization value and encoded in four bits, as shown in figure 5.

Build an ADPCM Speech Analyzer/Synthesizer

The Oki Semiconductor Corporation produces a number of integrated circuits (ICs) that perform ADPCM encoding and decoding. Of these, the MSM5218RS and the MSM5205RS are worthy of attention. The 5218 is designed to perform both storing and reproducing of digitized speech, while the 5205 provides only the reproducing function. Using these CMOS (complementary metal-oxide semiconductor) components, we can put together a cost-effective speech-synthesis system that produces highly intelligible output and yet makes efficient use of memory.

Figure 6 on page 40 is the block diagram of the MSM5218RS IC. It is designed to work with 12-bit analog-to-digital converters and contains both an ADPCM analyzer and synthesizer. An internal 10-bit D/A converter is provided to reconstruct the waveform where direct analog output is wanted, or the decoded PCM data may be routed to an external D/A converter.

The schematic in figure 7 on pages 42 and 43 diagrams a speech-synthesis circuit built around this chip (see photo 2 on page 41). In the

(5a)

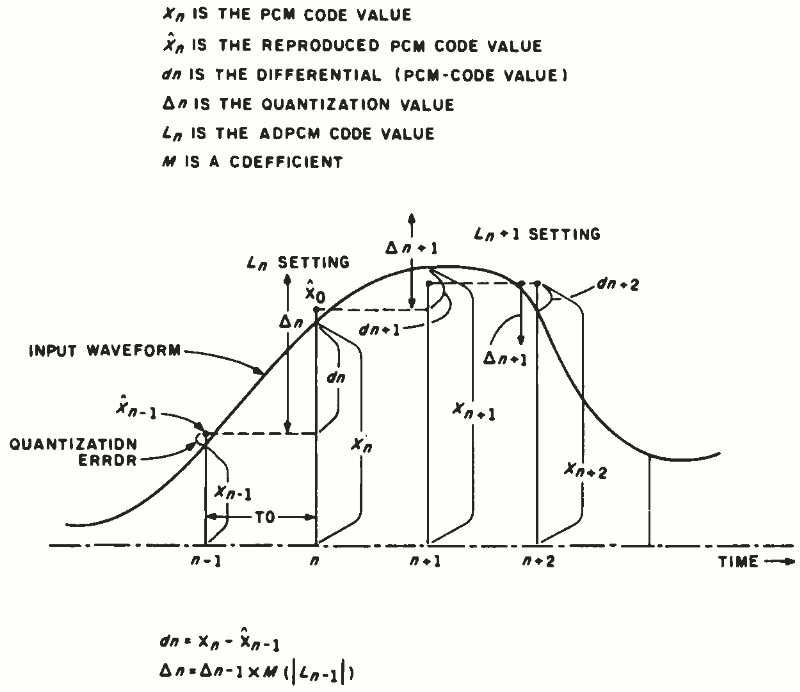


Figure 5: *Adaptive differential pulse-code modulation (ADPCM) improves upon DPCM by dynamically varying the quantization between samples, depending upon their rate of change, while maintaining a low bit rate, condensing 12-bit PCM samples into only 3 or 4 bits.*

In ADPCM, each sample's encoding is derived by a procedure that includes the following steps. A PCM-value differential dn is obtained by subtracting the previous PCM-code value from the current value. The quantization value Δn (delta-n) is obtained by multiplying the previous quantization value times a coefficient times the absolute value of the previous PCM-code value. The PCM-value differential is then expressed in terms of the quantization value and encoded in four bits. The mathematical relations are shown here in figure 5a, whereas figure 5b shows a typical encoded waveform.

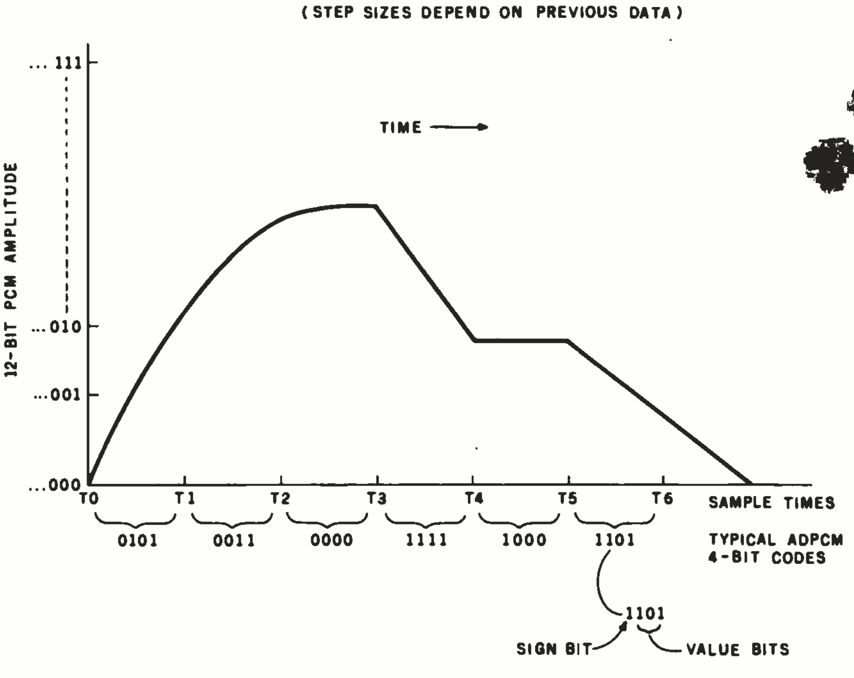
circuit, a low-cost 8-bit A/D converter is used in place of a higher-resolution, more costly 12-bit converter. The Oki MSM5204RS 8-bit CMOS A/D converter, employed here, uses a successive-capacitor-ladder conversion system. It also incorporates a sample-and-hold stage that enables direct input of rapidly changing analog signals. An external clock signal provides timing for the chip; the clock's frequency is not critical and can be anywhere from 450 to 500 kHz.

The frequency bandwidth of the signal input to the A/D converter is limited by an active low-pass filter, IC2, an Oki ALP-2 filter with a 1.7-kHz cutoff frequency. Attenuation is 18 dB per octave above the cutoff frequency. (Although frequencies up to 4 kHz can theoretically be captured with an 8-kHz sample rate, in this application the lower cutoff frequency gives better-sounding reproduction.)

A/D Conversion in Operation

Data conversion is started when the $\overline{\text{S·CON}}$ (start conversion) line (pin 13) of the MSM5218 forces the write line ($\overline{\text{WR}}$), pin 15) on the 5204

(5b)



ADPCM CODE STRUCTURE

SIGN BIT	VALUE BITS	COMMENTS	
1	000	MINIMUM EXCURSION	NEGATIVE DIRECTION
1	100	MEDIUM EXCURSION	
1	111	MAXIMUM EXCURSION	
0	000	MINIMUM EXCURSION	POSITIVE DIRECTION
0	100	MEDIUM EXCURSION	
0	111	MAXIMUM EXCURSION	

A/D converter into a low state. After conversion is complete, the A/D read line ($\overline{RD}$), pin 14) is brought low to latch the data onto the 5204's output lines. At a clock rate of 450 kHz, the 5204 completes the 8-bit conversion in approximately 73 microseconds.

The digital representation of the input data from the 5204 is fed into a CD4014 serial-to-parallel converter (IC9) for transposition into the serial format required by the MSM5218's input. Because we are using an 8-bit converter and the MSM5218 expects 12-bit input, the four remaining low-order bits are clocked in as zeros by the CD4024 counter (IC7) and sections of the quad NAND gate (IC6). These components provide four extra SI·CK (serial input OR clock) pulses with zero-logic-level data.

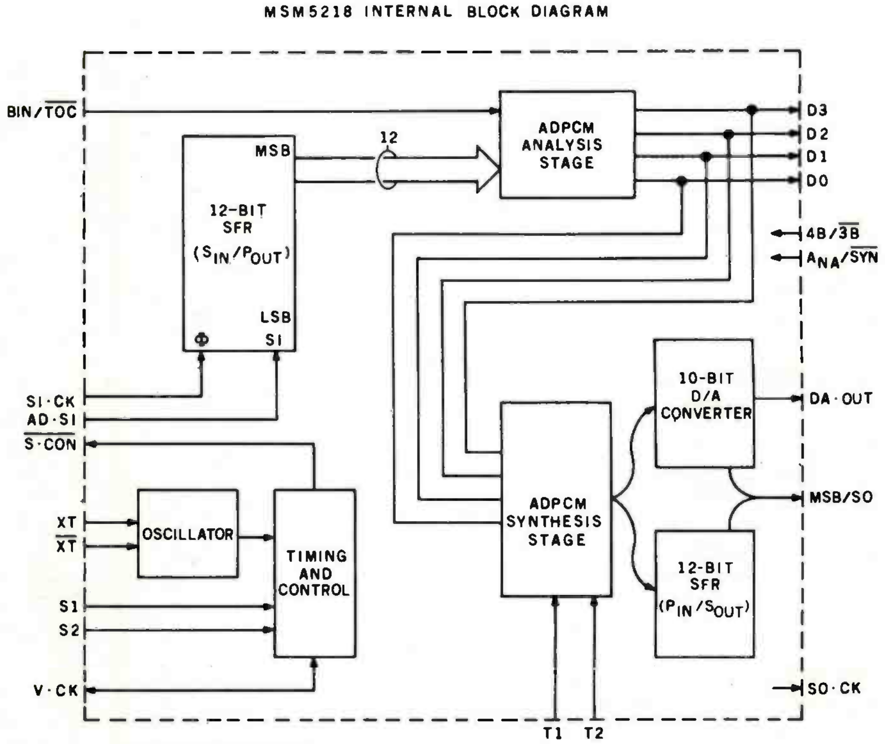
Selectable Parameters

The MSM5218 can analyze or synthesize ADPCM speech using a variable sampling rate. Three internal preset VCLOCK rates can be selected, or an externally supplied signal up to 384 kHz can be used. The logic levels on the 5218's pins S1 and S2 define the VCLOCK reference in both analysis and synthesis modes, as shown in the lower right corner of figure 7. The host computer, or any other external hardware, synchronizes itself with the 5218 by monitoring the state and transition timing of the VCLOCK signal (pin 1).

In addition to selecting the VCLOCK rate, you can choose encoding of the ADPCM data in either 3 or 4 bits, depending upon the logic level on the 4B/$\overline{3B}$ line (pin 7). A logic 1 selects 4-bit ADPCM values.

Data Transfer and Rates

In the dual-function MSM5218, the data lines D0 through D3 are bidirectional and used either for output of analyzed ADPCM data (for storage) or for input to the speech-synthesizer circuitry. In the analysis mode (with pin 6 held high), the current encoded ADPCM value is available on D0 through D3 at the occurrence of the rising edge of VCLOCK. If you have set S1 and S2 for 8 kHz and 4B/$\overline{3B}$ for 4-bit data, the resulting bit rate is calculated as follows:



SFR–SHIFT REGISTER
S_{IN}/P_{OUT} – SERIAL IN/PARALLEL OUT

Figure 6: *Functional block diagram of the Oki Semiconductor MSM5218RS ADPCM integrated circuit.*

8000 × 4 bits = 32,000 bps

Remember that we originally calculated that a rate of 96,000 bps would be needed to reproduce speech with this same fidelity. (Here we used an 8-bit A/D converter for economy; the bit rate would be the same for a 12-bit converter.)

With a slight sacrifice in fidelity, the bit rate can be reduced further. By selecting the 4-kHz sample rate and 3-bit ADPCM codes, a 12,000 bps rate is achieved.

This may still sound like a lot of data, especially when you compare it to phoneme and LPC (linear-predictive coding) speech synthesizers like the Votrax SC-01A and the Digitalker, which by comparison use data rates of 70 to 1000 bps. The difference, of course, is speech quality and intelligibility. A phoneme or LPC synthesizer generates its own sounds and forms them into words. An ADPCM synthesizer, on the other hand, retains the inflection and intonation of the original human voice. With ADPCM, as with an analog recording, it's possible to have a voice output that reproduces the regional accents of the human speaker.

The circuit of figure 7 can be used as both an analyzer and a synthesizer. Both subsystems function concurrently when the MSM5218 is in the analysis mode; the results, the reconstructed waveform, can be heard in real time (delayed by 3 VCLOCK periods). In figure 7, this output is smoothed by a low-pass filter and externally amplified to drive a speaker.

Use of the ADPCM Circuit

As I said at the beginning, the purpose of this project is to create intelligible machine-generated speech. With the circuit of figure 7 connected to a Z80-based computer, and using the LOAD routine in the program of listing 1 (the algorithm shown in the flowchart of figure 8), you can analyze and store 10 seconds of speech (or 20 seconds at the 4-kHz

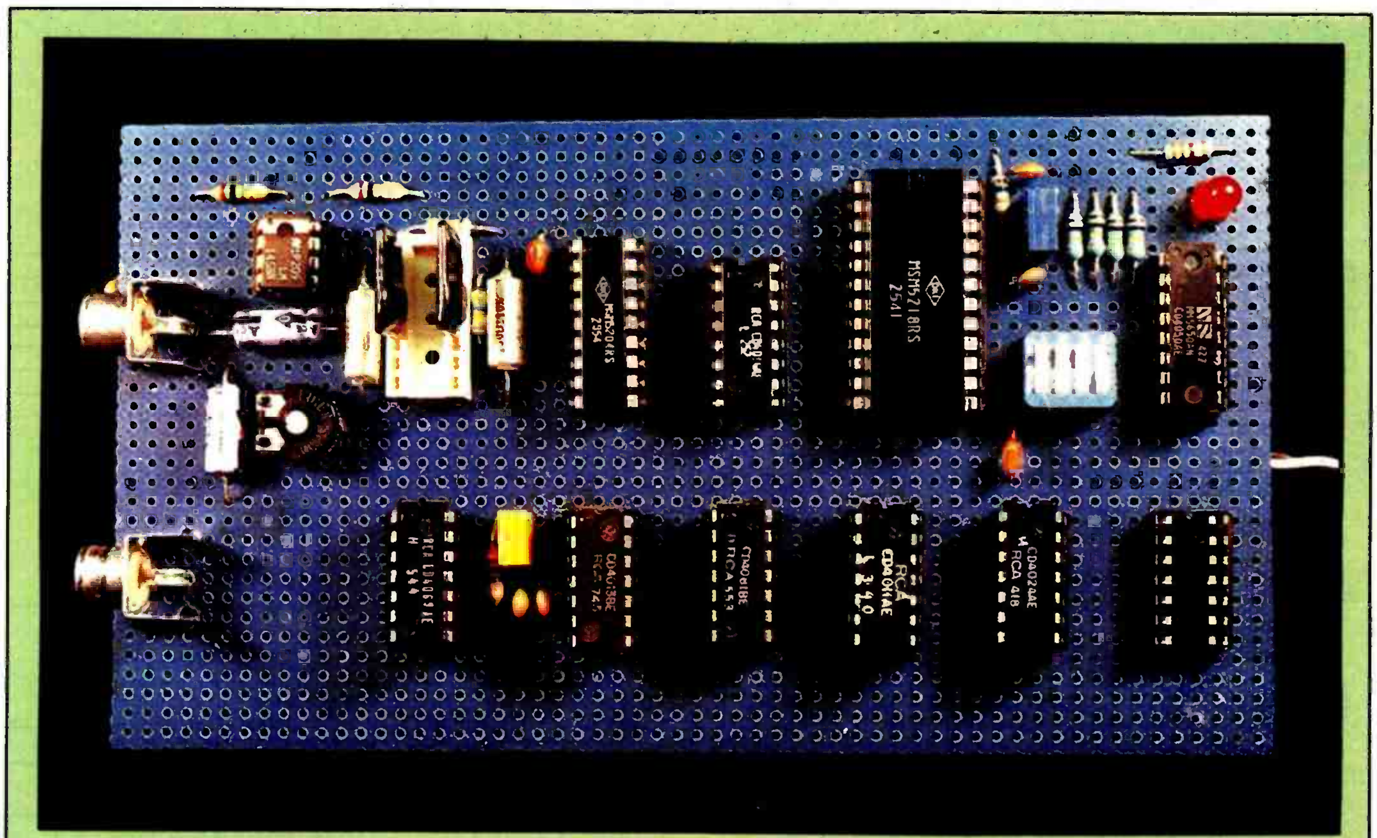


Photo 2: *Prototype of the speech analysis and synthesis circuit of figure 7, built around the Oki Semiconductor MSM5218RS integrated circuit. The empty IC socket is used for ribbon-cable connection to the host computer.*

sample rate). The program simply turns on the synthesizer by lowering the reset line and then observing VCLOCK. At every negative-going transition it reads a 4-bit ADPCM nybble (there are 2 nybbles per byte) and stores it in a memory-resident table.

For experimental purposes I set this table to occupy a rather large region of user memory (40K bytes). For most practical applications, you might prefer to store segments of speech on disk and load them into memory in smaller increments.

Once some speech has been stored, you can play it back using the DUMP routine from listing 1 (whose algorithm appears in figure 9). With the MSM5218 set to the synthesis mode, the ADPCM codes are sequentially loaded on each rising edge of VCLOCK.

If you want to store some speech permanently and then play it back in a dedicated application (as an annunciator, for instance), you won't need the analysis part of the circuit after the ADPCM codes have been stored.

One significant aspect of ADPCM speech synthesis is the ease of producing a custom vocabulary.

For such cases you may wish to use the synthesize-only circuit of figure 10, which uses the 18-pin MSM5205RS ADPCM-synthesis chip instead of the dual-function 24-pin 5218 (see photo 3 on page 48). The 5205's synthesis capabilities are equal in every way to thoses of the 5218, but the 5205 saves the expense and complication of the analysis section. The resulting 2-chip circuit, the parts of which cost less than $15, can be easily manufactured for a variety of applications.

I was pleasantly surprised at the fidelity using ADPCM at 32,000 bps. It was still more intelligible than the majority of current synthesis techniques even at 12,000 bps. While testing the software I attached the input of the analysis unit to an FM radio. Even when using the 1.7-kHz filters, I was surprised how good even music sounded.

Summary of ADPCM Synthesis

Probably the most significant aspects of ADPCM speech synthesis are the simplicity of the hardware and the ease of producing a custom vocabulary. You don't have to send a word list and recording tape to a manufacturer and wait for the com-

Text continued on page 48:

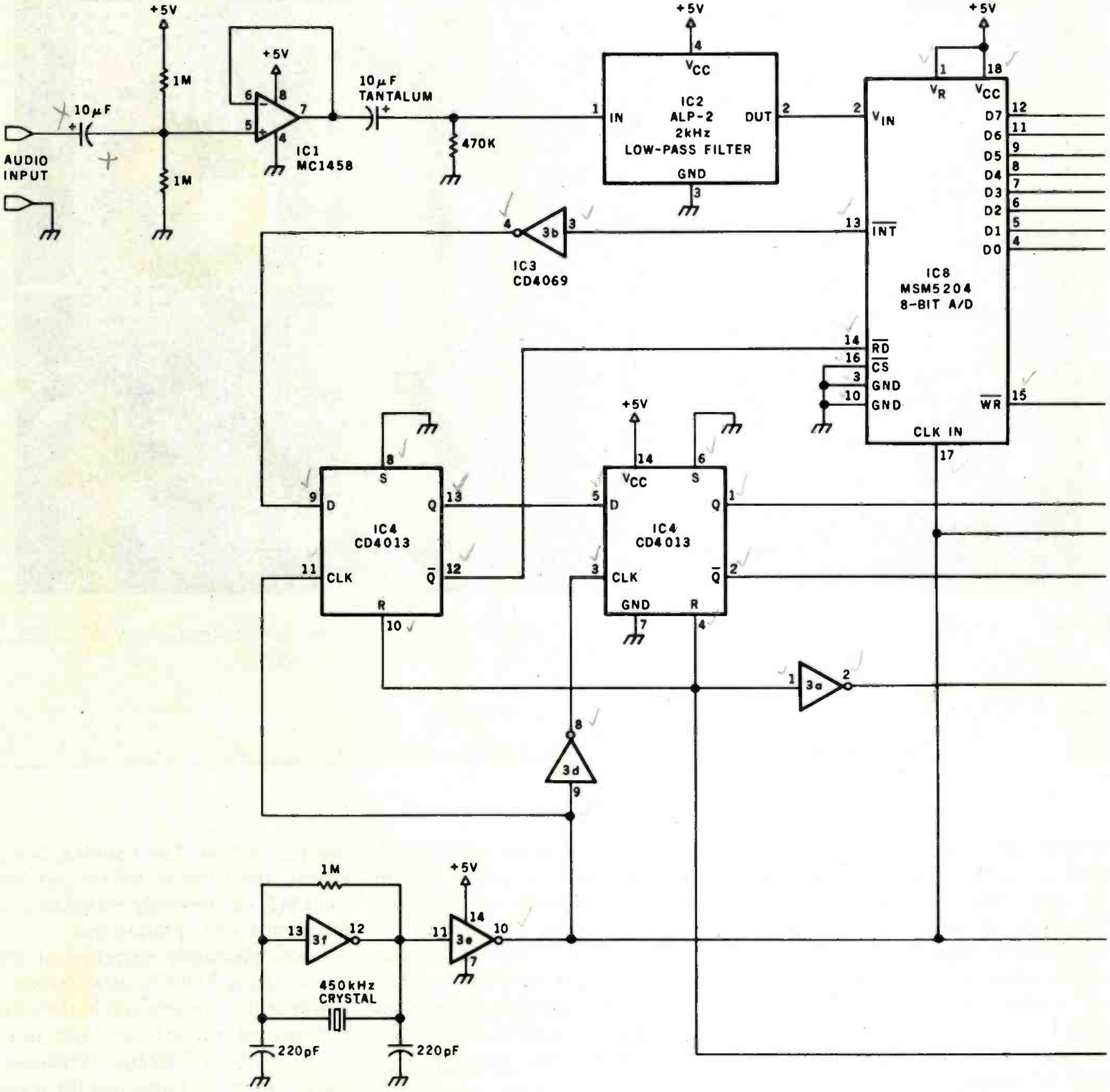
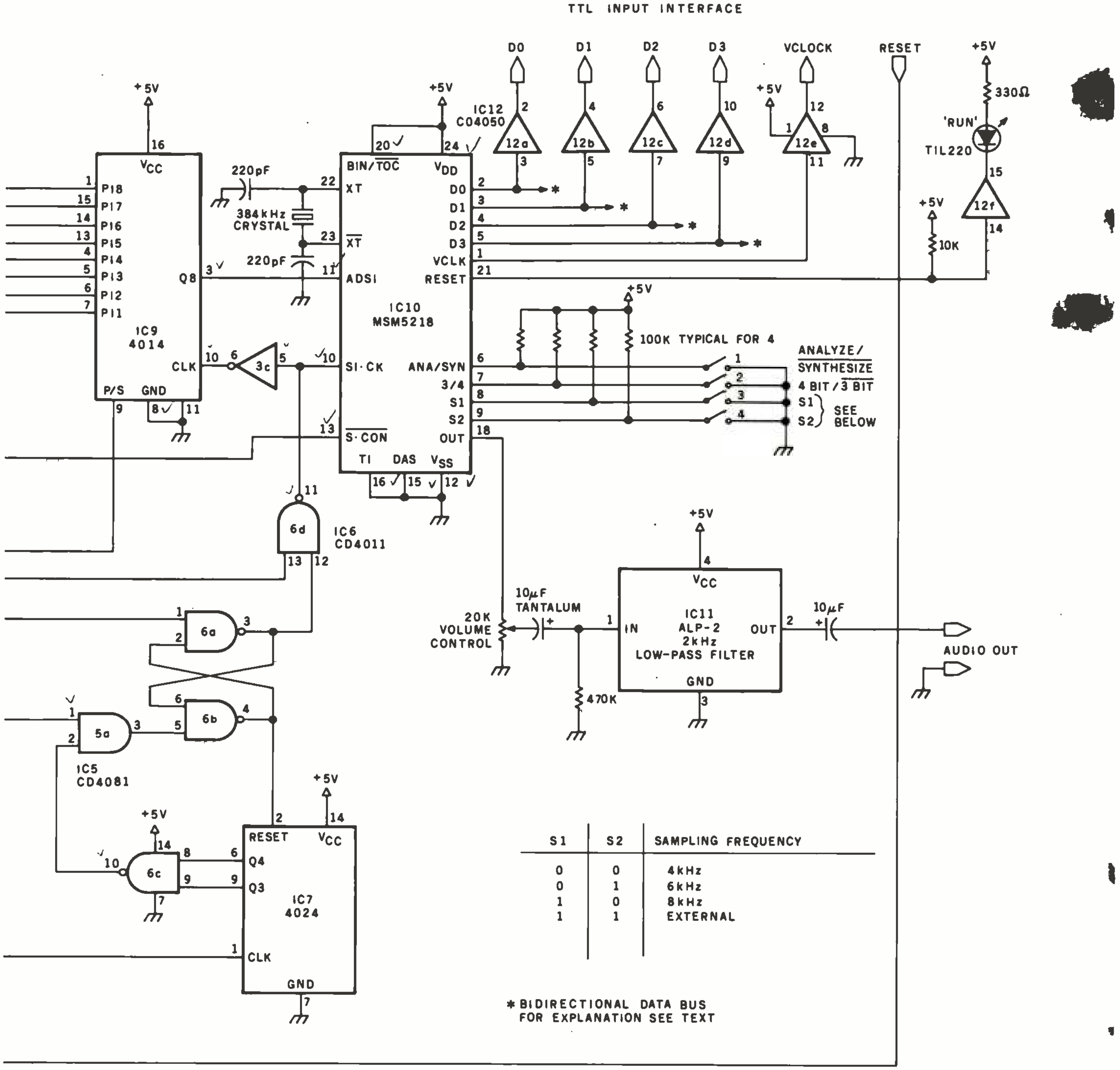


Figure 7: *An ADPCM speech analysis and synthesis (storage and reproduction) circuit built around the Oki MSM5218RS chip. A low-cost 8-bit A/D converter is used in place of a higher-resolution and more costly 12-bit converter. The Oki MSM5204RS 8-bit CMOS A/D converter, used in this circuit, contains a successive-capacitor-ladder conversion system. It also incorporates a sample-*



S1	S2	SAMPLING FREQUENCY
0	0	4kHz
0	1	6kHz
1	0	8kHz
1	1	EXTERNAL

* BIDIRECTIONAL DATA BUS
FOR EXPLANATION SEE TEXT

and-hold stage that enables direct input of rapidly changing analog signals. An external clock signal provides timing for the chip; the clock's frequency is not critical and can be anywhere from 450 to 500 kHz.

The frequency bandwidth of the signal input to the A/D converter is limited by an active low-pass filter, IC2, an Oki ALP-2 filter with a 1.7-kHz cutoff frequency and attenuation of 18 dB per octave above the cutoff frequency.

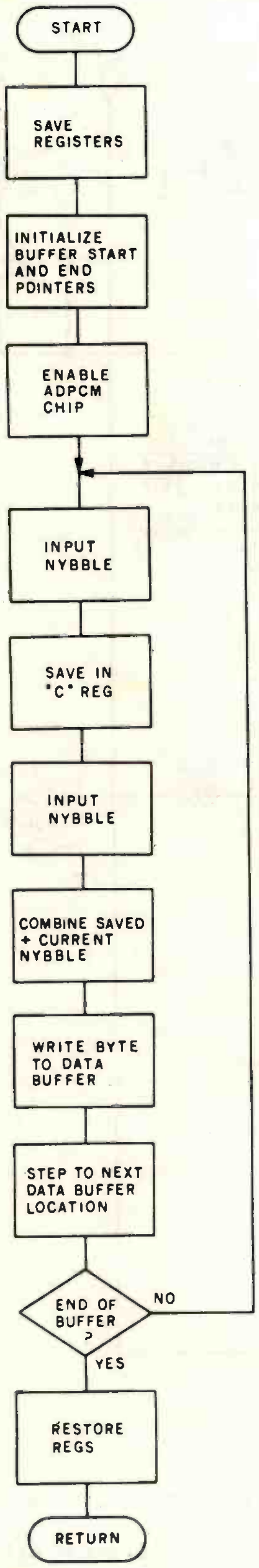


Figure 8: *Algorithm of the LOAD routine in the program of listing 1. Used with the circuit of figure 7, LOAD takes analog voice signals from a microphone or other source and stores them in ADPCM-encoded form in user memory.*

Listing 1: *Z80 assembler program to control the speech-synthesis circuit of figure 7.*

```
                 ;
                 ; THESE ROUTINES ARE USED TO ALLOW A Z-80
                 ; BASED MICRO TO LOAD AND DUMP THE 4 BIT
                 ; NYBBLES CREATED BY THE OKI ADPCM CHIP.
                 ;
                 ; ONE I/O PORT IS USED FOR BOTH INPUT AND
                 ; OUTPUT. THE BIT MAP FOR THE PORT IS AS
                 ; FOLLOWS :
                 ;
                 ;
                 ;   B7   B6   B5   B4   B3   B2   B1   B0
                 ;                       *    *    *    *
                 ;                       D3   D2   D1   D0
                 ;
                 ;                   * CLOCK ON INPUT, RESET
                 ;                     ON OUTPUT
                 ;
                 ;  *    *    *    UNUSED
                 ;
                 ;
                 ; SINCE THE MASTER CLOCK OF THE OKI CHIP IS
                 ; USED BY THIS PROGRAM, ANY OF THE CLOCK
                 ; RATES MAY BE SELECTED WITHOUT MODIFYING
                 ; THIS CODE.
                 ;
                 ; AT 8KHZ, YOU WILL FILL 4K BYTES PER SECOND.
                 ;
                 ;
4000                        ORG 4000H       ; START AT 4000H ON D/G CPU.
4000              LOAD      EQU $
4000 F5                     PUSH AF         ; SAVE ANY REGS
4001 C5                     PUSH BC         ;   THAT I WILL CLOBBER
4002 E5                     PUSH HL         ;     DURING THE ROUTINE
4003 2641                   LD H,41H        ; BUFFER STARTS AT
4005 2E00                   LD L,00H        ;  4100H
4007 06DF                   LD B,0DFH       ; AND ENDS AT DF00H
                 ;
                 ;
4009 3E00                   LD A,00H        ; PICK UP 0.
400B D311                   OUT (11H),A     ;  AND TURN OFF RESET TO ADPCM
                 ;
400D CD2740       LOOP1     CALL NIN        ; BIT UP NYBBLE FROM ADPCM
4010 07                     RLCA            ; PUT THE
4011 07                     RLCA            ;  NYBBLE AT THE
4012 07                     RLCA            ;    TOP OF THE
4013 07                     RLCA            ;     REGISTER.
4014 4F                     LD C,A          ; AND SAVE IN THE C REG
4015 CD2740                 CALL NIN        ; PICK UP ANOTHER NYBBLE
4018 B1                     OR C            ; COMBINE WITH SAVED NYBBLE
4019 77                     LD (HL),A       ; AND SAVE IN THE BUFFER
401A 23                     INC HL          ; STEP TO NEXT LOCATION
401B 73                     LD A,B          ; PICK UP END POINTER
401C BC                     CP H            ; ARE WE AT THE END ?
401D 20EE                   JR NZ,LOOP1     ; NO, DO ANOTHER
401F 3EFF                   LD A,0FFH       ; YES, PICK UP ALL 1'S
4021 D311                   OUT (11H),A     ; AND RESET THE ADPCM
4023 E1                     POP HL          ; RECOVER THE
4024 C1                     POP BC          ;  SAVED REGISTERS
4025 F1                     POP AF          ;   WE SCRAMBLED
4026 C9                     RET             ; AND RETURN TO THE CALLER.
                 ;
                 ;
                 ;
4027              NIN       EQU $
4027 DB11         INHIW     IN A,(11H)      ; PICK UP INPUT FROM ADPCM
4029 CB67                   BIT 4,A         ; CHECK FOR A 1 ON THE CLOCK
402B 28FA                   JR Z,INHIW      ; WAIT FOR ONE TO COME
402D DB11         INLOW     IN A,(11H)      ; PICK UP INPUT FROM ADPCM
402F CB67                   BIT 4,A         ; CHECK FOR A 0 ON THE CLOCK
4031 28FA                   JR Z,INLOW      ; WAIT FOR ONE TO COME
                 ;
                 ;  WHEN A 1 TO 0 TRANSITION HAS OCCURRED, THE DATA
                 ;  IN THE A REG IS THE NYBBLE WE WANT TO STORE.
                 ;
4033 E60F                   AND 0FH         ; MASK OFF THE HI BITS
```

Listing 1 continued on page 46

UDS gives 212 users three ways to go!

212A—Today's most popular modem. UDS offers a fully Bell-compatible unit with complete local and remote test capability. Select 0–300 or 1200 bps for full-duplex asynchronous communication. The UDS 212A is FCC certified for direct connection to the dial-up telephone network, and available in multi-channel, rack-mounted configuration.

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Circle 402 on inquiry card.

Created by Dayner/Hall, Inc., Winter Park, Florida

Listing 1 continued:

```
4035 C9        00760          RET              ; AND RETURN TO CALLER
               00770 ;
               00780 ;
               00790 ;
               00800 ;
               00810 ;
               00820 ;
               00830 ;
4036           00840 DUMP     EQU $
4036 F5        00850          PUSH AF          ; SAVE THE REGS
4037 C5        00860          PUSH BC          ;   JUST LIKE
4038 E5        00870          PUSH HL          ;    BEFORE
4039 2641      00880          LD H,41H         ; SET UP START
403B 2E00      00890          LD L,0H          ;  ADDRESS OF BUFFER
403D 06DF      00900          LD B,0DFH        ; SET UP END TOO
403F 3E00      00910          LD A,00H         ; PICK UP ALL 0'S
4041 D311      00920          OUT (11H),A      ; AND TURN OFF RESET TO ADPCM
               00930 ;
               00940 ;
4043 7E        00950 LOOP2    LD A,(HL)        ; PICK UP STORED DATA BYTE
4044 E6F0      00960          AND 0F0H                ; ISOLATE THE UPPER NYBBLE
4046 07        00970          RLCA             ; AND SWING
4047 07        00980          RLCA             ;  IT TO
4048 07        00990          RLCA             ;   THE LOWER
4049 07        01000          RLCA             ;    NYBBLE
404A CD6040    01010          CALL NOUT        ; WRITE THE NYBBLE TO THE ADPCM
404D 7E        01020          LD A,(HL)        ; PICK UP THE BYTE AGAIN
404E E60F      01030          AND 0FH          ; LOWER NYBBLE THIS TIME
4050 CD6040    01040          CALL NOUT        ; WRITE IT TO THE ADPCM
4053 23        01050          INC HL           ; STEP TO NEXT BUFFER POSITION
4054 78        01060          LD A,B           ; PICK UP END OF BUFFER POINTER
4055 BC        01070          CP H             ; ARE WE THERE YET ?
4056 20EB      01080          JR NZ,LOOP2      ; NO, DO SOME MORE
4058 3EFF      01090          LD A,0FFH        ; PICK UP ALL 1'S
405A D311      01100          OUT (11H),A      ; TURN ON RESET TO ADPCM
405C E1        01110          POP HL           ; RECOVER THE
405D C1        01120          POP BC           ;  REGS THAT WE
405E F1        01130          POP AF           ;   HAVE CLOBBERED
405F C9        01140          RET              ; AND RETURN TO CALLER
               01150 ;
               01160 ;
               01170 ;
4060           01180 NOUT     EQU $
4060 4F        01190          LD C,A           ; SAVE A FOR LATER
4061 DB11      01200 OLOW     IN A,(11H)       ; PICK UP ADPCM BYTE
4063 CB67      01210          BIT 4,A          ; TEST FOR 0 BIT
4065 20FA      01220          JR NZ,OLOW       ; WAIT FOR ONE TO COME
4067 DB11      01230 OHIW     IN A,(11H)       ; PICK UP ADPCM BYTE
4069 CB67      01240          BIT 4,A          ; TEST FOR 1 BIT
406B 28FA      01250          JR Z,OHIW        ; WAIT FOR ONE TO COME
               01260 ;
               01270 ; WHEN 0 TO 1 TRANSITION IS DETECTED, WE PUT OUR DATA
               01280 ; OUT TO THE ADPCM.
               01290 ;
406D 79        01300          LD A,C           ; RECOVER THE SAVED DATA
406E D311      01310          OUT (11H),A      ; WRITE TO THE ADPCM
4070 C9        01320          RET              ; AND GO BACK TO CALLER
               01330 ;
               01340 ;
               01350 ;
               01360 ;
               01370 ;     END OF LOAD/DUMP ROUTINES
               013[illegible]0 ;
               01390 ;
0000           01400          END
00000 TOTAL ERRORS


DUMP    4036 00840
INHIW   4027 00650   00670
INLOW   402D 00680   00700
LOAD    4000 00300
LOOP1   400D 00420   00540
LOOP2   4043 00950   01080
NIN     4027 00640   00420 00480
NOUT    4060 01180   01010 01040
OHIW    4067 01230   01250
OLOW    4061 01200   01220
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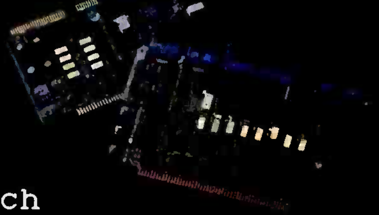

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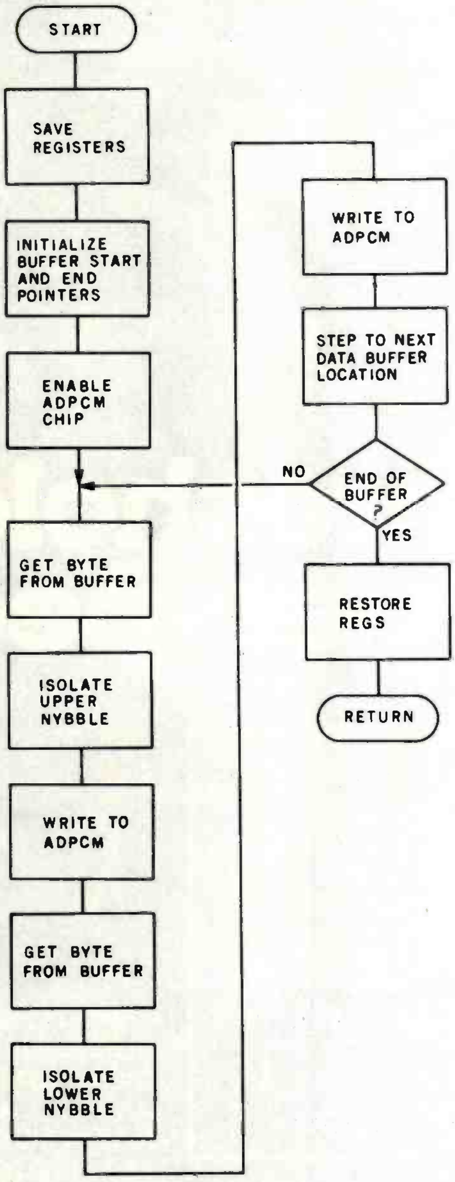

Figure 9: *Algorithm of the DUMP routine from listing 1. This routine takes the stored ADPCM-encoded speech from memory and causes the circuit of figure 7 to reconstruct the voice waveforms.*

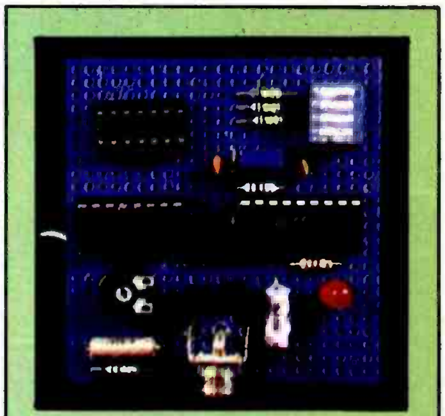

Photo 3: *Prototype of the synthesize-only circuit of figure 10, built around the MSM5205RS chip.*

Text continued from page 41

pany to spend days doing a Fourier analysis of the tape. To produce a ROM (read-only memory) containing your custom vocabulary, you can use merely a microphone and a simple LOAD/DUMP routine. It may require 4 to 5 times more memory space than other high-intelligibility speech-synthesis schemes, but the price of that memory is minuscule compared to the cost of producing vocabularies for the other schemes.

Future Applications of ADPCM

We've looked at ADPCM here only as it relates to voice synthesis, but in actuality, the possible applications of ADPCM to speech *recognition* prompted my initial interest.

The first phase of any speech-recognition technique is digitizing the waveforms and getting them into the computer for analysis, compression, and comparison. My previous article on voiceprints (reference 5) demonstrated the large quantity of hardware necessary to merely condition the waveform for traditional speech-recognition methods. With ADPCM and these Oki chips, we have an inexpensive (under $30) circuit for digitizing voice waveforms and presenting them to a computer in a form that it can digest.

Even though 1500 to 4000 bytes of raw data per second of speech stream into the computer, the data thus recorded should be unique for each individual word. Speech recognition could be accomplished by brute-force comparison of all the data, or perhaps there exists some applicable compression algorithm that might reduce one second of data to 200 bytes or so. The final compacted data would not be for reconstruction of the original waveform but rather stored as a signature of the input word (derived from an ADPCM code table) for use in comparison.

We have accomplished the first step and now have means to place the ADPCM codes in memory. In the course of the next few months I will be experimenting with various compression and comparison techniques in hope of developing a practical speech-recognition project, But if by chance you happen upon the solution to the problem overnight, let me know.

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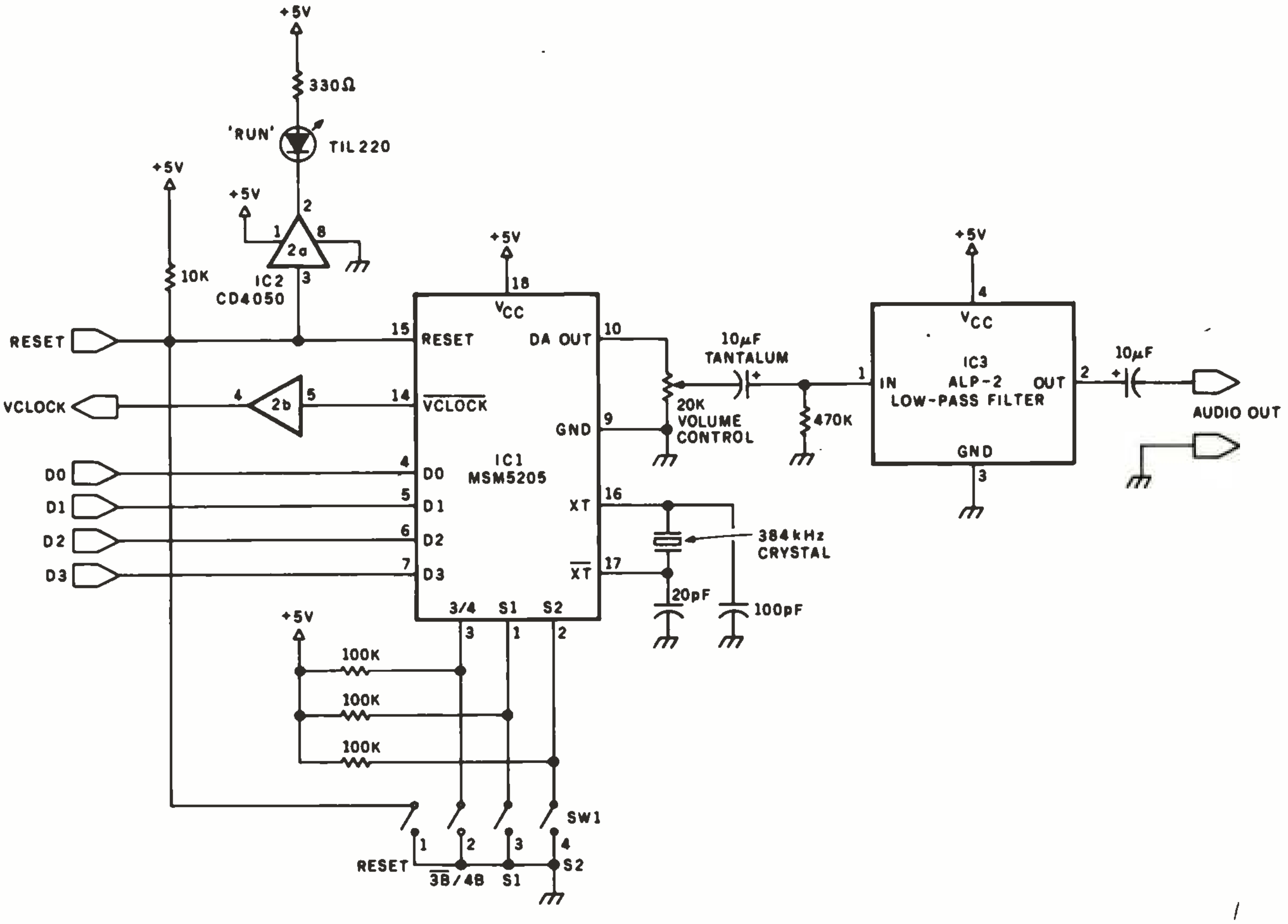

Figure 10: *A voice-reproduction circuit built around the Oki MSM5205RS speech-synthesis chip. This circuit is useful in applications where you need a fairly inexpensive means of reproducing a custom vocabulary. You can store your vocabulary with the circuit of figure 7, and load the encoded speech into this simple circuit for output.*

References

1. Ciarcia, Steve. "Build a Low-Cost Speech-Synthesizer Interface." June 1981 BYTE, page 46.
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3. Ciarcia, Steve. "Build an Unlimited-Vocabulary Speech Synthesizer." September 1981 BYTE, page 38.
4. Ciarcia, Steve. "Talk to Me: Add a Voice to Your Computer for $35." June 1978 BYTE, page 142.
5. Ciarcia, Steve. "Use Voiceprints to Analyze Speech." March 1982 BYTE, page 50.
6. *General Explanation of Oki ADPCM Speech Synthesis LSI (MSM5205RS).* Tokyo: Oki Electric Ltd., 1982.
7. Mier, Edwin E. "Competitors Fear AT & T's New $1 Billion Scheme." *Data Communications*, December 1982, page 39.

Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.*

Ciarcia's Circuit Cellar, Volume I *covers articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II *contains articles from December 1978 through June 1980.* Ciarcia's Circuit Cellar, Volume III *contains the articles that were published from July 1980 through December 1981.*

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To receive a complete list of Ciarcia's Circuit Cellar project kits available from the Micromint, circle 100 on the reader service inquiry card at the back of the magazine.

For those of you who would like to construct an ADPCM analyzer/synthesizer, the chips are readily available from Oki Semiconductor Corporation as part of an experimenter's kit.

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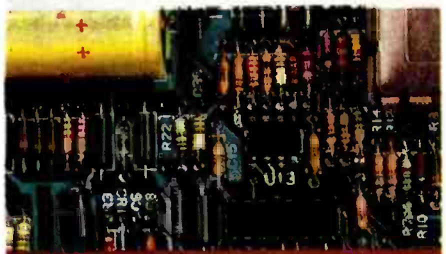


16-BIT

The state of the art in microprocessor technology has advanced a great deal in just one year. New applications programs and systems software designed specifically for 16-bit microcomputers make this new group of machines perform in a way that's all but impossible for 8-bit micros. Last year the theoretical advantages of 16-bit microprocessors were clear but using revamped 8-bit software made their performance disappointing. The 16-bit world is just opening up.

In this issue we look at several new 16-bit micros, both portable and desktop models; a popular 16-bit operating system; a new 16-bit language; and a 16-bit operating environment for applications programs.

I'll begin with the Sunrise. This new machine has three microprocessors, with an 8088 as its main processor. It's an office computer that is portable in two different senses: the entire computer will fit in an attache case, but the keyboard is also a separable, very light, battery-powered computer with its own 8-bit processor and liquid-crystal display.

A good-looking machine, the Gavilan portable combines the computing power of an Intel 8088 microprocessor with a software architecture that an 8-bit processor could not support. The hardware is at least a year ahead of its time. Gavilan designers have packaged 336K bytes of RAM, a bit-mapped 8 by 66 liquid-crystal display, and 320K bytes of disk storage in a machine less than a foot square and only 2.7 inches thick.

The DEC Professional 350 is a single-chip microcomputer version of a 16-bit Digital Equipment Corp. minicomputer—an arrangement that brings minicomputer software and processing power into the microcomputer world. With the telephone management option, this computer offers advanced voice and data features.

The Hewlett-Packard Series 200 Model 16 uses HP's own 16-bit BASIC and reveals the great computational power of its microprocessor unhampered by an 8-bit language. The Series 200 Model 16 also represents a milestone in concentrated

DESIGNS

computing power. In a remarkably small box (233 square inches), the computer holds up to three quarters of a megabyte of RAM, which gives the 68000 processor plenty of room in which to work.

The 16-bit Texas Instruments 99/2 costs less than $100, and at that price is the world's best bargain in computing power. It is an excellent home computer for students who use the TI 99/4A in school. Software for the 99/2 will also run on the older 99/4A.

The Altos 586 uses a 10-MHz 8086 as its central processor and Intel's companion 16-bit input/output processor, the 8089, as an intelligent disk controller. A Z80 manages the system's serial ports. Together, the three processors create a high-performance six-to-ten-user system in a compact desktop unit.

The Fujitsu Micro16s has five microprocessors in its standard configuration, with an 8086 as the main processor and a Motorola 6809 managing the display. Fujitsu also offers optional 68000 and Z8000 processor boards, giving buyers a choice of today's three most popular 16-bit microprocessors. Fujitsu is the first company to install Concurrent CP/M on its own microcomputer, providing a degree of multitasking impossible in an 8-bit processor.

The Pronto Series 16 uses the Intel 80186 and an unusual physical architecture to minimize the desk space that it occupies. The 80186, which incorporates the functions of 20 to 30 chips in addition to the processor itself, can be used to create a very compact yet powerful machine.

The Docutel/Olivetti M20 uses the Zilog Z8001 microprocessor and its own Professional Computer Operating System. The M20's underrated Zilog 16-bit chip provides a unique ability to redefine some internal 16-bit registers as 8-bit, 32-bit, or even 64-bit.

The Sritek processors and memory boards for the IBM Personal Computer turn that popular machine into a powerful, 8-MHz Xenix system capable of supporting several users. Buyers can choose the Motorola 68000, the National Semiconductor 16032, or the Intel 8086 or 80286 to be the heart of the PC.

16-Bit Software

Gary Kildall and David Thornburg describe DR Logo, Digital Research's 16-bit version of a language already popular in the 8-bit world.

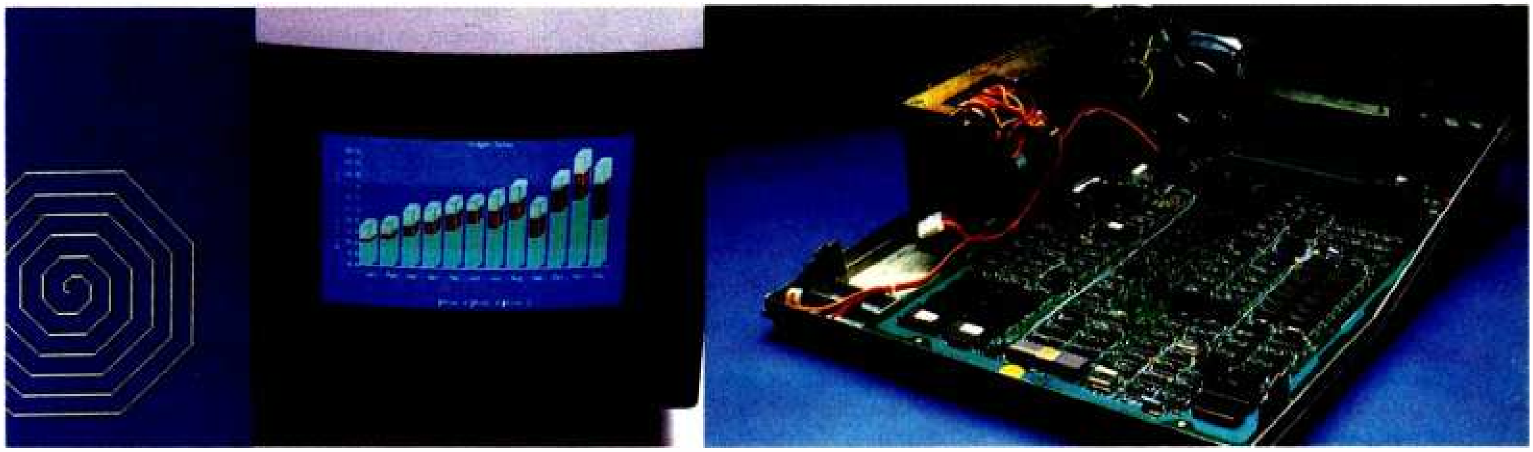
Tim Paterson, who wrote the original version of MS-DOS while at Seattle Computer, explains the workings of this 16-bit operating system in great detail.

In an interview with BYTE, Bill Coleman of Visicorp provides a close look at the Visi On operating environment and the applications programs that will run under it.

A Year's Progress

Microcomputer technology is moving ahead fast and furiously. What's next? By June 1984, 256K-bit RAMs will be commonplace, 16-bit software will be in full flower, and even more powerful microprocessors will begin to appear in products.

— Phil Lemmons



Sunrise Systems

A Texas computer company produces a system to be custom-tailored by OEMs.

Bruce Roberts
Technical Editor

Down in Texas the good ol' boys make good ol' computers. North of Dallas the Silicon Ranch stretches for miles in Texas's answer to California's Silicon Valley and Massachusetts' Route 128. Striking, futuristic buildings and industrial parks house many high-technology start-ups funded with venture capital as free-flowing as Texas crude oil. One of these companies is Sunrise Systems Inc.

After looking at the numerous existing computer systems, the lack of shelf space and dealers, and the costs of service and support staffs, Sunrise Systems decided to take a different approach in bringing its computers to market. Sunrise would design and produce computers, but let other companies worry about selling and servicing them. As an original equipment manufacturer (OEM) supplier, Sunrise set out to design a system that could be easily customized to the particular needs of an individual vendor. The "Swiss Army" business computer that resulted has a little something for everyone but manages versatility in a practical, commonsense way. The most distinctive characteristic of the C8/16 system is the wealth of applications programs included with it.

When you turn on the system, your program choices are shown immediately on the screen: an appointment calendar, a four-function calculator, a speaker telephone and auto dialer, a tape recorder for dictation, a teletype terminal, a typewriter/electronic note taker, Microsoft BASIC, and more. It sounds like a general-purpose business machine and it is.

Photo 1: *The C8/16 computer system from Sunrise Systems. The KP-C8 keyboard processor in the foreground with a 40-character by 6-line LCD is a prototype with six function keys instead of 10. The microcassette tape recorder is on the right side of the unit, above the speaker grill. The ROM pack on the left plugs into the side of the keyboard by the display. The FP-8/16 flat pack in the rear has two half-height 5¼-inch disk drives and a P-4/4 color graphics printer.*

The C8/16 system from Sunrise Systems (see photo 1) consists of a portable computer with a 40-character by 6-line or 80-character by 3-line liquid-crystal display (LCD) that can be connected to a main system unit complete with disk drives and both 8- and 16-bit microprocessors. The portable portion, called the KP-C8 keyboard processor, has an 8-bit CMOS (complementary metal-oxide semiconductor) NSC800A microprocessor and can be battery powered. The microprocessor is National Semiconductor's low-power version of the Zilog Z80 that can run all the popular CP/M software. This unit is loaded with features, including a microcassette drive for voice and digital storage, an integral high-speed modem, a real-time clock, serial and parallel input/output (I/O), television and color-monitor outputs, telephone and data links, 64K bytes of dynamic random access read/write memory (RAM), and 16K bytes of CMOS static RAM (expandable to 64K bytes) for battery-powered use. All of the built-in programs just mentioned are stored in the 32K bytes of read-only memory (ROM). The keyboard processor with all these abilities weighs less than 5 pounds.

The main system unit, or FP-8/16

flat pack, is designed to stay in the office and has a 16-bit 8088 and an 8-bit Z80A microprocessor. The list of standard features includes 128K bytes of RAM (expandable to 512K bytes), two 5¼-inch disk drives that store 160K or 320K bytes in an IBM PC-compatible format, a 300- to 1200-bit-per-second (bps) modem, serial and parallel ports, RGB (red-green-blue) color-monitor output, an external disk-drive connector, and telephone and data input/output. This unit is the heavy portion, and it weighs a manageable 15 pounds.

Marketing the Sunrise System

Sunrise is orienting this system toward professionals and managers with limited computer experience. The designers think the middle managers of business have been ignored by the computer industry or presented with computers that are not very easy to use. Sunrise is aiming for the over-35, first-time computer user, with sales representatives, managers, and business professionals at the center of the marketing efforts.

The main criteria for business computers as Sunrise sees it are reliability, service availability, general-purpose multiple functions, simplicity, price, and portability, in about that order.

The concept of an office in a briefcase should appeal to many business people on the go. The lightness of the keyboard processor will also be appreciated. The C8/16's improved communications give rise to an extended office; salespeople can call in orders from the field and receive price updates in return, or people can take the portable unit home and access information back at the office in the flat pack unit.

Photo 2: *The Xerox 1800 portable computer is a custom version of the C8/16 computer system from Sunrise Systems. Note that the Xerox model uses the 80-character by 3-line LCD. The briefcase is optional.*

The Xerox 1800 Portable Computer

From the folks who brought you the Memorywriter, Xerox's answer to the IBM Selectric typewriter, we now have the Xerox 1800 portable computer. All five of the founders of Sunrise Systems worked at Xerox previously, so it should not be a surprise that Xerox will be among the first customers relabeling and marketing the Sunrise system. In fact, Xerox gave rise to Sunrise Systems by looking for an outside supplier to redefine initial Xerox designs and produce an integrated, portable business computer. Thus, Sunrise Systems was formed in June 1982 and in October began producing the first prototypes of the computer.

Xerox handles all marketing, service, and support for its version of the Sunrise. Sunrise designs and manufactures the units for Xerox to its specifications.

The Xerox 1800 portable computer uses the 80-character by 3-line liquid-crystal display (LCD) version of the keyboard processor, and the case design, layout, and colors are unique, but most of the other specifications remain the same. Xerox is offering its own cathode-ray tube (CRT) terminal as an option.

The estimated prices are $2000 for the keyboard processor and $4000 for the keyboard, printer, and the flat pack together.

The Keyboard Processor Software

The terminology and focus for this computer system are different from those of most existing microcomputers. With this system, you push buttons; you don't type keystrokes. The advanced programs in cartridge form aren't called software; they are applications packs, similar to video game cartridges.

For example, to simplify the system, Sunrise uses the built-in microcassette drive, a tutorial ROM pack, and the LCD display to introduce the computer to the first-time user. A tutorial audio cassette gives a brief overview of the computer and walks you through all the different programs and functions. The user's manual has been kept concise and very short, 30 pages. Realizing that most people don't read manuals but just start using the machine, Sunrise made the manual short and simple with a style similar to the two-level approach of the menus on the screen. After being selected from the menu of programs, each program presents a menu of its options. The nesting of the programs doesn't get any more complicated than that on the screen.

Photos © Bob Lukeman, Southern Lights Studio Inc., 1983.

At a Glance

Name
C8/16 Computer System

Manufacturer
Sunrise Systems Inc.
2209 Midway Rd.
Carrolltown, TX 75006

Components
KP-C8 keyboard processor
- Size: 16 inches wide, 9 inches deep, 2 inches high
- Weight: 4.5 pounds
- Electrical needs: rechargeable nickel cadmium batteries or 110 VAC adapter
- Processor: 2.5-MHz National Semiconductor NSC800A (CMOS version of Z80)
- Memory: 32K bytes of system ROM, 16K bytes of CMOS RAM, 64K bytes of dynamic RAM, 64K-byte ROM packs with applications, 64K bytes of CMOS RAM optional
- Keyboard: standard typewriter-style keyboard with 63 keys, 10 function keys, and 4 cursor-control keys
- Display: 40-character by 6-line or 80-character by 3-line liquid-crystal display with graphics capability (240 by 64 or 479 by 24 dot matrix). Television output: 40-character by 24-line text, 256 by 192 pixel bit-mapped graphics with 15 colors; software-labeled function keys
- Standard: built-in direct-connect modem, 300 or 1200 bps; real-time clock; microcassette tape recorder, with 512K bytes of digital data or 15 minutes of analog voice; input/output ports: RS-232C serial, Centronics parallel, RGB monitor, television RF modulator, telephone, data link, and external microphone/speaker; built-in speaker; power-on self-test of components; cartridge slot for ROM packs
- Software: calendar, calculator, speakerphone and auto dialer, tape recorder/dictation, teletypewriter terminal, typewriter/note taker, Microsoft BASIC

FP-8/16 flat pack
- Size: 18 inches wide, 12 inches deep, ¾ inch high
- Weight: 15 pounds
- Electrical needs: 110 VAC
- Processors: 4.77-MHz Intel 8088 and 3.58-MHz Zilog Z80
- Memory: 128K bytes of dynamic RAM, expandable to 512K bytes
- Disk drives: two 5¼-inch floppy-disk drives, 160K or 320K bytes each
- Display: RGB or B/W monitor output: 80-character by 25-line or 40-character by 25-line text; 160-by-200-pixel 16-color, 320-by-200-pixel 4-color, or 640-by-200-pixel B/W bit-mapped graphics.
- Standard: built-in direct-connect modem, 300 or 1200 bps; real-time clock; input/output ports: RS-232C serial, Centronics parallel, RGB or B/W monitor, telephone, data link, power, internal printer port, and memory expansion
- Software: CP/M-80, CP/M-86, and MS-DOS operating systems

EB-SS expansion box
- Size: 18 inches wide, 12 inches deep, ¾ inch high
- Electrical needs: 110 VAC
- Disk drives: two 5¼-inch single-sided floppy-disk drives, 160K bytes each
- Standard: disk-drive controller; data-link input/output port
- Software: CP/M-80 operating system

P-4/4 color graphics printer
- Size: 4½ inches wide, fits into flat pack unit
- Standard: 4-color text and graphics printer, roll paper; installs in the flat pack unit or the expansion box

Typical System Price
Approximately $2000 for the keyboard processor, and $4000 for the complete C8/16 system with keyboard processor, flat pack, and color graphics printer.

Software ergonomics guided the layout of the 10 function keys for the applications built into the system ROM. Certain functions are assigned to a key and remain consistent throughout the different programs. One example is the quit function (software-labeled EXIT) on the rightmost function key.

The software labels for the function keys appear across the bottom of the screen, showing what each key does when pressed. Initially, the labels provide a main menu of what applications are available on the computer. When you choose an application, the labels across the screen change to reflect the new meaning of the function keys under that program. The menus are never nested more than two deep.

The basic functions in the Sunrise keyboard-processor firmware are calendar, calculator, loading other software from a ROM pack or disk, speakerphone and auto dialer, tape recorder, teletypewriter terminal, typewriter/note taker, Microsoft BASIC, time and date, and setup. All functions work in the battery-powered (portable) mode except for the typewriter (print mode), terminal, and telephone, which require full power for operating I/O devices.

The calendar holds as many as 250 entries (limited to 10K bytes of CMOS memory), more than enough for a week's appointments. Each 40-character entry is automatically stored in CMOS memory. Entries can be added, changed, or deleted, with three entries visible on the LCD screen and more on an external monitor. Alarms may be set for each event that will sound if the system is on.

The four-function calculator is simple and straightforward, with a memory and the ability to use variables. The basic math functions and three memories are provided. If a printer is attached to the system, the results may be printed as well as displayed on the LCD screen.

A ROM pack function allows other software to be loaded and run from ROM packs that plug into the keyboard unit. Similarly, a link function allows software to be loaded and

Text continued on page 60:

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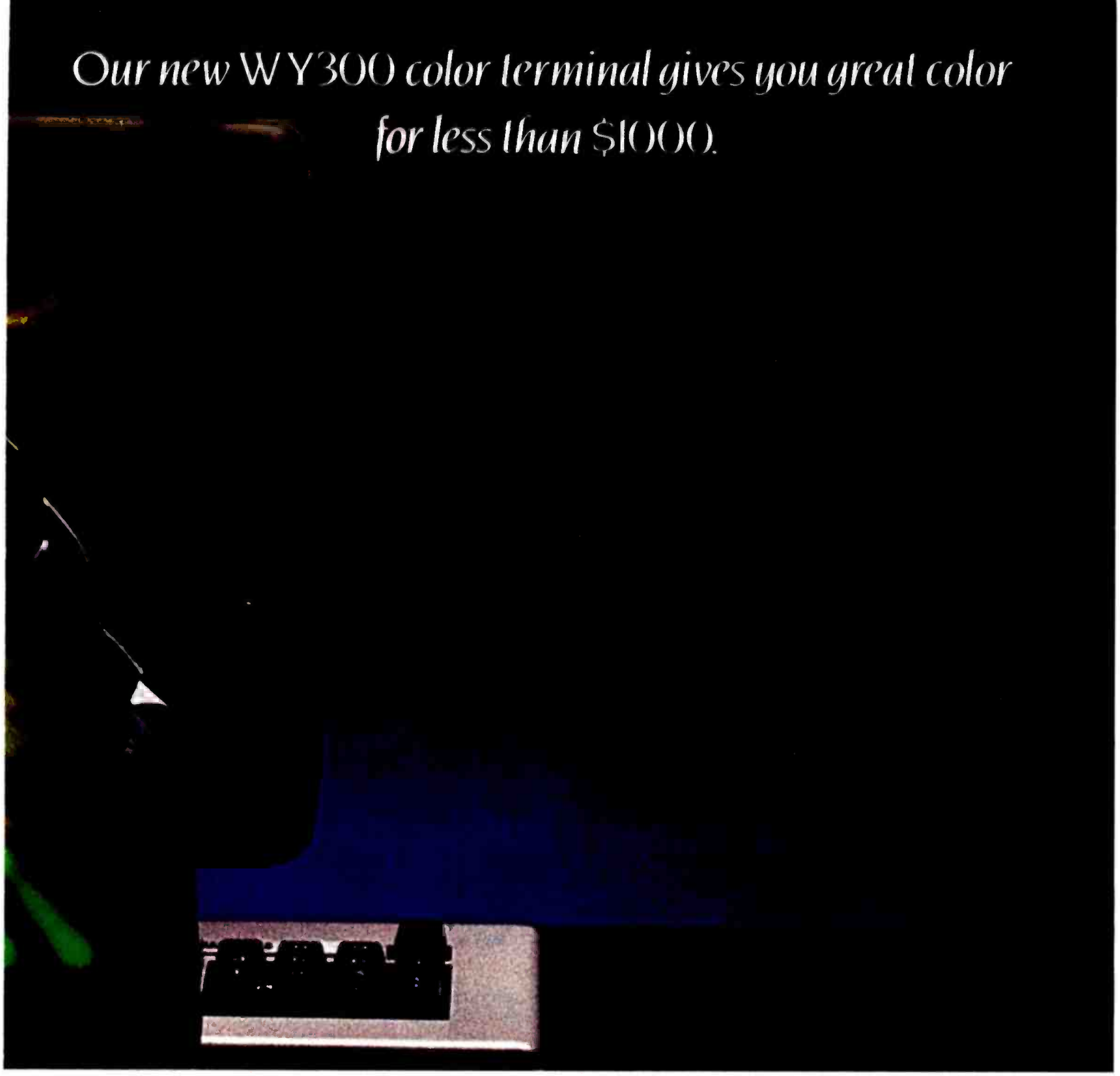

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run from a floppy disk when the flat pack unit or expansion box is attached.

The telephone program has options for a speaker telephone (using the keyboard's speaker), an answering machine, an auto dialer that can redial the last number, manual dialing, call answering, hanging up, hold, volume controls, and a directory of phone numbers. The telephone answering machine uses the cassette to answer the phone and play a recording, gives a tone, records a message, and then resets for the next call. The telephone directory can hold 30 entries for your most frequently called numbers. Each number can be dialed with a single key command that is as many as 30 characters long. This will fit an alternate long-distance service number and access code. The telephone dialer can automatically strip off the area code when calling local numbers.

In tape recorder mode, you can use the keyboard processor as a dictation machine with all the functions of a portable audio-cassette recorder. The function keys provide rewind, find (a tape block name), fast forward, stop (the tape), play, volume up, volume down, record, pause, and exit (to return to the main menu) capabilities.

The terminal program lets you use the keyboard as a dumb terminal to send and receive data over the telephone line. The software permits either automatic or manual dialing of a remote computer as well as determination by you of the settings for duplex modes and parity. The internal modem handles communications at 300 bps (Bell 103 compatible) or at 1200 bps (Bell 202 compatible). When the keyboard is connected to the flat pack, data transfer takes place at the higher rate. The time of connection and length of the call are displayed with the help of the real-time clock.

The typewriter function expects a printer to be attached to the system for printer output after each character is typed, after each carriage return, or upon command. You can specify margin and tab settings. Before the characters are sent out to the printer, the output can be edited. All the normal typewriter characters are available, but underlining and boldface are not supported.

The note-taking mode uses 10,000 characters of the nonvolatile CMOS memory, which you can save as a file on the cassette before continuing to enter another note. The program prompts you as the memory fills up. Files may be entered, edited, deleted, printed (in the full power mode), saved to the tape, or retrieved from the tape. You provide the file name for the document, and the system keeps track of the time and date it was created, as well as the last date that it was revised.

The setup program lets you change many of the default values for the system. You can suppress the software labels at the bottom of the screen if you want a larger window area, or if you are familiar with the functions and don't need to be reminded.

The cassette drive turned out to be a better storage device than was anticipated. You can store as many as 512K bytes of digital information on

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a microcassette. The cassette can be used to provide backup storage for data and programs on the Sunrise system. When used as a dictation machine, the Sunrise will store 15 minutes of speech on each side of the tape.

The software follows the same "open architecture" concept that the hardware does. The machine can be custom configured by putting together the appropriate existing modules along with specialized accounting, financial, or insurance programs that a customer would like included. Putting the programs into system ROM and setting up the menus and function keys should be fairly easy for Sunrise.

Software Expandability

More sophisticated programs can be used by plugging in the ROM cartridges (ROM packs) or loading disk-based software from the flat pack or a disk expansion box. The ROM packs contain as many as 64K bytes of memory, leaving room for larger programs like the Suncalc electronic spreadsheet, expanded calculator and calendar programs, and maybe even games. Games? Why not? Virtually every business computer has some games. The new electronic office worker should be allowed a little levity. All work and no play makes the Sunrise a dull computer.

An integrated office-function pack has extended versions of the phone, calendar, and text/note-taker programs. This may be expanded into an integrated word-processor, spreadsheet, database, and graphics program, too, given the current popularity of the 1-2-3 and Context MBA all-in-one programs.

More sophisticated programs are possible by using ROM packs or loading software from the flat pack.

ROM packs can be used to address vertical markets without creating new versions of the machine. A program that helps keep track of field sales by outside salesmen is near the top of the list for applications to be put into ROM packs.

Sunrise systems plans to produce a graphics pack designed to utilize the keyboard's 80-character by 3-line LCD with its bit-mapped graphics. The keyboard system will support the CP/M graphics system extension (GSX) and its utilities for the 479 by 24 dot display. Most graphics for this display thus far have been limited to games.

The management of files or lists of information with a database manager is another likely candidate for a ROM pack program. This capability would let you organize the type of information and how it is stored in, for example, a mailing list.

An IBM 3270-series terminal emulator is a logical choice for an additional program that will handle communications with corporate mainframes. Many data-processing managers are getting more involved in microcomputer access to company information and insisting on 3270 communications protocols. This op-

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tion would allow the Sunrise to interact directly with the mainframe instead of just uploading and massaging information. This disk-based program would require the use of the flat pack with its disk drives. The 3270 program would turn the keyboard and flat pack units into a 3270 look-alike terminal. The keyboard processor would talk to the flat pack, which would send information on to the mainframe computer.

The flat pack provides the disk drives and microprocessors that enable the C8/16 system to run the CP/M-80, CP/M-86, or MS-DOS operating systems and their numerous business programs. The programs can be used as they are with an 80-character by 25-line external monitor. To fit the smaller LCD-screen formats, however, they will probably need to be modified. A version of BASIC for the 8088 microprocessor is available in a ROM pack.

The KP-C8 Keyboard Processor

The KP-C8 keyboard processor has a standard typewriter-style keyboard, as its name implies. Sunrise kept the keyboard simple so that novice computer users would not be intimidated or overwhelmed by an array of keys and functions (like the IBM Personal Computer keyboard). With the exception of the Shift Code, all of the 63 keys automatically repeat after being held down for ½ of a second. The 10 function keys are integrated into all the software modules and reduce the number of dedicated function keys. They are not labeled on the keyboard; their functions are controlled by the software and identified by labels that appear on the bottom row of the LCD screen. The cursor (arrow) keys can be used alone or with the Code and Shift keys to move the cursor one character, to the edges of the display, or to the beginning or end of a file, or to scroll the display up and down.

The receptivity of the business market to LCDs seems to be good. Sunrise Systems is currently offering a 40-character by 6-line or an 80-character by 3-line display on the keyboard processors. Sunrise uses only bit-mapped LCDs (429 by 24 dots on the 80 by 3 display) to get limited LCD graphics capabilities. The labels across the bottom of the screen for the 10 function keys provide one example of this. The brightness and contrast of the liquid-crystal display are adjustable through software as part of the setup program.

The 8-bit NSC800A microprocessor runs at 2.5 MHz in either a batter-powered or full-power mode. This low-power CMOS Z80 work-alike is conservatively rated to run for two hours off the batteries. Ten hours seems to be a more realistic estimate. A low-power indicator warns you if the batteries are low. When you turn the power on, the system performs its own diagnostics and checks out the various components.

The keyboard processor can switch between as many as four 64K-byte banks of memory. The first bank of memory contains the 32K bytes of system, extended system, and identification ROMs and 16K bytes of battery-powered CMOS RAM. Theoretically, you can use a full 64K bytes of CMOS memory instead of just the 16K bytes supplied with the system, but you probably won't need to. The system seems to get along fine with its current setup. The design will accommodate the new 8K by 8 CMOS static RAMs. These RAMs will provide four times the current CMOS memory capacity.

The second bank of memory allows for as many as 64K bytes of expansion memory in each ROM pack. The system switches from internal memory to the external memory in the ROM cartridges as if the memory chips on the printed-circuit board had been replaced by the ROM chips.

The third bank of main system memory uses the 64K bytes of dynamic RAM in the full-power mode. A fourth bank of auxiliary RAM will allow for future system expansion of 64K bytes of CMOS RAM.

The Sunrise system has three methods of getting software into the computer's memory. A program can be part of the 32K bytes of system

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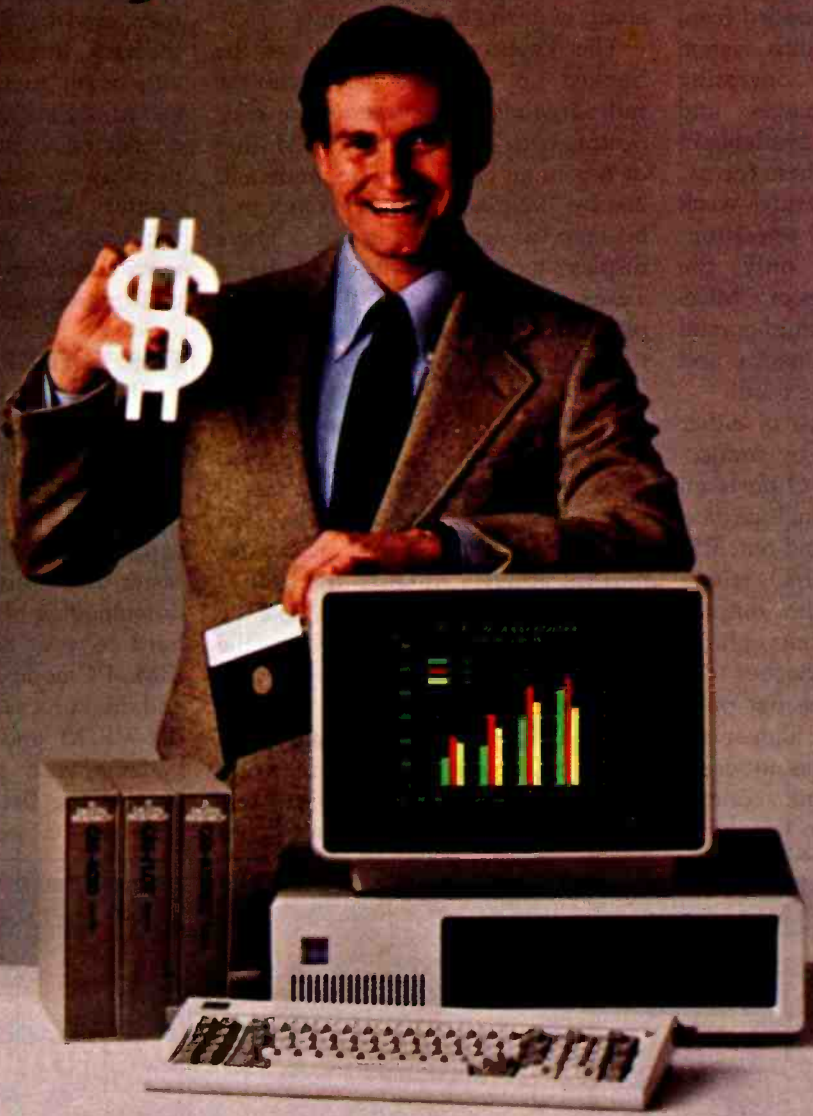

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ROM inside the keyboard processor, it can be loaded by plugging in a ROM pack, or it can be loaded from an external floppy disk into system memory (RAM). The operating systems, computer languages, and application programs are available in several combinations of these forms.

All of the keyboard features work in the full-power mode of operation. Under battery power only the microprocessor, 16K bytes of CMOS RAM, internal ROM, liquid-crystal display, keyboard, ROM packs, and tape drive features may be used.

If you look at the back of either unit, you will be greeted by connectors of every sort. The I/O ports on the back of the keyboard include data in and out, telephone in and out, RS-232C serial I/O, parallel I/O, television output, external monitor output, and auxiliary speaker/microphone I/O. The data port attaches the keyboard processor to the flat pack or expansion box with a high-speed data-packet link, but it does not use a full synchronous data-link control (SDLC) protocol. The two telephone jacks enable you to connect a telephone device to the computer along with the keyboard unit.

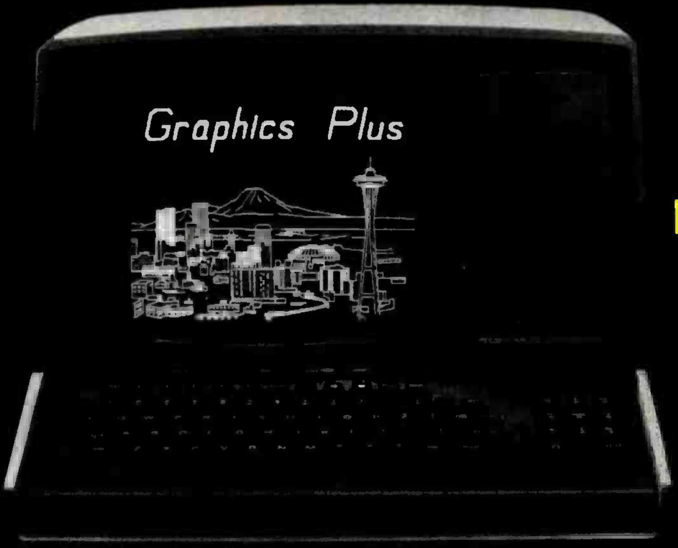
The keyboard processor can be hooked up to a television via the radio frequency (RF) modulator connector, with 40 characters by 24 lines of text in an alphanumeric mode and 256 by 192 pixels with 15 colors in a bit-mapped graphics mode. These display modes are provided by a Texas Instruments 9918 chip, complete with sprite graphics capabilities that are not yet used by the computer.

The keyboard also has a TI 76489 sound-generator chip that can produce three independent musical voices and one voice of noise. This could give the Sunrise computer musical abilities equal to the best of the low-cost color computers like the Commodore 64. At this time, the company is not actively supporting this feature.

The underside of the keyboard processor presents a graphic description of the system layout and cable interconnections. Once you begin to connect the keyboard processor to other system units, the mobility can be hampered by the cables attached to the back. In your office you will probably want to have the power plugged in, a data link or telephone cable connected to the flat pack unit, and possibly a cable hooked up to a printer. All those cables coming out the back of the keyboard make it more cumbersome to hold in your lap or to move around the room.

FP-8/16 Flat Pack Features

The flat pack unit is designed to make it easy and comfortable to move up to floppy disk and networking capabilities. The flat pack expands the keyboard processor's capabilities with the floppy disk's faster data storage and retrieval, the downloading of programs and data, a hard copy or disk "message server," IBM PC-compatible disk formats, and dual processors that can run both the CP/M and MS-DOS operating systems with their numerous programs. The flat pack can also function as a computer using the



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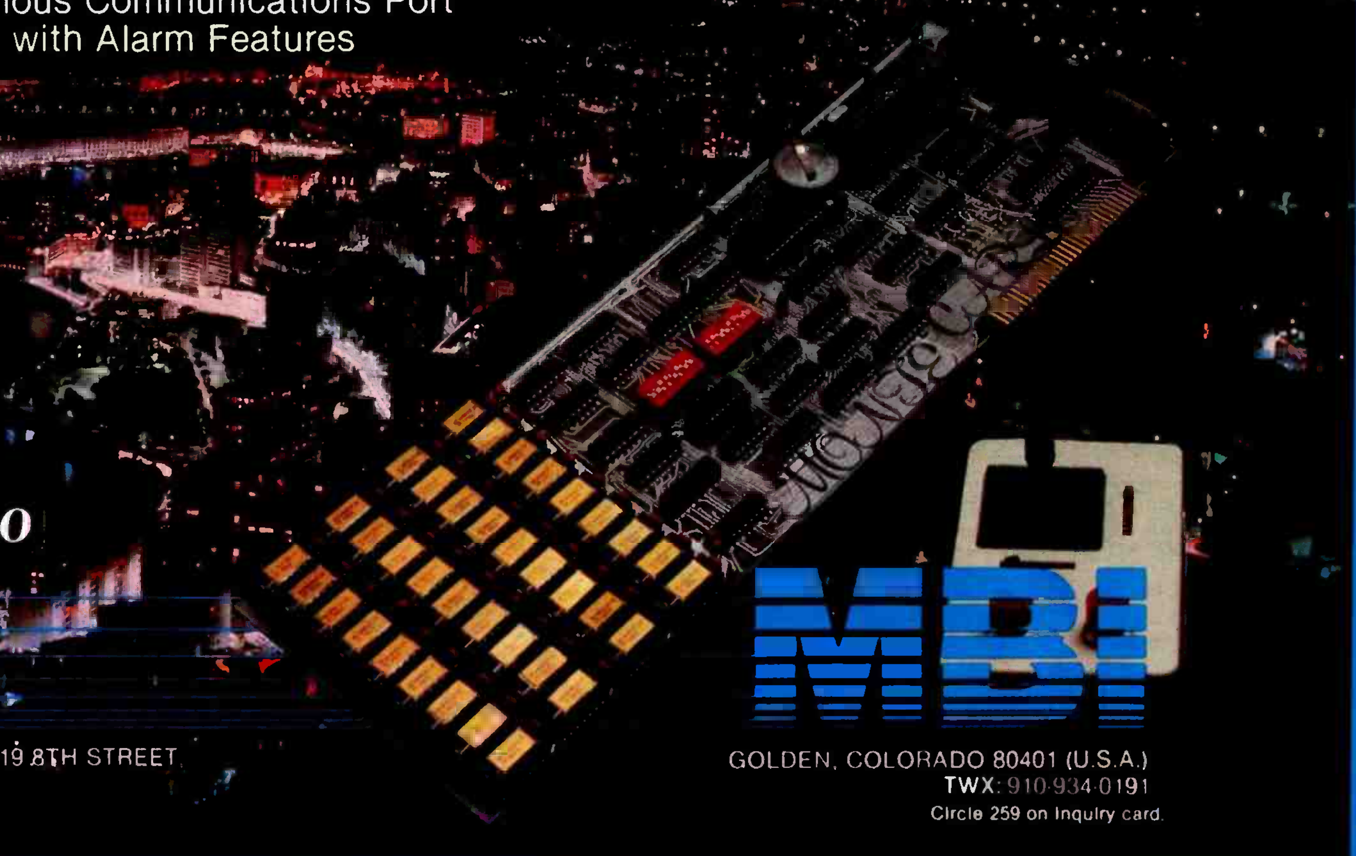

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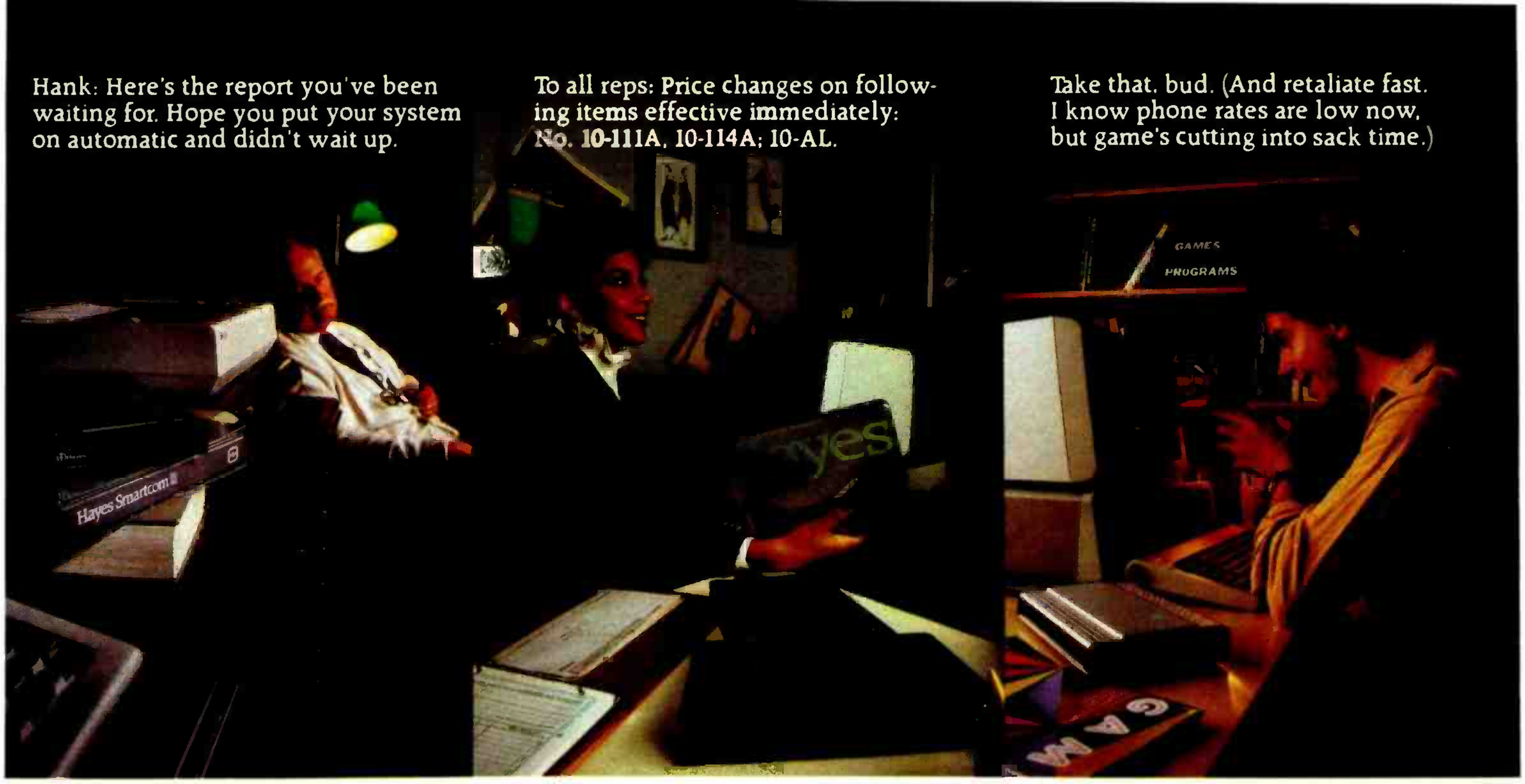
Hank: Here's the report you've been waiting for. Hope you put your system on automatic and didn't wait up.

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Both work with rotary dials, Touch-Tone* and key-set systems; connect to most timesharing systems; and feature an audio speaker.

Either Smartmodem is a perfect match for many different computers. And if you have an IBM PC, Hayes also provides the perfect communications software.

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You can treat dial-up and log-on sequences the same way. In fact, Smartcom II comes with codes already set up for four popular information services. COMPUSERVE,® DIALOG'S KNOWLEDGE INDEX,℠ DOW JONES NEWS/RETRIEVAL® SERVICE, and THE SOURCE,℠ AMERICA'S INFORMATION UTILITY.℠ Procedures for obtaining an account with each of the services are included in the Smartcom II manual. But that's not all.

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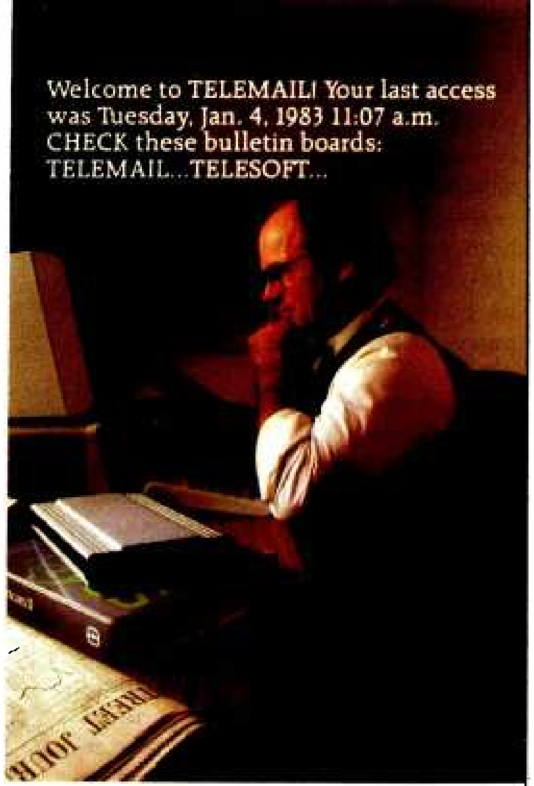

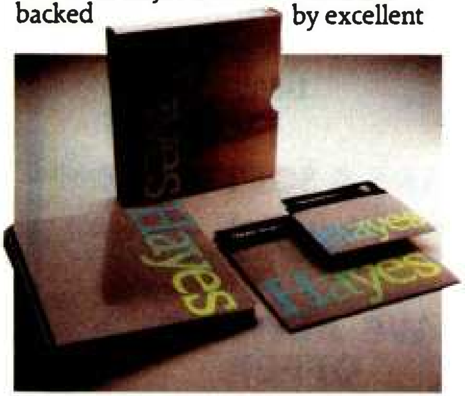

keyboard processor as a display terminal.

A 16-bit 8088 microprocessor controls the flat pack unit, making larger program workspaces possible because the 8088 can address 1 megabyte of memory. The Z80A microprocessor enables this dual-processor system to run all the CP/M-80 software. Disk-based software on the flat pack can be loaded into the keyboard processor and run, or the keyboard unit can act as a display for the flat pack. ROM packs can also be plugged into the flat pack.

For the flat pack the possible connections include telephone in, telephone out, data in, data out, external monitor output, serial I/O, parallel I/O, external disk, and power. The reset button and power switch are also on the back of the flat pack unit. A real-time clock with battery backup uses an LED display that shows through the little window on the front of the flat pack to indicate the power is on.

The built-in modem can transfer data at 300 bps (Bell 103-compatible) or 1200 bps (Bell 202-compatible) through the telephone connectors. The data connectors are the other half of the high-speed data-packet link to the keyboard processor, which passes blocks (packets) of information back and forth. The video output can display 80 or 40 characters by 25 lines of text; it can display, with bit-mapped graphics, a 160 by 200 dot array in 16 colors, a 320 by 200 dot array in 4 colors, or a 640 by 200 dot array in black and white, all on an external black and white or RGB monitor.

Part of Sunrise's concept of a computer system is that the main processing unit with the disk drives doesn't need to be on someone's desk. The flat pack can easily be on a credenza or table in the office, accessible by a cable or telephone link to the keyboard processor. This approach allows a flat pack unit to be shared between several keyboard processors that call the flat pack up at different times. Two keyboard processors can also be continuously sharing one flat pack in a local area network arrangement. Using a printer, the flat pack can act as a hard-copy "message server," or by putting data on the disk, it can act as a disk message server. Sunrise is planning on adding an Ethernet interface later.

Options and Extensions

You can get the keyboard processor without the microcassette tape drive if you like, but it seems to provide several useful features that justify including it in a typical system. The flat pack can be considered an upgrade option too; the alternative is the EB-SS expansion box with just the floppy-disk drives and a disk controller. This would provide a minimal expansion unit for a single keyboard processor.

The P-4/4 color graphics printer fits into the left rear corner of the flat pack and uses an internal printer port. Only 4½ inches wide, it prints text and graphics in four colors on a roll of paper.

A portable letter-quality printer that can handle multiple copies should be available soon. The low-profile printer uses 8½-inch-wide paper, is only 2 inches high by 4 inches deep, and prints as fast as 80 characters per second.

One insurance salesman says he could increase his closings by 100 percent with hard-copy printouts of contracts at the client's office. Real estate agents, insurance salespeople, and auditors could use the printer to leave copies of calculations and agreements with their customers. The ability to make multiply-copy impressions is important because many business forms have multiple layers.

Sunrise is offering an optional briefcase into which the keyboard and flat pack units fit in two compartments. The briefcase splits apart between the compartments to offer a smaller carrying case for just the keyboard processor.

Battery-powered disks are also now possible. It might not be long before the disks and a printer could be put together into a portable unit that fits into a briefcase.

Sunrise is planning to offer 80-character by 6-line displays by the fourth quarter of 1983. You can have a display as large as 80 characters by 8 lines without any change to the architecture of the computer. Laboratories such as Thompson-CFF Corporation have produced 40-character by 24-line displays, but they need to be more reliable. Eighty-character by 24-line LCDs may be economically competitive with other types of displays by the end of 1984.

Sunrise does not currently offer a cathode-ray tube (CRT) terminal with the common 80-character by 24-line format, although representatives did demonstrate one in their office with multicolor high-resolution graphics. Customers can get larger conventional displays now, but Sunrise will not sell the larger LCD screens or plasma displays until they come down in price.

Summary

Several configurations of the Sunrise computer system are possible due to the dynamic architecture of the C8/16 system. The system has been designed to be as flexible as possible and will accommodate future developments when advanced chips become inexpensive. The engineers at Sunrise have an ambitious goal of outperforming the product specifications, so many capabilities are understated or conservative. A hard-disk drive interface and bit-mapped color graphics have already been put in the system.

The specifications for the computer are updated every 3 to 4 months. The use of modular blocks of hardware that can be easily modified for customers makes this easy. The keyboard processor, for example, is made of seven blocks that can be powered up or down separately to conserve energy in the battery-powered mode. The software also follows this modular approach, giving customers a choice of which programs or functions are built into the keyboard unit. The system could easily be a dedicated financial or accounting processor.

But Sunrise will be facing stiff competition from lower-cost battery-powered portable computers like the TRS-80 Model 100 with similar applications. The Epson QX-10 also offers an easy-to-use package of integrated programs, called Valdocs (valuable documents), in a stay-at-home computer. However, the Epson HX-20 portable computer is limited in its business capabilities when compared to the Sunrise keyboard processor.

One way of viewing the Sunrise system is as a vastly improved version of the Sony Typecorder for the same price. All of the components of the Sunrise C8/16 computer system have feature-rich hardware and a flexibility of operation not that common in personal computers. Sunrise Systems has modest plans for its first year; it will be happy selling about 20,000 machines. End users will be getting an excellent deal, a custom computer for less than the price of an IBM Personal Computer. The specifications of the customer come first at Sunrise. Perhaps this is the dawning of a new age of dedicated computers.■

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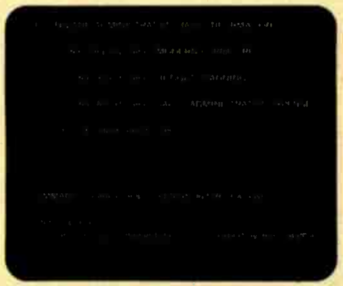
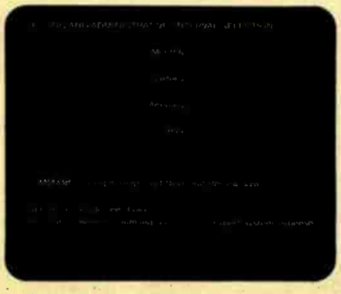


Gentlemen, start your computers.

Time: 0

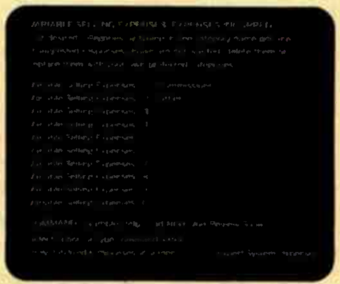


Select budget intervals.

Time: 0.5

Enter sales revenue.

Time: 1.0



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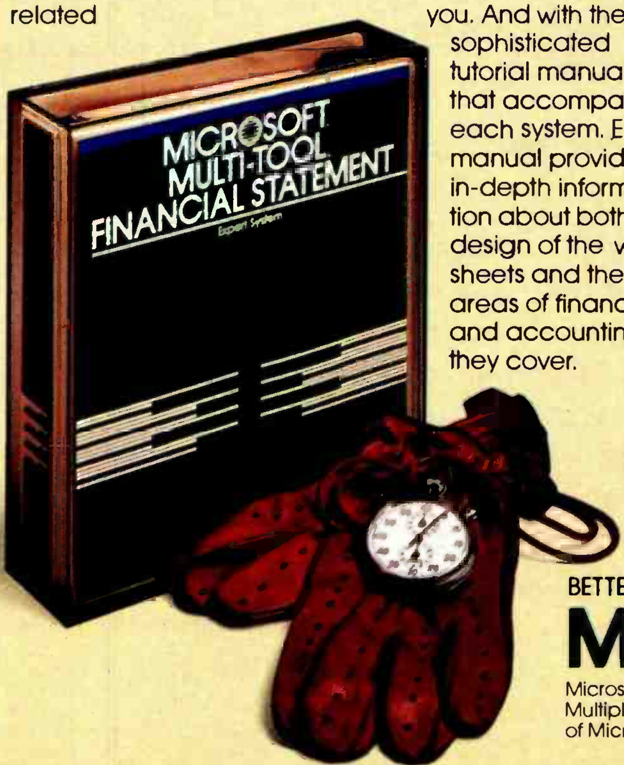

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Product Description

The Gavilan Mobile Computer

Phil Lemmons
West Coast Editor
BYTE/McGraw-Hill, 4th Floor
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The Gavilan portable computer is a traveling professional's dream come true. Lightweight and powerful, this new 16-bit computer promises to redefine industry standards for truly portable micros.

Weighing only 9 pounds and measuring 11.4 by 11.4 by 2.7 inches, the Gavilan, along with its optional 4-pound printer, fits comfortably in a standard-size attache case. Yet this battery-powered machine has up to 208K bytes of RAM, a built-in 320K-byte 3-inch disk drive, an 8-line by 66-character bit-mapped liquid-crystal display that flips up from its resting place on the keyboard, a full-size keyboard with numeric pad, and a touch panel that's used as a pointing device.

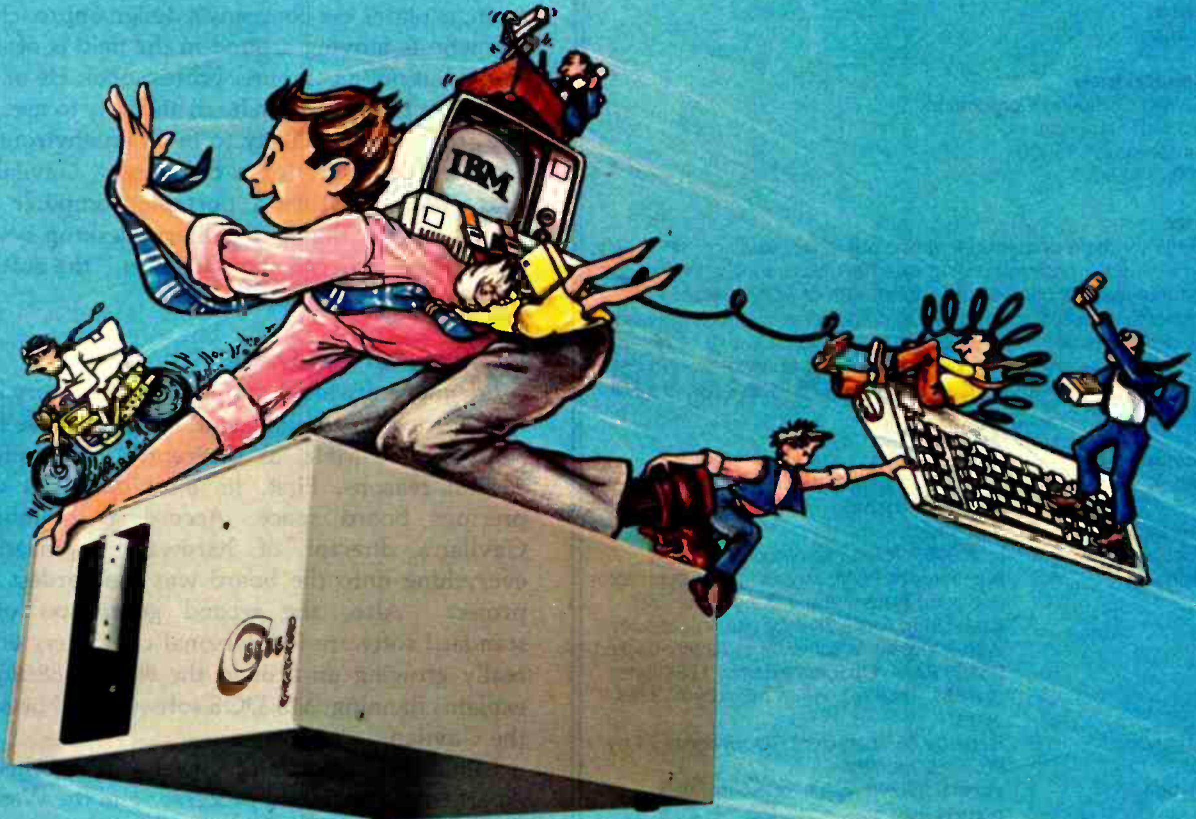
The Gavilan is expected to sell for $3995 when volume deliveries begin late in the third quarter of this year. For an additional $1000 you can get the 50-character-per-second dot-matrix printer that clips onto the back of the computer.

The touch panel, a potential rival to the mouse for nonkeyboard input, lets you manipulate integrated applications programs by pointing at objects on the screen, selecting objects to act on, and choosing an action from menus that appear on demand. Much like Lisa's operating system, the Gavilan's uses a desktop manager with pictorial symbols for applications, file "drawers," file "folders" in the drawers, and "documents" in the folders. Symbols indicate which files are open and which programs are available and running at any time. The Gavilan saves the "state of the desktop" in battery-backed RAM when the system is turned off, then restores the desktop when the machine is turned back on.

A New Standard for Portables

Until now, portable computer users have had to choose between battery-powered machines that are easy to carry but much less useful than desktop computers, and larger machines that are useful but heavy and dependent on

Performance Breakthrough...



...the CYBERDRIVE™ for the IBM Personal Computer

13.5 or 27 million bytes of disk capacity in a single cabinet with an integrated mini-cartridge tape for secure data backup.

Setting an exciting new microcomputer standard, the CYBERDRIVE[1] combines a full package of features.

It offers new, higher performance levels, with an integrated business-oriented backup device.

As the **CYBERDRIVE** is made available for other systems, media transfer is assured regardless of the host hardware or Operating System.

The CYBERDRIVE slashes the seek time dramatically—e.g. the usual 5 Megabyte stepper-motor Winchester disk offers average seek time typically in the range of 100 to 200 milliseconds (incl. head settling).

With the **CYBERDRIVE,** the average seek time across more than five times as much data is only 33 milliseconds (incl. head settling).

This basic speed, coupled with disk cache buffering and a peak transfer rate of 1 million bytes per second, make the CYBERDRIVE a performance champ!

The integrated mini-cartridge tapes used for backup of data allow dumping of (for example) 10 million bytes of data in about 10 minutes... much faster than other tape or floppy disk backup techniques. Hardware read-after-write error checking is incorporated in the tape device.

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RM/COBOL[2] compiler-the micro industry standard.

MBSI[3] RM/COBOL general business applications (derived from **MCBA[4]** minicomputer packages)... thousands in use... money back guarantee... source program license.

CRT![1] from Cybernetics (COBOL Reprogramming Tool!)-Program generator for **RM/COBOL** to ease program development and maintenance . . . an alternative to a Data Base System.

CBASIC2[5] & CBASIC86[5] compilers... for aficionados of a useful BASIC.

The software is available on a variety of industry-standard Operating Systems including CP/M[5]-MP/M[5] (both -80 & -86), OASIS[6], PCDOS, and UNIX[7]. Inquire for specific details and prices.

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714/848-1922

At a Glance

Name
Gavilan

Manufacturer
Gavilan Computer Corporation
240 East Hacienda
Campbell, CA 95008
(408) 379-8005

Price
$3995 for main unit, including one disk drive, liquid-crystal display, modem, serial port, recharging external power supply, printer port, communications port, disk controller, 48K of ROM, 64K of RAM, connector for second disk drive and additional memory, Gavilan Office Pack (4 applications), MBASIC and MS-DOS 2.0, carrying case. Optional printer approximately $1000; optional second disk drive, $695; with additional 64K RAM, $975; with 128K of RAM, $1245.

Components

Size:	width 11.4 inches; depth 11.4 inches; height 2.7 inches
Weight:	9 pounds
Processor:	Intel 8088 16-bit microprocessor
Memory:	80K bytes of RAM, including 48K bytes for operating system and 32K bytes for user data. Up to four 32K-byte plug-in capsules with applications software in battery-backed CMOS RAM. Optional external 128K bytes of RAM. Total maximum memory of 336K bytes
Display:	8-line by 66-character LCD; optional 24 by 80 video monitor
Keyboard:	integral full typewriter keyboard with numeric pad
Nonkeyboard input:	touch panel that allows fingertip to serve as a pointer device and to select various commands built into the panel, such as Help, View, and Select
Storage:	integral 3-inch, 320K-byte floppy disk; a second drive (same size as printer) that connects by cable to the main unit is optional
Expansion:	up to four 32K-byte RAM capsules
Input/output:	300-bps built-in direct-connect modem; telephone jack for modem; interface for optional printer, disk drive, and expansion memory; RS-232C port for transmission up to 9600 bps; jack for video output; jack for external power supply
Power supply:	integral rechargeable nickel-cadmium battery pack containing 10 half-D cell batteries; AC adapter that plugs into standard AC outlet and recharges batteries in approximately one hour if system is not in use

Software
MS-DOS and MBASIC are standard. Supercalc, Superwriter, PFS File and PFS Report are available for a total price of $425. The Gavilan Office Pack (4 applications) and operating system will be available by September.

Optional Printer
4-pound thermal-transfer printer that clips onto back of main computer unit; 11.4 by 4.9 by 3.0 inches. Prints at 50 characters per second and will print up to 6000 characters per charge of battery unit. Other options: 32K-byte RAM capsules; second 320K-byte, 3-inch floppy disk with 128K bytes of RAM in same housing; acoustic modem; 24-line by 80-character video montior; adapter for power from vehicle cigarette lighter.

plug-in power. Both users and designers of portables have faced trade-offs—to get true portability they've had to sacrifice usefulness. Intended for the traveling professional, the Gavilan combines the best of both worlds.

John Banning, chief of Gavilan's software development team, explains the company's design approach: "The person who is moving around in the field is often a professional but not a computer professional. He or she needs a computer that is easy to learn and easy to use. The traveling professional is likely to be in an environment where there's no support for a computer." Gavilan designers thus concluded that a portable computer must offer more, not less, than a stationary desktop system. "From that point of view," Banning says, "the software really drives what's going on."

Demands on Hardware

Friendly software requires a lot of memory and a 16-bit microprocessor to manage it. Gavilan chose Intel's 8088, running at 5 MHz, as the central processing unit, for several reasons. First, its 8-bit data bus would save precious board space. According to John Zepecki, Gavilan's director of hardware engineering, fitting everything onto the board was the hardest part of the project. "Also, the second generation of industry-standard software for personal computers of this size is really growing up around the 8086/8088 architecture," explains Banning. MS-DOS software will be available for the Gavilan.

Minimizing the use of power was another challenge. Apart from the central processor and the Western Digital disk-drive controller chip, the Gavilan uses CMOS (complementary metal-oxide semiconductor) technology. Power is turned off frequently to limit the power consumption of the disk controller and the central processor. Whenever the 3-inch Hitachi disk drive is not in use, both the drive and its electronics are turned off. The 8088 shuts down the Western Digital WD 1797 disk controller and saves information about its state. Whenever the operating system has no task scheduled for the central processor, the 8088 is turned off. In that case, the 8088 first saves its own state in battery-backed RAM, then disables the memory-write lines, and finally turns itself off. When power is restored to the 8088, it resets in one of several ways depending on what information was previously saved.

The rest of the machine uses high-speed CMOS logic, has 32K bytes of 8-bit wide CMOS static RAM (random-access read/write memory) and 48K bytes of 8-bit wide CMOS ROM (read-only memory). A single gate array controls either the liquid-crystal display (LCD) or a 24 by 80 video monitor. An 80C51 CMOS UART (universal asynchronous receiver/transmitter) manages the keyboard, the touch pad, and the asynchronous communications port.

Of the 80K bytes of memory contained in the Gavilan main unit, the 32K bytes of RAM are used for data storage and the 48K bytes of ROM for the operating-system and user-interface firmware. Up to four additional

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Gavilan's History

Gavilan Computer Corporation of Campbell, California, was founded in February 1982 under the name Cosmos Computer Corporation. The company chose that name because it believed it suggested "OS" for operating system and "CMOS" for the complementary metal-oxide semiconductor technology around which the company wished to build a portable computer with an advanced operating system. But to assure better trademark protection in world markets the company changed its name to Gavilan Computer Corporation in March 1983.

Manny Fernandez, Gavilan's president and chief executive officer, is a former president of Zilog Inc. Gavilan is a private corporation and has obtained substantial capital from a group of venture-capital investors that includes New Enterprise Associates, San Francisco; Smith Barney Venture Corporation, New York; Abingworth Ltd., London, England; Associated Venture Investors, Menlo Park, California; Genesis, Los Gatos, California; and Robertson, Colman, Stephens & Woodman, San Francisco.

Gavilan recently moved into a 30,000-square-foot building in Campbell and has arranged to move later into a 250,000-square-foot building to be built in an industrial park in San Jose, adjacent to Campbell.

The software staff has grown from an original 12 to 18 by March 1983. John Banning, chief of Gavilan's software development team, is a former director of software and architecture at Zilog. Working under him are two former Apple programmers, three alumni of the Xerox Palo Alto Research Center, and others from Hewlett-Packard, Tandem, and Tektronix. The hardware staff includes four electrical engineers and three mechanical engineers. John Zepecki, the hardware director, is a former vice-president of systems engineering for Magnuson Computer Systems.

Gavilan announced in April that IMCOSS, a major German company in the computer industry, has signed a contract as an OEM of the Gavilan. As well, Gavilan has signed other major OEM and end-user agreements.

RAM or EPROM (erasable programmable read-only memory) capsules can be plugged into the top rear left of the main unit. The capsules can contain either applications programs or user workspace. If the capsules contain RAM, lithium batteries in the capsule are used to save the contents of memory for as long as a year. Another 128K bytes of RAM can be supplied in a small module along with an optional second microfloppy disk drive. The interface connections for managing both the drive and the memory are standard equipment and are located on the back of the main unit.

The liquid-crystal display was chosen for considerations of space and power. A full-size 24 by 80 video display is optional and plugs into a standard equipment jack on the right side of the machine. The telephone jack for the modem and the jack for the external power supply are in the same area.

The internal power supply consists of 10 half-D cell nickel-cadmium DC batteries. Seven are arranged parallel to the long dimension of the display and three are perpendicular to that dimension. The Gavilan will run off the batteries for eight hours. An AC adapter is standard equipment and provides power for either operating the machine or recharging the batteries. The adapter can restore the batteries to 80 percent of capacity in one hour.

Other standard hardware includes an RS-232C serial interface for communications at up to 9600 bits per second (bps) and a built-in 300-bps direct-connect modem, for which the telephone jack is provided as noted earlier.

The 4-pound optional printer contains its own batteries and can print up to 60,000 characters per charge. The printer operates by thermal transfer of ink from a ribbon and can print on regular letterhead or thermal paper. A platen feeds sheets to the printing mechanism. The printer plugs directly into the system input/output bus through a connector on the back of the main unit. Some of the lines on that connector can be cabled to the optional second disk drive to manage expansion RAM of up to 128K bytes housed in the drive. The optional outboard RAM and four capsules that plug into the main unit can increase system RAM to a maximum of 336K bytes.

Other options are an acoustic modem and an adapter for using a car cigarette lighter as a power source.

Gavilan Software

Gavilan will supply its own built-in operating system, capsules containing Gavilan's own generic applications programs, development software to enable OEMs to write programs for specific applications, and MS-DOS for running software developed for the broader personal computer market. The Gavilan's multitasking operating system supports print spooling and background communications.

The software is novel in several ways. For one, the user interface actually controls the software. Another major innovation is the degree of integration of the applications, supported by underlying data structures. The Create command, available to the user in all applications, can create elements in one application that we think of as belonging exclusively in another application. In the middle of text, for example, Create can embed a spreadsheet cell. A formula determines the value in the cell. The cell can have a name, such as "annual revenues," and when there is a change in the values from which the annual revenues are calculated, a corresponding change is automatically made in the text.

The Built-in Software

The built-in software corresponds in some respects to a conventional operating system and occupies the first 48K

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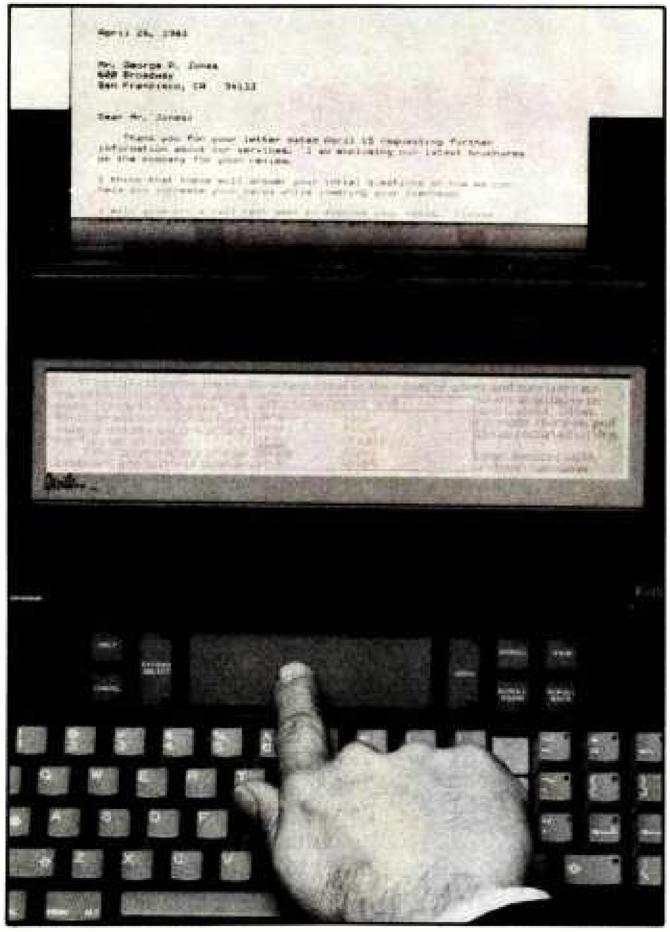

Photo 1: *Pressing Gavilan's touch panel activates a wide array of functions. Moving your fingertip across the unlabeled central area gives you control of the pointer. Pressing any of the other areas will perform the function indicated.*

bytes of the 80K bytes of RAM built into the Gavilan's main unit. Into those 48K bytes are packed the operating system kernel, the FORTH-like interpreter, the human-interface software, and the data-structuring software.

Gavilan chose to use an interpreted operating system to minimize use of memory and developed its own extended dialect of FORTH for use as the interpreter. John Banning says that use of sophisticated compiler technology enables the Gavilan interpreter to generate very compact code. The extensions of FORTH make programs in the language easier to document and maintain. Banning describes FORTH as "a language that can be efficiently interpreted and in which programs can be performance-tuned by taking little pieces of a program and recoding them in assembly language." Gavilan started tests in March to determine which parts of the software to recode for faster operation.

The Gavilan file system stores "documents" and indexed data structures. "Documents" are files that the human-interface software can display and manipulate using the various human-interface commands. The indexed data structures form the basis of operations such as the personal filing system and record processing systems.

The human-interface software controls all interaction with the user. Applications software communicates with the human interface through the data-structuring software.

The data-structuring software holds documents, which are sequences of elements where an element is any of the things that can be shown on the display and manipulated by the human interface. This underlying data structure permits mixing many different kinds of elements in one document and is responsible for the remarkable degree of integration in the Gavilan applications software. According to Banning, the data structures were the hardest part of the software development. "The worst thing was figuring out not only what these data structures would be, but what was the interface between these structures and the human interface. In other words, what was the interface between the data structures and an application program?"

Gavilan's main approach to application programming is one in which each element in a document has associated with it an "element manager." The element manager is a piece of software that implements a number of standard actions that the human interface knows about, such as "display yourself, a selection has been made." This is reminiscent of Smalltalk and other object-oriented languages in which data objects include both data and information about how the data can be manipulated.

"Every element that's held in the data structuring software has a tag on it, and there's a translation mechanism of what you get from that tag to a particular element manager," Banning explains. "When the human interface decides what part of the document to display, depending on what the user has been doing, the interface calls down to the data-structuring software and says, 'display this particular element.' The structuring software decides which application, which element manager, is associated with that element, and invokes that element manager to do that particular operation—moving data, changing properties, displaying yourself, setting up a selection, things like that. There is a standard list of operations that each element manager has to define. The element managers are inside the plug-in RAM capsules; all the element managers that go with one application are in a single capsule. Once you have the word-processing capsule, for example, your Gavilan can read documents that contain textual elements."

Banning stresses that the operating system "puts the user in charge of what's going on. The human interface is the user's representative in the software world."

The User Interface

When you open the Gavilan by flipping up the display, it shows a view of a desktop. The desktop shows file drawers, file folders, or whatever documents you have open on your desk. Drawers contain folders and folders contain documents. The degree of indentation on the display indicates what contains what.

The desktop also shows symbols for various capabilities that you can invoke, such as an appointment

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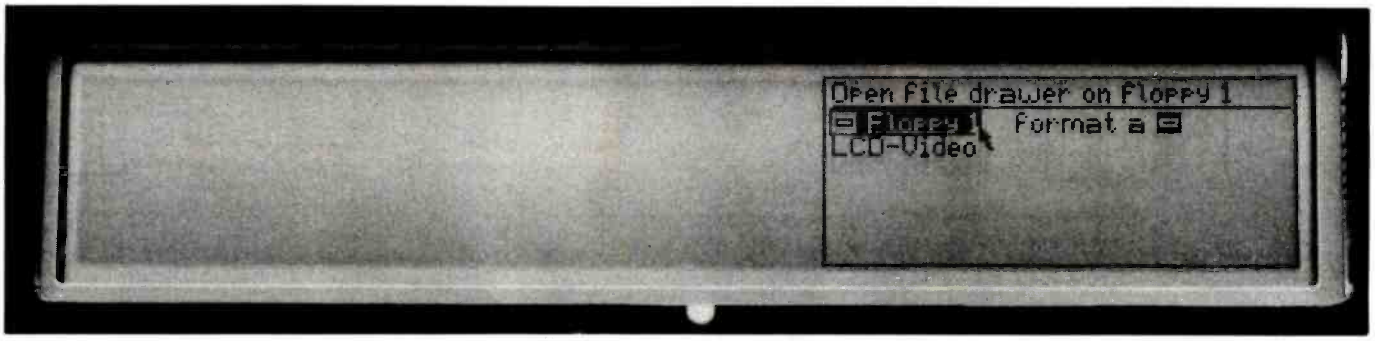
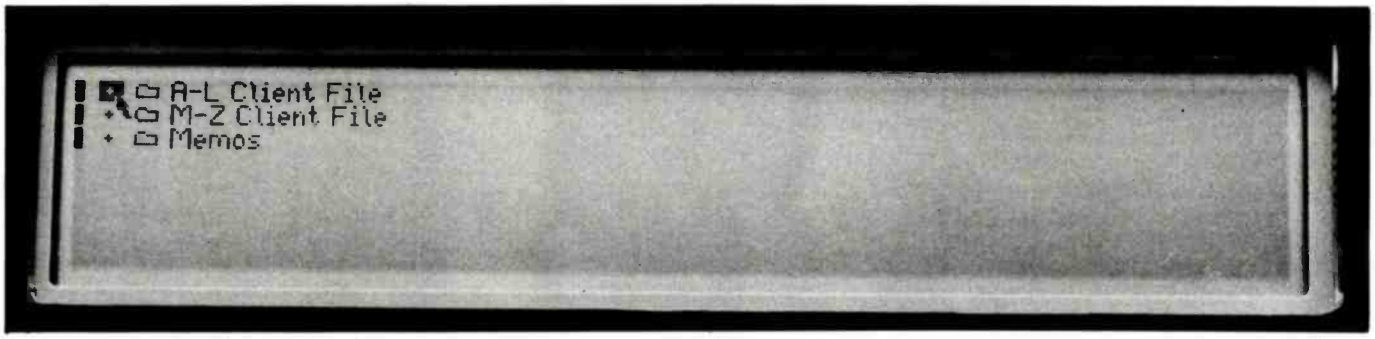


Photo 2: *The Gavilan desktop view summarizes the state of the system. Here the arrow is pointing to floppy-disk drive 1, and the command "Open file drawer on floppy 1" is highlighted. When you tap the touch pad (not shown), the operating system opens the file drawer (a metaphor for the floppy disk) on the disk.*



```
A-L Client File
M-Z Client File
Memos
```

Photo 3: *After the file drawer is opened, the screen displays the three file folders in the drawer. Each folder's name is preceded by a bar that indicates one level of nesting within the drawer, by a + sign that indicates the folder is closed, and by the symbol for a file folder. The + sign preceding the folder "A-L Client File" is highlighted because the pointer is on it. If you touch the pad now, the operating system will open the file folder and change the + sign to the open box that symbolizes an open folder.*

```
A-L Client File
 Joe Baker
 Reggie Davis
 Al Jones
M-Z Client File
Memos
```

Photo 4: *The A-L Client File is now open, and three files are shown inside it. Each of these three files is preceded by two bars, which indicate the level of nesting with the file drawer, and by the + sign that indicates a closed file. The operating system will open the Al Jones file, now highlighted, if you tap the touch pad.*

```
A-L Client File
 Joe Baker
 Reggie Davis
 Al Jones
  Insurance
  Letters
   Letter of 3 Aug. '82
   Pay your bill letter
```

Photo 5: *The Al Jones file is now open and the display shows its contents: an insurance folder and a folder of letters. The pointer is on the "Letter of 3 Aug. '82," which you can open by tapping the touch pad.*

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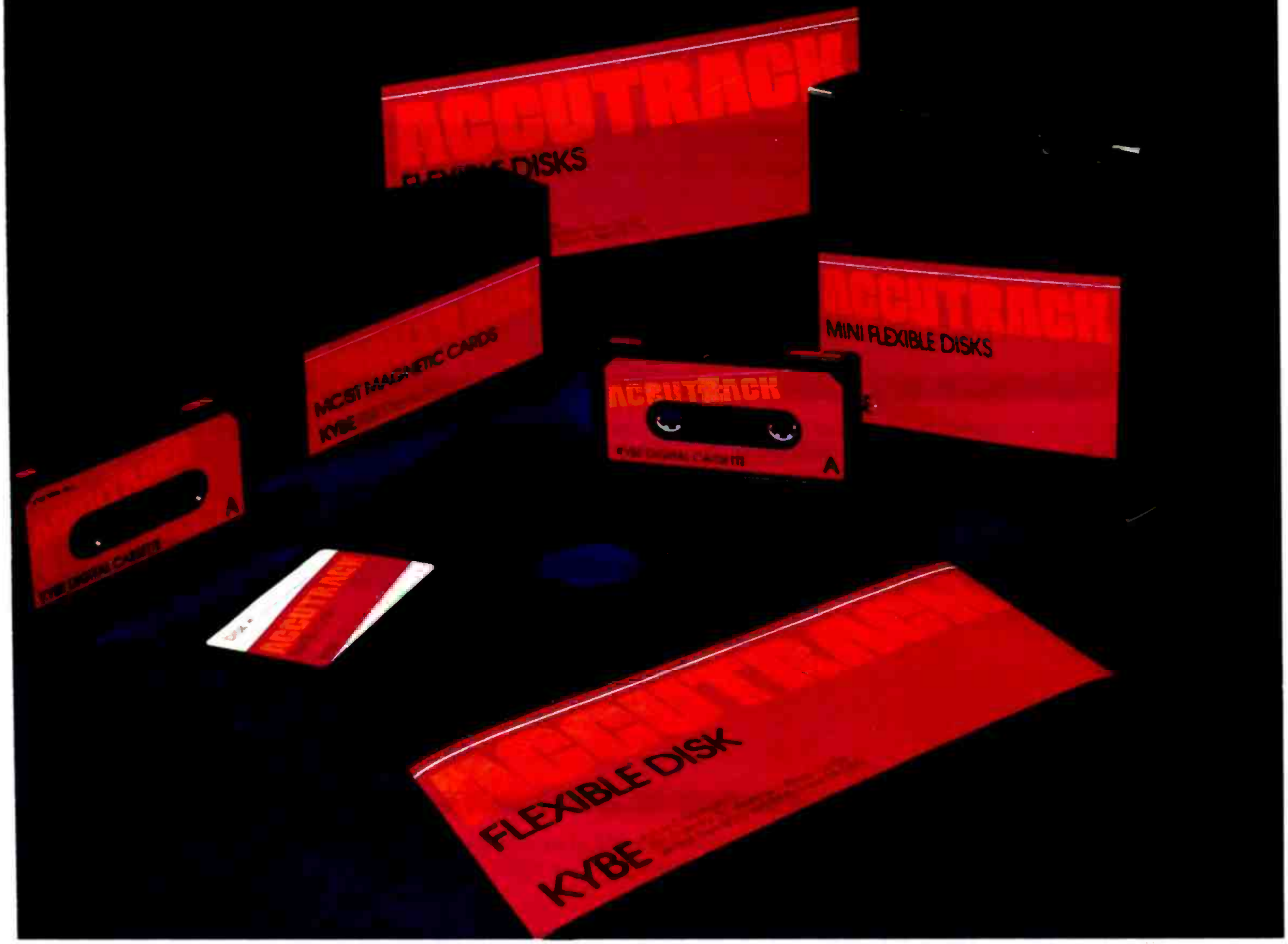

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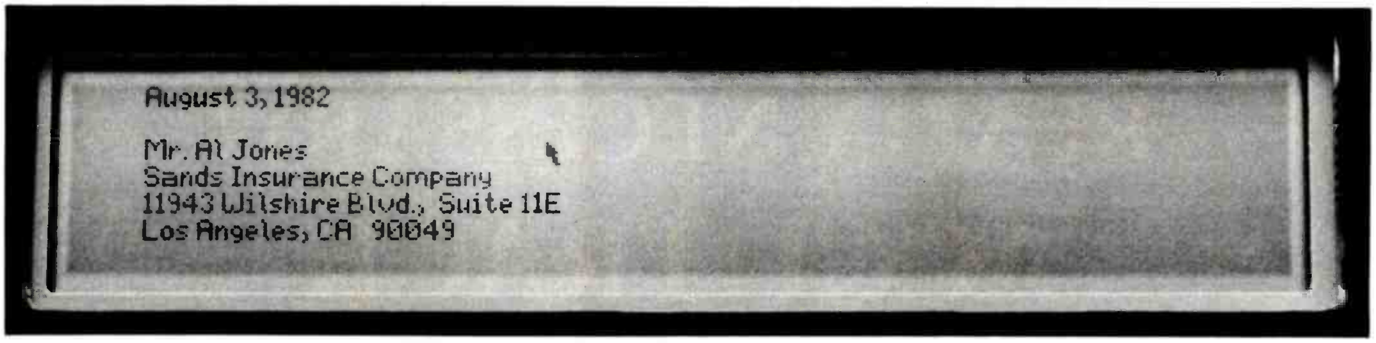
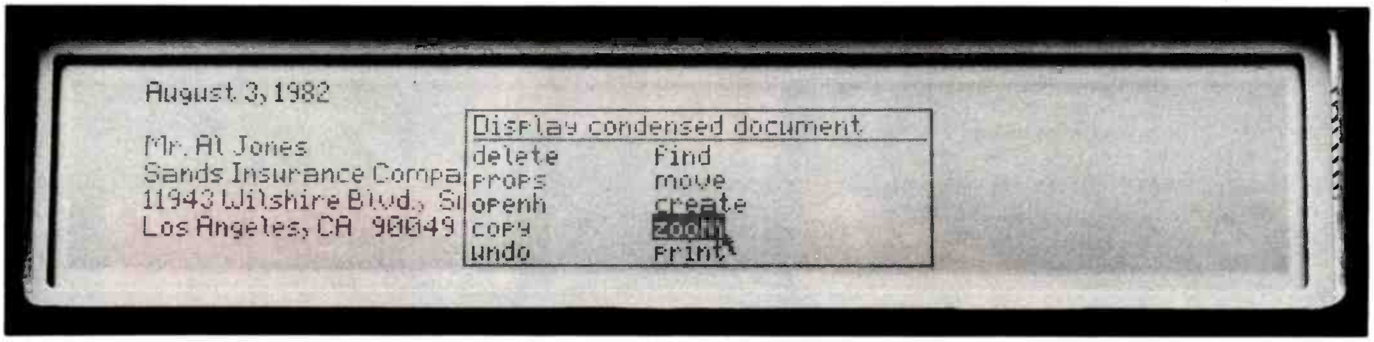


August 3, 1982

Mr. Al Jones
Sands Insurance Company
11943 Wilshire Blvd., Suite 11E
Los Angeles, CA 90049

Photo 6: *Now the letter is open and its beginning is displayed. The pointer can be maneuvered for editing. You can get a list of editing commands by pressing the Menu area of the touch pad.*



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Mr. Al Jones
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Los Angeles, CA 90049

Photo 7: *A menu of commands has popped up over the letter, and the Zoom command is highlighted. The line above the menu always displays a brief description of the highlighted command. The Zoom command gives you a distant view of the document, which will be shown condensed.*

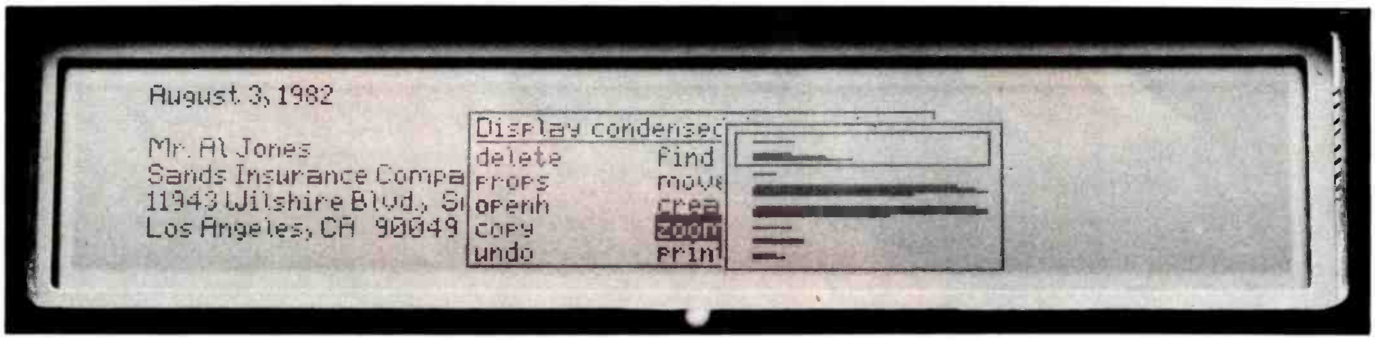

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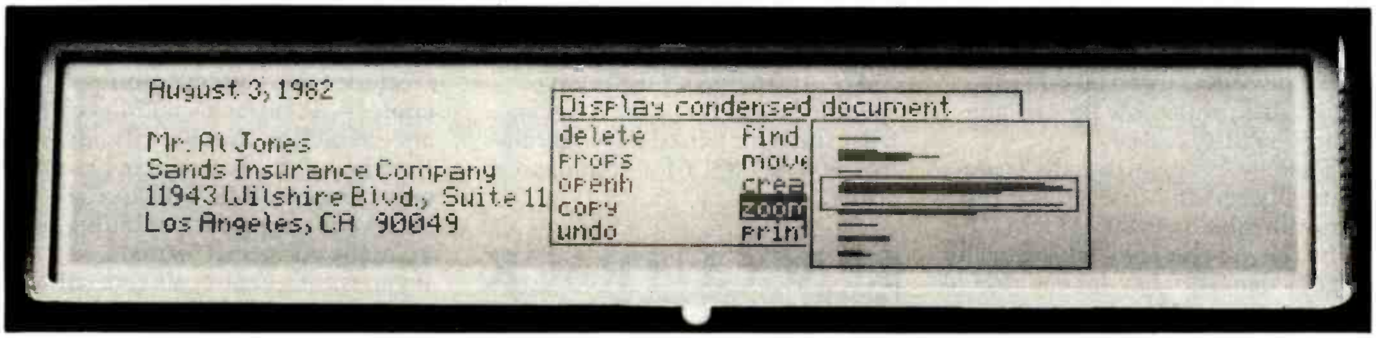
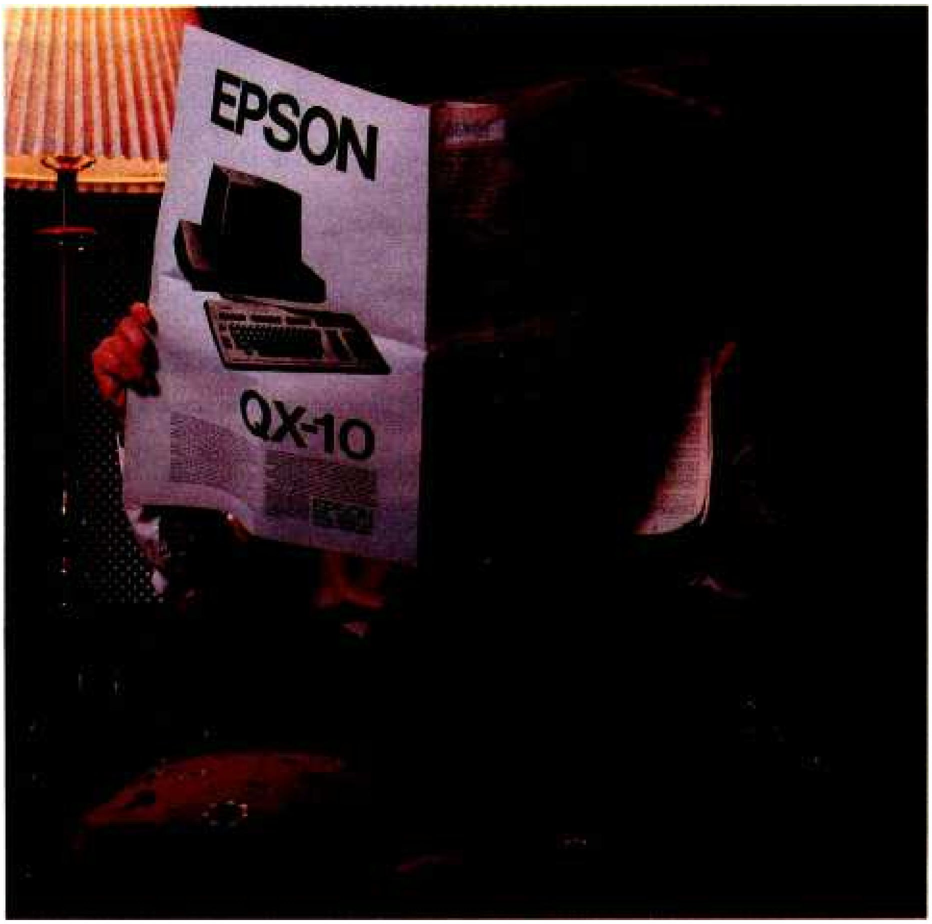
Photo 8: *When the Zoom command is in effect, the pointer is replaced by a frame that encloses the part of the document that is displayed full-sized on the screen. This helps orient the user and gives a preview of the appearance of the entire letter.*



August 3, 1982

Mr. Al Jones
Sands Insurance Company
11943 Wilshire Blvd., Suite 11
Los Angeles, CA 90049

Photo 9: *The user has moved the frame to another section of the letter. When you tap the touch pad, the selected paragraphs will be displayed.*



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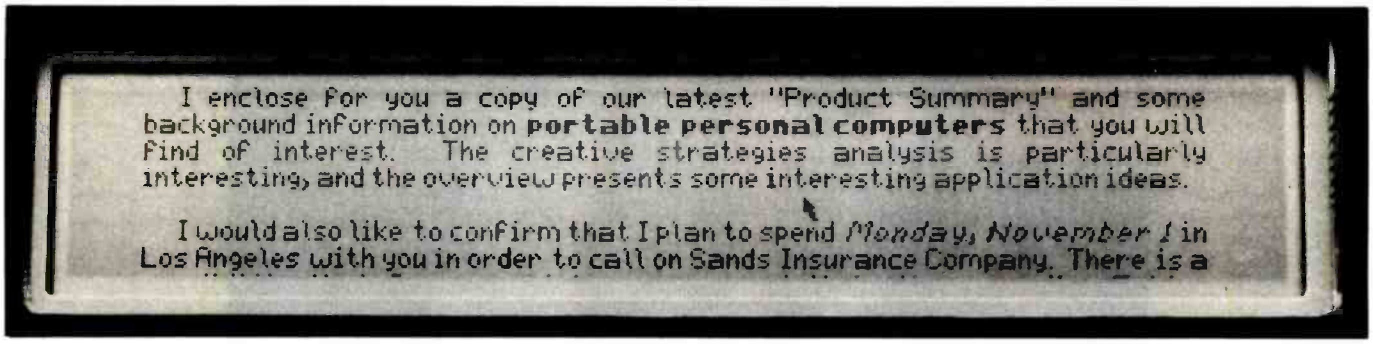


I enclose for you a copy of our latest "Product Summary" and some background information on **portable personal computers** that you will find of interest. The creative strategies analysis is particularly interesting, and the overview presents some interesting application ideas.

I would also like to confirm that I plan to spend *Monday, November 1* in Los Angeles with you in order to call on Sands Insurance Company. There is a

Photo 10: *Here are the new paragraphs. Note the use of bold and italic characters. (The camera angle obscures the last line of the eight-line display.)*

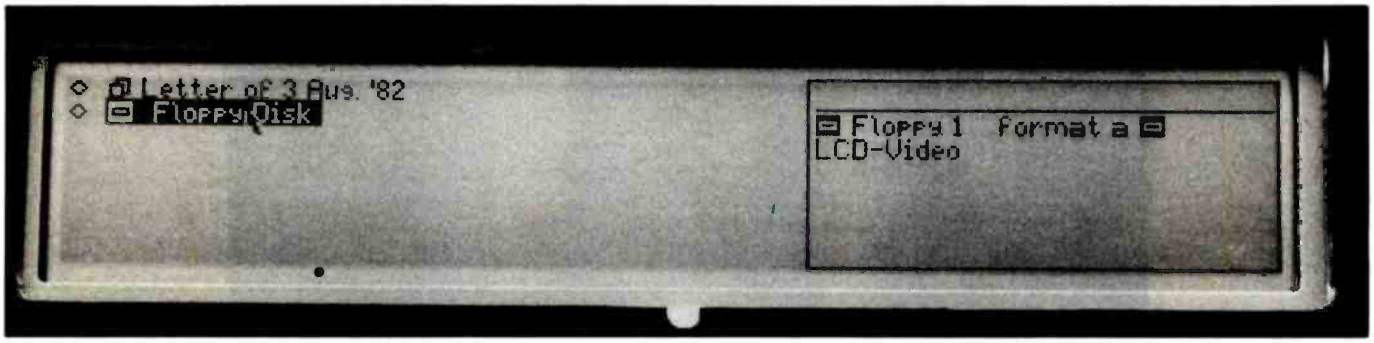


Photo 11: *By pressing the View area of the touch pad, you can return to the desktop. The desktop now shows that the file drawer and the letter of August 3 are open. When you return to the letter, you'll return to where you were when you pressed the View area of the touch pad.*

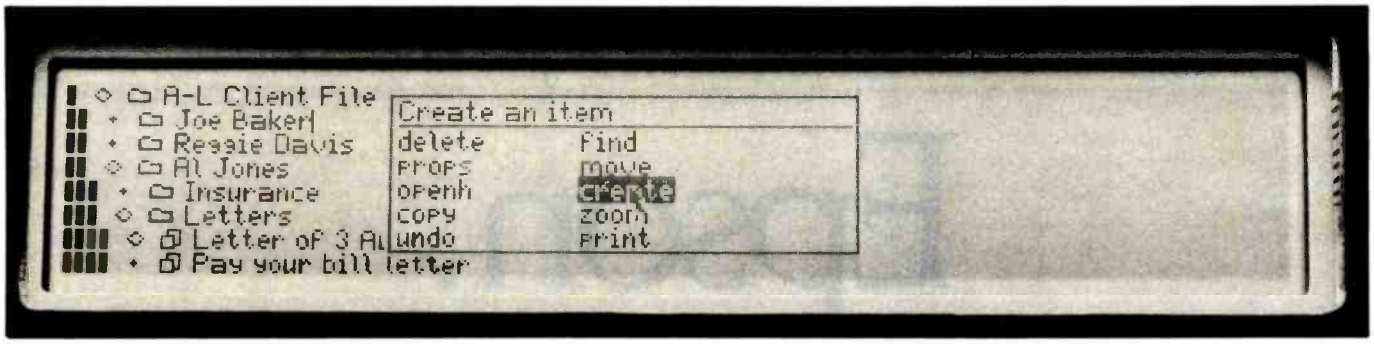
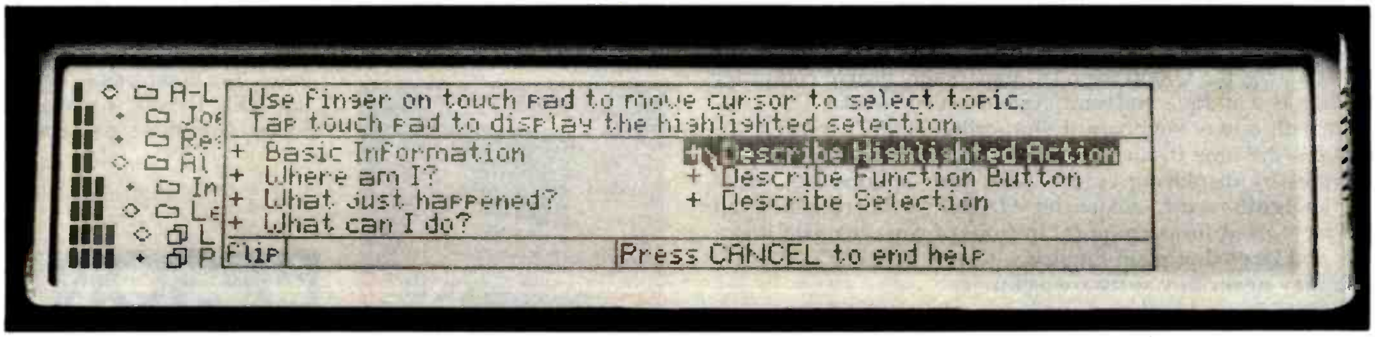


Photo 12: *You're ready to create a new file folder. The vertical bar after "Joe Baker" indicates an insertion point. If you create a file folder now, it'll be inserted between "Joe Baker" and "Reggie Davis."*



Use finger on touch pad to move cursor to select topic.
Tap touch pad to display the highlighted selection.

Photo 13: *If you're unsure about how to use a command you can always press Help. The Flip command at the lower left of the Help area can be selected to toggle the display between the help menu and the work area about which help is sought.*

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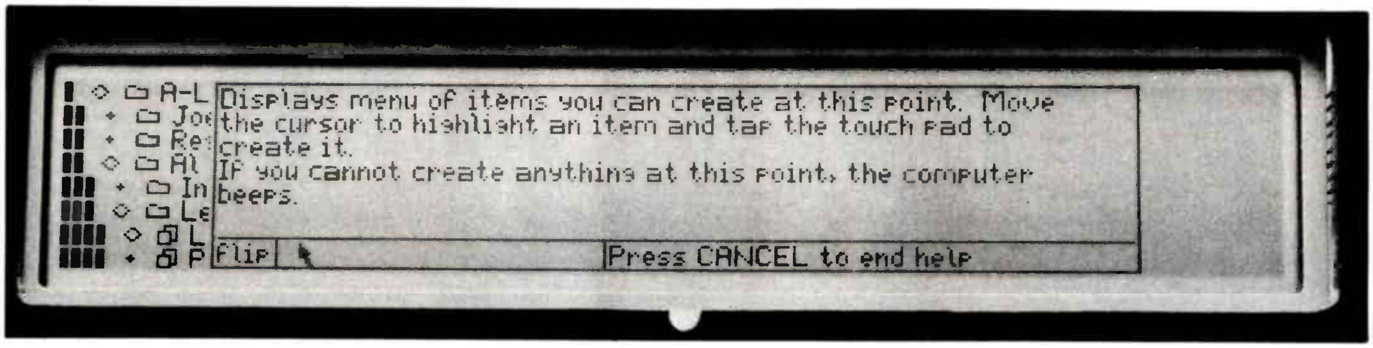


Displays menu of items you can create at this point. Move the cursor to highlight an item and tap the touch pad to create it.
If you cannot create anything at this point, the computer beeps.

Press CANCEL to end help

Photo 14: *The Gavilan's help text for the Create command.*

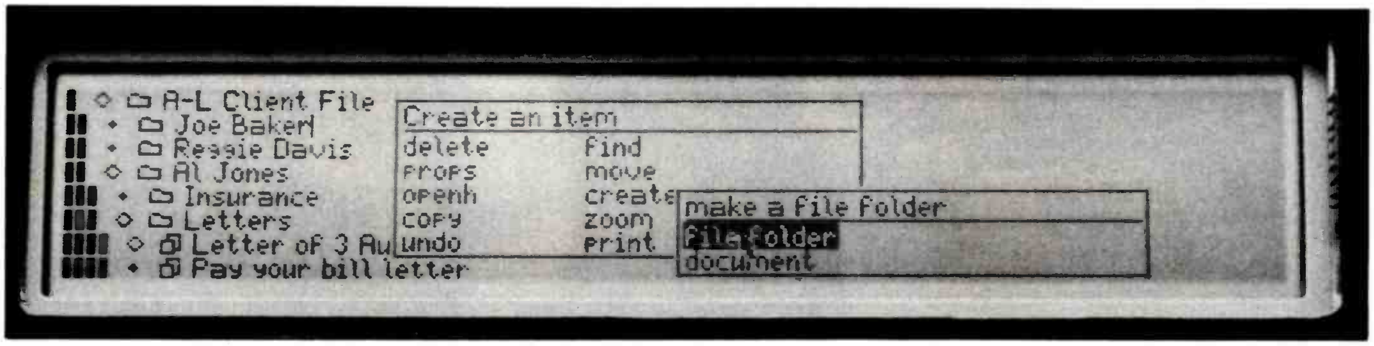


Photo 15: *By pressing the Cancel area on the touch pad, you can return from the Help display to the desktop. The Create command is still active and you have a choice of creating a new file folder or document. The pointer is on file folder, and by tapping the touch pad, you can create a new folder.*

calendar, different kinds of communication methods, the ability to switch over to video display from the LCD display, and so on. From anywhere in the system, you can always get back to the desktop by pressing the View button on the touch panel (see photo 1 on page 80).

The touch panel has nine labeled areas. In addition to the View area, there are Help, Select, Extend, Menu, Scroll, Scroll Again, Scroll Back, and Cancel.

The tenth and central area of the touch panel lets you control the pointer, or cursor, by moving your fingertip across the touch panel in the desired direction. The movement of the pointer is independent of where you put your finger down in this central area of the touch panel; the pointer follows the direction of your finger's motion. As you move the pointer over the symbol for an action, that symbol is highlighted. Then you invoke the action by tapping the touch pad.

You select an object for the action by moving the pointer over a character and then tapping the Select area with your fingertip. The character is highlighted to show that you can now work on it. To select a whole word, tap twice. Three taps select a sentence, four a paragraph. Another way to select larger units of data is to tap once to highlight the first character, then tap the Extend area of the touch panel, then move the pointer to the other end of the desired data and tap the Select area again. To insert something new, you move the cursor between two characters, and a vertical insertion bar appears. Then you type in the new information.

To get a list of your choices, you tap Menu. If you need assistance, you tap the Help area; the feedback depends on the context. The help information tries to answer the four most likely questions: What just happened? Where am I? What am I looking at? What can I do next?

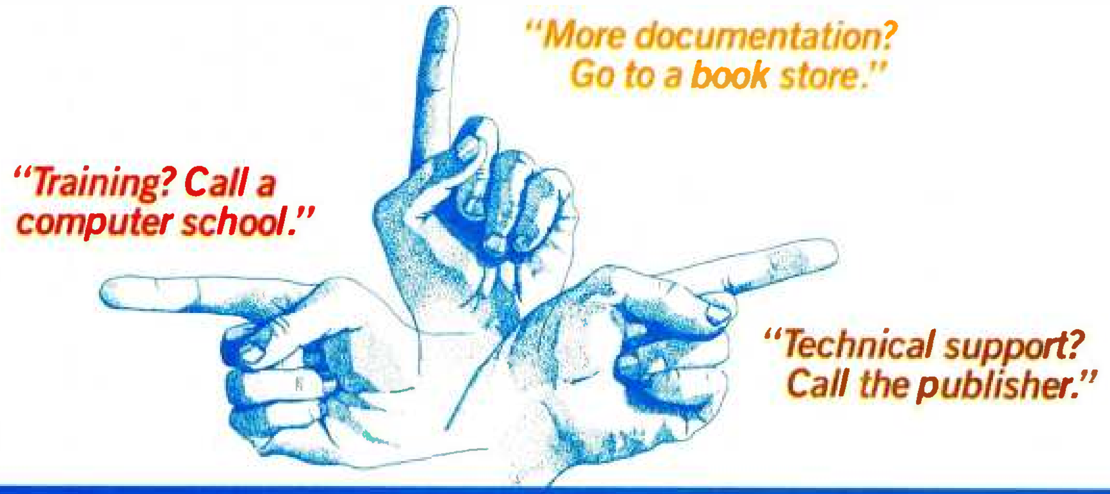
While the Help command is in effect, an area at the lower left of the LCD shows the word "Flip." If you move the pointer onto that word and tap the touch panel, you can flip back and forth from help text to the data that you were trying to work on. Because Flip remains highlighted, you have to tap only once to toggle from help text to data.

The Scroll, Scroll Back, and Scroll Again areas of the touch panel move your view to different areas of the data. The Cancel command terminates Help, Select, Menu, and so on.

Touching the Menu area of the panel always brings the standard menu. This contains 10 fundamental commands arranged on the display in 2 columns:

Delete	Find
Props	Move
Open	Create
Copy	Zoom
Undo	Print

Props, or "properties," lets you change the display output from LCD to video, or, in word processing, the paragraph formatting, or, in the spreadsheet, the column widths. Delete, as its name implies, deletes what has been selected. Similarly, Undo nullifies your last action and is



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actually implemented in the file system, which is returned to a previous state.

Zoom makes the information on the display appear farther away. In combination with the Scroll command on the touch panel, Zoom lets you maneuver rapidly around a large document.

Create lets you generate a paragraph, document, spreadsheet, section heading, chapter of a document, form for data entry, or cell in a spreadsheet.

A sequence using Create might go like this. You select Create and are given the options—files, folders, spreadsheets, section headings, chapters, forms, or cells. If you select file folder, you are taken to the desktop, where you are asked to type in the name of the file alongside a newly displayed folder symbol. Then you go back to the Create menu, where you select document. That takes you back to the desktop, where you enter the name of the document. You open the document by selecting it and tapping the touch panel or by pressing the Menu area of the touch panel and using the Open command. You then produce the document, creating whatever kinds of elements you need.

From the standard menu, you can go to another menu more specific to the context. What defines the context is not the application program you're using, but the kind of data you selected in the document. This interpretation occurs because each document can include spreadsheets and word processing and other kinds of elements.

The menu's Move and Copy commands, as their names suggest, move or copy information both within the same document and from one document to another. You first select the data to copy or move. If the desired destination is in a different document, you press the View area of the touch panel, which takes you to the desktop. There you can select any document or program and go look at a document, then get the standard menu and select Move or Copy to transfer the selected block of data. There is no formal procedure for moving data from one application to another because the documents consist of data elements. Thus, as long as your capsules contain the right element manager, you can use different types of elements in any application.

The files on the desktop display are preceded by either a plus symbol, which indicates the file is closed, or an open box, which indicates the file is open. You change the files by moving the pointer over one of those two symbols and tapping the touch panel. Once you've opened the file, you can examine it. The Zoom command gives you a "map" of the whole document.

Then the Scroll commands let you find a particular area of the document. Pressing the Scroll area of the touch panel causes a frame to appear on the screen, which represents a window. You can then move the frame over the part of the document that you want to see next by moving your finger on the touch pad. When the frame surrounds the data you want to see next, you tap the pad and that selected area displays at closer range.

Once you've used a Scroll operation, you can repeat it or reverse it by pressing the Scroll Again and Scroll Back areas of the touch panel. Find lets you search for a string. Print is self-explanatory.

Gavilan Applications Software

Gavilan is developing its own word processor, spreadsheet, "portable secretary," communications and mail system, and forms control software. (As of March, the word processor was in an advanced stage of development and the other applications were in earlier stages.)

The word processor includes global search and replace, the Move and Copy commands described earlier, and will support multiple fonts and page and paragraph formatting. The spreadsheet will handle the usual financial calculations in the familiar format. The portable secretary will provide a "to do" list, appointment scheduling, a "tickler" reminder file, time recording, expense reporting, travel routes and schedules as well as reports of calls and other activities. The communications software will provide access to databases, company computers, and electronic mail. The forms system will permit designing forms in which some fields are prompts, some are for data entry, and others result from calculations done on data-entry fields.

Languages and Development System

Gavilan plans to sell BASIC and Pascal to run under MS-DOS. The company will also sell a development system that permits outside programmers to develop applications software in the UCSD Pascal p-System. The re-

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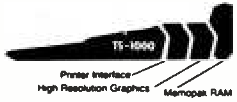

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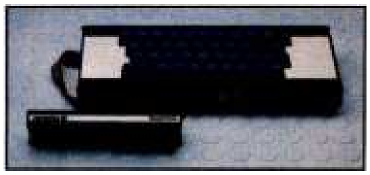

CENTRONICS PARALLEL AND RS232 INTERFACES
Memotech's Interfaces enable your TS-1000 to use a wide range of compatible printers. The resident software in the units gives the complete ASCII set of characters. Both Memopak Interfaces provide lower case character capabilities and up to 80 column printing. The RS232 Interface is also compatible with modems and terminals.

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sulting programs will be able to take advantage of the standard Gavilan user-interface software and interpreter.

The development system will consist of the UCSD p-System, a "capsule builder," and a "message builder." The capsule builder takes Pascal code and organizes it in such a way that it can work with the Gavilan user-interface software and data-structuring software. The program can then be loaded into one of the RAM capsules that plug into the four slots at the left rear of the machine. Another development tool called the "message builder" receives all of the program-message text that will be used to interact with the user, from the level of individual words in menus up to paragraphs of help information. The message builder compacts the messages by compressing individual characters and by assigning unique codes to commonly occurring phrases.

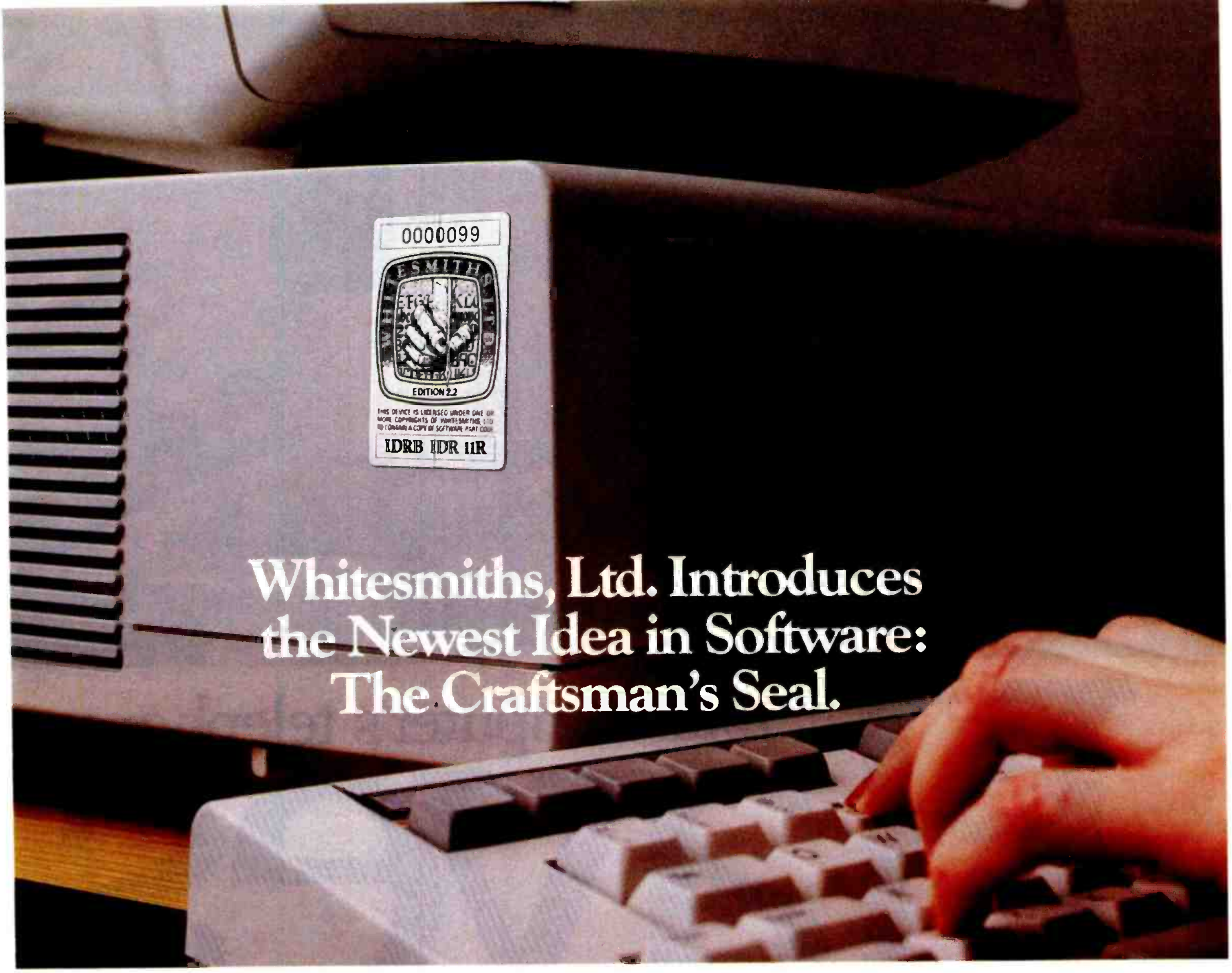
Market Impact

Successful and timely completion of the Gavilan project may influence several important trends in microcomputing. The use of the touch panel as a pointing device may challenge the popularity of the mouse as a nonkeyboard input device. A successful touch panel requires sophisticated algorithms to interpret the movements of the user's fingertip across the panel. In March, Gavilan had two different algorithms working, the more recent one much more efficient than its predecessor. Once the algorithm is perfected to give the on-screen pointer instantaneous and extremely precise response, the touch panel would seem to be a more natural pointing device than the mouse. People are accustomed to pointing with the fingertip, not the palm.

More important, the Gavilan mobile computer promises to set new industry standards not only for truly portable computers, but also for integration of applications software. The use of elements and element managers may achieve such a high degree of integration as to make the traditional concept of applications programs obsolete.

Beta-test deliveries of the MS-DOS version of the Gavilan start this month. The proprietary operating system and applications software begin alpha tests at Gavilan in August and beta tests by selected outside users in September. In early March, the Gavilan user interface appeared almost complete, the word processor included everything but printing and pagination, and the spreadsheet and other applications were in earlier stages of development.

Portables as useful and light as the Gavilan will probably lead even more people to use computers in their offices. One reason not to buy a desktop computer today is that you must work with paper while traveling; when you return to the office, you have to type your handwritten notes into the computer. That is precisely the kind of duplication of effort that computers should eliminate, and the Gavilan portable computer is doing just that while simultaneously moving the whole industry forward. ■



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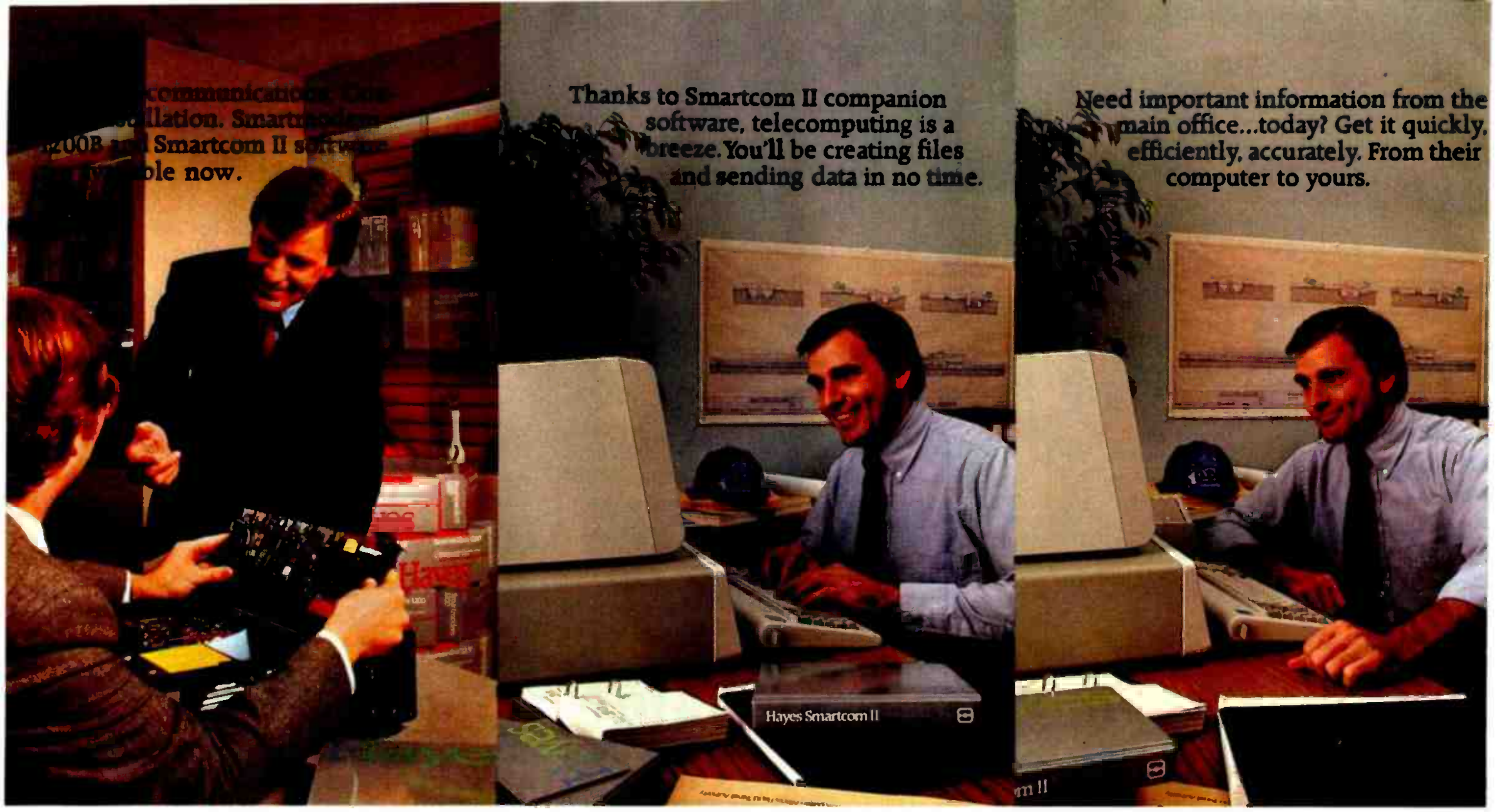

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Microcomputer architecture must complement the work habits of the people who use computers as tools. Most managers and office workers perform various tasks in a given day and often switch quickly from one to another. People who work as part of a team spend a considerable amount of time communicating with one another. Digital Equipment Corporation designers took these factors into account in creating the Professional 300 Series. They decided that new machines must be able to perform several tasks at once, apply the same user interface to each task, communicate efficiently, and, as an added bonus, use the same software as Digital's popular minicomputers.

The Professional 300 Series consists of two models that differ only in storage capability and slot space. The 325 has one dual floppy-disk drive and three option slots and can be upgraded to a 350 model, which has an optional Winchester hard disk and three additional slots.

These personal computers are really desktop-sized versions of the PDP-11, one of Digital's popular minicomputers. Both models share the PDP-11 instruction set and memory management and provide the user with about 90 percent of the throughput of a PDP-11/24. Both have an operating system based on Digital's RSX-11M+. For the user, this means that software applications developed for more than 500,000 installed PDP-11 and VAX systems are candidates for easy migration to a desktop personal computer.

Three major components—the system unit, the monitor, and the keyboard—comprise the Professional 300 system (see photo 1). The system unit contains the processor, memory options, power supply, and mass storage in a case that measures 23¼ by 14⅝ by 6½ inches. The main logic module contains the F-11 central processing unit, a chip set equivalent to a PDP-11/23-Plus (see photo 2). Its instruction set includes 87 instructions and eight addressing modes of either 16-bit words or 8-bit bytes. Although the system works with 16-bit addresses, providing for 64K bytes of logical address space, the Memory Management Unit (MMU) constructs 22-bit addresses that allow up to 4 megabytes of RAM (random-access read/write memory).

Two memory modules totaling 256K bytes of RAM connect to the main system logic module with 40-pin connectors without occupying an option slot (see photo 3). The standard configuration also includes 16K bytes of ROM (read-only memory) and 32K bytes of RAM for bit-map control. Options requiring extra memory include the necessary additional RAM on the option module. A nonvolatile clock and RAM use a rechargeable nickel cadmium battery to maintain the time and date even when the system power is turned off. Each Professional System also includes a unique 47-bit identification ROM that is readable from software and can be used for either system verification or as part of a piracy-protection scheme.

A 208-watt power supply that comes with an integral fan handles a Professional 350 equipped with all available options. The disk-drive units are easily accessible from the front of the chassis. Both Professional Series systems come with an RX50 dual-disk subsystem that is capable of storing up to 800K bytes of formatted data in fixed-length blocks on two 5¼-inch floppy disks. This subsystem includes a separate single-board controller module and extensive internal self-testing and diagnostic firmware. An optional 5-megabyte Winchester disk is available for the 350 model. The 350's module cage contains six slots for the addition of peripherals. In the standard configuration, one slot is occupied by the floppy-disk controller and another is taken by the video controller. The back panel of the system unit enclosure has connectors for a serial printer port, the video monitor port, an RS-232C/423A serial-communications port, AC power, the telephone-management interface, and a 16-pin Ethernet plug.

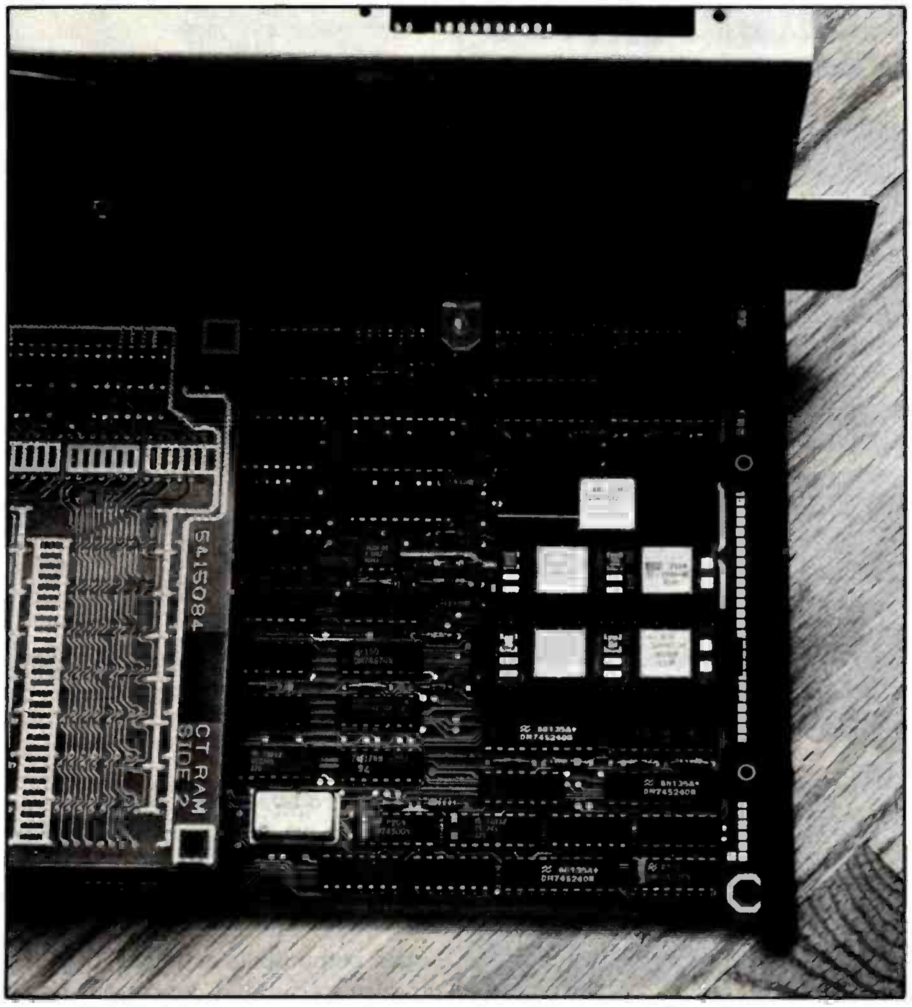

Photo 2: *The F-11 chip set provides users with the power of a minicomputer in a microprocessor-based desktop computer.*

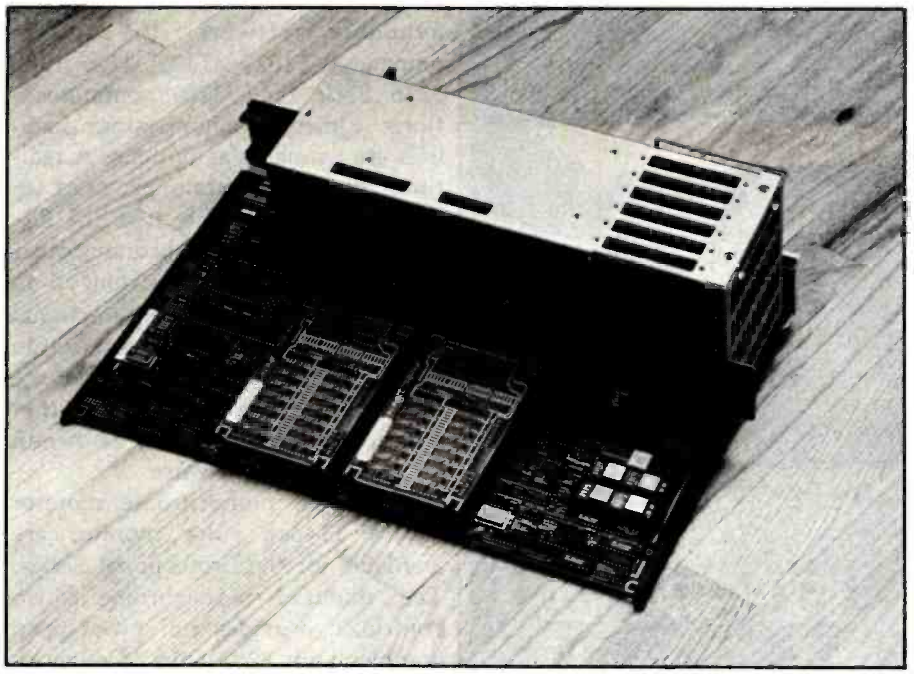

Photo 3: *By using daughter boards for additional memory, the designers were able to avoid occupying an expansion slot.*

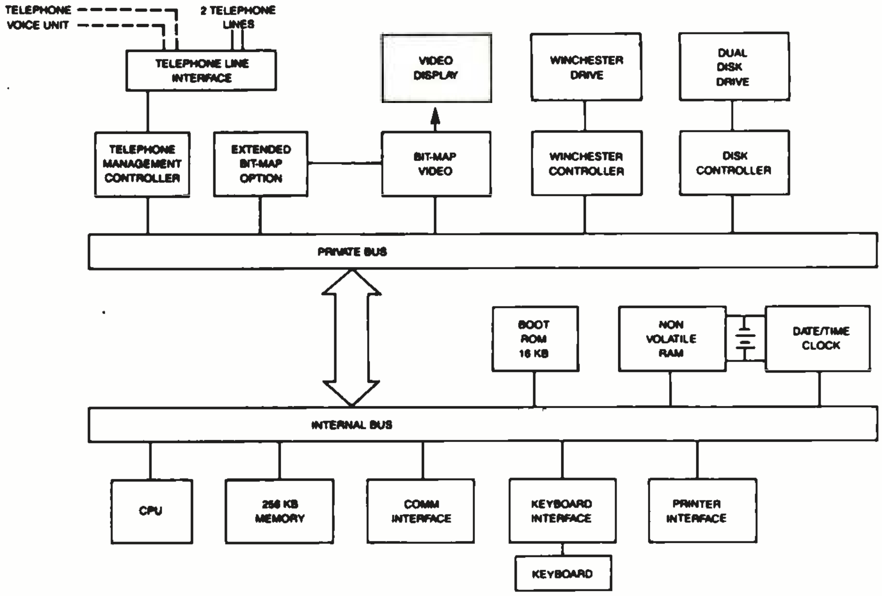

Figure 1: *A block diagram of the Professional 350 system.*

The Professional's designers assumed that managers and office workers rarely work alone. Instead, they spend their time communicating with others and accessing data from larger computers, activities that require powerful and concurrent communications facilities. The standard communications port on the Professional handles asynchronous or synchronous communications. By using available software, the system manages VT102, VT125, 3276 BSC, 3276 SNA, and 3780 communications. Other communications facilities are available as options. A real-time interface module provides an IEEE-488 bus interface, two EIA RS-232C-compatible asynchronous ports that are programmable from 50 to 9600 bps, and a 24-bit bidirectional parallel port. An Ethernet connection is also provided at the rear of the system unit, although currently that connection is supported by neither an option card nor software.

A 12-inch monochrome monitor and a 13-inch color monitor are available for the Professional Series. The standard monochrome video controller provides full bit-mapped graphics with 32K bytes of memory on the board, supporting a 960 by 240 pixel (picture element) display. An extended bit-mapped option provides memory for two additional bit planes as well as RGB (red-green-blue) control for the color monitor. Both monitors are designed to be as small as possible to keep the computer system's footprint—the size of the surface it occupies—as unobtrusive as possible.

The keyboard was designed to meet three major criteria: it must conform to international standards, accommodate Digital's multinational character set, and provide user-defined function keys. Using these criteria and basing their work on ergonomic studies, the designers provided 105 keys and separated them into four logical groups. A main typing array of 57 keys conforms to the international touch-typist layout. Immediately to the right of the main keyboard are the editing pad and the cursor-control keys. The most commonly used editing keys—Find, Insert, Remove, Select, Next Screen, and Last Screen—are located just to the right of the main array. The cursor controls are arranged in an inverted T, the most efficient configuration for touch-typists. To the right of the cursor controls is an 18-key numeric pad that makes it possible to enter large amounts of numeric data

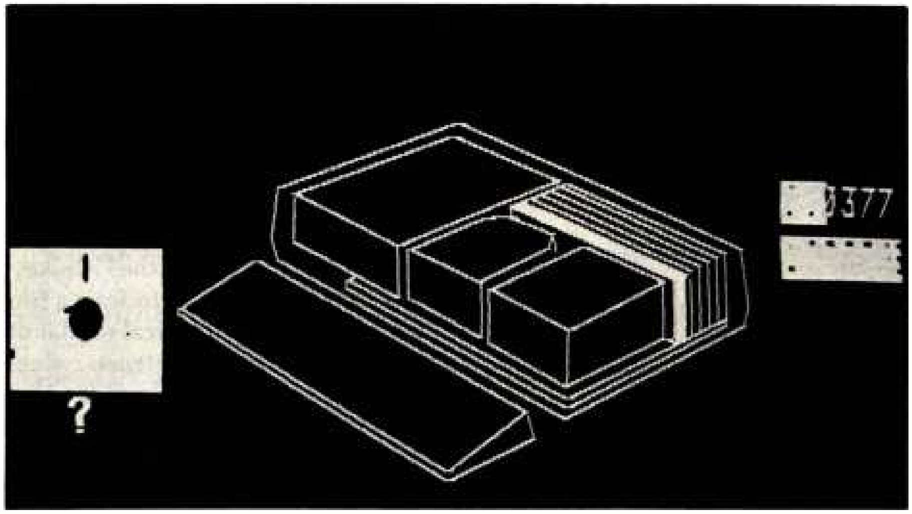

Photo 4: *The use of graphic error messages is another example of the designers' goal of reducing the confusion and complexity often associated with computers.*

quickly. The pad layout is compatible with all existing software dependent on Digital's VT100 keypad arrangement. Across the top of the keyboard is a row of 20 function keys. Applications programmers can program all but four of these keys. Digital's designers also provided a special windowed area at the top of the keyboard for key labels. Digital did extensive tests with computer novices to help ensure that the functions of the keys are obvious from their labels.

User Interface

Digital made a concerted effort on the design of the user interface for this family of personal computers. In all aspects, from installation and maintenance features to the operating system, the designers anticipated prospective users' habits and needs. A novice user can install the hardware, the operating system, and application software and do minor maintenance without technical help. The system components assemble quickly. For example, you simply connect the keyboard to the monitor with a cable, connect the monitor to the system unit in the same way, plug the power cord on the system unit, insert the Winchester disk, plug into an AC power outlet, and hit the switch. The option cards were designed with zero-insertion-force connectors and install on a system bus designed to eliminate the need for switches and jumpers.

The Professional's CTI system bus has many notable features. Like the older LSI-11 bus, the Professional's system bus has 22-bit addressing and multiplexes addresses and data by combining 16-bit data signals with the 22-bit address signals on 22 signal lines. Each option module installed on the bus generates two different hardware-interrupt signals with an associated register indicating the memory location of the interrupt-handling routine associated with this signal. The design of the interrupt-handling hardware makes the interrupt priority independent of the slot position.

When the user installs a module, an option-present signal alerts the main system logic module. Because each option contains identification information in ROM, the system easily locates and identifies all installed options. Each bus slot has a fixed address, and an option card assumes the address of the slot it occupies. And except for the hard disk and the floppy-disk controllers, any option card works in any slot.

The installation of the operating system is equally simple. A series of copies from floppy disk to hard disk with software prompts guide the way. Application programs use a similarly simple procedure under control of an automatic installation utility. The Professional 350 also offers diagnostics both in ROM and on disk that run every time the system boots. The diagnostics for the main system logic run first and are followed by a segment that detects which options are installed. Then diagnostics on each module transfer to RAM to be run by the central processing unit. Error messages take advantage of the machine's bit-mapped graphics by drawing a picture of the system and highlighting the failing component in reverse video (see photo 4). All the system's modules can be replaced and can be removed either with fingers or a ballpoint pen. These features reflect Digital's belief that a user who has to call a technician soon becomes convinced that the computer is complex and difficult to use.

Software Availability

Digital's design goals are further evident in the company's three-pronged software effort: the Professional Operating System (P/OS), the Professional Developer's Toolkit, and third-party application programs.

The operating system is derived from Digital's RSX-11M+, an event-driven multitasking software system. The design team regarded multitasking capabilities as mandatory. As the personal computer becomes an integral part of the professional's working patterns, the designers reasoned, the machine must function in the same manner as its user, which means working at multiple tasks.

Throughout the design process, the goal of a consistent user interface was cardinal. Today, some operating systems force users to have as many different interfaces as they have application packages. Digital believed that a continual proliferation of interfaces would impose a major constraint on the perceived usefulness of personal computers. P/OS removes that constraint by making it simple for programmers to work with a consistent user interface that controls every application on the system. The combination of multitasking, the user interface, and published standards, tools, and guides for application is a design that responds to the needs of the Professional's market.

In the initial release of the operating system, a single menu-tree structure, help-message handler, error-message handler, and a common file

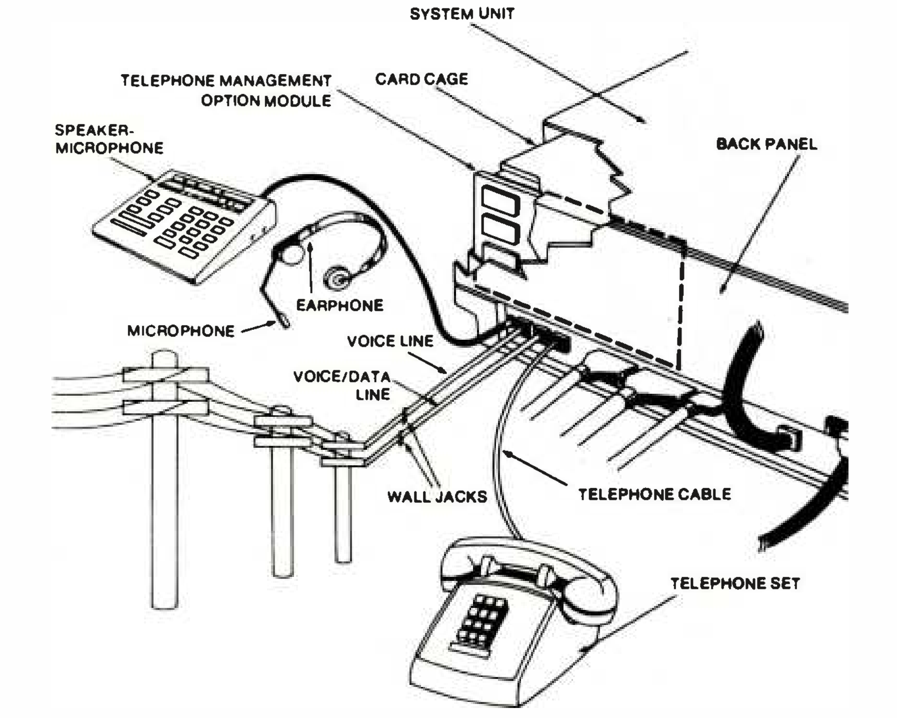

Figure 2: *The Telephone Management System incorporates voice and data communication through telephone connections.*

Application	Product; Company
Word processing	Prose, Prose Plus; Digital Equipment
Calendar/tickler	Executive Desk Set; Cortex
Spreadsheet	Advanced Visicalc; Visicorp
Graph	Visiplot/Visitrend; Visicorp. Corgraph; Cortex
Decision support	MAPS; Ross Systems
Project management	micro/MAPPS; Structural Programming Inc.
Data management	Visifile; Visicorp. NPL; Desktop Software
Statistics	SPSS; SPSS Inc.

Table 1: *Professional Series users have access to these application software packages, which incorporate the consistent user interface.*

structure characterize the user interface. While the hardware architecture makes it possible to take advantage of windowing and various cursor-positioning schemes such as mice or bit pads, the software design team felt that the first priority should be establishing a consistent interface. The other options will evolve as users demand them.

For an example of how the user interface works, consider what happens when you want to use a new application package on the Professional system. First you insert the disk and call the automatic application installation utility, which copies the program into the program library. At the same time, the utility copies the error messages into the appropriate library, puts text in the help library, integrates the application's menu into the menu tree, and places the name of the application package in the main menu. During this process you can also rename that application program or position it at a particular place in the menu tree. All of the application programs Digital developed use this same installation approach. One advantage of a consistent user interface is that you can get online help at any time simply by pressing the Help key.

Other P/OS features include a file-structure protocol identical to that on PDP-11 and VAX systems, which makes file transfers between the Professional and those systems much easier. A set of file services, print services, disk utilities, and a memo editor called PROSE are included with the operating system. The designers also furnish an interactive BASIC interpreter, PRO/BASIC, to meet the user's everyday programming requirements. PRO/BASIC is a compatible subset of Digital's BASIC-Plus-2 and VAX-11 BASIC, the only exception being that the PRO/BASIC has additional graphics commands. Features of the language include 31 character variable names, extended IF. . .THEN. . .ELSE statements, single and double precision, program chaining, and online help.

Development Tools

For special applications that require the user to design custom software, Digital has provided the Professional Developer's Toolkit. This package of tools lets a programmer use the power and resources of a VAX or PDP-11 minicomputer to write programs for the Professional Series microcomputers. The Toolkit supports seven languages (see box on page 102) and contains programming utilities RMS (Record Management System), FMS (Forms Management System), and CGL (Core Graphics Library).

In a typical development scenario on the Professional, a programmer enters and edits source code using PROSE. Then the programmer uses the communications utilities provided with the Toolkit and takes advantage of the identical file structure protocols to pass the source code to a larger PDP-11 or VAX system. The minicomputer compiles the code and transmits the result back to the Professional system, where the program-

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The Professional Developer's Toolkit supports these languages:

BASIC-Plus-2 *is an extended BASIC compiler that offers structured programming constructs; access to global variables, functions, and constants; and support for implicit or explicit data types.*

FORTRAN 77 *is an extended implementation of the ANSI (American National Standards Institute) subset Fortran-77 standard (X3.9–1978). Professional Tool Kit FORTRAN-77 contains many of the full-set language features and extensions not included in the standard. Full-language features include double-precision and complex data types, intrinsic functions, exponentiation forms, format editor descriptors, and generalized DO loop parameters.*

COBOL 81 *is based on the 1974 ANSI COBOL Standard (X3.23–1974) and includes some of the features planned for the next standard.*

DIBOL *allows for the use of P/OS system services while maintaining many of the standard DIBOL features found on VAX/VMS, RSTS/E, CTS-300, and CTS-310.*

Professional Macro Assembler

Pascal *is a true optimizing compiler with an extended implementation of the Pascal language. The extensions assist the application programmer in accessing P/OS system services and simplify application design. Extensions include ISAM (indexed sequential-access method), separately compiled procedures, sets of up to 256 elements, 31 character identifiers, FIND and LOCATE I/O procedures, and an OTHERWISE clause for the CASE statement.*

C *(available from Whitesmiths Ltd.)*

mer uses an interactive debugger to refine the program. Later, the programmer uses the frame-development tools to create menus and error messages for the program. Additionally, an application-builder program creates floppy-disk copies for distribution. Finally, the programmer may develop algorithms that use the identification number located in ROM to combat software piracy.

A Toolkit style guide helps programmers maintain the consistency of the user interface. For example, execution of a command should be initiated by pressing the DO key rather than Enter or Return. Digital's design goal is that end users will get some applications programs from Digital, some from their own programming staff, and some from third-party vendors, but all the programs will look and act as if they came from the same programmer. Already, Professional Series users have access to software that has been developed with the consistent user interface (see table 1). Much of this application software is also available for both the Professional and Digital's larger systems, and the common file structure provides an easy migration path to established minicomputer software.

Telephone Management

In another example of designing a personal computer around the work habits of the user, Digital introduced a Telephone Management System (TMS) option (see figure 2). A potential user of the Professional system probably spends at least 20 percent of the day on the telephone. That time can be made more productive by using TMS, which lets the computer maintain a personal directory of numbers, dial calls, log and file messages, and answer the phone when necessary. Additionally, TMS can provide facilities for dictation and transcription. Perhaps most impressive is that the TMS hardware will support *composite documents*, which combine text, graphics, and voice—which are necessary components of the automated office.

The TMS has three components: a controller board that fits into the option-card cage of the system unit, an attachment plate that goes on the rear of the system unit, and an accessory box designed to resemble the keyboard. The controller board contains most of the TMS logic, including the modems, DTMF transceiver, tone-detection circuitry, and Codec, a voice encoding and decoding chip.

Bell Laboratories' 103J/212A equivalent modems provide the user with 300- or 1200-bps (bit-per-second) data communication over standard telephone lines, and Touch-Tone signals can be transmitted with the DTMF transceiver. The tone-detection circuitry detects dial, busy, and ring-back tones. Analog voice signals from the telephone line or voice unit are converted into digital signals by the Codec circuitry. These signals can then be stored on the Professional's Winchester disk, on a file server, or on a larger system. The process also reverses to reconstruct analog signals from transmission on the phone line or voice unit. A CVSD (continuously variable slope delta modulation) 32K-bps encoding scheme maintains high-quality voice playback.

A plug-in attachment on the back of the system provides modular-jack connections for two telephone lines, allowing the user simultaneous voice and data connections. Additionally, this attachment provides the necessary connections for the user's telephone and the optional voice unit, which contains a full telephone dial pad, conference phone buttons, and dictating-machine control keys. The unit also has a speaker and a microphone.

The TMS hardware operates through a standard handset or an external speaker. In combination with an optional communication-services software package, the user can maintain a personal calling directory and automatically invoke dialing of either voice or data calls. The communications software also provides for VT102 and VT125 terminal emulation using the TMS modems and permits file transfer between other Professionals as well as to RSX and VMS systems. The hardware's potential, however, still remains to be reached,

Text continued on page 106

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A DEC on Every Desk?

John J. Snyder, Ph.D.
POB 6046
Boulder, CO 80306


The VT180


The Rainbow 100


The DECmate II


The Micro/PDP-11

Digital Equipment Corporation has developed an entire line of microcomputers to meet the needs of a variety of users. In addition to the Professional Series, the following machines are available:

- *The VT180, an 8-bit microcomputer based on the CP/M operating system and floppy-disk drives*
- *The Rainbow 100, a dual-processor 8-bit and 16-bit microcomputer based on CP/M, CP/M-86, and MS-DOS operating systems with an optional hard disk*
- *The DECmate II, a 12-bit microcomputer with an optional hard disk; compatible with Digital's vintage line of workhorse PDP-8 minicomputers*
- *The Micro/PDP-11, a 16-bit multiuser microcomputer with a built-in hard disk, also compatible with Digital's line of PDP-11 minicomputers; runs six of the PDP-11 operating systems (see table 1 for a comparison of the Digital lineup).*

The VT180

The VT180 Personal Computing Terminal is Digital's entry-level microcomputer and has been available since early last year. Actually, the name VT180 is an unofficial designation for the combination of a standard VT100 terminal with the VT18X option. Although the VT100 is a "smart" terminal, it is not user programmable in terms of applications software. The VT18X option for the VT100 terminal consists of two circuit boards that fit inside the terminal and a pair of 5¼-inch floppy-disk drives in a separate low-profile enclosure.

The resulting VT180 contains a standard Z80 microprocessor running at 2 MHz with 64K bytes of RAM (random-access read/write memory). Each floppy disk has 180K bytes of storage, and the system can access up to four drives in two enclosures.

The Rainbow 100

The Rainbow 100 is a dual-processor model featuring both the 8-bit Z80 and the 16-bit 8088 microprocessor chips. This machine's distinctive appearance is highlighted by the long, very thin, detached keyboard and a video display in a truncated pyramid barely larger than the monitor tube itself.

The unit also has an overgrown attaché case, which doesn't always appear in the ads. The system unit contains the processors, memory, disk drives, power supply, and slots for three option cards in a case that measures 19 by 14.3 by 6.6 inches. The unit can be mounted horizontally on a desktop or, even better, vertically on a floor stand to save valuable desktop space.

The Rainbow 100 uses Digital's special CP/M 86/80 operating system. This system automatically senses whether an application program has been written in CP/M-80 (for the 8-bit Z80) or in CP/M-86 (for the 16-bit 8088) and then executes the program on the appropriate microprocessor. MS-DOS, from Microsoft, will also be available and will offer the possibility of running software developed for the IBM Personal Computer.

The standard Rainbow 100 starts with 64K bytes of main memory, expandable to 256K bytes. The dual floppy-disk drive stores 400K bytes on each disk and uses one spindle motor to spin both disks. And the size of this package is identical to a standard single-disk drive. A second dual-disk drive as well as a 5-megabyte Winchester hard-disk drive may be installed in a separate cabinet. Color and bit-mapped video graphics options are also available.

The DECmate II

The DECmate II resembles the Rain-

Specification	VT180	Rainbow 100	DECmate II	Professional 325	Professional 350	MICRO/PDP-11
Word size	8-bit	8-bit and 16-bit	12-bit	16-bit	16-bit	16-bit
Processor	Z80	Z80 and 8088	DEC 6120	LSI-11/23-Plus	LSI-11/23 Plus	LSI-11/23-Plus
Main memory (bytes)						
Standard	64K	64K	96K (64K words)	256K	256K	256K
Maximum	64K	256K	96K (64K words)	512K	1 megabyte	4 megabytes
Operating system(s)	CP/M	CP/M-86/80 (combined 8- and 16-bit CP/M), MS-DOS (16-bit)	WPS-8, COS-310	P/OS (from RSX-11M-Plus)	P/OS (from RSX-11M-Plus)	CTS-300, DSM-11, RSTS/E, RSX-11S, RSX11-M, RSX11-M-Plus, RT-11, Unix*, others
Optional coprocessor	—	—	Z80	Z80	Z80	—
Private memory	—	—	64K	64K	64K	—
Operating system	—	—	CP/M	CP/M	CP/M	—
Expansion slots	—	3	3	1	4	6 (dual LSI-11 cards)
5¼-inch floppy disks						
Number (std-max)	2–4	2–4	2–4	2–4	2–4	2
Storage per disk	180K bytes	400K bytes	267K words	400K bytes	400K bytes	400K bytes
Maximum storage	720K bytes	1.6 megabytes	1.1 megabyte words	1.6 megabytes	1.6 megabytes	1.6 megabytes
8-inch floppy disks						
Number (std-max)	—	—	0–2	—	—	—
Storage per disk	—	—	128K words	—	—	—
Maximum storage	—	—	256K words	—	—	—
5¼-inch Winchester disk						
Availability	—	optional	optional	(must upgrade to 350)	optional	standard
Storage	—	5.0 megabytes	5.0 megabytes		5.0 megabytes	10.0 megabytes
Ports						
Serial**	2	2	2	2	2–3	6
External disk	—	—	—	—	—	1
Graphics						
Colors	—	16 or 4 from 8	4 from 8	8 from 256	8 from 256	(via optional graphics terminal and software)
Resolution (characters)	80 by 24	320 by 240 or 800 by 240	320 by 240	960 by 240	960 by 240	
Prices						
Base	$1795 (plus VT100 terminal)	$3495	$3745	$3995	$4995	$10,225 (without any terminals)
5-megabyte Winchester	—	$4200	$4000	(upgrade to 350)	$3500	(10-megabyte Winchester standard)
CP/M module	—	—	$495	$695	$695	—

*Unix and others are available from software houses.

**One serial port is for a printer and a second is for data communications with modem control.

Table 1: *An overview of six microcomputers from Digital Equipment Corporation.*

bow 100 but is a very unique microcomputer in its own right. It uses Digital's proprietary 12-bit 6120 microprocessor, which executes the instruction set of the PDP-8 minicomputer family. The operating systems are Digital's WPS-8 Word Processing System and COS-310 Commercial Operating System, featuring DIBOL (Digital's Business-Oriented Language, similar to COBOL). With the addition of a Z80 microprocessor on a circuit card, the DECmate II can also run a CP/M program while the 6120 processor runs another application.

Like the Rainbow, the DECmate II comes with a dual-disk drive that stores 400K bytes on each 5¼-inch floppy disk. Another dual-disk drive may be installed in the main cabinet. In separate enclosures, a 5-megabyte Winchester hard disk and a pair of 8-inch DEC-compatible (RX02) floppy-disk drives may be included in the system. The 8-inch drive controller permits direct transfer of information to and from the earlier DECmate I machines. A graphics option of four

Text box continued on page 106

Text box continued:

simultaneous colors is also available. With the standard DECmate II screen, the colors appear as different shades of gray. A color monitor will soon be available.

The MICRO/PDP-11

The MICRO/PDP-11 is basically a more powerful multiuser version of the Professional 350 with 6 serial lines, each of which supports a terminal, printer, or communication link.

The basic system comes with 256K bytes of main memory and an operating system license but without a terminal. Initially, Digital's popular VT100 series terminals are available for use with the system. Any of the Digital microcomputers mentioned above, with or without their own Winchester disks, can also be used as terminals.

Because the MICRO/PDP-11 will be serving as many as six users, it comes with a larger-capacity 10-megabyte Winchester hard disk. Along with the greater disk-storage capacity, the system can support up to 4 megabytes of main memory with its PDP 11/23 Plus processor. Again, a dual-disk drive is included (400K bytes of storage on each 5¼-inch floppy disk).

The MICRO/PDP-11 supports Digital's standard 16-bit PDP-11 minicomputer operating systems: CTS-300, DSM-11, RSTS, RSX-11S, RSX11-M, RSX-11-M-Plus, and RT-11. Unix and other operating systems are available from software houses.

Digital also supplies several high-level language compilers including BASIC, COBOL, DIBOL, FORTRAN, MACRO, and Pascal. Virtually any available PDP-11 minicomputer software can be run on the MICRO/PDP-11.

The system cabinet for the MICRO/PDP-11 is somewhat larger than that for the Professional 350, so it can accommodate the larger-capacity 10-megabyte disk, larger power supply, and additional card slots for memory and other options. The backplane has slots for as many as 6 dual LSI-11 option cards. A wide variety of specialized options for the LSI-11 bus are available from Digital and other vendors. The unit measures 27 by 21½ by 6 inches. It can be mounted either vertically on a floor stand or horizontally. A rack mount kit is also available.

The CP/M Option Module consists of a Zilog Z80 microprocessor with 64K bytes of memory onboard. Included with the unit is a floppy disk containing the CP/M operating system. This option is available only for the DECmate II and the Professional Series, which do not come with a built-in Z80 processor. With the CP/M Option Module installed, the Z80 can run any of the popular CP/M software while the microcomputer's main processor is busy working on something else.

Text continued from page 102:

and the Professional's design ensures additional uses. The following applications can be expected in the near future:

- *Dictation:* A dictation wand can be obtained as an accessory for the voice unit. Using the wand, a manager will be able to dictate text, which can be converted to digital signals and transmitted across Ethernet to a secretary's Professional Series system.
- *Transcription:* Using the earphone and foot pedal, which are available as accessories for the voice unit, a secretary can transcribe the dictated text.
- *Voice annotation on text:* Text being read from the video screen will be annotated simply by positioning the cursor where the comment is to occur. When the Comment key on the voice unit is depressed and the comment has been dictated, it will be converted from analog to digital signals and imbedded in the text. The technique can, of course, be used to edit text prepared by a typist.
- *Voice messaging:* The Telephone Management System, with proper application programming, will be able to accept and digitize voice messages. This ability permits the caller to dictate a message that can be appended to a text header prepared by the secretary. Under proper program control, the TMS system can alternately provide a complete telephone answering service.

Conclusion

The Digital Professional Series family was designed to meet the needs of the modern business organization. Whether the need is for desktop computing power, personal computer clusters, or system-to-system communications, the 325 and the 350 offer functionality with ease of use. Perhaps most important is the Professional's ability to expand capabilities within a consistent user interface.■

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SOFTWARE

- BPS Business Graphics™

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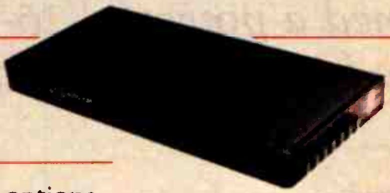

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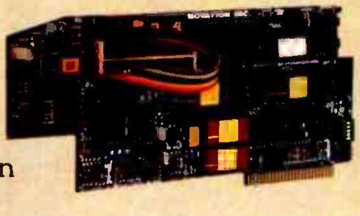

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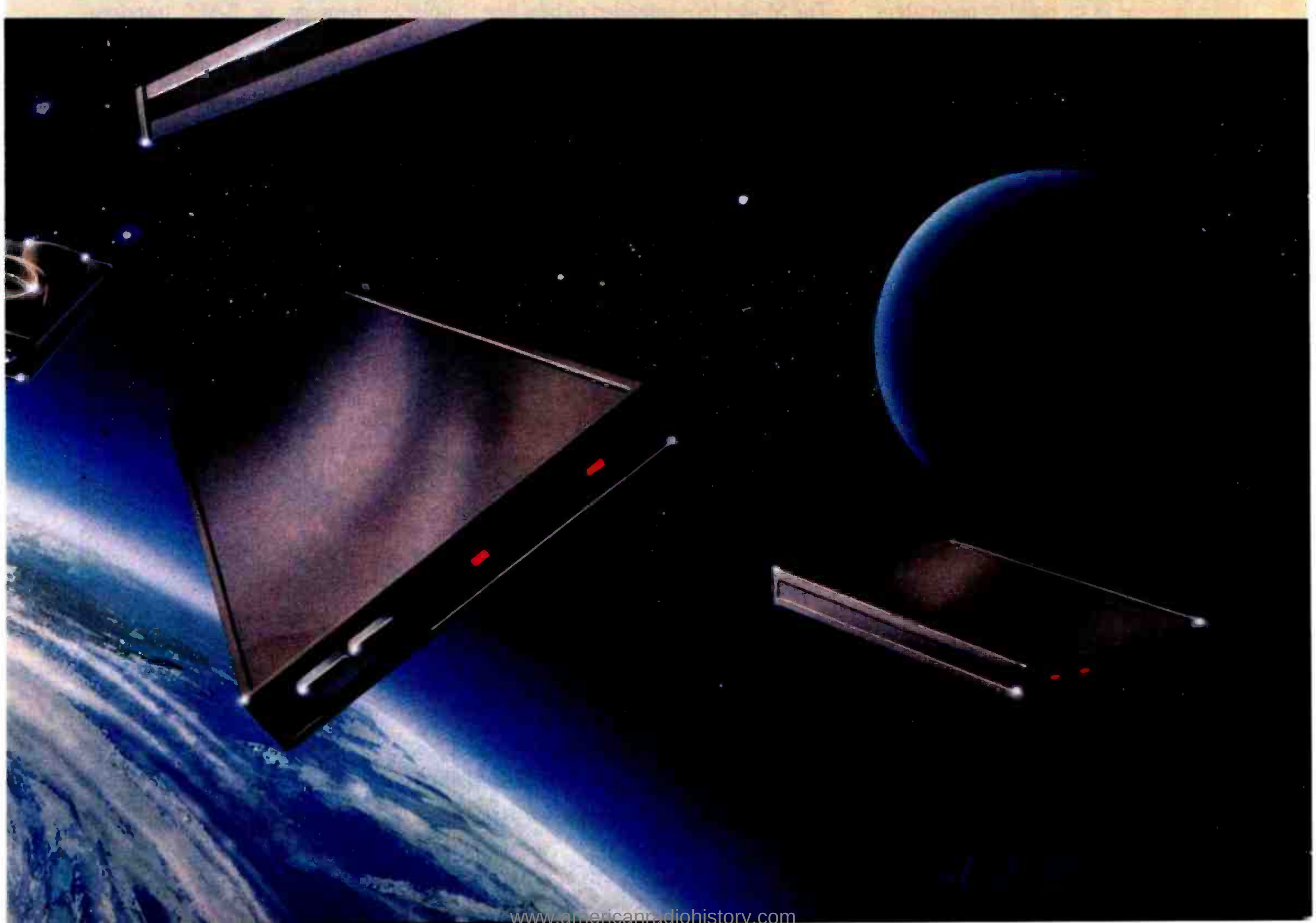

Tight Squeeze

The HP Series 200 Model 16

How Hewlett-Packard crammed a powerful 16-bit microcomputer into a square foot of desk space.

John Monahan
Desktop Computer Division
Hewlett-Packard
3404 East Harmony Rd.
Fort Collins, CO 80525

Although Motorola's powerful 68000 microprocessor may be fairly new to many people in the personal computer field, Hewlett-Packard has been using this processor in its desktop computers since 1981. Not only was HP one of the first large manufacturers to adopt the 68000, but last November, the company released its *fourth* 68000-based machine, the Series 200 Model 16 (see photo 1).

The Model 16 is intended to be a lion packaged as a house cat. In addition to its 16-/32-bit microprocessor running at a clock rate of 8 MHz, this machine offers an RS-232C interface, an HP-IB (Hewlett-Packard Interface Bus, IEEE 488) interface, 128K to 512K bytes of volatile memory or RAM (random-access read/write memory) with provisions for up to 4 megabytes, a

Photo 1: *The Hewlett-Packard Series 200 Model 16 microcomputer (formerly the HP 9816). Even with the optional dual microfloppy-disk drive (3½-inch disks), the unit is extremely compact.*

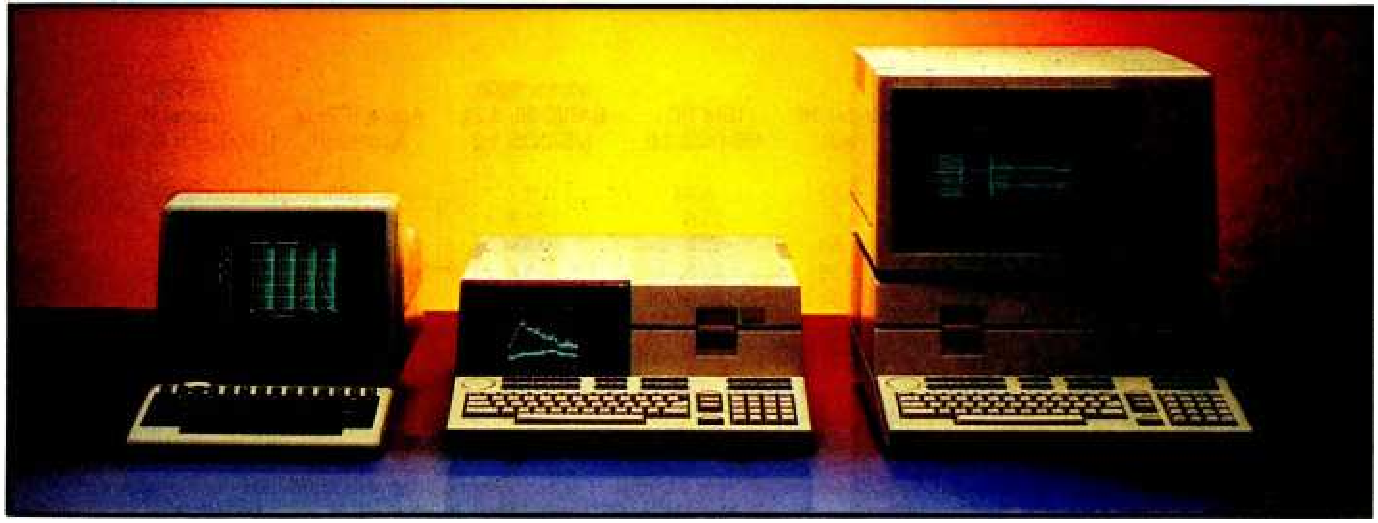

Photo 2: *The Hewlett-Packard Series 200 family. From left to right, the Model 16, the Model 26, and the Model 36. Each of these machines shares a common architecture based on the 68000 microprocessor. The Model 26, introduced in June 1981, is designed for computer-aided testing applications. The Model 36, introduced in January 1982, has a high graphics resolution for use as a computer-aided design workstation.*

9-inch display with 400- by 300-pixel graphics resolution, a variety of mass-storage options (from 3½-inch floppy to 64-megabyte hard disks), and a large library of software already available. And thanks to an intricately designed printed-circuit board and Sony's new 3½-inch floppy-disk format, the Model 16 is probably the smallest desktop machine around.

To understand what the Model 16 does, it's important to know how it came about. The Model 16, originally known as the HP 9816, is the third member of the Series 200 family (see photo 2). First came the Model 26 (or HP 9826), which is primarily a rack-mountable, testing and data acquisition machine with several backplane slots (eight compared to the Model 16's two). Then came the Model 36 (or HP 9836), which has extensive graphics capabilities and two built-in floppy-disk drives. This unit is intended for engineers and scientists who design and analyze at their desks or laboratory benches.

The Model 16 was designed to perform all the technical tasks of the 26 and 36 and to be software-transportable with them and with HP's 32-bit workstations in the HP 9000 computer family. The Model 16, however, is packaged and priced as a personal computer for more general use. The basic unit, with 128K bytes of memory and no disk drives, is $3985. Because its 16-bit architecture greatly increases the speed of software packages such as Context MBA and Visicalc, the Model 16 is now finding its way into business applications as well as the analytical applications that have been HP's traditional market.

I'll now relate how HP came to select the 68000 microprocessor for its line of 16-bit microcomputers and implement it in Series 200 machines. I'll also discuss the Model 16 itself, including its growth potential, hardware packaging, and peripheral compatibility.

The First Step

In 1979, HP's Desktop Computer Division in Fort Collins, Colorado, conducted a study to determine which microprocessor should be used in a new test/control computer, the HP 9826, which would later become known as the Model 26.

According to Sandy Chumbley, then research and development manager for the Model 26, "There were two primary factors that led to the 68000. First, we had a design objective to develop a product with two times the performance of the machine it was to replace [the HP 9825].

"Second, we were designing a pretty sophisticated software system and believed that the 68000 was a better fit for what we were trying to accomplish."

In May 1979, when HP started looking at the 68000, the company already had a Model 26 design and a fairly good prototype based on the Intel 8086 processor. However, it became apparent to software engineers that the 8086 would not meet performance expectations because its address space was segmented into 64K-byte blocks and provided only 1 megabyte of total address space.

"We were design-centered around the BASIC interpreter," Chumbley says, "so we did some extensive analysis on the 68000, the 8086, and an HP-built processor. The 68000 turned out to be faster than either one by a factor of 1.5 to 2.0." Also, the 68000, with its 24-bit address bus, offered a 16-megabyte linear address space that made coding much easier. And like the 8086, it provided memory-mapped I/O (input/output). This meant that memory or I/O cards plugged into the backplane could be mixed and matched without special instructions or signals.

Other advantages engineers saw in the 68000 were its 16-bit external data bus; its 32-bit internal data bus; its instruction set with 14 addressing modes and 5 main data types; its 8-MHz clock rate; and its 17 registers, each containing 32 bits (in addition to a 32-bit program counter and a 16-bit status register). Motorola's enhancement program for the 68000 chip was

Benchmark	Model 16 Integer	Model 16 Real	IBM PC MS-DOS 1.0	Victor 9000 BASIC-86, 5.21, MS-DOS 1.2	Apple II Plus Applesoft	TRS-80 Model II Model II Basic
empty DO loop	0.34	0.82	6.43	7.7	6.66	7.98
division	3.12	3.61	23.8	21.8	29.0	19.4
subroutine jump	1.02	1.50	12.4	16.9	13.9	17.1
substring	1.96	2.55	23.0	24.6	32.3	24.8
prime number program	13.27	18.64	190.0	197.0	241.0	189.0
disk write	70.0	—	32.0	50.3	175.0	—
disk read	40.3	—	22.9	21.3	217.0	—

Table 1: *BASIC language benchmark results. All times are given in seconds. The benchmark programs employed are the same as those used in previous BYTE articles (see January 1982, page 54, and November 1982, page 246). Benchmarks for the Model 16 were run with looping variables in both real and integer formats for comparison. Data for machines other than the Model 16 is from the November 1982 issue of BYTE. Note that with the large memory of the Model 16, disk write and read operations could be improved to about 6 seconds by using two 32K-byte character strings.*

another plus. In the future, Series 200 products will be able to evolve as the main processor family does.

To illustrate the power of the 68000 processor, we have compared the Model 16 with several other personal computers (see table 1). For the comparison we used a series of BASIC benchmark programs and results that appeared in the November 1982 BYTE (page 246).

The Footprint Feat

For all its power, the Model 16 takes up about as much desk space as an "in" basket (see table 2). Its "footprint" is 1.7 square feet. HP also supplies a "garage," to be placed under the unit, for the keyboard. When the keyboard is "parked" in this garage, the Model 16's footprint is 1 square foot exactly.

To ensure that the Model 16 would have such a small footprint, HP decided to package the Model 16 in the same case as the HP 2382 terminal. But despite this small size, the computer's architecture could not be compromised, nor could costs be increased.

"We looked at a number of alternative architecture implementations," says Joe DeWeese, then project manager for the Model 16's hardware, "and decided that one main board containing the majority of the functionality was the best solution in terms of cost, reliability, and serviceability."

This decision posed some real challenges for the man chosen to design the microprocessor board, Lyle Frey. "There was a lot of interplay in the selection of parts and, to some extent, the function of the board," Frey says. "Many of the features were negotiated by what would fit," he adds. "In fact, many of the parts for the original board didn't fit, so they were implemented differently."

Packaging requirements further complicated the board's design. For instance, the case for the HP 2382 terminal offered no provisions for physically supporting processor boards vertically (the 2382 was designed for horizontal boards). This was remedied by installing two horizontal boards and plugging the vertical boards into them.

Computer	Footprint (square inches)
HP Series 200 Model 16	238
IBM Personal Computer	420
Victor 9000	310
Apple III	361

Table 2: *Footprint comparisons. The Model 16's footprint is an incredible 238 square inches (1.7 square feet), which makes it a little over half the size of the IBM Personal Computer. To make the footprint even smaller, a keyboard "garage" is available to allow you to "park" your keyboard underneath the system when not in use. This brings the footprint down to 144 square inches (1 square foot).*

Cooling problems were solved by using the processor and video-display boards to direct the air flow of the cooling fan. Also, cut-outs were designed into the boards so that air could flow through them. After considerable testing, a board arrangement was devised that directed the air in a U-shaped pattern—an air plenum—so that there was less than a 15-degree Celsius internal rise in temperature under worst-case conditions.

The result of our work was an eight-layer circuit board for the main processor, with special integrated circuits that allow a chip density equivalent to two ordinary integrated-circuit chips per square inch, making it perhaps the densest board in any personal computer today. It slides out of the Model 16 without requiring the removal of other boards. Furthermore, it's totally operational with just a 2-pin power connector (5 volts and ground). Photo 3 shows the 9-inch by 10.3-inch board with its 125 special-purpose integrated circuits.

"What's impressive about the design," says Frey, "is not so much high technology as the fact that we stayed within PC [printed-circuit] board design rules and manufacturing techniques shown to be reliable and still

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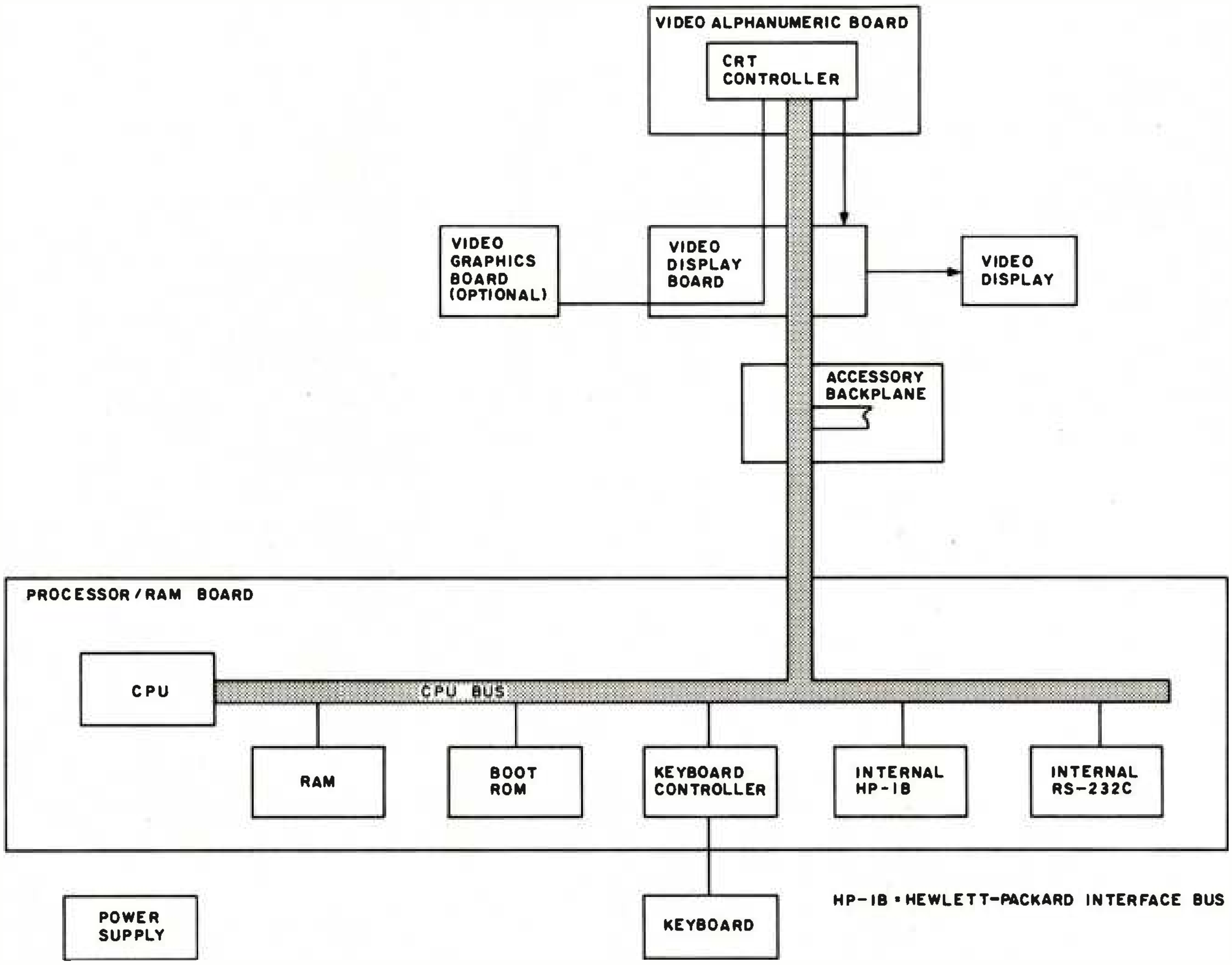

Figure 1: *Block diagram of the Model 16 hardware system.*

packed everything on such a small board."

Figure 3 shows the processor board's layout. It contains the entire central processor system, plus 128K or 256K bytes of RAM, an RS-232C interface, an HP-IB (IEEE 488) interface, the keyboard processor, connections for other boards, and either 16K or 48K bytes of bootstrap code in ROM (read-only memory).

Getting the Boot

The bootstrap ROM performs two major tasks to ensure quality and flexibility. Task one is the testing of all hardware when the Model 16 is switched on. The results of this self-test are displayed on the video screen. If a noncritical resource has failed, the bootstrap ROM allows you to decide whether you want to continue operation. The ROM further tests and reports the status of all I/O or memory cards plugged into the rear expansion slots.

The second function the boot ROM performs automatically is to search all mass-storage devices connected to the Model 16 and to load the operating system that has been given the highest priority. Thus, you can store operating systems on any of several supported mass-storage devices. These devices include ROMs, floppy disks, Winchester disks, and disks on HP's Shared Resource Management network. Pressing any key on the keyboard during power-up signals the bootstrap ROM to list all operating systems available, so you can decide which one to load.

Assuring Quality

Once the packaging problems were solved, the final six months of development were spent building pilot production units for later evaluation in HP's STRIFE (stress and life) program. The idea behind STRIFE is to force failures by pushing products beyond "the edge of the envelope," as test pilots say.

In addition to the extensive environmental tests that HP performs, 3 of the 20 prototype Model 16s were subjected to simultaneous temperature, humidity, and power cycling conditions far beyond their specified tolerances. Design and component flaws that appeared even once in a single machine were analyzed and corrected in all 20. This method of failure acceleration uncovered about 20 problems that were solved before the Model 16 was released to production. Also, before public introduction, some Model 16s were placed in an office environment in

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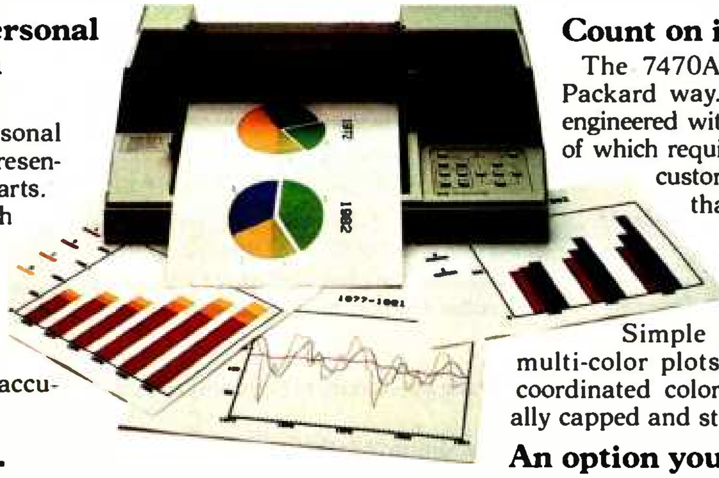

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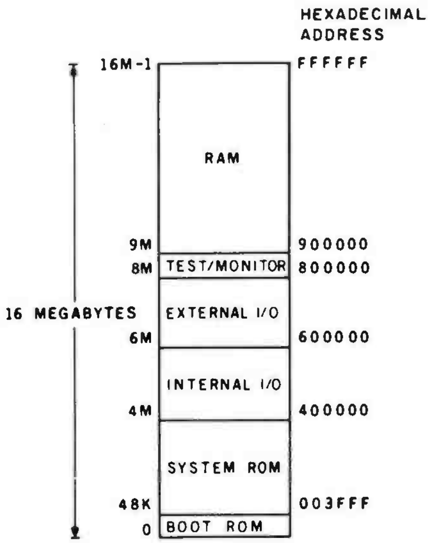

Figure 2: *Memory map for the Model 16.*

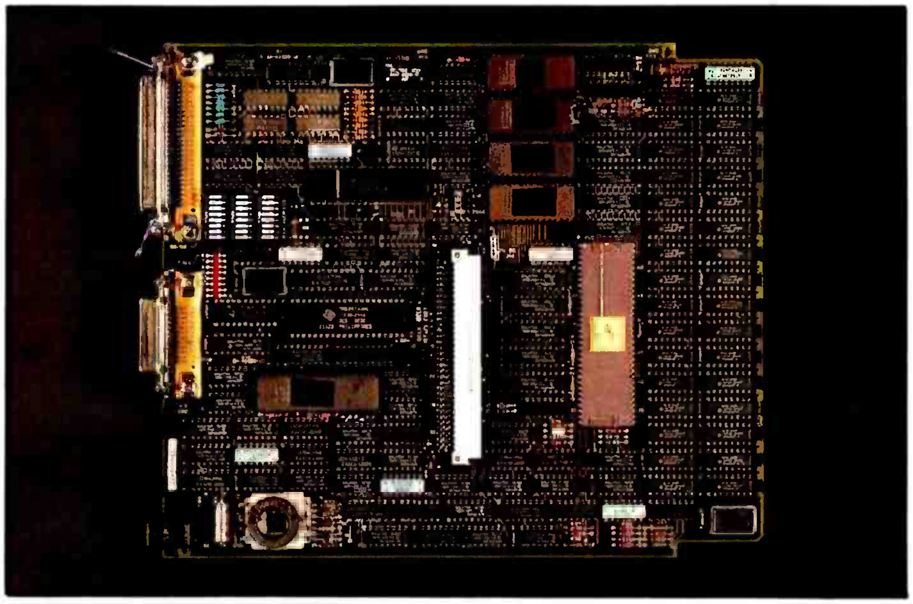

Photo 3: *One of the most tightly packed boards in the microcomputer industry. The main processor board of the Model 16 is only 9 by 10.3 inches but contains 125 special integrated circuit chips, the equivalent of 185 normal (14- to 18-pin) chips. The result is a chip density equivalent to approximately 2 chips per square inch.*

order to detect any flaws that might occur in a more normal situation.

Decentralized Processing

Figure 1 describes the Model 16's internal architecture. All system resources are memory-mapped within the 16-megabyte address space of the 68000. This address map provides room for 7 megabytes of RAM in addition to all of the internal and external I/O subsystems (figure 2). Both internal and external RAM areas are made up of 64K-bit dynamic RAM chips.

In addition to the powerful 68000 processor, which was highlighted earlier, there are three more processors and LSI (large-scale intergration) controllers inside the Model 16. This multiprocessor architecture allows decentralized processing, freeing the 68000 for system and processing tasks. Three processors provide this decentralized processing:

Motorola 6845: The Model 16's 9-inch video display is controlled by a Motorola 6845 CRT controller. This chip has access to the character (alphanumeric) and graphics buffers contained in the 68000's address space, and thus display refreshing is performed independently of the 68000. The alphanumeric display information is stored in a separate RAM area as character codes and is displayed through a ROM routine containing the dot patterns for all 256 characters in the Model 16's repertoire.

EXTRA EXTRA

S-100 World News

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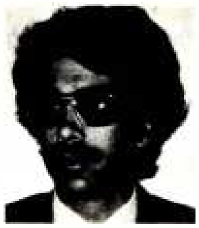
Image achieved by DGS' CAT 1600 Series color video graphic workstation. Picture courtesy of Digital Graphic Systems, Inc. See story below.

GRAPHICS: NOW MAX-IMIZED

CANOGA PARK—March 30, 1983—The decreasing costs and increasing density of memory made possible the present boom in digital graphics. Graphic systems designers are now able to take another major step with the introduction of MAX-M, a one megabyte memory board for $1983. As large size system memory and multi-megabyte Virtual Disk, MAX-M opens up major new low cost implementations.



Wayne Maw, Director of R&D for RGB Dynamics, Salt Lake City, Utah, reports, "My application is dependent on speed. With the Macrotech dynamic board, I have the needed speed." The RGB system is a Z80-based, high resolution color directory system for shopping malls, due for April release.

Empirical Research Group of Kent, Washington, creates a state-of-the-art high resolution color video graphics system by integrating their fast 68000 computer, Macrotech system memory, and the color video image processor from Digital Graphic Systems, Inc., Palo Alto, California. Radcliffe Goddard of Digital Graphics states, "High speed image processing requires large system memory to provide instantaneous display frame paging."

The demand for MAX-M by the graphics industry was nearly instantaneous following the initial Macrotech announcement.

MAX—256K to 1M S-100 Memory

CANOGA PARK—March 30, 1983—Mike Pelkey, Macrotech International president, today released details of the revolutionary MAX line of S-100 memory boards. Pelkey stated: "IEEE-696 now has a new standard for dynamic memory. The MAX product line offers 256K to 1M, at a price that ranges down to less than $0.00023 per bit." Pelkey continued, "The MI product line now includes our ultra fast (70 ns) 128K static memory, with battery backup capability, plus the 150 ns dynamic memories—in every 128K step from 256K through 1M (1024K) bytes, and add-on kits to permit field upgrade of sizes."

The extreme density of the MAX family is made possible through the use of proprietary PALs (programmable array logic). Also stated as available for add-on to any size MAX is Macrotech's popular M³ memory mapping architecture. M³ permits the 16-bit address space of an 8-bit processor to be dynamically mapped in 4K pages into as much as 16 megabytes of physical memory.

Parity error detection and 8/16 bit data transfer capabilities are provided as standard on the MAX series memory board.

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	256K/768K	MKT-2/7	876
	256K/896K	MKT-2/8	967
	256K/1M	MKT-2/M	1060
	384K/512K	MKT-3/5	600
	384K/768K	MKT-3/7	784
	384K/896K	MKT-3/8	876
	384K/1M	MKT-3/M	968
	512K/768K	MKT-5/7	284
	512K/896K	MKT-5/8	376
	512K/1M	MKT-5/M	468
	768K/896K	MKT-7/8	192
	768K/1M	MKT-7/M	284
	896K/1M	MKT-8/M	192
M³ option		MKT-M3	121
Software (provided on 8" disk) Virtual Disk for MP/M II* and CP/M 2.2, CP/M 3.0* Bios modules, CP/M memory tests			$ 25
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MAX Technical Manual			15

Software for M³ Available

BURBANK—March 30, 1983—"M³ bank switching for 8-bit processors is much more useful with the new creative systems programs," states Dan West of Westcom Systems Inc. MP/M II* disk intensive applications are greatly improved with the new Virtual Disk routines now available through Macrotech OEM's and dealers for their M³ memory boards.

Westcom Systems, as the software consulting firm for Macrotech, has also provided subroutine listings to easily incorporate M³ mapping into the new CP/M 3.0* (CP/M Plus*) Bios module. The advantages of CP/M 3.0* with disk buffering, hashed directories, and user program expansion go hand in hand with Macrotech's flexible "bank switched" memory capabilities.

All Macrotech software and manuals are available through Dan West's Compuserve account #70250,102.
Leave comments/questions as E-Mail.

These new techniques can combine the above features with custom needs of the future, such as printer buffering, multi-page display and memory-intensive graphics displays.

The software listings are included in the Macrotech memory board manuals and are optionally available on 8" diskettes.

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*CP/M 3.0, CP/M Plus, and MP/M II are registered trademarks of Digital Research Inc.

Circle 227 on inquiry card.

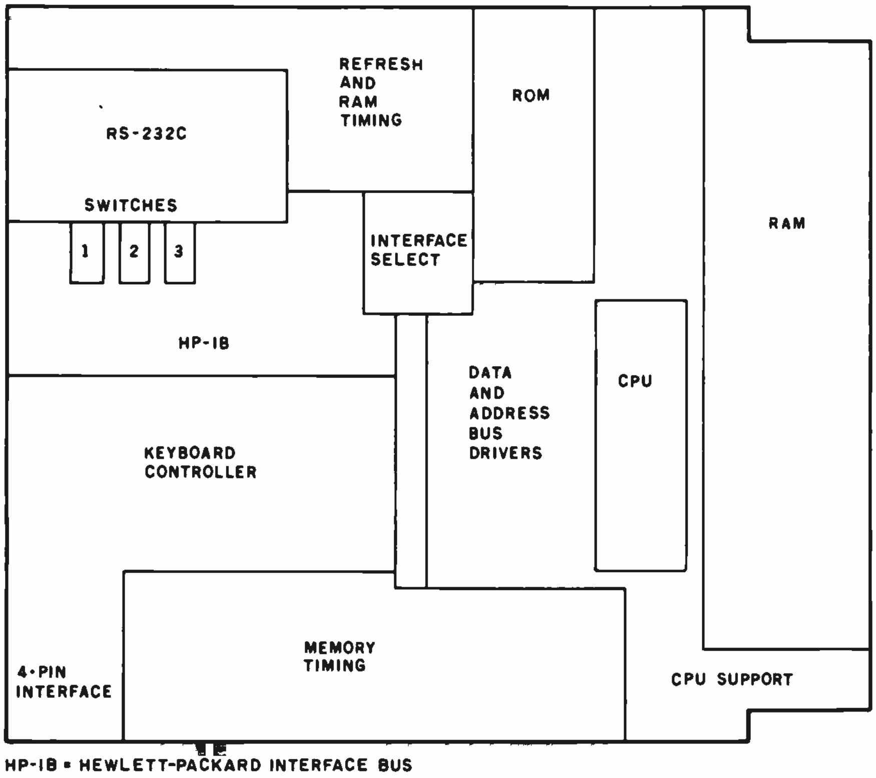

Figure 3: *The layout of the main processor board of the Model 16.*

The graphics information is also stored in a separate RAM area. It is combined with the alphanumeric image into the video pattern. The alphanumeric and graphics video can be switched on or off independently or displayed simultaneously.

Intel 8041: User input to the system is provided by the detached keyboard or by HP's rotary control knob. When a key is pressed, the Intel 8041 microprocessor generates an interrupt to the 68000. This information is transferred to the 68000 only as needed, so the processor does not have to monitor or poll the keyboard.

The rotary control knob is an analog-like input device that generates 120 pulses per revolution. In practice it is more efficient than a keyboard, especially for repetitive tasks like moving a cursor through an electronic spreadsheet.

Texas Instruments 9914: Both RS-232C and HP-IB interfaces come standard in the Model 16. (HP-IB is the industry model for the IEEE Standard 488-1978.) The Texas Instruments 9914 chip provides controller/talker/listener functions for increased I/O performance.

With the 9914 chip, data transfer rates on the HP-IB range up to 60K bytes per second. These rates can be increased fivefold to over 300K bytes per second when HP's DMA (direct memory access) controller card is used. With DMA, data can be transferred directly to or from an interface or the system memory, independently of the 68000, at a rate that is limited only by the memory itself.

The Twivel

What HP calls the Twivel is not a new dance, but a device designed to make the Model 16 easier to use. The Twivel (for tilt and swivel) is a carriage that holds the Model 16 so that you can tilt the display screen up or down, left or right.

The Microfloppy

The Model 16 was further designed to sit atop the HP 9121 floppy-disk drive that's built around the Sony 3½-inch microfloppy disk. Interestingly, the microfloppy holds as much data on one side as one of HP's 5¼-inch floppy-disks holds on two.

The reason for this is density. HP engineers packed 7100 bits per inch on the Sony disk, compared with the 5100 to 5400 on the 5¼-inch disk. Moreover, the Sony disk runs at 135 tracks per inch; the larger disk runs at 48 tracks per inch. The Sony disk has 70 tracks per side, and the 5¼-inch disk has 35 tracks on each side (for a total of 70). The bit density on the Sony disk allowed HP engineers to get the same number of sectors on it as are on the 5¼-inch disk. Thus, because the number of tracks and number of sectors are equal for both disks, capacity is the same.

The 9121 spins at 600 revolutions per minute (rpm), which provides much better performance than a 5¼-inch disk spinning at 300 rpm. The other differences are that the 9121 is 20 percent less expensive than HP 5¼-inch drives ($1775 versus $2230) because no double buffering is required, and it is half the size of the 5¼-inch drives.

Another contribution of the 9121 is its unique disk monitor. The 9121 constantly monitors disk use and tells you when it's time to replace a disk.

The 3½-inch disk is made to the reliable. It's encased in a hard polymer jacket and has a sliding protective cover for the read/write opening. This makes it much less susceptible to damage from mishandling than the 5¼-inch disks.

Software

As I mentioned earlier, the 68000 was chosen over the Intel 8086 primarily for software reasons. HP's next logical step was to make sure that a diversity of software was available when the Model 16 was introduced.

To marshall resources inside and outside Hewlett-Packard, a software attack team (SWAT) was formed. "This marshalling of applications resources, with visits to independent software vendors, was one of the most fun parts of the program," says Gilbert Sandberg, then research and development section manager for the Model 16 project.

'The applications available at introduction and those continually

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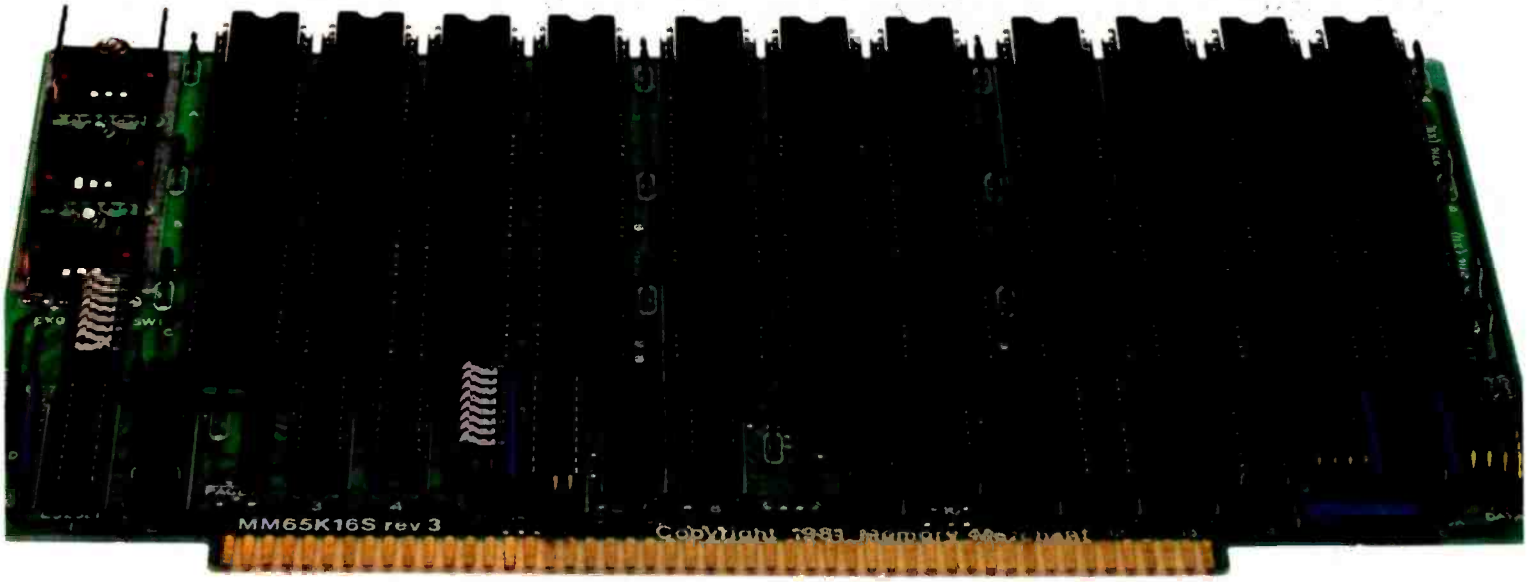

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¹ MP/M is a trademark of Digital Research

Photo 4: *The Model 16 was designed for business as well as technical applications. Here the Context MBA software package takes advantage of the Model 16's graphics capability.*

being added are the results of this effort," says Sandberg. One of the newer packages is Context MBA (from Context Management Systems), which integrates an electronic spreadsheet, word processing, graphics, data communications, and a database (see photo 4). Visicalc, graphics presentations, forecasting, and project management are also offered. Technical software ranges from digital-filter design to numerical analysis, statistics, AC-circuit analysis, and linear systems analysis. Dozens of other programs are available from independent vendors. (Table 3 is a partial listing of software available for the Model 16.)

Operating-system software and programming languages are key elements in the Model 16's power and performance. Two HP-developed operating systems/languages are currently available for the Model 16: Pro-BASIC and Pascal. Additional languages and operating systems are available from third parties or are under development by HP (see table 4).

HP's Pro-BASIC has a number of powerful features and is very fast (see the text box on page 124).

The Model 16's Pascal uses a true compiler rather than a p-code interpreter. This results in a much faster execution speed. This Pascal is also compatible with UCSD Pascal and has powerful graphics and I/O libraries, a full 68000 assembler, and systems programming extensions.

Growth

Compatibility is a family trait within Series 200. Starting with the Model 16, it's possible to move up to the Model 26, Model 36, or even the 32-bit HP 9000 because software is highly transportable among these computers. This, however, represents just part of the Model 16's potential. The personal computer can also act as an intelligent terminal or be connected to HP's Shared Resource Management (SRM) network.

Series 200 Terminal Emulator software enables the Model 16 to respond like an intelligent terminal for transferring ASCII (American National Standard Code for Information Interchange) files to or from a host mainframe.

SRM permits up to 68 Series 200 computers in any combination (including the HP 9835, 9845, and HP 9000 computers) to share files and peripherals. The computers are connected via twisted-pair cables to a Model 26, which controls the network. The maximum cable length allowed is 60 meters between computers and 240 meters end to end. Consider a hypothetical SRM network: design engineers using the Model 36 and an HP 9000 computer can share the same specifications or diagrams from a graphics library; two Model 26s could be loading the same program simultaneously from a shared disk, or one computer could be logging data while the other analyzes it.

With this system, the Model 16 could easily be used for software development where everyone on the network has a current copy of the source code. Or the Model 16 could be used for planning because a master file of schedules can be updated by anyone in the group. Each user has a private directory where sensitive files can be protected from destruction or unauthorized access. Users can even leave electronic messages or charts for each other.

One of the design objectives for the SRM network is transparency; the

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Context MBA	Context Management Suite 101 23864 Hawthorne Blvd. Torrance, CA 90505	$795
Visicalc	Hewlett-Packard dealers	$250
Master Word Processor	University Software RFD #1, Box 6 Fitchville, CT 06334	$475
Protrastar (WP)	Protracoa 1134 Aster Ave., Suite K Sunnyvale, CA 94086	$500
Forecasting	Hewlett-Packard dealers	$500
Graphics Presentation	Hewlett-Packard dealers	$750

Table 3: *A partial list of application software currently available for the Model 16. More than 27 other programs are available from Hewlett-Packard or independent vendors.*

Operating System or Language	Price
Pro-BASIC	$355 (on disk)
HP Standard Pascal	$1515
* FORTRAN	—
Assembly language	(included in Pascal)
* Multiforth	—
* CP/M-68K	—
* C	—
* HP-UX (Unix-based operating system)	—
HPL (APL)	$355

Table 4: *Operating systems and languages for the Model 16. An asterisk (*) indicates that the product is presently under development. FORTRAN will be available from IEM Inc., POB 1818, Fort Collins, CO 80522. Unix is a trademark of the Bell System.*

same mass-storage commands are used to talk to a network disk that are used to talk to a personal disk. To access an SRM disk, for example, you simply change one line of code in a BASIC program. That is, the mass-storage specifier in the MASS STORAGE IS command is changed from :HP8290X to :REMOTE. From here on, all mass-storage commands, such as ENTER or OUTPUT, have access to files on the SRM disk.

Expandability

Directly related to the Model 16's growth potential is the number of peripherals and instruments that can connect to it on the two backplane ports. The first port is a 24-pin HP-IB connector. A variety of HP peripherals, including disks, printers, plotters, and the 9111A graphics tablet, are interfaced via this port. See table 5 for a partial list of supported peripherals.

Of course, HP has been known for its scientific and technical instruments for many years, and hundreds of these instruments can be quickly connected to the HP-IB port.

The second port on the back of the Model 16 is a data communications interface. This 50-pin connector can be

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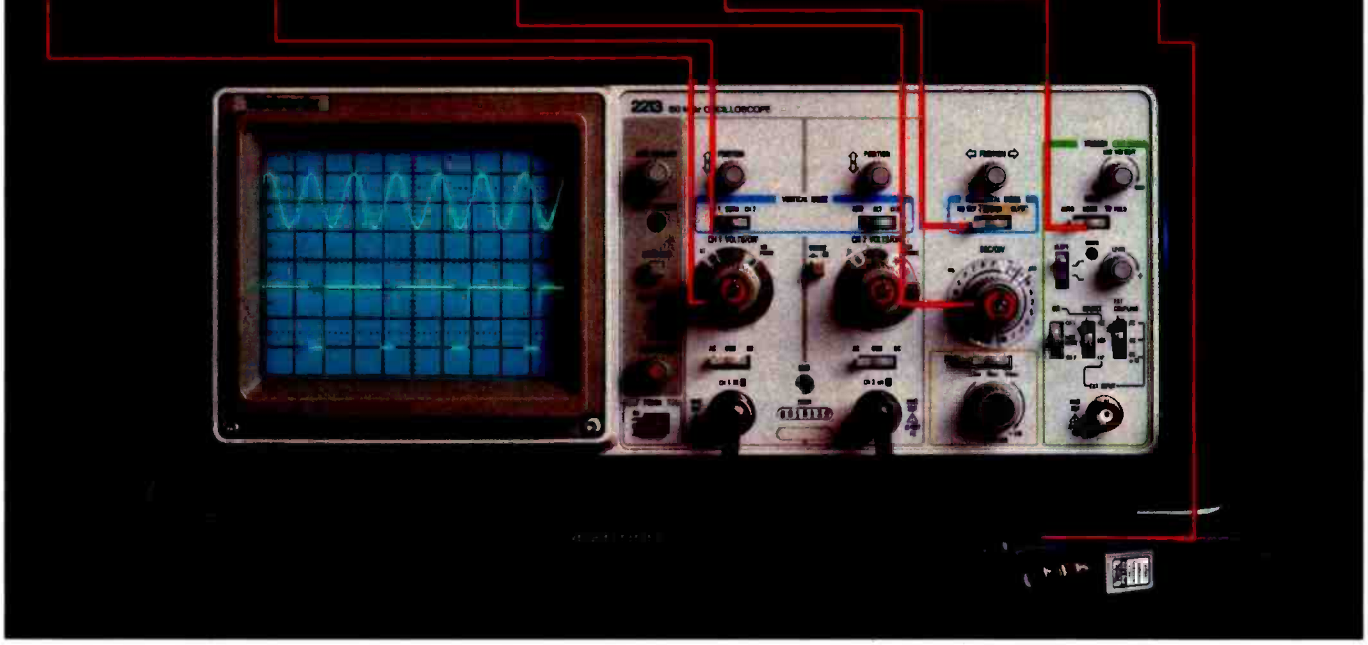

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HP's Pro-BASIC

Over the last 10 years, Hewlett-Packard's Desktop Computer Division (DCD) and Engineering Systems Division (ESD) have added capabilities to HP's version of BASIC to a point where its name requires some distinguishing adjective. Hence, Series 200 computers, including the Model 16, and HP's 9000 family of 32-bit computers use what HP calls Pro-BASIC.

According to Martin Nielsen, a computer scientist at DCD, Pro-BASIC's "power and features make it as good or better than languages like Pascal or FORTRAN."

What has HP added to BASIC that extends its capabilities? First, Pro-BASIC provides more than 200 operators, functions, and statements—four times what ANSI BASIC offers—plus 20 general-purpose I/O (input/output) statements and 14 special HP-IB (IEEE Standard 488-1978) statements for controlling instruments and peripherals.

For instance, interrupts and the overhead processing they involve are performed automatically. This permits transparent control of input or output instructions to an HP-IB device or file.

For computer-aided design applications, matrix extensions permit the designer to invert a matrix with one statement: MAT A = INV (B).

Similarly, operations like finding matrix determinants and performing element-by-element multiplication, subtraction, division, or addition, plus mixed and scalar/matrix operations, are also performed with single statements.

For the programmer, one of Pro-BASIC's notable advantages is a complete set of program constructs. The LOOP . . . EXIT, REPEAT . . . UNTIL, and WHILE statements are what Nielsen calls "flexible looping constructs," which, unlike a FOR . . . NEXT statement, enable you to exit a loop on different conditions that are not sequential.

REPEAT . . . UNTIL repeats statements in a structured loop until the expression following UNTIL is true. The WHILE statement repeats a structured loop as long as its expression is true. LOOP . . . EXIT repeats statements in a structured loop as long as the EXIT expression is false. Further, you can have multiple exit points within the loop.

Another powerful Pro-BASIC statement is designed to eliminate crossing GOTOs, or what Nielsen calls "spaghetti code." IF . . . THEN and IF . . . THEN . . . ELSE . . . END IF provide conditional branching or execution of one or more statements depending on whether the specified condition is true or false.

Pro-BASIC also makes branching more efficient. In most BASIC systems, n-way branching can be performed only if the value X is an integer (e.g., ON X GOTO 1102, 1470, 2655). Pro-BASIC provides a SELECT statement, allowing it to branch on strings as well as numbers. Those numbers need not be integers.

With Pro-BASIC a programmer can use the statement SELECT X, CASE 1, CASE 47, CASE 92 to 117; in other words, a whole range for each case may be specified. If, then, X happens to be 1, CASE 1 is executed; if X is 47, then CASE 47 is executed, and so on. Moreover, an ELSE statement will execute CASE ELSE if X happens to be other than 1 or 47 and does not occur from 92 to 117.

Subprograms in Pro-BASIC are just like procedures in Pascal and subroutines in FORTRAN in that they provide separate, independent environments functioning as "little black boxes" that do one job each. Variables, for instance, may be used in one subprogram without being confused with variables of the same name in another subprogram. Moreover, parameters, even optional parameters, can be passed in, allowing the subprogram to default the ones that are not passed in.

Pro-BASIC subprograms are recursive; they can call themselves. This is useful in data structures, where trees that define other trees are set up, and for array sorting, polynomial evaluations, and the like.

Another feature of Pro-BASIC is interrupt branching. A large number of events can be established to cause branches in the program.

Many BASICs, especially in the microcomputer class, are fairly limited in their editing capabilities. Pro-BASIC allows indentation for easy reading, cross-referencing for documentation (broken down by main program and subprogram), plus key words like FIND and CHANGE for searching and replacing.

The use of Pro-BASIC has also spread to HP 1000 minicomputers in addition to the HP 9835, 9845, Series 200, and HP 9000 lines. As Nielsen says, "It's an excellent language for first-time users to learn, yet it provides the features that allow the experienced programmer to really squeeze the most from the power of the machine."

hooked directly to data communications devices or data terminal equipment via an adapter cable that terminates in a standard RS-232C-compatible DB-25 connector.

Also on the back of the Model 16 are two other I/O slots located under a removable protective cover. These provide external access to the 68000 address, data, and control buses.

The top slot is used to add RAM or ROM cards or a DMA controller. A RAM card provides 256K bytes of additional memory. ROM cards provides up to 512K bytes of storage for languages such as HP's Pro-BASIC. The lower slot accepts these cards plus a number of I/O cards. The I/O cards permit you to expand the system to include a second HP-IB or RS-232C port, a BCD (binary-coded decimal) interface, a programmable data-communications interface card, a color video (RGB—red-green-blue) card, or a general-purpose input/output (GPIO) interface card.

For still more flexibility, HP offers the HP 9888A I/O Expander. It provides 15 additional I/O slots, which allow you to expand the system to over 4 megabytes of RAM or add up to 8 more interface cards.

Summary

Motorola's 68000 microprocessor is an important element in HP's Series 200 computers. The processor can meet the performance objectives HP has set for these computers, and future en-

Device	Product Number	Description	Price
floppy disks	9121S	3½-inch single floppy-disk drive	$1200
	9121D	3½-inch dual floppy-disk drive	$1775
	82902M	5¼-inch single floppy-disk drive	$1520
	82901M	5¼-inch dual floppy-disk drive	$2230
	9895A	8-inch dual floppy-disk drive	$5910
hard disks	9133A	4.6-megabyte Winchester plus 3½-inch floppy	$4260
	9134A	4.6-megabyte Winchester	$3500
	9135A	4.6-megabyte Winchester plus 5¼-inch floppy	$4760
	9134B	8.2-megabyte Winchester	$4360
	9133B	38.2-megabyte Winchester plus 3½-inch floppy	$5160
	7908P	16½-megabyte disk/tape drive	$11,130
	7911P	28.1-megabyte disk/tape drive	$14,800
	7912P	65.6-megabyte disk/tape drive	$17,350
printers	82905B	serial impact printer	$795
	2602A	letter-quality daisy-wheel printer	$2100
	2671G	serial thermal graphics printer	$1540
plotters	7470A	"A" size two-pen plotter	$1575
	9872C	"B" size eight-pen plotter	$5860
bit pad	9111A	graphics tablet	$2275

Table 5: *A partial list of peripherals supported by the Model 16.*

hancements for the 68000 mean that these computers will also be enhanced. Further power is provided by three coprocessors in the Model 16's decentralized processing scheme.

For all its power, the Model 16 remains a personal computer. Its small footprint, made possible by its eight-layer processor board with a chip density equivalent to two 14- to 18-pin integrated circuits per square inch, enables the computer to fit easily on a desk. Other features, such as the rotary control knob, user-definable keys, and the Twivel help make the Model 16 easy to use.

The Model 16 was designed to be affordable. The basic unit with 128K bytes of RAM sells for $3985, without disks. An enhanced unit with 512K bytes of RAM and a ROM-based ProBASIC interpreter costs $5550. The HP 9121D dual floppy-disk drive, which fits neatly under the Model 16 and uses 3½-inch disks (270K bytes per disk), costs $1775.

The Model 16 was built to be reliable. Environmental and STRIFE testing assure a very low failure rate prior to delivery, even for early production models.

The Model 16 was designed with a wide growth path. Software is interchangeable with that of the other Series 200 computers, as well as with the HP 9845 and the 32-bit HP 9000 computers. HP's Shared Resource Management network allows files and disks to be shared among groups of users.

More than 30 different peripherals and over 200 instruments easily connect to the Model 16 over its HP-IB interface. An RS-232C interface is also built-in for increased flexibility. Other available interfaces include binary-coded decimal, data communications, color video, and a general-purpose card.

A variety of HP and third-party software is available for technical and management applications.

All in all, the HP Series 200 Model 16 is indeed a lion packaged as a housecat. ■

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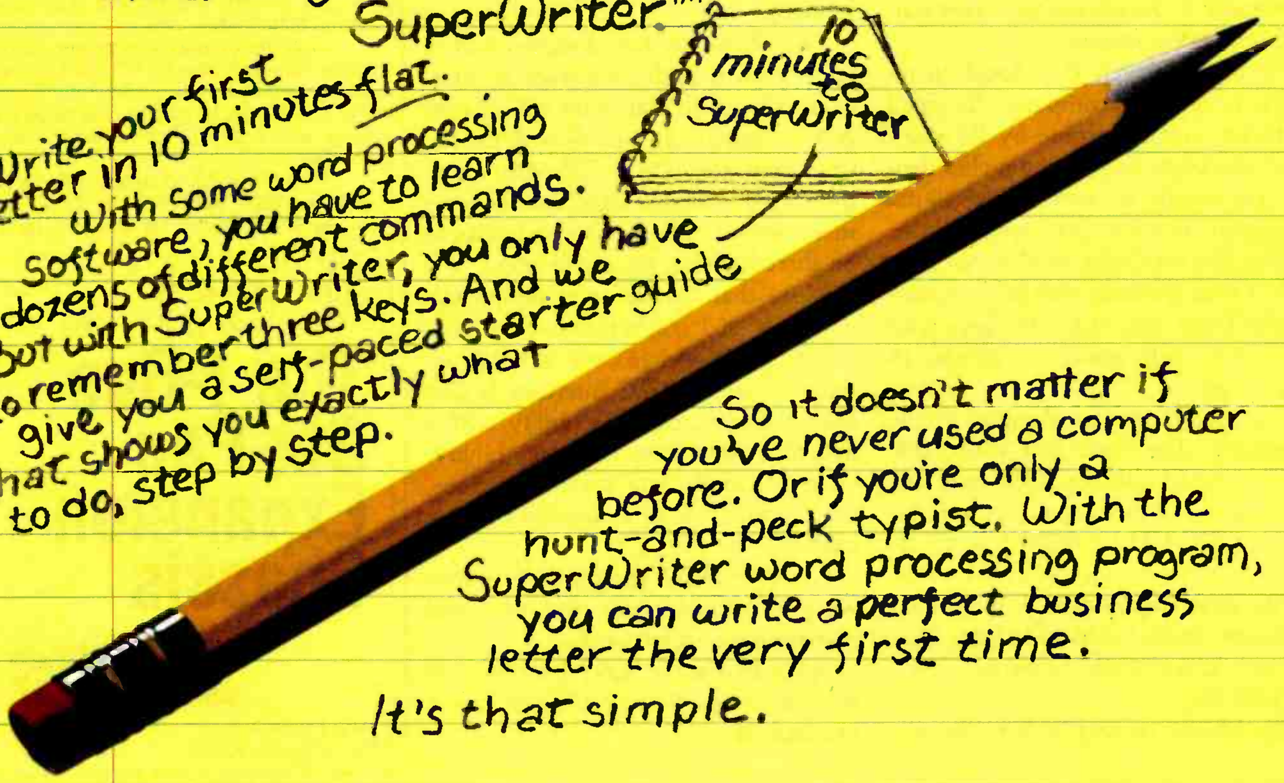

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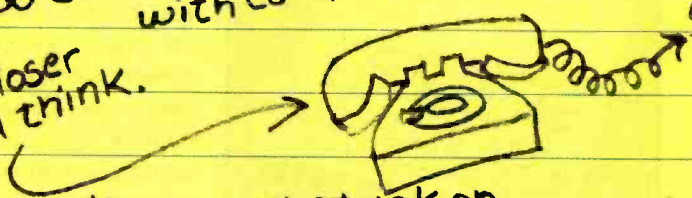

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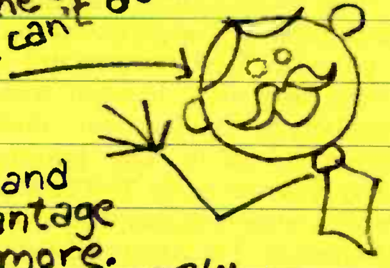

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Designing a new low-cost computer system is a delicate balancing act. Your system must satisfy the needs of your market, respond to the challenges presented by your competitors, and still be profitable to build and market. In designing the new Texas Instruments 99/2 Basic Computer, we managed to achieve all of the above requirements in only four and a half months, which may be record time for a new system.

The TI-99/2 was developed to compete directly with such low-cost computers as the Sinclair ZX81 and the Timex/Sinclair 1000. The tremendous demand for computers that sell for less than $100 demonstrated a growing need for a low-cost computer-literacy product for both children and adults. Our primary goal as designers of the TI-99/2 was to build a home computer that would enable people of all ages to take part in the computer revolution around them. It would also be used as a learning computer for students from grade school through college.

To satisfy consumers' needs, a low-cost computer must function beyond the computer-literacy stage; only then can it enable novices to improve their newly developed skills, through activities such as personal record keeping, education aids, and even mind-challenging games. Furthermore, the computer must be capable of growing with individuals who want to develop more advanced skills or applications.

Photo 1: *The Texas Instruments Basic Computer 99/2 is designed to compete directly with low-priced computers such as the Timex/Sinclair 1000. BASIC programs written on the 99/2 can run on the TI-99/4A, but the reverse is not true.*

Texas Instruments set what we considered to be very aggressive goals in the design and manufacture of the TI-99/2. In this article we'll discuss those goals and how we met and sometimes, in our opinion, surpassed them in the course of the four and a half months between the initial concept and the completion of working prototypes for the January 1983 Consumer Electronics Show (see photo 1).

Design Requirements

We believed a major portion of our market would be first-time computer buyers looking for a minimal investment in the world of computers. We kept the price low, hoping that those who decided computer programming was not for them would not regret the expense. Our basic assumption about these potential buyers was that they would base their purchase decisions on price, not features. Computing power, expandability, and the availability of peripherals would be a relative measure for choosing from among several computers in the same price range.

We felt strongly that the first-time buyer must not be intimidated by the product. The console, we decided, must be simple, and the keyboard must be no more complicated than a typewriter keyboard. A cluttered keyboard, with multiple-function keys—and, therefore, multiple legends—would generate an immediate "I'll never learn to use that" attitude. In addition, we thought the computer should be sufficiently simple to operate and self-contained enough to ensure ease of use.

Once the beginner starts to develop computer skills, the computer needs peripherals that make new applications accessible. An economical program and data-storage unit was necessary, as were preprogrammed application software packages to increase the computer's utility. We decided that the system would also need a low-cost printer for listings and as a way of keeping track of program output. In addition, the system needed to handle the memory expansion that becomes necessary as programming expertise increases.

For computer owners who progress to more advanced applications, a range of more sophisticated peripherals is necessary. We saw a need for communications or networking devices; high-density, fast-access mass storage; and printer/plotter-type peripherals to provide a very powerful but low-cost computer system (see photo 2). Growth beyond these levels of sophistication would probably entail buying a computer with greater capabilities.

To ease the upward migration to more sophisticated computers, we decided to make our computer part of an integrated product line based on the 99/4A. Integrating the computer with other TI products would enable us to provide compatible software and peripherals for other members of the TI Home Computer Family. Programming techniques and computer programs developed on a low-cost machine could be used on the more advanced machine without being rewritten. Peripherals for the new machine would then be compatible with the more expensive console, and none of the equipment and programming exchanges would become obsolete.

Having identified these requirements, we selected the following characteristics for the TI-99/2:

Photo 2: *Peripherals for the 99/2. The line of low-cost peripherals includes, from top to bottom: the HX-1000 printer/plotter, the HX-2000 Wafertape Digital Drive tape unit, and the HX-3000 RS-232C interface.*

1) a computer system for less than $100 that consists of a console, an external AC adapter for power, and a minimum of 2K bytes of RAM (random-access read/write memory) and 16K bytes of ROM (read-only memory)
2) a built-in, two-channel black-and-white RF modulator (channels 3/4) for connecting the system to a standard TV (use of black and white was necessary to achieve cost goals)
3) a built-in interface for a standard audio-cassette recorder to provide economical mass-storage capability. Only audio in/out would be supported by the system. Cost would not allow support of motor control
4) a built-in Hex-bus interface to provide compatibility with the line of low-cost peripherals
5) an operating system that would be a subset of TI-BASIC as used on the TI-99/4A Home Computer console. Thus the software written on the 99/2 would be upward compatible with the 99/4A. For cost reasons, the 99/2 would not use the Graphics Read-Only Memory (GROM) programming language of the 99/4A and, therefore, 99/4A command cartridges would not be compatible with the 99/2. Software compatibility would be provided by BASIC programs stored on cassette
6) no sound, color, or joystick capability would be supported, again because of cost constraints
7) the full system bus structure would be available at an expansion port on the rear of the console. This would facilitate memory-expanding Solid State Software cartridges (not 4A compatible) or any other future system expansion
8) a nonintimidating, 48-key typewriter-like keyboard with only two legends per key top. Layout and functionality of the keyboard would match that of the 99/4A. To achieve the goal of two legends per key, lowercase letters would not be supported.

To enhance user acceptance and utility of the keyboard, we needed a raised key that provided tactile feedback as it was pressed. But we also needed the economy of a Mylar key material. Our mechanical design team came up with a keyboard system that provided both advantages: using a Mylar key matrix under an

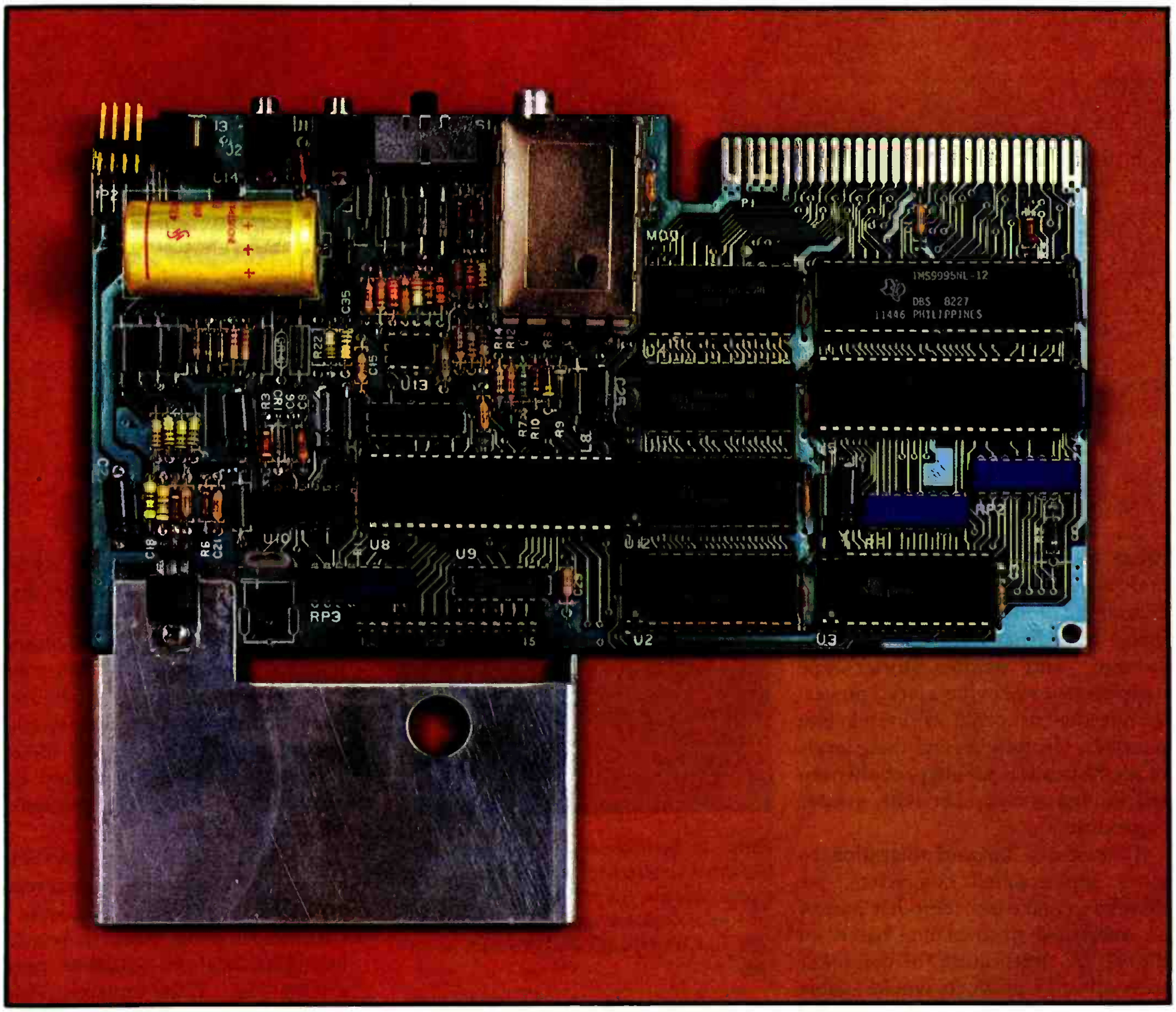

Photo 3: *The main circuit board of the 99/2 contains the TMS9995 microprocessor, video controller chip, I/O controller chip, two static RAMs (4K bytes), three ROMs (the final version will have one 32K-byte ROM), a two-channel RF modulator, and the 5-volt DC regulator with heat sink.*

"elastomeric" key-top assembly. The elastomeric system provides 48 raised keys in a single molded sheet, an arrangement that takes advantage of the elastomeric properties of the material. Depressing the key actuates the Mylar underneath.

Internal Architecture

We decided to use the new high-speed TMS9995 microprocessor that runs at 10.7 MHz, a standard crystal frequency. We chose the TMS9995 over the TMS9900 because it requires fewer external control components and less circuit-board space due to its smaller package (see photo 3).

The 99/2 uses a standard address/data bus system. By using a 16-bit microprocessor and DMA (direct memory access) video processing, we attained a high-speed system performance. Initially, the system had only 2K bytes of RAM. But when we expanded the system from 16K bytes of ROM to 32K bytes of ROM to allow the software to run a full file-management system without a plug-in module, we decided our overhead use of RAM was too high. We added 2K bytes of RAM to carry the overhead of the system BASIC and still give us a reasonable amount of space for the program.

The total RAM in the computer is actually 4.2K bytes, including the 256 bytes of scratch-pad memory in the TMS9995 microprocessor. That scratch-pad memory helps improve the speed of the system. The 32K-byte ROM has a physical address space of 24K bytes, and the last 8K bytes of ROM are bank switched to preserve a 32K-byte expansion-port capability (see figure 1).

The expansion port has all system control address and data bus signals available. This allows expansion with RAM, ROM, or I/O (input/output) cartridges. The 32K-byte expansion address space can be configured in

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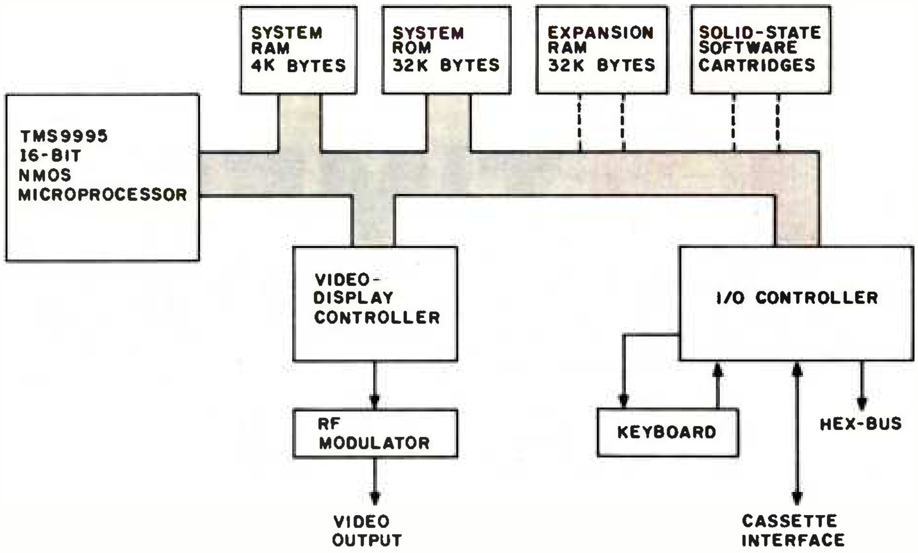


Figure 1: *Internal architecture of the TI-99/2.*

8K-byte increments of memory with ROM building up at the low end of the expansion address space and RAM building down from the high end of the expansion address space.

The system contains two gate arrays; one controls the video display, and the other handles I/O functions. Gate arrays are a low-cost method of designing custom ICs (integrated circuits). Starting with an array of logic elements on an IC, the manufacturer simply designs a mask to connect the elements in the final metalization procedure. To change the logic on a chip, you simply change the mask.

The video-display controller is a DMA processor that shares RAM and ROM with the microprocessor. The shared-memory structure improves the ability to effectively update and scroll the video display, thus allowing more time to be allotted to the central processing unit.

The I/O controller handles the Hex-bus interface, cassette interface, keyboard, I/O, clock generation, system reset, and RAM/ROM chip-select generation. This gate array allows higher system integration and therefore lowers the cost of the system.

The 99/2's BASIC language is architecturally different from the BASIC used in the 99/4A. To the user it appears the same, but to meet our goal of cost reduction we had to redesign the internal modules. For example, the RAM and ROM are in different places in the 99/2 and 99/4A. Still, for the most part the BASIC commands produce the same responses as the 99/4A BASIC. In addition, the system is faster to execute and uses fewer parts.

We decided to go with Solid State Software to meet the need for a plug-in module that would allow the user to personalize the system through configuration software. The user could turn the system into a terminal emulator, a learning aid, or a game machine.

We didn't want the beginning user to have to hook up too many external parts.

We built the RF modulator into the system to simplify use. We didn't want the beginning user to have to hook up too many external parts.

The 99/2 uses a 128-character set. Each character is an 8 by 8 dot matrix. It takes 8 bytes, or 64 bits, of information within the ROM to define each character. There are 1024 bytes of ROM in the system committed to screen generation; these are unavailable for system BASIC.

One byte of RAM is required for every character location on the screen (768 bytes for a 24-character by 32-line screen display). The central processing unit writes a code into each of those RAM locations. The gate array then reads that code and knows which of the 128 characters to display on the screen. The video controller chip and the microprocessor share the system in order to keep the display from flickering, which can be annoying to the first-time user.

The video controller chip has dominant control of the bus system. When it wants the bus, it gets it—no matter what the central processing unit is doing. We designed it that way to satisfy the refresh-rate requirements. The processor can compute only when the video controller is not using the system. The central processing unit can compute only during border times, when the electron beam is not drawing a trace on the screen, such as during the horizontal retrace, vertical retrace, and top and bottom border times.

When the screen is full of characters, the video controller has the bus 90 percent of the time, and the central processing unit can be used for computing only about 10 percent of the time, which slows down the computer drastically. To overcome this limitation, we designed the video controller with enough intelligence to know not to tie up the system when nothing is displayed on a line. At the end of every line that is generated, the processor writes what is called a blank end-of-line character. The video controller responds to this character by releasing the bus for the rest of that row on the line.

When the screen is blank, the video controller accesses the memory only 1/768 of the maximum computation time available. Because a line of BASIC code seldom fills an entire screen line, the computing time is greatly increased by this feature. If we need to compute quickly, the system has the ability to disable the video chip; then there are no interruptions to computing time. The software controls the screen and can be accessed through BASIC.

BASIC

To facilitate our computer-literacy goals for the 99/2, we provided three additional BASIC statements that are not compatible with the 99/4A but that do allow the user to develop some assembly-language programming skills. These are the PEEK, POKE, and MCHL (machine-language execute) commands that let the user read/write directly into memory. By using the MCHL command, the user can execute an assembly-language program. Most applications on the 99/2 will not require the PEEK, POKE, and MCHL commands, but their availability gives users a chance to do assembly-language programming, even though it is not supported by the 99/4A console BASIC.

The 99/2 users manual explains any of the incompatibilities. It is important for the user to know these when writing a program that uses the assembly-language capabilities of the 99/2. Those instructions will be flagged as errors on the 99/4A. We felt that anyone who can program in assembly language will understand how to change the program to run on the 99/4A. Anything written totally in BASIC will be compatible.

System Software

The system software of the 99/2, we decided, would provide power-up initiation and system configuration definitions and would allow users to select operation in BASIC or to use an application module that had been previously inserted into the expansion port. We decided to implement a subset of the TI-99/4A console BASIC to satisfy the upward software compatibility users need to migrate to another computer system.

Because of architectural limitations, the 99/2 does not support several features—CALL COLOR, CALL SOUND, CALL JOY, CALL CHAR$, and CALL SCREEN. The cost of the additional hardware required to support these features would have caused us to exceed our pricing goals.

In addition, the system would not use the TI-99/4A GROM language because of the cost of the hardware required to support GROM chips. We had to develop a completely new BASIC interpreter for the 99/2 that was optimized to use the speed advantages of our architecture yet provide a meaningful subset of TI-BASIC. We included a full file-management system in the system software to take full advantage of the Hex-bus peripheral system.

Within the time frame we gave ourselves, we didn't have sufficient resources to develop a complete software system for the 99/2, so we decided to go to an independent third party for the software generation. We needed a group that was willing to undertake a task of this magnitude in the time allotted.

We contacted the University of Southwestern Louisiana (USL) in Lafayette, Louisiana, because its computer science department had worked with TI before and came highly recommended. After we discussed our concepts and needs with them, the USL team accepted the challenge. During the course of the four and a half months in which we prepared prototypes for the January 1983 Consumer Electronics Show

(CES) in Las Vegas, Nevada, the USL team members provided very useful feedback on the 99/2 system architecture.

Development Schedules

The entire 99/2 system was conceived, designed, and developed in time to introduce working prototypes at the CES show. The full development cycle, from concept through production, including qualification and certification, was approximately eight months long. This achievement required the cooperative dedicated efforts of many TI groups both inside and outside the Consumer Group.

Our Semiconductor Group developed two new gate array ICs, from layout to working prototypes, in two months. Logic design of the gate arrays was done in Lubbock, Texas, by the IC design organization of the Personal Computer Division in approximately one month.

The mechanical design team of the Personal Computer Division designed and developed the console, AC adapter, cassette/video connections, and the keyboard in time to have prototypes at the CES show, also in about four and a half months. Development included implementation of advanced assembly techniques to allow reduced manufacturing time and lower cost. Our Industrial Design team provided the styling of the console.

The full development cycle, from concept to production, was approximately eight months.

Other members of the TI Consumer Group also contributed greatly to the successful introduction of the TI-99/2. Our packaging design and artwork team worked many extra hours to provide the appropriate packaging material for the unit, while our manual-writing staff developed a series of four manuals for the 99/2 that gradually progress in complexity to handle the range from novice to computer hobbyist.

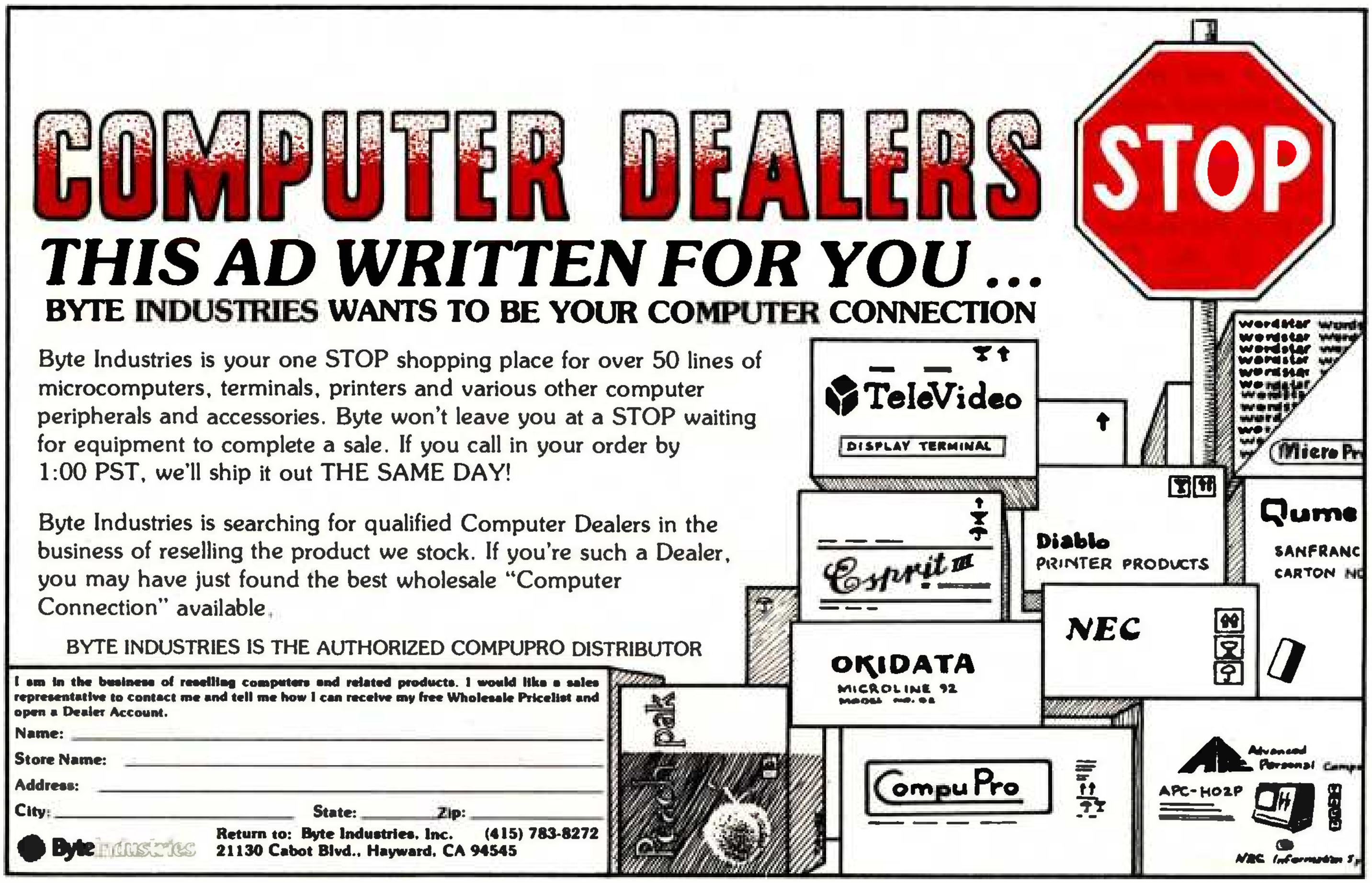
Final Thoughts

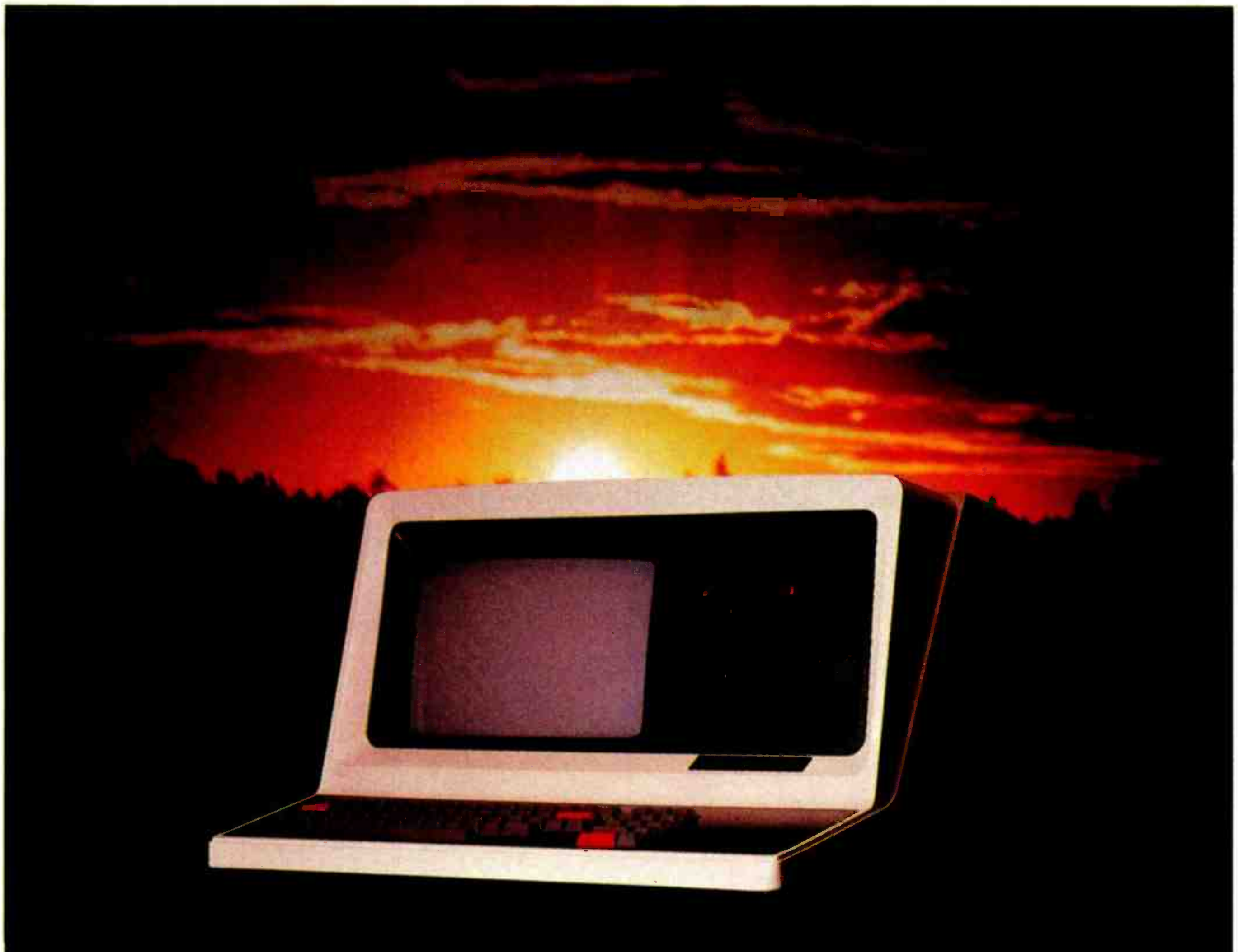
The TI-99/2 is not just another low-cost, entry-level computer. It is a computer system designed for education and personal use. Users will find it an inexpensive introduction to microcomputers. With the use of Solid State Software cartridges such as Learn to Program and Learn to Program BASIC, individuals and schools can easily obtain instruction in computer programming.

By introducing peripherals and inexpensive software simultaneously with the computer, Texas Instruments believes this system will grow with an individual, inspire confidence in the use of computers, and foster the continued growth of the computer revolution. ■

About the Authors

Harry Littlejohn was program manager and project engineer and Mark Jander was project design engineer for Texas Instruments' TI-99/2 design group.





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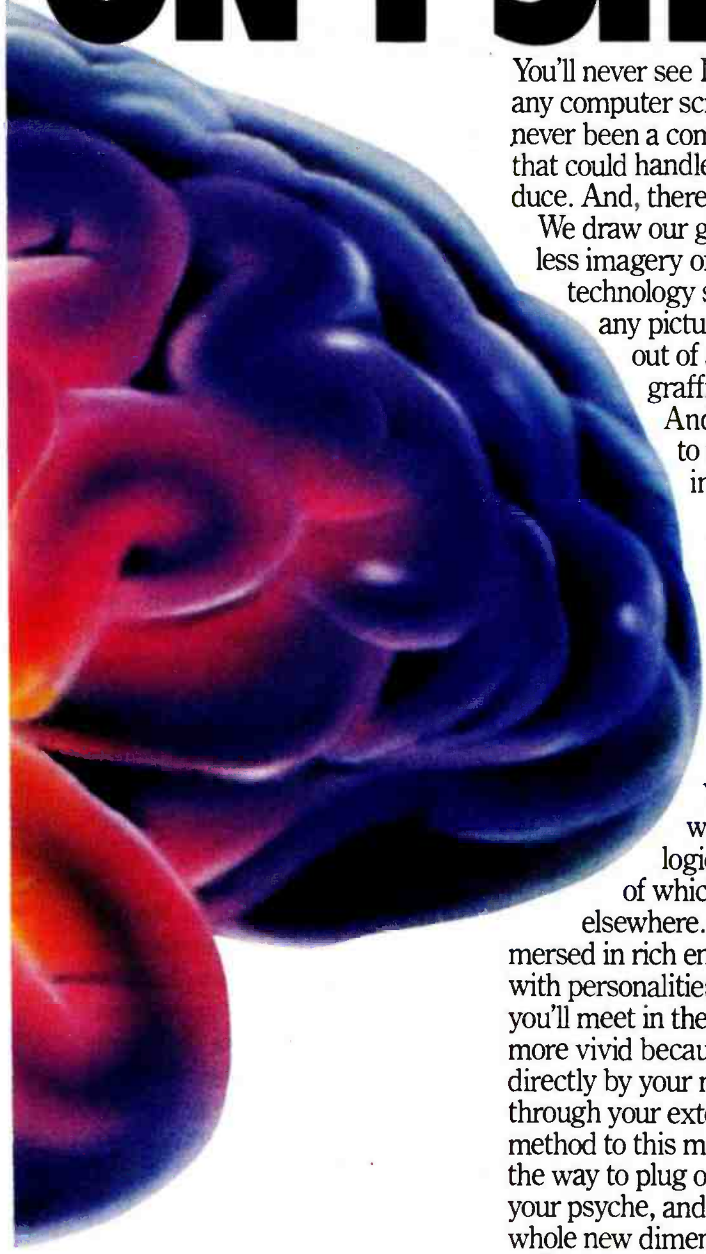

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Implementing Minicomputer Capabilities in a Desktop Microcomputer

Multiple users, Xenix and local-area networks characterize the Altos 586.

Colin Nayler
Altos Computer Systems
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The advent of powerful 16-bit microprocessors that support high-performance operating systems has set the stage for desktop microcomputers in the $8000-to-$12,000 price range that perform on a par with the much more expensive minicomputers. The 586 from Altos Computer Systems is one such machine. It was designed to offer a multiuser system with the Xenix operating system and support for a variety of local-area networking (LAN) and communications protocols.

In using the Xenix operating system, a joint development of Altos and Microsoft based on Bell Laboratories' Unix System III, the 586 is one of the first desktop microcomputers to offer the sophisticated facilities of Unix software. The 586 runs Xenix—as well as the MP/M-86, MS-DOS, Oasis-16, and Pick operating systems—in a stand-alone configuration, and it also supports LAN and communications protocols including Ethernet and bisynchronous, and will soon support X.25 and IBM's Systems Network Architecture (SNA) protocols. Such communications support allows this desktop machine to be a mode for corporate-wide office automation.

Photo 1: *The new Altos 586 microcomputer offers affordable, fast 16-bit processing to accommodate five users, expandable to eight. The 586 uses the Xenix operating system and provides integral networking capability.*

Although the 586 is designed to meet multiuser and multitasking requirements, it can also be configured for single users who require large storage capacity or Unix software capabilities. The computing power of the Intel 8086 processor is enhanced for both single and multiple users by a design that employs two auxiliary I/O (input/output) processors and a proprietary memory-management scheme, all of which aid the efficient use of Xenix.

Memory Management and Xenix

Xenix presents problems for any 8086-based multiuser system because the microprocessor lacks certain important protection features that minicomputers running Unix software have, such as individual protection for memory contents when more than one user resides in memory at the same time. To overcome this obstacle, Altos's designers developed proprietary memory-management hardware, built with PAL (programmable arrayed logic) and RAM (random-access read/write memory) circuitry around the central processor.

This memory-management system enables the central processor to set a user-mode bit when the machine runs

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an application program. When this bit is not set, the system is in system mode, which runs the operating system kernel. The memory-management system also disables certain operations in user mode, such as I/O instructions and memory accessing not belonging to a currently active user. If a user attempts any of these operations, the system issues a nonmaskable interrupt that clears user mode and puts the machine in system mode. Without this protection, these operations can corrupt the system for all users.

The heart of the memory management system is a 256- by 14-bit logical RAM section, into which Xenix writes the control bits for as many as 256 memory segments (pages) of 4K bytes each, along with a page-relocation value that relates logical and physical address space. The control bits define legal memory access and are read by PALs, which function as comparators to detect the execution of illegal instructions and alert the central processor to prevent illegal writes. The relocation value becomes part of the physical memory address, permitting memory segments to be assembled noncontiguously while the central processor makes accesses as if the memory were a solid block.

The memory-management system thus makes it possible for the 8086 to run Xenix efficiently by providing a paging system that permits "scattered loading" of processes into logical memory: the 4K-byte pages can be scattered throughout the 1-megabyte logical memory (i.e., mapped anywhere), eliminating the time-consuming search for extensive contiguous physical memory to load a process. Unlike some minicomputers, the 586 can swap pages of lengthy programs back and forth between the scattered areas of noncontiguous main memory and a swap area on the hard disk. The 586's intelligent hard-disk controller further speeds swapping by writing and reading multiple pages in less than one revolution, rather than the several revolutions required by many minicomputers.

Making Xenix Universal

Regardless of its processing power, disk storage, and communications capabilities, however, the 586 would not be appropriate for corporate-wide office automation without some way to make its Xenix operating system amenable to the typical business user. To this end, Altos has created a "business shell" that presents Xenix's capabilities in an easy-to-use menu-driven format.

This Xenix business shell is compatible with virtually any RS-232C terminal and is accompanied by several integrated applications programs for nonprogramming personnel, including an electronic mail package developed by Altos, a financial planner based on Microsoft's Multiplan, the Horizon word-processing system, a Business Basic III interpreter, a seven-module accounting package, and an interactive tutorial.

A "business shell" presents Xenix's capabilities in an easy-to-use format.

System programmers can use the shell's facilities to customize software for end users by modifying menus and prompts. The menu system is composed of a collection of ASCII (American National Standard Code for Information Interchange) files that may be viewed and modified either through the menu development portion of the system or directly with any text editor. Data is stored almost exactly as it will appear, which allows precise control over the final screen displays. Moreover, the menus and prompts themselves are structured around the Xenix file system as a convenient mechanism for customizing software.

The shell frees a user from having to learn the myriad commands that make Xenix a versatile and powerful tool, but not an easy one to master. The Xenix command "mkdir," for example, creates a new directory; "cat" concatenates files and displays them; and "rm" removes them. In contrast, the 586's Xenix interface offers clear menu choices at each stage of a user's interaction with the system. When additional input is required, the system prompts for it at the bottom of the screen. For inexperienced users, the 586's business shell provides complete online assistance, displaying information about any menu or selection. Sophisticated users can execute Xenix commands directly simply by prefacing them with "!" or by entering the standard Bourne shell or C-shell.

Local Networking and Remote Communications

Xenix capabilities and 16-bit architecture in a desktop computer are impressive, but the range permitted by ribbon or RS-232C cable between a terminal and the microprocessor is not great. A stand-alone multiuser system cannot address the processing requirements of users on another floor or another continent. Sophisticated networking and communications capabilities are required, which the 586 solves by offering two LAN configurations and the bisynchronous, X.25, and SNA communications protocols.

The more modest networking scheme is Altos's proprietary RS-422 twisted-pair LAN software called Altos-Net, which is supplied in the 8K bytes of ROM (read/only memory) in the main board's Z80 processor. Based on UNET software from 3COM, Altos-Net runs at 800 bits per second (bps) and uses a bit-oriented synchronous data-link control (SDLC) protocol to link as many as 32 Altos 16-bit machines. Implementing this protocol was greatly simplified because Altos-Net is not an inter-vendor LAN. At the physical layer of the seven-layer International Standards Organization (ISO) model, for example, a single-chip RS-422 driver can produce a differential signal for both the clock and data transmissions, each of which is sent as a pair of "mirror images" that cancel external noise. At the link layer, a Zilog communications chip functions in a low-level SDLC-like mode, offering the speed of a bit-oriented, carrier-sense protocol without the expense of collision detection. Transmission is in packets consisting of an opening flag (six "1"

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The remaining five layers of the ISO model are implemented by the UNET software, which offers file transfer, virtual terminal capability, transmission control protocol, electronic mail and internet protocol.

Ethernet on a Chip

The 586 is one of the first systems to offer Ethernet capabilities on a chip for users who need a more expansive, higher-performance LAN or who seek to implement an industry standard to link machines from several vendors. Altos expects this protocol to become the de facto standard for local-area networks because of Ethernet's high performance, availability, low cost, and acceptance by a rapidly growing list of vendors.

In the 586, the Intel Ethernet chip set resides on half of the system's communications board, while the other half provides either remote synchronous communications or four additional serial I/O channels. "Ethernet on a chip" actually consists of two separate chips hardwired together—a controller and an encoder/decoder. The controller chip is located on the system's lone Multibus interface and is programmed from the 8086. At the opposite end of the board, the encoder/decoder chip connects with the half-inch Ethernet transceiver cable through an Ethernet port.

The Ethernet chip replaces a far more expensive Ethernet controller board from 3COM, which Altos previously used in the 586. The chip runs the Ethernet protocol and also contains small numbers of FIFO (first-in, first-out) registers to buffer the packets. Moreover, it has a built-in DMA (direct memory access) interface, which replaces an external DMA channel and provides an internal I/O port. As a result, the Ethernet chip does not need to make two memory accesses to manipulate data (one to read from memory and one to write to I/O, or vice versa); it gets the data from memory in a single access.

The Ethernet chip's intelligence rivals that of the central processor in certain respects. A user can tell the chip what to do by writing a program into memory because the chip gets all of its instructions directly from memory, not from another processor. For the same reason, the chip can run the Ethernet protocol while remote communications protocols are being run by their own processor. Were the networking and communications protocols to share a processor, they could not run simultaneously.

Unlike the Ethernet chip set, the serial I/O communications chips on the other half of the communications board must receive instructions from an Intel 80186, which shares the board and runs 128K bytes of local memory. This extra processor is necessary because Xenix is not a real-time operating system and is thus not designed to service communications protocols efficiently.

Each of the board's two serial I/O chips supports two channels, and two of these four channels support synchronous communications. Unlike the Z80 on the main board, which has most of its code in immutable ROM, the communications board contains only minimal ROM but has a large amount of RAM. This makes it an excellent candidate for economical communications software upgrades. Augmented versions of X.25, SNA, and other protocols can be implemented simply by loading them onto the communications board from a disk. Because the 80186 contains 128K bytes, it will probably be several years before a hardware upgrade will be needed to accommodate these newer protocols. The communications board also contains a socket for an optional 212-type 1200-bps full-duplex modem module.

More limited comunications capabilities are standard on the 586 through its six serial I/O ports. Five of these channels can operate in asynchronous mode at all 15 standard data rates between 75 bps and 19,200 bps. In addition, two external registers can be loaded with a 16-bit unsigned integer to generate a unique rate setting for these channels. Each channel has its own programmable timer, which allows the channel to have its own data rate. The sixth channel provides external clocking on

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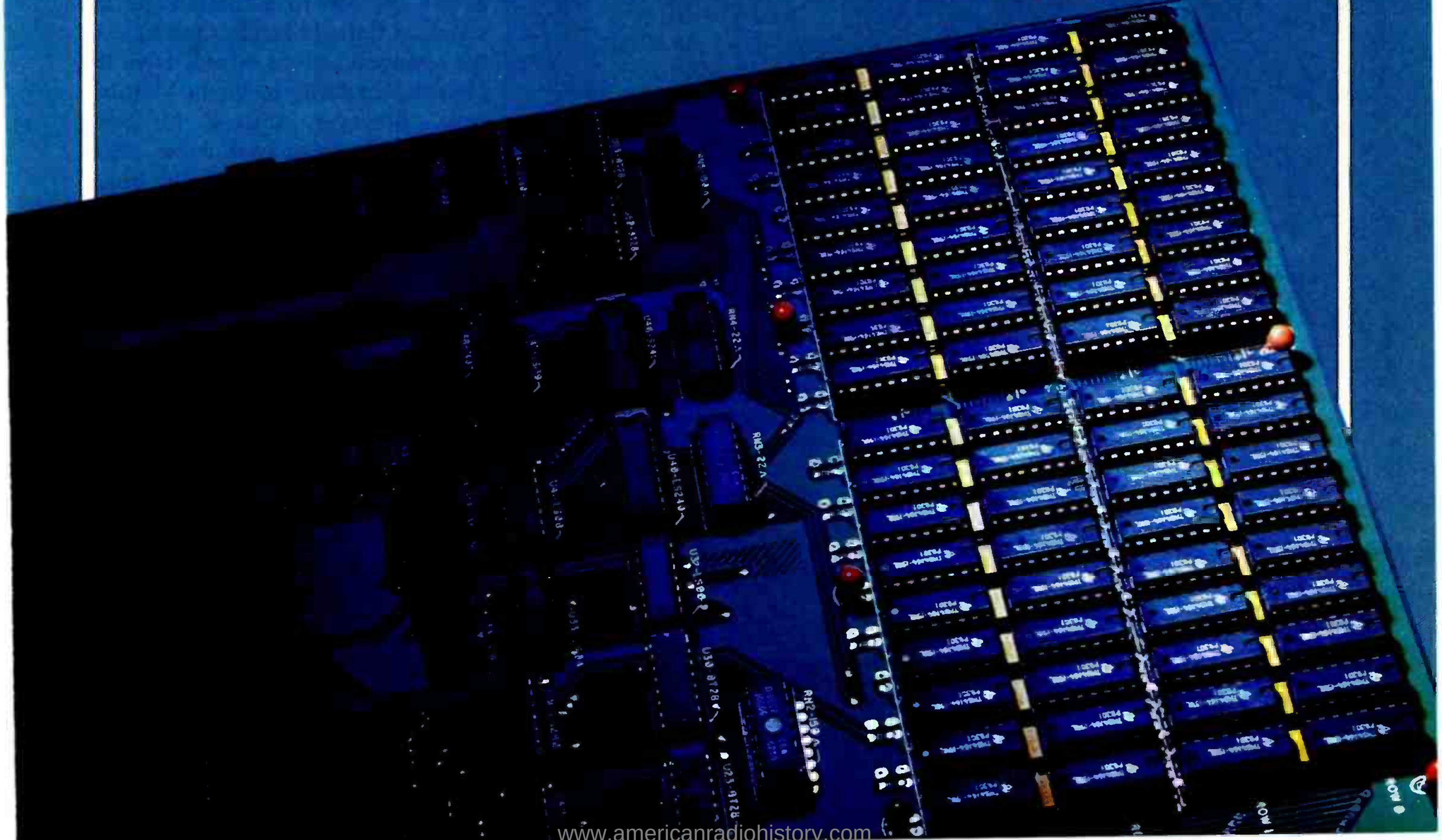

both transmit and receive clocks to support synchronous serial devices.

Architecture of the 586

A fully loaded 586 contains four printed-circuit boards. The main board holds the 8086 and 512K bytes of memory; a Z80 I/O processor supporting six serial I/O ports, floppy-disk accesses, and an RS-422 LAN port; and sundry memory-management components enabling the system to support Xenix. A second board holds an intelligent hard-disk and tape controller with an Intel 8089 I/O processor. An optional communications board provides an Ethernet chip set and processors supporting either the bisynchronous, X.25, or SNA protocols, or four additional serial I/O ports. The fourth board is an optional memory-expansion board providing an additional 512K bytes of RAM. A standard 586, consisting of the central processor board with 512K bytes of RAM, six serial ports, a 10-megabyte hard-disk drive, a 1-megabyte floppy-disk drive, and Altos-Net, sells for $7990.

The 586 system multimaster bus is electrically identical to the Intel Multibus, using the same signals and signal timing. This compatibility allows the 586 to accommodate the standard slotted Multibus interface of the communications board. Here the physical similarity to Intel's Multibus ends, however. Instead of using Intel's card cage or backplanes, Altos placed the hard-disk controller board atop the main board and provided a short ribbon connector between the two. Because the central processor and the Z80-based I/O processor are on the same board, they are simply hard-wired together. The 512K-byte memory expansion board plugs directly into the central processor.

The 10-MHz 8086, which includes parity error detection per byte on the main memory, can fully direct its power to run applications and the heart of the operating system, leaving the I/O details to the Z80 and the 8089. The 586 offers superior performance to systems using an unaided central processor to handle I/O bookkeeping duties partly because these three processors can run simultane-

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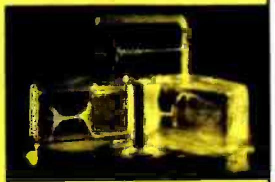

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8089 S.W. Cirrus Dr.
Beaverton, OR 97005
Phone (503) 644-9014

Circle 303 on inquiry card.

ously and more or less independently.

Although the 8086 and the Z80 are on the same board, they perform different logical functions. The central processor performs 8- and 16-bit signed and unsigned arithmetic functions in binary or decimal, including multiplication and division, data transfers, string operations, and bit manipulation.

With 8K bytes of ROM and 2K bytes of RAM, the Z80 handles the serial I/O channels for six RS-232C ports, sparing the 8086 from character interrupt processing. The Z80 also controls a 5¼-inch floppy-disk drive, containing either a 512K-byte single-sided or 1-megabyte double-sided disk. As part of its serial I/O duties, the Z80 permits asynchronous and bisynchronous communications. It also supports an RS-422 port for Altos's proprietary limited-range 800,000-bps local-area network, called Altos-Net. Finally, the Z80 accesses a battery-backed calendar and clock on the main board, eliminating the need for the software to ask the time and date when the system is turned on each day. The Z80 always talks with the 8086 through DMA and a pair of interrupt lines.

The 8089 I/O processor, which resides with 16K bytes of RAM on the hard-disk controller board, also communicates with the 8086 through main memory. This controller can support two 5¼-inch hard-disk drives—typically the Miniscribe 2012 or Seagate ST412—and one 12-megabyte (formatted) start/stop (funnel) tape drive. The controller handles seeking, serial data transfers, and DMA into system memory. The 8089 can read a full track in one disk revolution, which is important for running Xenix.

Conclusion

By offering virtually all levels of users ready access to the powerful features of a minicomputer running Unix software, the 586's Xenix business shell provides a capstone for the system's networking and communications capabilities and marks an important step in the direction of corporate-wide distributed data processing. ■

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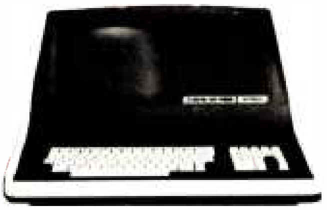

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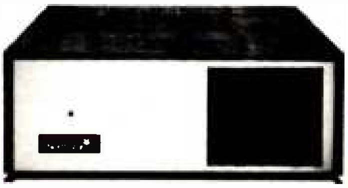

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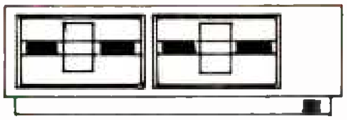

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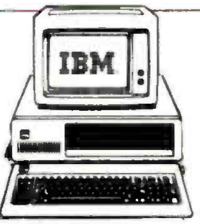

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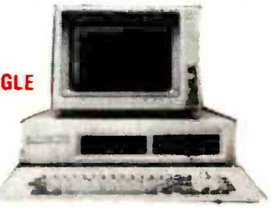

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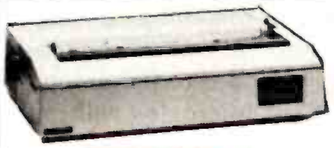

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A Machine for All Processors

The Fujitsu Micro 16s

The Micro 16s, with its plug-in processors, was designed to run a large variety of operating systems and applications programs.

Wayne Clingingsmith
Fujitsu Professional Microsystems
3320 Scott Blvd.
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The Fujitsu Micro 16s personal business computer (see photo 1) offers a unique architectural design: interchangeable microprocessors. It lets users choose from among the most popular processors available today. Eventually, more microprocessors will be added to this group, ensuring that the Micro 16s will not become obsolete.

The primary advantage, of course, is the ability to interchange operating systems, which provides the path to a wide assortment of applications programs.

Applications Processors

The main circuit board of the Micro 16s does not contain a central processor (see photo 2). By pulling the central processors off the main board and configuring them on plug-in boards, the designers of the Micro 16s have made it possible to use any of several Primary Applications Processors. One or two processor boards can be plugged into the Micro 16s, and either one can be in control of the bus, the memory, etc.

Boards are available now for a 16-bit processor, the 8086, and the Z80A 8-bit processor. In the near future, boards will be available for 16-bit processors such as the 68000 and 80286.

The 68000 board should be particularly attractive. It will have an 8-MHz clock rate letting it perform 1 million instructions per second. And it will be capable of running the Unix operating system along with a wealth of applications programs that have primarily been confined to minicomputers and mainframes.

The Micro 16s can easily adopt whatever operating system is currently in style.

Flexibility

Flexibility is the cornerstone of this computer's architecture. It confronts head-on an issue that is often swept under the rug: the finite life span of an operating system. Like many things, operating systems go in and out of style. One sometimes wonders, "What is the operating system of the day?" The Micro 16s is the first microcomputer to address this problem directly.

For example, a person who owns a computer that uses an 8086 microprocessor with the MS-DOS operating system—and who makes a substantial investment in hardware, software, and peripheral devices—may learn that the particular industry involved has subsequently adopted the Unix operating system. Now a 68000, a Z8000, or some other chip would be needed.

Micro 16s owners won't lose any investment in existing peripheral devices. The Micro 16s, because of its architecture and its bus system, can adopt whatever operating system turns out to be au courant. It becomes a simple matter to add the appropriate applications processor board and the new software, rather than acquiring an entirely new system with new peripheral devices and converting all the old programs. With the Micro 16s, the old programs would still be usable with the old processor.

A Look Inside

Inside the Micro 16s there's a main circuit board with a card cage having six card slots. A diagram of this is shown in figure 1. On this board are 128K bytes of volatile memory, a

Photo 1: *The Fujitsu Micro 16s personal business computer.*

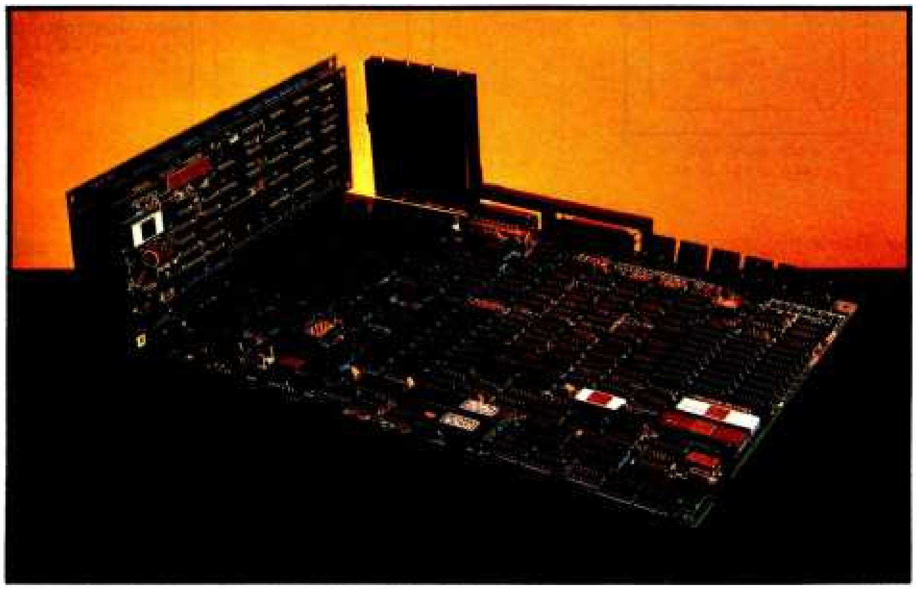

Photo 2: *The main circuit board of the Fujitsu Micro 16s. Two processor boards are plugged into the expansion slots.*

dedicated video subprocessor (based on the 6809 processor), and 64K bytes of additional memory for this processor. Because these memory chips have an extremely low failure rate, the chips are soldered to the board rather than merely plugged in.

What's more, the Micro 16s has a floppy-disk controller, an RS-232C serial controller, a Centronics parallel controller, a light-pen controller, and a 4-channel A/D (analog-to-digital) converter all built in.

It is important to note that all these basic I/O (input/output) controllers are located on the motherboard. They don't take up any of the six plug-in slots.

The applications processors are configured on plug-in boards. The system, as delivered, comes with both an 8086 and a Z80A applications processor board plugged into slots 1 and 2. The 8086 board has a socket for the 8087 arithmetic processor and controllers for DMA (direct memory access). Either or both of the boards can be replaced as a user's requirements change.

The package as described so far, including an RGB color monitor, CP/M-86, the Wordstar word-processing program, and Supercalc^2, retails for $3995.

Extra Memory

The first upgrade that one is likely to want is Concurrent CP/M-86, which offers a single-user/multitasking operating environment. It enables you, with a single keystroke, to switch between a spreadsheet, a word-processing program, and a calendar operation. If the Micro 16s is functioning as a terminal in regard to a mainframe, you may want to switch back and forth to an operation running on that remote processor. For example, in slot 3 you might add the memory necessary to support this operating environment.

Four single-board memory options will be available—128K, 256K, 512K, or 1024K bytes. Yes, I said 1024K bytes of volatile memory on a single board. This will be made possible by the new 256K-bit volatile-memory chips.

The 128K-byte memory board will have two additional RS-232C ports. This is valuable for addressing both a serial printer and a modem. Also, if you are using the MP/M operating system, these extra ports enable other users to access your database through remote terminals.

Other Peripheral Devices

A hard-disk controller will soon be available using one slot on the main circuit board. Fujitsu will be offering a 5-, 10-, and 20-megabyte Winchester disk drive for this computer.

The remaining two slots (after memory and hard-disk controller) provide room to add a mix of additional peripheral devices. For example, you may want to attach a number of terminals to the system. A multiport RS-232C controller card will soon be available to allow this. Under MP/M-86, the Micro 16s would be able to run several terminals and printers at the same time.

If you have many applications and you would like local-area networking, the Micro 16s will offer two choices: Omninet (with a data-transmission rate of 1 megabit per second)

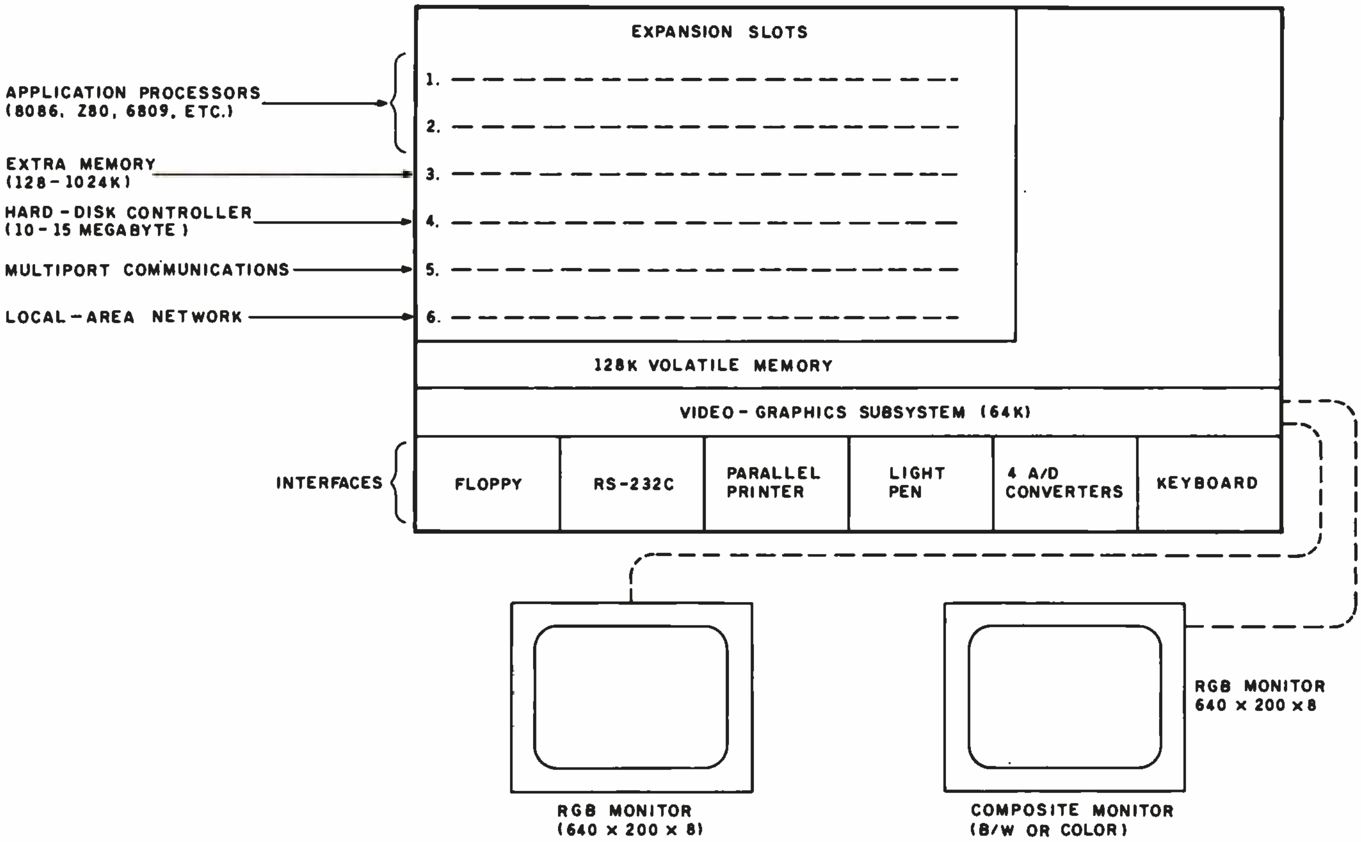

Figure 1: *Diagram of the Fujitsu Micro 16s computer. Two applications processors (the 8086 and the Z80A) come standard with the unit along with an RGB monitor and dual disk drives. The video-graphics subsystem uses a 6809 processor and has its own 64K bytes of memory. Slots 2 through 5 are identical and can house any combination of cards.*

Operating System	Description	Available
Concurrent CP/M-86	Single-user, multitasking on 8086-based systems	6/83
MP/M-86	Multiuser, multitasking on 8086-based systems	12/83
MS-DOS	Microsoft's version of IBM PC-DOS	11/83
GSX	Graphics system extension	8/83
Unix	68000-based, powerful networking system	5/84

Table 1: *Additional operating systems for the Fujitsu Micro 16s.*

and Ethernet (10 megabits per second).

Omninet allows you to interconnect several microcomputers. For example, several users could then share a hard disk. Ethernet is designed for those in high-throughput environments, where you may want to interface with a DEC computer or other mainframe computer systems.

An IBM 3278 controller board will be available to connect the Micro 16s to mainframe computers over a coaxial cable at 2.5 megabits per second.

Operating Systems

The power and flexibility of the Micro 16s rely heavily on a variety of operating systems, listed in table 1. Many are significant new operating systems being made available by Digital Research Inc., the developer of the popular CP/M operating system.

Concurrent CP/M-86 from Digital Research enables you to perform multiple tasks, such as entering data and printing the hard copy of a letter, at the same time. This permits an operator to perform other tasks while waiting for input or output functions to complete. MP/M-86 lets several users perform multiple tasks on the Micro 16s. MS-DOS enables programs developed for the IBM PC to operate in the Micro 16s, while Unix extends the multiuser, multitasking capability of the machine still further, including features such as networking.

Digital Research's GSX graphics interface is an extension to the CP/M system that provides a universal graphics protocol for graphics devices. It significantly eases the interface to the video-terminal subprocessor and provides portability for CP/M-based programs.

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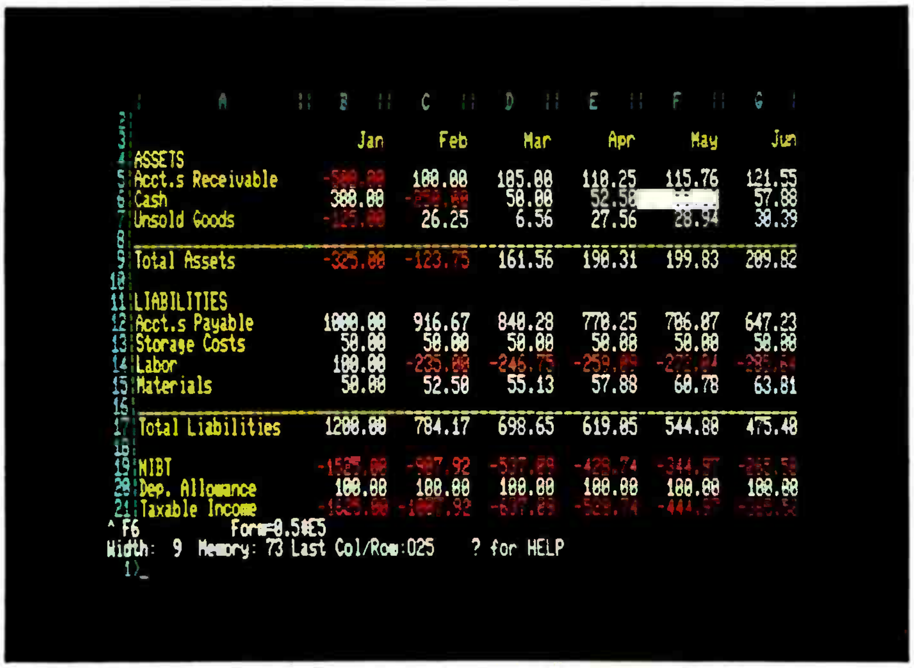

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 !      A       !! B !! C !! D !! E !! F !! G !
 2!
 3!                Jan      Feb      Mar      Apr      May      Jun
 4!ASSETS
 5!Acct.s Receivable [illegible] 100.00  105.00   110.25   115.76   121.55
 6!Cash          300.00 [illegible]  50.00    52.50 [illegible]    57.88
 7!Unsold Goods  -125.00   26.25     6.56    27.56    28.94    30.39
 8!
 9!Total Assets  -325.00  -123.75   161.56   190.31   199.83   209.82
10!
11!LIABILITIES
12!Acct.s Payable 1000.00  916.67   840.28   770.25   706.07   647.23
13!Storage Costs   50.00   50.00    50.00    50.00    50.00    50.00
14!Labor          100.00  -235.00  -246.75 [illegible] [illegible] [illegible]
15!Materials       50.00   52.50    55.13    57.88    60.78    63.81
16!
17!Total Liabilities 1200.00 784.17 698.65   619.05   544.80   475.40
18!
19!NIBT       [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
20!Dep. Allowance 100.00  100.00   100.00   100.00   100.00   100.00
21!Taxable Income [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
^ F6          Form=0.5*E5
Width:  9  Memory: 73 Last Col/Row:025    ? for HELP
  1>_
```

Photo 3: *An example of the colors available in the character mode of the Micro 16s. Shown is a Supercalc² table.*

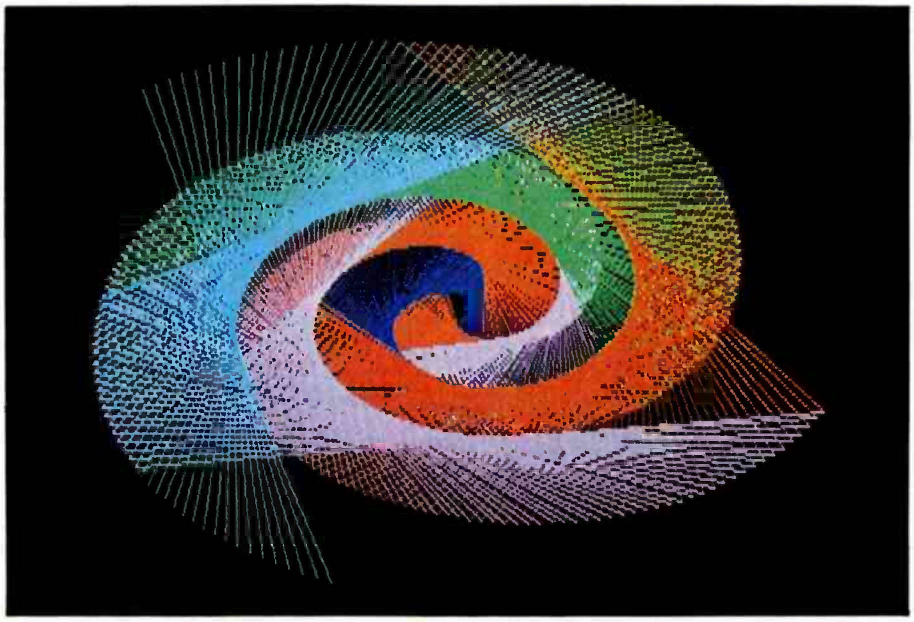

Photo 4: *An example of the color-graphics capability of the Micro 16s.*

Video Display

The Micro 16s's video display is a self-contained video-display terminal handling not only video, but also keyboard interrupts and I/O processing.

Video display is handled by the independent video processor that is sent high-level commands by the main processor. The video processor resides on its own bus and does not use an expansion slot. By running in parallel and not requiring any main processor bus cycles, it supplies the main system with characters and high-resolution graphics without taking up user address space. This makes it easy for the Micro 16s programmer to manage the video display without worrying about which operating system or main applications processor plug-in board is used. Parallel processing also increases throughput and allows the main system to maintain a high clock rate because it does not have to be synchronized with the video display.

The Micro 16s can display 221 characters, including the standard ASCII (American National Standard Code for Information Interchange) character set, engineering symbols, graphics, and forms graphics (see photo 3). Each character can be displayed in one of eight colors, with a choice of eight background colors (black, blue, red, purple, green, light blue, yellow, or white). Two levels of intensity are also possible in character mode, allowing a total of 16 displayable colors. In addition, "blink" and "reverse" attributes are available.

The video display supports the ADM 3 terminal mode and uses escape sequences for performing certain smart terminal functions. These include setting video and cursor attributes and setting and getting cursor position.

The video display also has a graphics mode that features 640 by 200 pixels, displayable in one of eight colors. In addition, the video processor supports high-level commands such as to draw a line, draw a box, paint, and print. Table 2 lists some of the 45 commands, which also include functions for a light pen, timer, and displayable time-of-day clock.

You can generate a graphics display by computing the appropriate set of points to be drawn using a BASIC program and then passing high-level line commands along with the necessary parameters to the video processor.

Photo 4 is an example of a complex display that can be quickly drawn by a BASIC program. The program computes the three apexes of a triangle and places them, as (x,y) coordinate pairs, into an array. A video-processor command is then invoked to place the parameters into the video terminal's 128-byte interface buffer. This is usually in the form of a line command (see table 2). For each line of the triangle, you send the code for the line command in the following format: command code, color code, function code, first coordinates, second coordinates, and box flag.

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Command Name	Function
PUT STRING	Displays a character string
PUT CHARACTER BLOCK 2	Writes characters and attributes to VRAM
GET CURSOR POSITION	Reads the cursor position
TAB SET	Sets tab positions
CHARACTER LINE	Draws a character line or box
CHARACTER OUT	Displays a character
GET LIGHT PEN POSITION	Reads the coordinates indicated by the light pen
LINE	Draws a line or box
CHAIN	Draws a broken line
POINT	Displays one or more points
PAINT	Paints the area inside a boundary
SYMBOL	Displays a character string in a specified location, orientation, and size
LINE2	Draws a line (for CIRCLE FULL)
GET BLOCK1	Reads a specified color
PUT BLOCK2	Displays a pattern in a specified color
GRAPHIC CURSOR	Reads specified coordinates
ERASE GRAPHIC VRAM	Erases the graphic VRAMs
DEFINE PF STRING	Defines a character string for a program function key
GET PF STRING	Reads the string defined for a PF key

Table 2: *Some of the graphics commands used by the video-graphics subsystem of the Micro 16s.*

The command code indicates what type of command it is; the color code selects one of the eight specified colors; and the function code selects how the output video will combine with other colors in the same area of the screen (foreground, background, OR, AND, XOR). The box flag selects a choice of a line, a box, or a box filled with the indicated color. For example, in photo 4 the line command was used and the triangle was rotated. Large colored-block areas could have been added with only slight changes in the line command. This is but one example of the power of the video-terminal processor.

A Detailed Look

Figure 2 is a block diagram showing the components of the Micro 16s in detail. The two slots for the processor boards do not have equal priority. Slot 1 is for the *master* processor. The 8086 and the 68000 processor boards can be inserted into these slots. These boards are equipped with controllers for DMA and a bootstrap-loader program in ROM (read-only memory). When the system is turned on, the master processor initially has control.

The master processor that comes with the machine uses an Intel/Fujitsu 16-bit 8086 microprocessor running at a clock rate of 8 MHz. As mentioned above, this board contains the master clock, driver circuits, a 4-channel DMA controller, and a bootstrap loader. At power-up, the loader program also performs power-up diagnostics. If a problem is detected, an error message is displayed to indicate where the problem is, and the ROM monitor program takes over to let the operator investigate the error in more detail, using DMA, input/output, and disk commands.

In slot 2 of the standard unit is an 8-bit Z80A microprocessor board. It operates at 4 MHz and has memory-bank-selection circuitry that enables it to address the full 24-bit (16-megabyte) address space of the Micro 16s. It also contains an offset register that allows its addresses to be offset by 64K bytes to avoid conflicts with the 8086 processor. Under the CP/M 2.2 operating system, all disk accesses are performed by the 8086 processor.

It should be noted that the Micro 16s does not come with a complete CP/M 2.2 system. Instead, the computer's CP/M-86 system can use the Z80A to simulate a CP/M 2.2 environment. Thus, all 8-bit CP/M programs can be run, but system components such as the 8-bit CP/M

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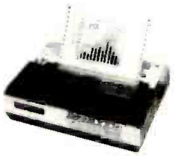

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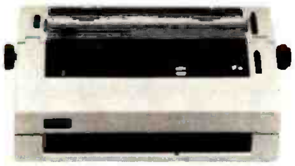

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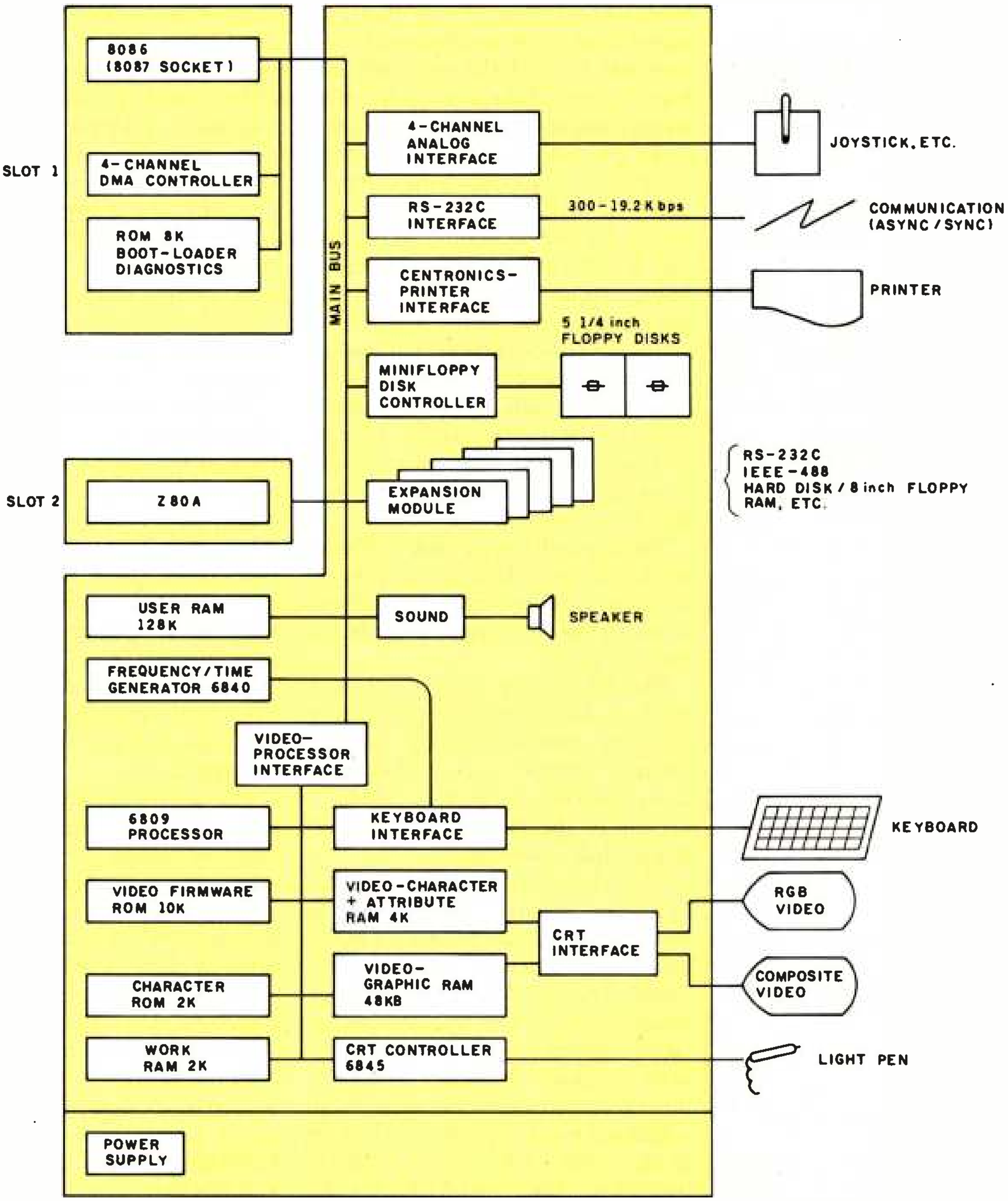


Figure 2: *A block diagram of the Micro 16s system. The 8086 processor is plugged into slot 1 and the Z80A into slot 2.*

assembler have been left out.

In order to accommodate the various processor boards, the main circuit board has a data bus unique to Fujitsu. The bus contains 130 pins on a positive-contact connector, ensuring high reliability. All the various control lines run to each of the expansion slots, including lines for interrupts, DMA-bus-requests, signals to refresh the dynamic RAM (random-access read/write memory) chips, system clocks, 16 bits of data, and 24 bits of address information. All the expansion slots have both maskable and nonmaskable interrupts available for use by expansion cards.

Slot 1, which is occupied by the master processor, has two extra control lines that go to control logic circuits on the main board rather than running the extent of the bus. These are the HREQA (halt-request A) and HACKA (halt-acknowledge A) signals.

Figure 3 is a simplified diagram showing how control is transferred from one processor to the other. "Flip-flop R" is set during power-on/reset, thereby clearing a halt-request line to CPU-A and enabling a halt-request to CPU-B. CPU-A then takes control of the bus and the boot-loader ROM program on that processor card starts its diagnostics and proceeds to load the operating system. Control of the bus can be transferred from one processor to the other under program control by setting or resetting a flip-flop. When this is done, a halt-request command is issued to the operating processor, which then completes its instruction, halts, issues a halt-acknowledge signal, and drops off the bus. The inactive processor then synchronously uses this acknowledge to end its previous halt state and regain control of the bus. It will later relinquish control over the bus if the procedure is repeated. This allows an orderly transfer of control.

The 5¼-inch floppy-disk controller can handle up to four drives. Because it plugs directly into the motherboard, it does not use any of the expansion slots.

The Micro 16s comes with two 5¼-inch double-sided double-density disks that provide 320K bytes of formatted storage each. The disk-controller chip is a Fujitsu (MB8877) version of the Western Digital 1793 floppy-disk controller.

The Micro 16s comes with 128K bytes of volatile parity-checking memory on Fujitsu MB8265 64K-bit dynamic-RAM chips on the motherboard. These RAMs can be refreshed using either pin 1 or the RAS refresh signal, which is controlled by the main processor on the bus. This combination assures easy interfacing with additional main processor cards (such as the 68000) that will be supported by Fujitsu. Additional RAM, up to 1 megabyte per slot, can be added using the expansion bus slots.

The printer interface is a standard Centronics 36-pin parallel interface. The RS-232C interface has a software-programmable data-rate generator and uses the Intel 8251A USART (universal synchronous/asynchronous receiver/transmitter) enabling both asynchronous and synchronous serial communications. Data rates from 300 to 19,200 bps (bits per second), asynchronous, and 0 to 64,000 bps, synchronous, are available.

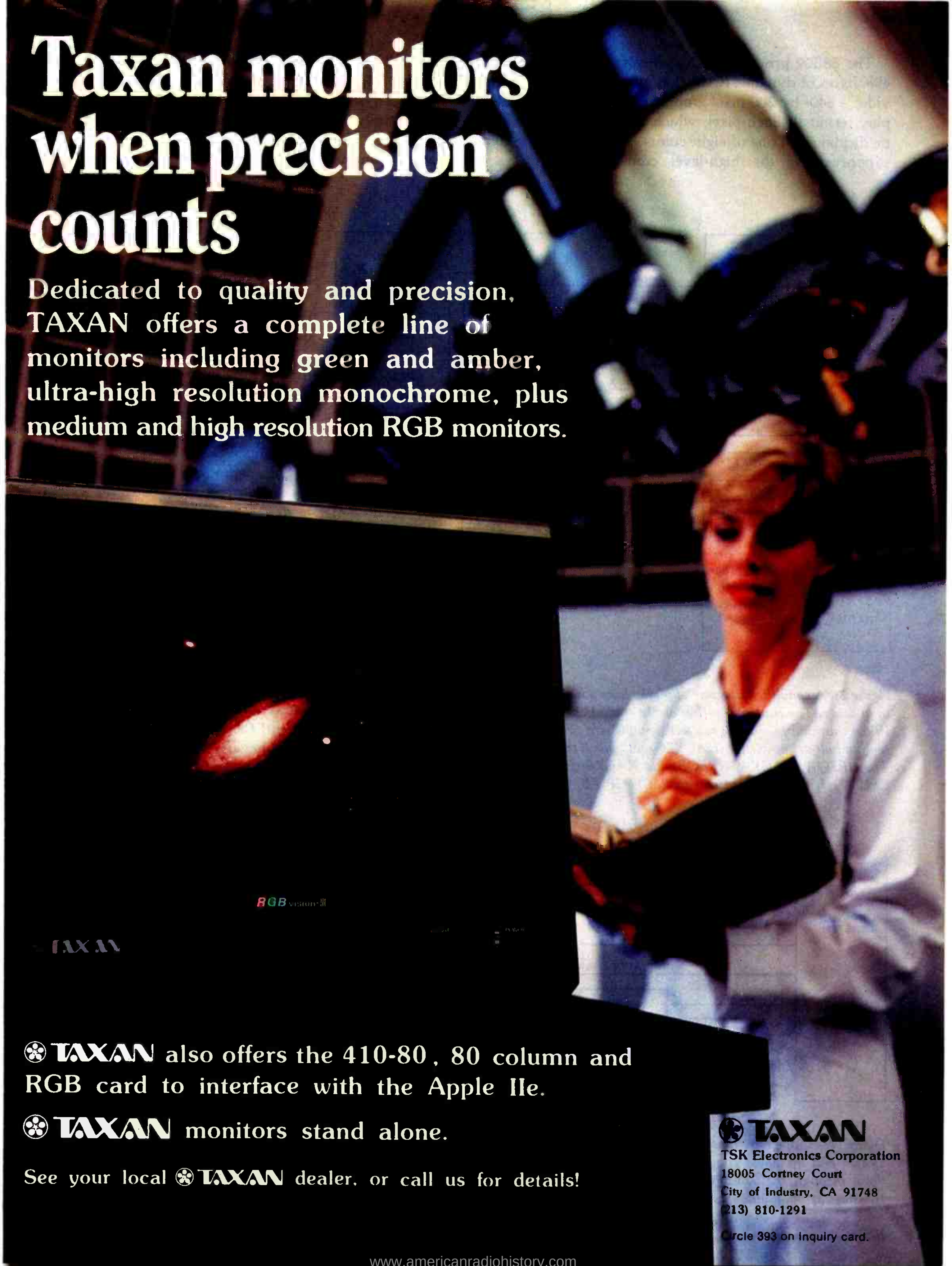
The speaker interface uses the 6840 timer chip connected to an audio amplifier to allow a full range of tones to be generated. The analog interface uses a Fujitsu MB4052, 8-bit, 4-channel, multiplexed, A/D converter. It delivers analog-to-digital conversion to a main applications processor in 5 milliseconds (ms).

The keyboard interface converts serial information from the keyboard into parallel data. Under software control, interrupts are directed to either the main processor or the video processor to handle keyboard inputs.

The keyboard uses a Fujitsu single-chip (MB88401), 4-bit microprocessor to scan the matrix and serialize the key-closure data. The keyboard data is then sent serially to the keyboard interface on the motherboard. Also, a built-in self-check function, a character-code table, and a key-matrix table are programmed into the 4-bit microprocessor. The low-profile detachable keyboard has a total of 98 keys with cylindrically sculptured key tops laid out in typewriter arrangement.

The power supply is designed to meet the power requirements for the standard system and allow for future expansion. It is even capable of supporting a Fujitsu 5¼-inch 5-, 10-, or 20-megabyte Winchester hard-disk drive in place of one of the 5¼-inch floppy-disk drives, along with a full megabyte of volatile memory.

The lower portion of figure 2 outlines the video-terminal section. This section is a completely independent video terminal. It has a 68B09E (2-MHz) processor as its controller and 10K bytes of video firmware contained in ROM. This firmware program operates on the high-level commands and the data sent from the main processor to control the character and graphics modes of the Micro 16s. The character data is stored in 2K bytes of Fujitsu MB8128 static RAM, along with 2K bytes of character-attribute RAM. A 6845 video-controller chip is used in conjunction with the character-attribute RAM, along with 2K bytes of character-generating ROM. This combination of components provides a color terminal running at internal bus speeds.



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The 68B09 processor also controls 48K bytes of dynamic RAM that provide a 640- by 200-pixel graphic display terminal. Each pixel, which can be displayed in one of eight colors, is supported by the high-level commands discussed earlier, and soon it will be supported by Digital Research's GSX-86 graphics-system extension for the CP/M family of operating systems.

The video section has two output interfaces available for the user: a high-quality RGB color output that supports two levels of intensity in character mode, and a composite video output with eight levels of gray scale for black-and-white monitors or eight colors on lower-quality color monitors.

Though a color monitor is standard with the Micro 16s, switches located on the motherboard control the polarity of the horizontal and vertical synchronization pulses to allow easy interfacing with the various RGB color monitors on the market.

A light-pen input interfaces through the 6845 video controller to the 68B09 processor. It is supported by high-level commands for easy program interfacing to the applications programs.

The method of passing data from the main processor bus to the video-terminal processor bus is accomplished via the 128-byte RAM common to both processors, a set of attention registers, and some control lines (see figure 4). The four attention registers were designed using a Fujitsu gate array. Three of these registers allow data to pass from the main processor to the video processor so that it can be asynchronously read or written. The video processor can also interrupt the main processor. Such interrupts can be generated, for example, by the interval clock timer or one of the function keys.

The main processor issues commands to the video-terminal processor through the 128-byte common RAM. After receiving this command, the video processor sends a busy signal to the main processor. The main processor then does not read or write to the remaining common RAM area until the busy signal is removed.

This prevents both processors from accessing the 128 bytes of RAM at the same time. The main processor can stop the video processor with an interrupt at any time should it become necessary to stop an operation in process. This gives it master control over the common RAM section.

Accessing common memory is inefficient when the data quantity is small: the video processor must send an attention interrupt that a com-

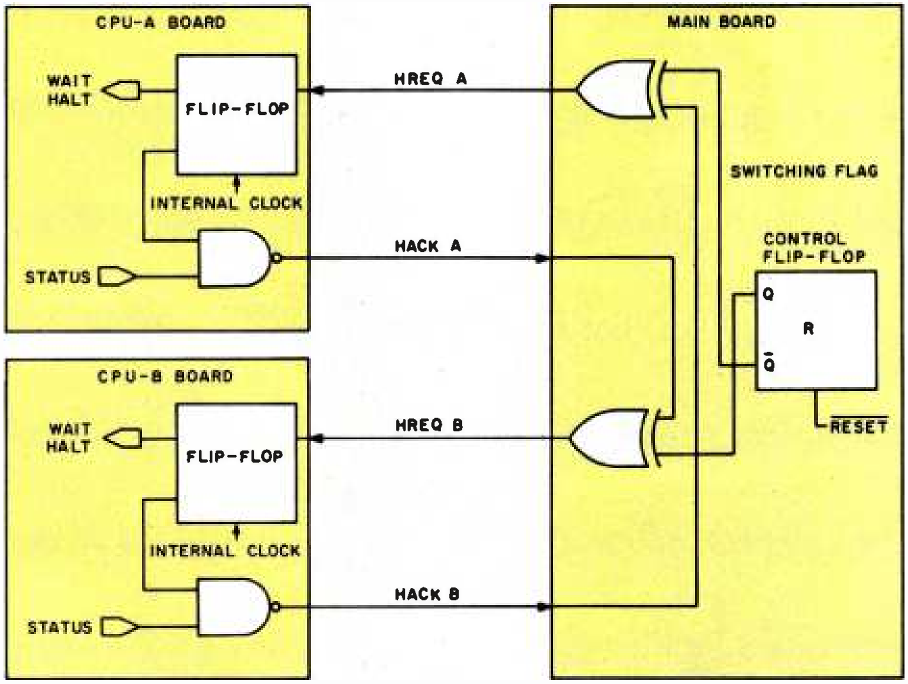

Figure 3: *A simplified diagram showing how control is transferred from one processor to another. The control flip-flop on the main board can be set under program control. When this happens, a halt-request signal is sent to the operating processor, which then sends a halt-acknowledge (HACK) signal, which then gives the other processor control. The HREQA, HACKA, HREQB, and HACKB signals are on the Fujitsu 130-pin bus. CPU-A refers to the processor in slot 1; CPU-B, the processor in slot 2.*

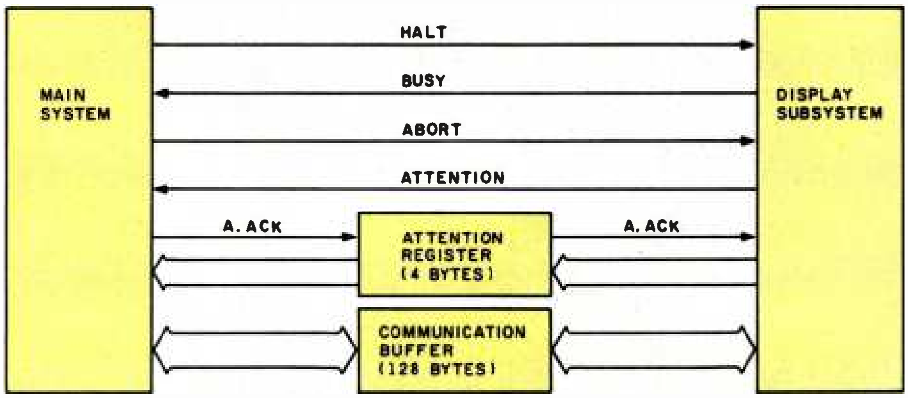

Figure 4: *A diagram illustrating how information is exchanged between the main system and the video-graphics subsystem. A large part of the information transfer is done through the 128-byte RAM known as the communication buffer. For faster transfers of small amounts of information, the 4-byte attention registers can be used.*

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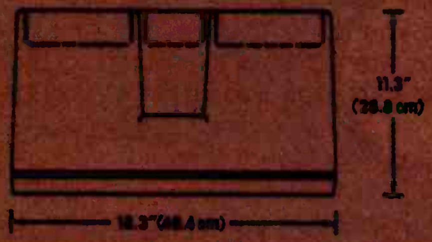

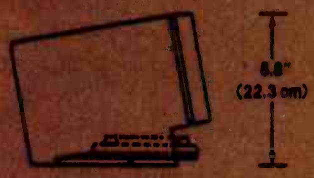

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mand that was sent to the video processor has been completed. Then the main processor must read the resulting data and status. To increase efficiency, another method can be used to transfer data. Separate attention registers are provided through which processing data and status information can be passed.

Data Storage

The Micro 16s lets you select from a powerful assortment of disk-storage subsystems. Currently, the Micro 16s comes with two 5¼-inch double-sided double-density floppy-disk drives. The floppy-disk controller provides addressing for four such drives.

Additional controllers are available for 8-inch floppy-disk drives and Winchester hard-disk drives.

Fujitsu provides an optional freestanding dual-drive double-sided double-density 8-inch floppy-disk subsystem. This subsystem allows up to 1.2 megabytes of data per drive.

Fujitsu also offers 5¼-inch Winchester drives in 5-, 10-, and 20-megabyte capacities.

Summary

The Micro 16s was designed to be a versatile package of hardware and software in a professional business system. Its unique bus architecture and integrated high-resolution graphics subsystem, coupled with the wide variety of applications processors, operating systems, memory expansion, and hard-disk options, offer the business user the growth and flexibility necessary to cope with ever-changing application requirements. ■

The Fujitsu Micro 16s personal business computer is marketed in the U.S. by Fujitsu Microelectronics, Professional Microsystems Division, Santa Clara, CA.

About the Author

Wayne Clingingsmith has 12 years of experience in LSI, component, applications, and systems design. Currently the hardware systems manager for Fujitsu's Professional Microsystems Division, he has a bachelor's degree from San Jose State University in electrical engineering.

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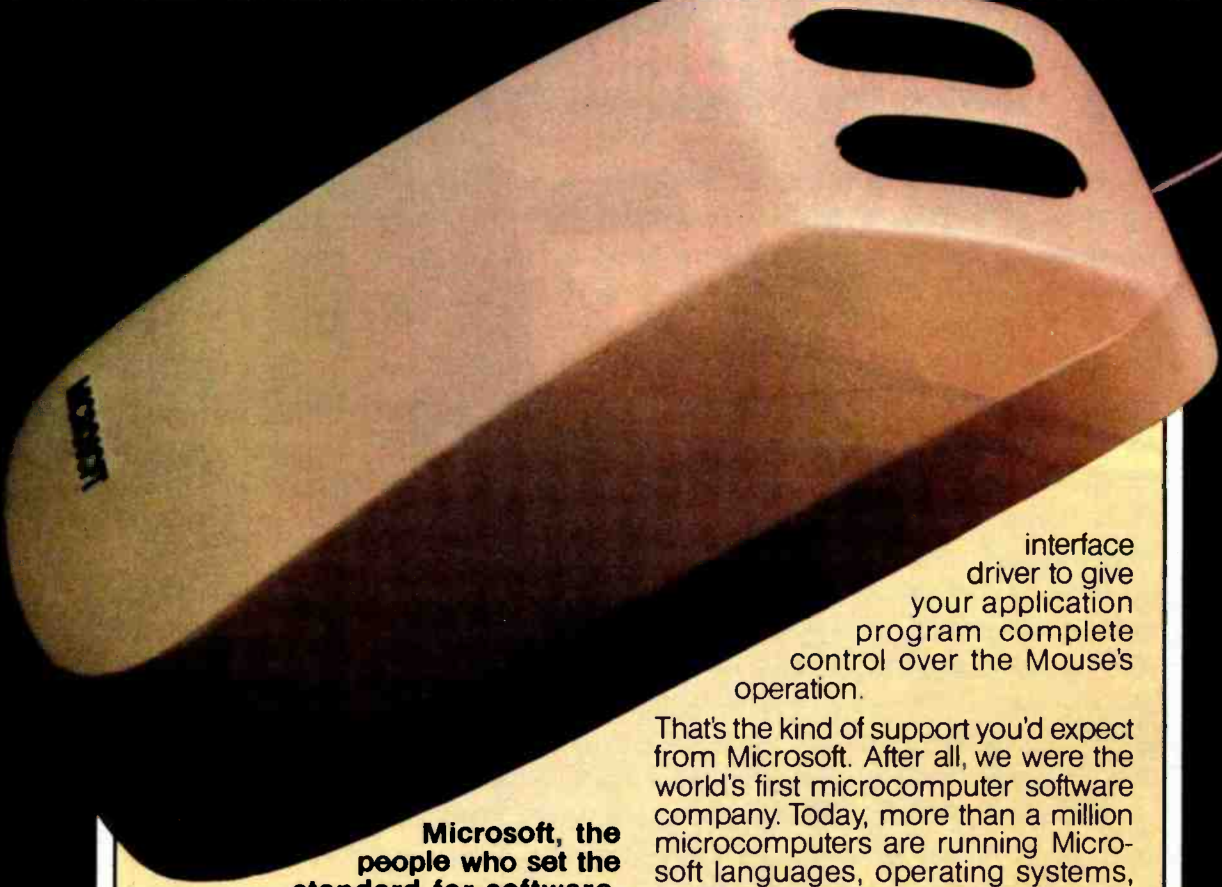
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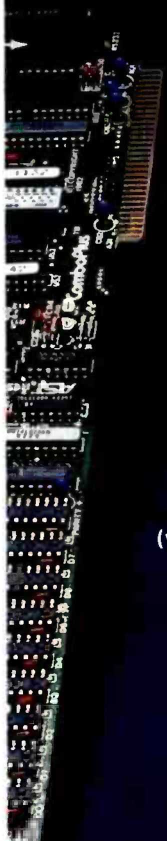

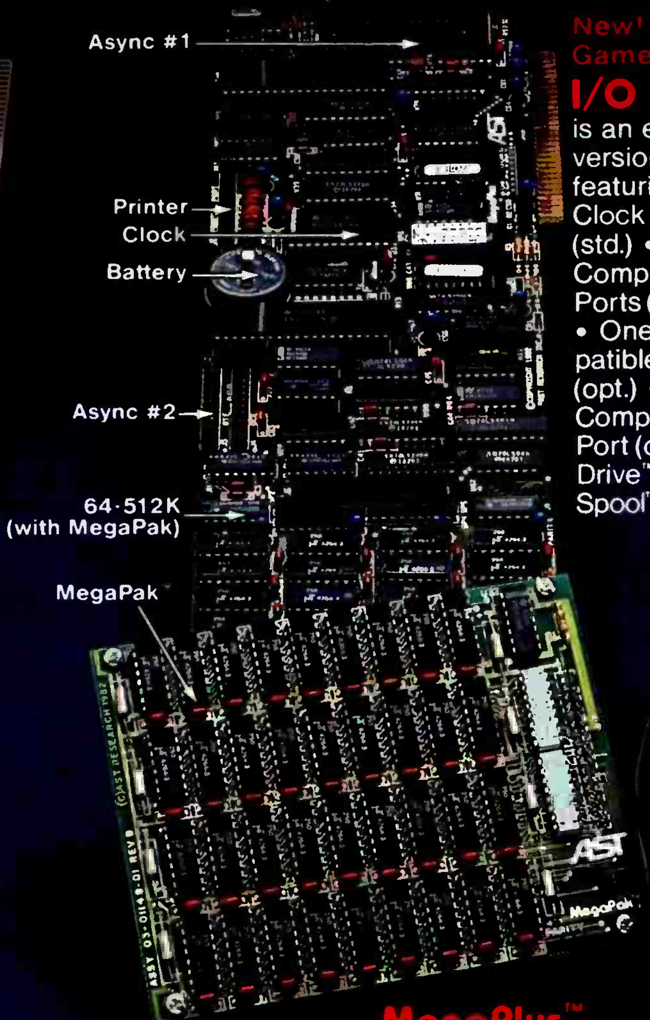

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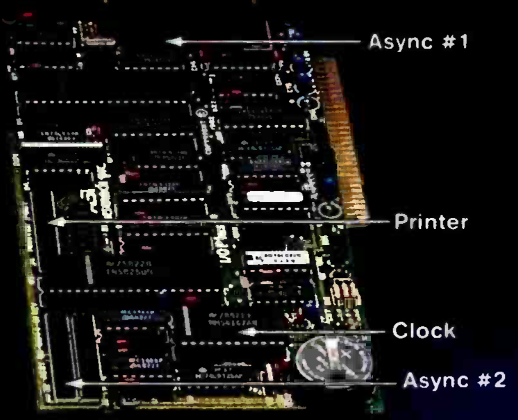

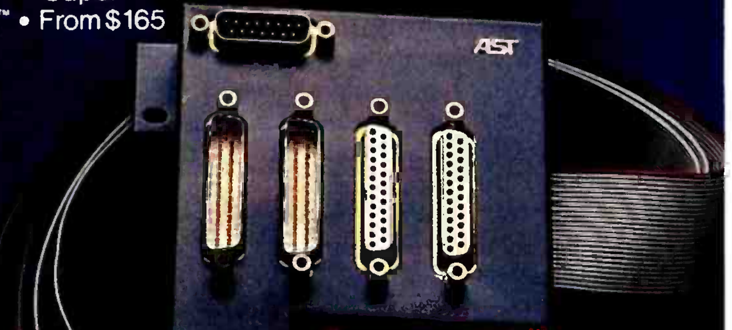

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The Pronto Series 16

The design of a new business-oriented microcomputer based on the Intel 80186 microprocessor.

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The challenge of developing a new business microcomputer is to produce a machine that is better than its competition. In designing the new Pronto Series 16 microcomputer we aimed to meet that challenge by concentrating on three vital areas: speed, storage capability, and ergonomics.

The new 80186 microprocessor chip makes the Pronto Series 16 run very fast. The Pronto comes with two 5¼-inch floppy-disk drives, each capable of storing 800K bytes of data. For even more storage, a Syquest 5-megabyte removable disk cartridge is available as an option. As for ergonomics, the Series 16's relatively small size, the arrangement of its components, and the design of its keyboard and display allow the machine to fit unobtrusively into your work space.

In establishing our design goals, we decided that our machine would be aimed at a specific audience: the individual user in a modern business office, an environment where the benefits of desktop computing would be most readily apparent. And our machine would come as a complete package. Some options, such as expanded memory and graphics, would be available, of course, for particularly demanding applications.

The result of our designs is a small 16-bit desktop computer based on the **Intel 80186 microprocessor** and Microsoft's MS-DOS 2.0 operating system. Its standard features include 128K bytes of volatile memory or RAM (random-access read/write memory), a high-capacity floppy-disk drive, a high-resolution monochrome monitor, communications interfaces (serial and parallel), and a bundle of software, including a word processor, a spreadsheet calculator, a database manager, and a graphics program. The complete package will sell for approximately $3000.

I will now describe the various components of the Pronto Series 16 system and explain the reasons for their selection. In every case, component selection has been made on the basis of how well that component can perform its particular job.

The Processor

To decide on our hardware we first considered software. Our goal was to have a machine that could go right to work in the average office; therefore, the essential software for this

Photo 1: *The keyboard of the Pronto Series 16.*

machine should be immediately available.

It would then seem logical to choose an 8-bit processor because a large library of software has already been established in past years for 8-bit computers. But on the other hand, the library of 16-bit material is growing every day, and it is unquestionably the trend of the future. And given the fact that a 16-bit machine has a greater capacity in terms of computational power and memory, we decided to use a 16-bit processor, confident that most of the essential software required for most business operations would be available, and that much of the new software to be produced for tomorrow's market will be for 16-bit systems.

Having committed ourselves to a 16-bit processor, we had to settle on a particular 16-bit family. Because we wanted a substantial software base for our system at the time of its introduction, our choice was limited to families already accepted in the marketplace. Many processors with good technical merits have not found great public acceptance, which results in a poor software base. Such processors were ruled out, and only three processor families remained: the Intel 8086, the Motorola 68000, and the Digital Equipment Corporation LSI-11.

The LSI-11 is the oldest of the three, having descended from the very successful DEC PDP-11 family. Consequently, it has a great software base. However, this software, with a few notable exceptions, is not aimed at the small-business user with a desktop machine. Another drawback of the LSI-11 is its relatively high cost in comparison with the 8086 and 68000 families.

The Intel family is descended from the very successful 8080/Z80 family of 8-bit processors, and much of the initial software support for the new 8086 family was derived by using an Intel assembly-language conversion program that allowed existing 8080 programs to be converted for the 8086. The Intel 8086 family was the first single-chip 16-bit microprocessor to achieve general acceptance in the marketplace.

The Motorola 68000 processor is generally viewed as having a more elegant architecture than the Intel family, but the 68000's later release has resulted in a great lag in software availability, particularly for the small business market.

We finally chose the Intel 8086 family of processors primarily because of the existing and potential software support. But within the Intel family there are four processors from which to choose, each with its own advantages and disadvantages:

- the 8086, Intel's original 16-bit chip, which has full 16-bit external and internal data buses
- the 8088, a downgrade of the 8086 with a 8-bit external bus (i.e., data is sent in and out of the processor 8 bits at a time rather than 16 bits at a time). This chip is less expensive and uses the same software
- the 80186, an enhancement of the original 8086, which features increased performance at a given clock rate and an extended instruction set; it has a higher level of integration, allowing many peripheral devices to be included on the processor
- the 80188, an enhancement of the 8088 that retains the 8-bit external data bus

Because one of our primary design goals was high performance, we opted for the full 16-bit external bus, eliminating the 8088 and 80188 as possibilities. We then selected the 80186 as our processor, even though it is more expensive than the 8086. The 80186, however, includes many necessary peripheral functions right on the chip. Because functions such as direct memory access (DMA), interrupts, timers, wait-state logic, and chip-select functions would have to be provided in our design anyway,

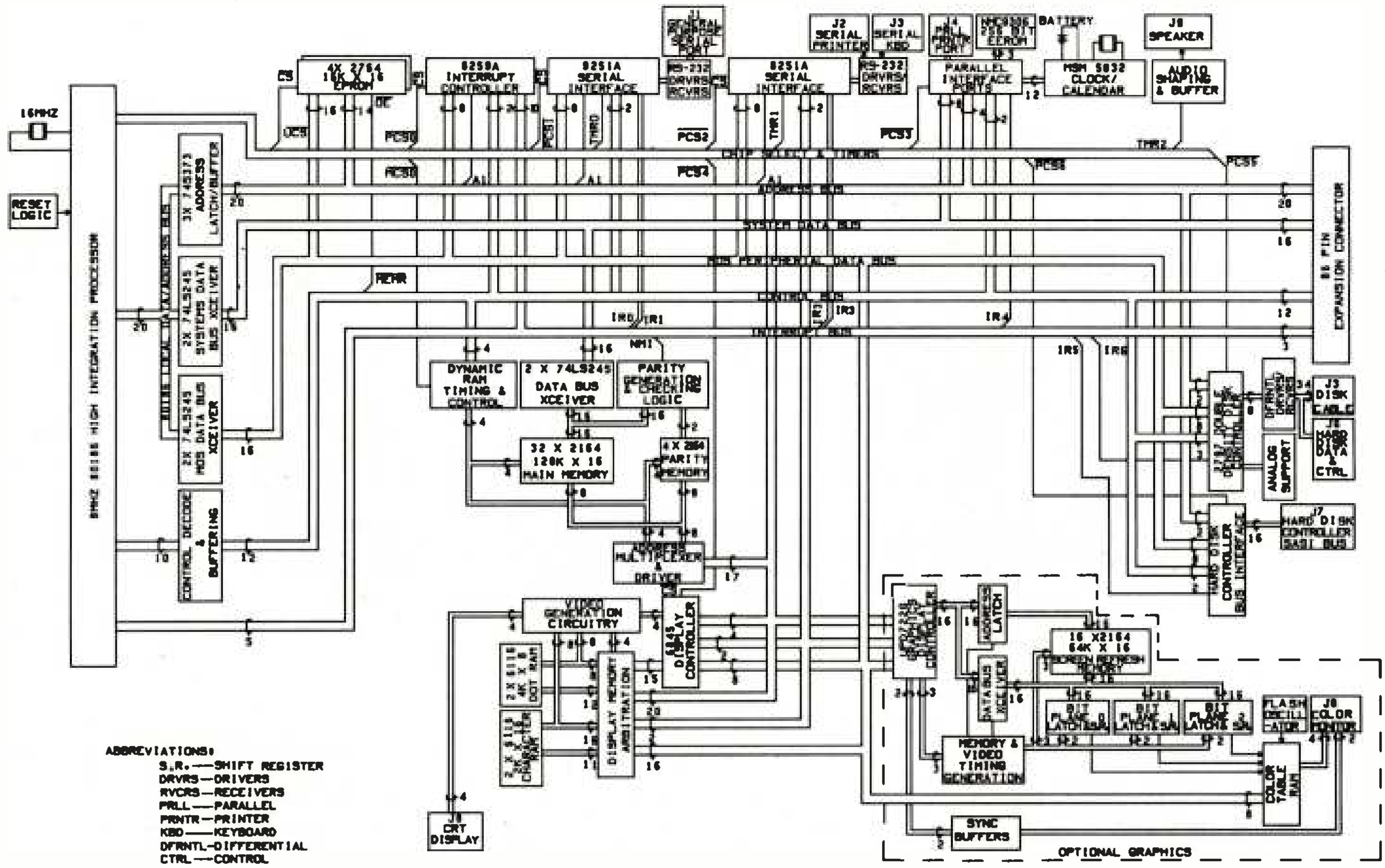

Figure 1: *A block diagram of the Pronto Series 16.*

the 80186 is actually a more cost-effective approach.

One advantage of the 80186 processor is that we can implement MS-DOS version 2.0 on it and thereby gain access to the wealth of software available for that operating system.

System Memory

Having selected a 16-bit processor for its greater processing power, we realized that the more sophisticated programs possible with such a processor would require more memory resources than is the norm with 8-bit machines. We felt that 128K bytes of RAM would be adequate for typical business applications. However, a number of applications may require increased memory size, up to 256K bytes, and for demanding applications, such as multitasking, it is important that the full memory potential of the 80186 (one megabyte) be available.

We elected to design our main memory using 64K-bit dynamic RAM chips because we felt that this was the most cost-effective way of implementing our chosen memory size. Our standard machine would come with 128K bytes of memory, and an additional 128K bytes could be obtained by adding memory chips. For further expansion, a 768K-byte memory board could be added to populate the 80186's full memory space.

Memory Speed

Another advantage of the Intel 80186 is that its memory-speed requirements are much less stringent than competing processors. In other words, you may use more economical memory components with the 80186 while still achieving full speed. The 80186 can run at full speed at 8 MHz even when provided with memory that has an access time as high as 311 nanoseconds (ns). By comparison, the Zilog Z80, running at a clock speed of 4 MHz, requires memory with an access time no greater than 265 ns.

The most economical 64K-bit RAM chips in most manufacturers' product lines have an access time of 200 ns, which is more than ample to allow the 80186 to run at a clock rate of 8 MHz.

Memory Reliability

For a computer intended primarily for business use, memory integrity is vital. A recent case of a man owed $20 who received a check for $400,020 illustrates what can result from a single bit error in computer memory. Although the reliability of the 64K-bit RAM chips has been demonstrated to be excellent, there is always the slight chance of a memory error. We deemed it unacceptable to allow errors to go undetected. Computer users must be confident of their system's integrity.

System reliability can be verified in two ways: parity error detection and error checking and correction (ECC). With parity error detection, the extra memory chips needed to store parity bits add to the system's cost. Because the 80186 is byte-addressable, it is

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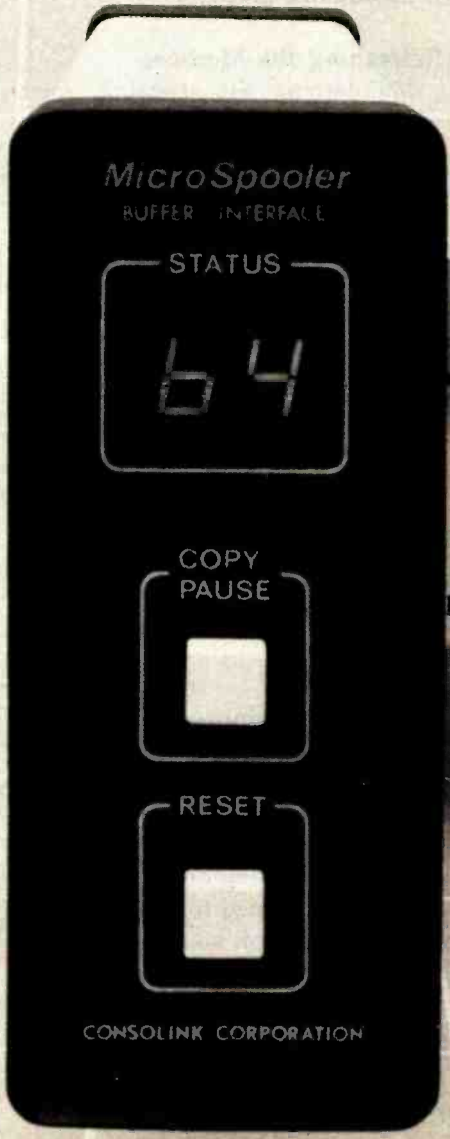

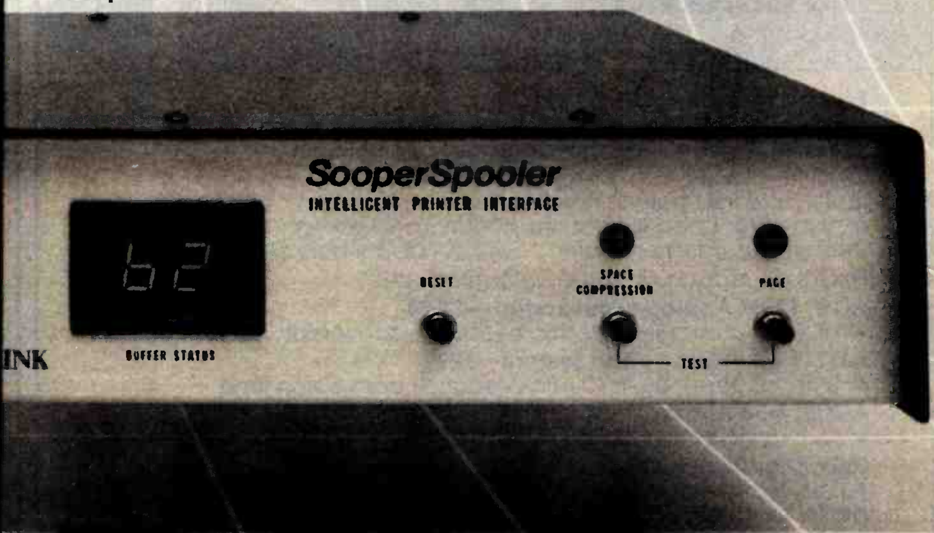

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necessary to add 1 parity bit for each byte, rather than 1 bit for a whole 16-bit word.

Adding ECC capability greatly increases the cost of the memory subsystem. Depending on the number of bits in error that the correction circuitry is designed to rectify, the cost of the circuitry can exceed the cost of the memory itself. Because memory errors should be rare, we decided that a better price/performance ratio would be achieved using simple parity error detection rather than elaborate and expensive ECC circuitry. When the detection circuitry finds a memory fault it issues a nonmaskable interrupt to the 80186 that causes the operating system to report the memory malfunction to the user.

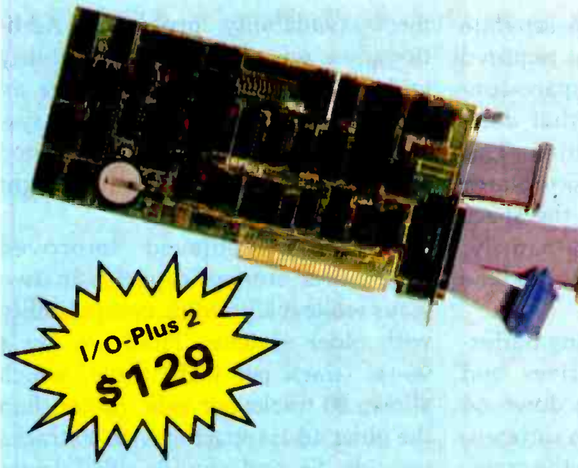
To further ensure reliability and confidence in the system, the software provides a memory test on power-up to determine if the memory is functioning properly.

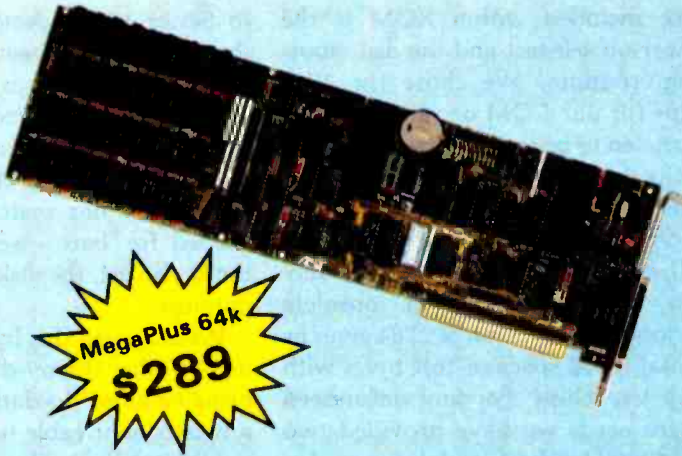
Refreshing the Memory

Maintaining the dynamic memory's high performance requires careful attention to its refresh circuitry. Each dynamic memory cell needs to be refreshed or recharged periodically. We elected to use burst-refresh rather than distributed-refresh circuitry to minimize time lost to processor arbitration. We have achieved a very low memory overhead of 3 percent for the refresh operation, roughly half of the typical figure. Also, by implementing the dynamic RAM controller using standard TTL (transistor-transistor logic) parts instead of an LSI (large-scale integration) memory controller, we were able to minimize the total memory cost.

Read-Only Memory

Our design choices for the ROM (read-only memory), like those for the main system memory, were influenced by the considerations of size, speed, and component selection. Because we wanted to offer complete systems with disk storage, we chose not to constrain ourselves with the requirement of a large ROM size to accommodate a BASIC interpreter. Therefore, the only software that we





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have included within ROM is the power-on self-test and the disk bootstrap routines. We chose the 2764 chips for our ROM because they are projected to be the most cost-effective device for our requirements. Lower-density ROM chips are attractively priced now, but we feel their price will start climbing shortly as production shifts away from obsolete devices. The selection of 2764 gives us a total ROM space of 16K bytes with only two chips. For any unforeseen future needs we have provided two additional sockets and jumpers for 27128 chips, allowing an ultimate ROM expansion to 64K bytes. These selected chips have access times of 450 ns, and so the 80186 must insert wait states. However, because the ROM is only used during the first few seconds each day as the system is first awakened, we felt the slight performance penalty was justified.

Floppy Disks

We believe that the amount of desk space a system occupies is a crucial consideration. In designing the Pronto Series 16 we decided to separate the system components that required frequent access from the space-consuming system electronics that don't require the operator's attention. This allows us to reduce the desktop area covered by our system to the space needed for bare essentials, namely, the keyboard, the disk drives, and the monitor.

We achieved this by adding buffering to the floppy-disk drives and bringing all of the data lines down on a twisted-pair cable (using a differential RS-422 line). This keeps the crosstalk interference down so that the cable can be lengthened without creating problems. The cable has substantial shielding to protect it from interference caused by nearby electronics and to keep it, in turn, from radiating interference to television sets, radios, etc.

For our floppy-disk system we selected the established 5¼-inch format. We avoided some of the latest-technology drives because standards, even with regard to size, have not yet emerged and several suffer from media-availability problems. Additionally, we desired compatibility with the older systems to ensure an ample software base. To keep the system's volume to a minimum we opted for half-height rather than full-height drives.

We have achieved improved floppy-disk storage capacity in two ways while maintaining compatibility with older systems. First, we use a 96-tpi (track per inch) drive, which allows 80 tracks per side, rather than the older 48-tpi spacing with 40 tracks per side. Second, double-sided drives are standard on our system, rather than an extra-cost option. Also, the Series 16 system supports both double-density and single-track density. The fact that the 96-tpi drive is exactly twice the track density of the older drives allows the controller to read older 48-tpi disks by skipping the odd-numbered tracks. Thus, the machine is able to read and write disks in the IBM Personal Computer format.

We selected the recently introduced Western Digital 2797 disk controller,

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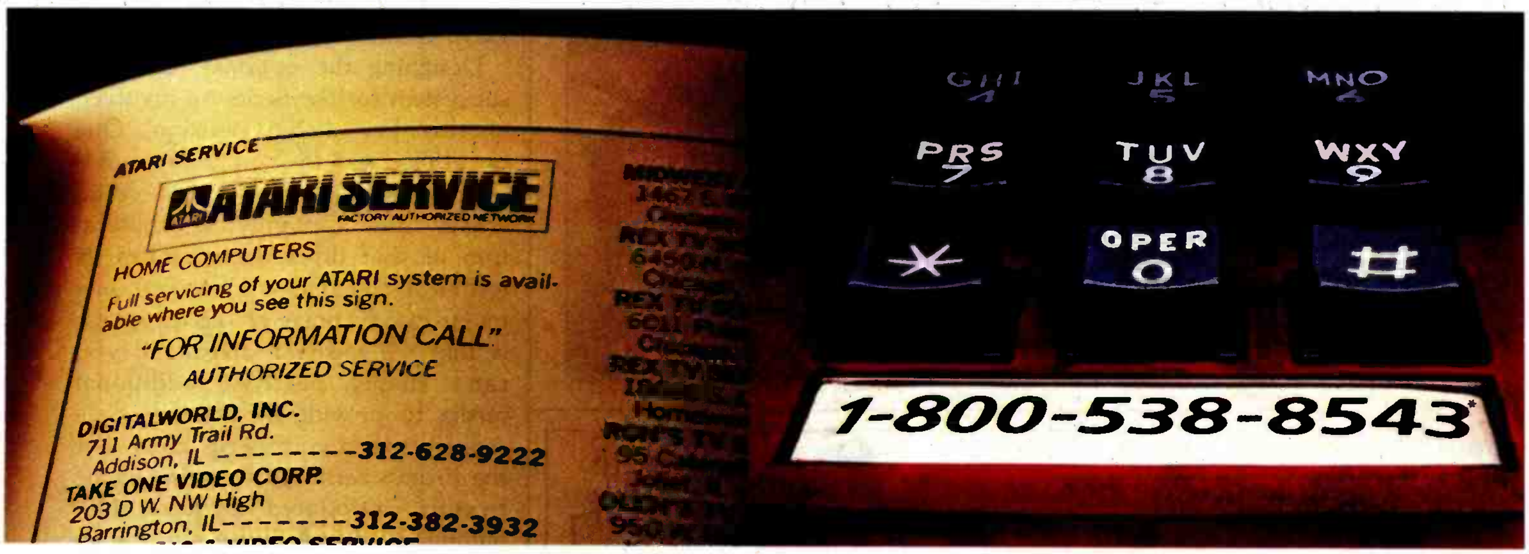

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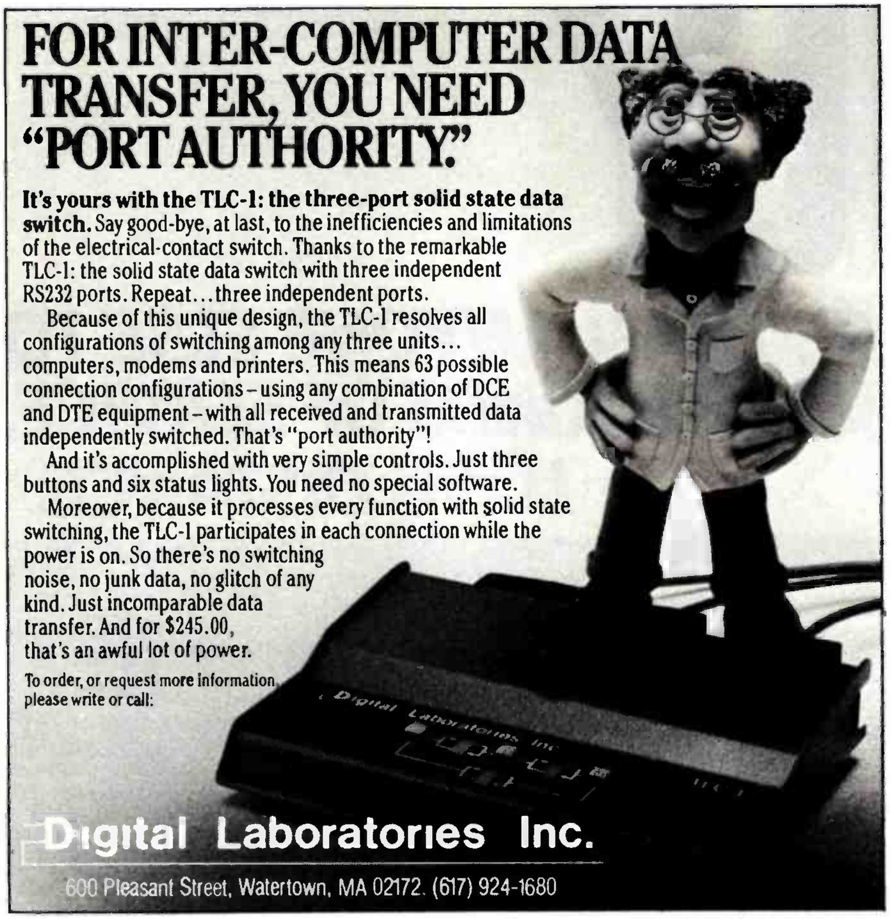


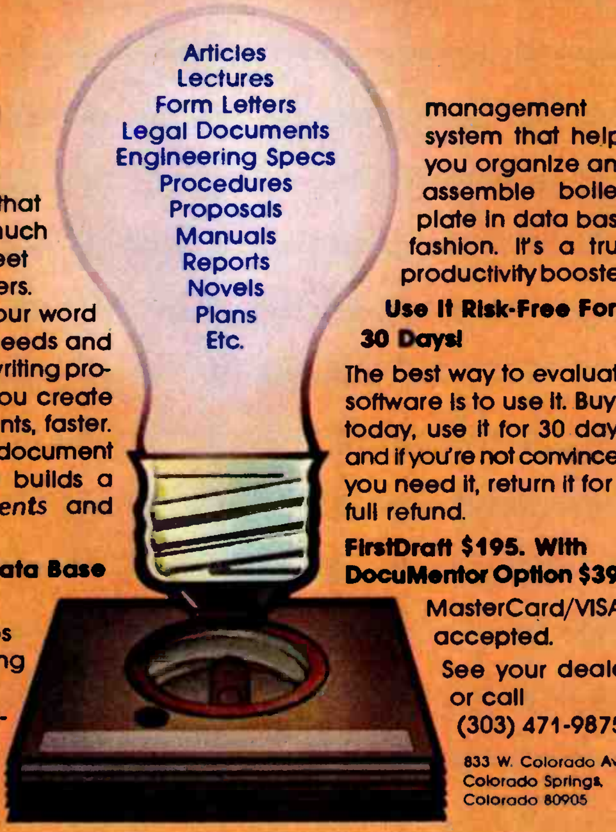
a descendant of the industry-standard Western Digital 1791 that includes an on-chip phase-lock loop data separator. This eliminates the need for external analog circuitry. The floppy-disk controller is interfaced to our system using one of the DMA channels provided by the 80186. Interfacing the disk using DMA instead of the usual processor-controlled I/O (input/output) allows the system to be used in a multitasking environment and makes it possible for more sophisticated software to overlap disk activity with processor activity to achieve a greater overall throughput.

Hard Disks

Designing the optional hard-disk subsystem for the Series 16 involved another key design decision. One possibility was the commonly available 5¼-inch, fixed-media Winchester drive. Certainly the proliferation of that drive demonstrates its technical soundness. However, one major disadvantage of this approach is that the media is fixed and you can't simply purchase additional media to provide increased storage capacity when your needs grow. For the Pronto Series 16 we selected the recently introduced Syquest 100-millimeter, 5-megabyte removable-media Winchester drive. This drive is the same size as the 5¼-inch floppy-disk drive and allows you to mount either the removable Winchesters or the floppy-disk drives as system needs dictate. The option of having either a single floppy and a single hard disk or a pair of hard disks alleviates the problem of Winchester-disk backup. Using dual hard-disk drives of identical capacity with removable media, you will have little trouble backing up your original data cartridge onto an archive cartridge in a short period of time.

The design of the hard-disk controller is an art in itself. We chose to leave the design of the critical error checking and correction circuitry and the data-separation circuitry to specialists and selected a ready-made controller. This controller makes good use of the available custom LSI technology to produce a cost-effective product. We interfaced the hard-

disk controller to our processor using processor-controlled data transfers. This may seem to contradict our statements about the merits of a DMA interface; however, because the 80186 is a markedly powerful processor, the I/O-to-memory Move instruction executes at the full bus bandwidth, 4 megabytes per second. As a result, DMA would not improve the performance of the system. The key here lies in the difference between the Winchester and the floppy disk. The Winchester controller has a buffer that can accommodate the data for a full sector. When the processor begins the transfer, all of the information is available in the buffer and ready to be transferred at full bus speed. In contrast, the floppy-disk controller transfers 1 byte every 32 microseconds; that's much slower than the processor's speed. For this reason the floppy-disk controller can use the DMA transfer to its best advantage. Because the 80186 provides for two DMA channels, the second channel has been reserved for a future network controller.



Security

We considered using several components in the system design to obtain a high level of security. In the past, software-based security schemes have been used to prevent unauthorized access to systems and their data. In many cases, an unauthorized system user can employ low-level software tools to read or corrupt data protected in this way. But, by incorporating system-access passwords in nonvolatile memory, we have minimized this problem.

The first step was to incorporate electronically erasable read-only memory (EEROM). We selected the NMC-9306 EEROM for our system because its capacity is well matched to our needs. A further advantage is that the 9306 is a bit serial device with a fairly obscure programming method. This is an added obstacle for the potential intruder to overcome.

Another function of the EEROM is to record a network identification number assigned at the factory. This is a unique 24-bit number designed so that, when the computer is hooked up to a future network system, there will be no problem assigning nodes within that system.

Removable Winchesters also add to the system's security. Besides being able to run several multimegabyte applications on the system separately, you can remove sensitive data from the machine and store it in a secure area away from the desktop system. No fixed Winchester scheme can guarantee the same level of protection.

General-Purpose Communication Ports

We began the Series 16's I/O subsystem design with an analysis of typical user needs. Most if not all business applications require a printer, and many applications require serial interfaces for such peripherals as modems and plotters. The vast majority of printers use either a Centronics-compatible parallel port or the industry-standard RS-232C

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serial interface. We decided to provide both types of interface.

The parallel port uses standard TTL components. We did not select the usual MOS (metal-oxide semiconductor) parallel-port peripheral chips for the system because they would have required TTL buffering before driving the possibly long printer cable. Instead, we chose the 74S374 chip, which can perform the I/O port function and buffering in a single package. We provided an interrupt from the parallel handshaking to allow real-time support of the printer in multitasking applications and to provide a printer-spooler capability.

The serial port is based on an Intel 8251A universal synchronous/asynchronous receiver/transmitter chip (USART). We selected this time-proven device instead of a more sophisticated serial communications controller chip because it provides the functions required without supporting unnecessary and costly bit-oriented modes. One reason for the great cost-effectiveness of the 8251A lies in its lack of an on-chip data-rate generator. In the Pronto Series 16 system this is not a problem because the 80186 processor includes three on-chip timers that may be pressed into service to provide data-rate generation with software-programmable data rates for 50 to 9600 bits per second.

Our system keyboard communicates with the processor over a serial line and is interfaced to the system using the receive half of a serial port. Two full serial ports are available for use with other industry-standard serial devices. To support multitasking, serial ports are fully supported by interrupts.

The Clock/Calendar Function

We feel a clock and calendar are absolute necessities in a small business machine. Our requirements for a clock system were as follows: battery life of one year or longer; hardware support of year, day, and month information; and continuously available time. Several otherwise-acceptable clock chips did not support year information, but supported tenths-of-a-second data instead. A few chips require up to 2 milliseconds to update the time after a clock tick, during which time the processor may not access the time information.

The chip we selected, the MSM5832, meets all of our requirements. Software for the system protects the integrity of the information in the clock/calendar and requires a system password in order to change the time and date.

The Display

Because we intended our computer to accommodate already existing software, we were somewhat constrained in the design of the monochrome display. Nevertheless, in significant areas we were able to improve the display while still maintaining software compatibility. First, we replaced the character-generator ROM that normally defines the character set of a system with a RAM-based character generator to provide a programmable character set. This allows programmers to customize the character fonts for individual applications, such as those requiring foreign language characters or mathematical symbols. [The monochrome monitor for the Pronto Series 16 can display 25 lines of 80 characters. Each character is composed of an 8- by 12-pixel map inside a 9- by 14-pixel area. . . . R. M.]

Second, we improved the way the processor accesses the display memory. In many displays, when the processor accesses the display memory, a glitch (a disruption of the screen) occurs. To avoid glitches, many manufacturers require the processor to wait for the horizontal or vertical retrace interval before accessing the screen. This wastes a tremendous amount of time.

In the Pronto Series 16 we increased the speed of the display memory so that we are able to perform two access cycles within a 562-ns character time. During the first cycle of 250 ns the screen memory is read for the display, and during the second cycle of 312 ns the processor has access to the screen without any glitching. As a result, the processor has to wait a maximum of only 562 ns instead of a maximum of 50 *microsec-*

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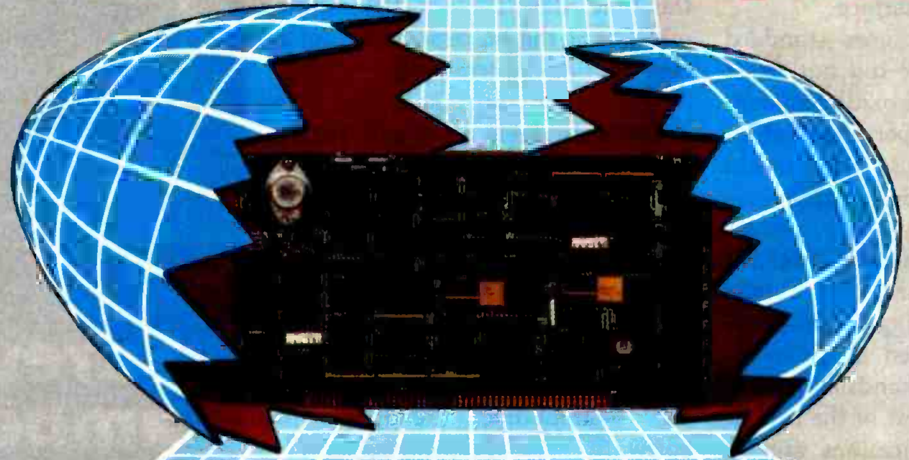

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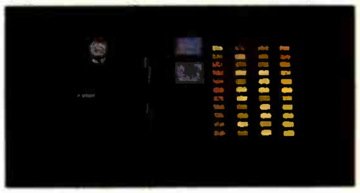

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• *Fully complies with IEEE 696 Standard* • Free copy of CP/M Plus™ included • Up to 4 floppies and three Winchester drives may be controlled by VFW-3 • Data transfers to and from board under DMA or programmed I/O control • Supports 24 bit address space.

CP/M Plus™: high performance single user operating system.

• CP/M® 2.2. compatible—no modification! • When used with SDSystems 256K memory board speeds are up to 7 times faster than CP/M® 2.2. • High performance file system • MP/M® II file password protection • Time and date stamps on files • Support for 1 to 16 banks of RAM • Support for 1 to 16 drives of up to 512 MB each • Easy to use system utilities with HELP facility • Powerful batch facility • Sophisticated programmer utilities.

RAMDisc 256: A solid state disk emulator that greatly increases system performance by eliminating disk waits in disk intensive applications. Excellent for spreadsheets, spelling checkers and software development.

• 256K capacity • 1 mb total bus capacity • CP/M® 2.2, PLUS ™ compatible • I/O port addresses user selectable • Storage locations addressed by on board 20 bit counter • On board refresh.

ROMDisc 128: An EPROM board that replaces a floppy disk drive for the purposes of booting CP/M® and loading application programs.

• Provides non volatile, permanent storage of programs and data • Utilizes 2732 or 2764 EPROMS, (16 max) • 128K capacity per board • 512K system capacity • Use with SDSystems RAMDisc to configure a stand alone or network discless system • CP/M Plus™ available in eproms • Serial port provided.

CP/M® 2.2 and CP/M Plus™ are registered trademarkes of Digital Research, Inc. *Z80 product of Zilog Corp.

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onds for the horizontal refrace interval. This low-overhead design yields a significant speed advantage in applications that require considerable access to the screen for things like character inserts and deletions in word-processing programs.

Our primary requirement for the system monitor was low operator fatigue. It is well known that screen flicker and blurred characters combined with improper phosphor color are leading contributors to operator fatigue. To minimize fatigue we selected a monitor with high bandwidth for sharp character definition, an antiglare coating for reduced reflection, and a long-persistence green phosphor to eliminate flicker and reduce eye strain.

Ergonomics

We have taken three notable steps to ensure that the Pronto Series 16 is a pleasant co-worker. I mentioned earlier that one of our major concerns is the desk space required by the system, and that by removing the system electronics from those components that require frequent operator access, we were able to reduce the desktop area covered by the system to the space occupied by the keyboard, the disk drives, and the monitor. The result of this modular approach is that the "footprint" of the system, the area it occupies on table or desk, is 230 square inches, significantly less than any competitive system on the market.

All of the components that do not require access by the operator are placed in a system box. While we believe that the system box is best located away from the work space, we designed the enclosure to be functional and attractive on a desktop as well. A clip on top of the system box allows the front surface of the unit to serve as a copy stand.

Unlike many others, the Series 16 monitor swivels in a wide horizontal arc and tilts to allow you to adjust the monitor's angle to suit your taste and eye level. For additional convenience, we have oriented the disk drives at an angle so that the face of the drive is perpendicular to your line of sight. This makes it easier to insert or remove disks. An added advantage of this orientation is that it reduces the footprint of the system even further by allowing the keyboard to nestle under the ledge formed by the disk drives.

The Keyboard

In order to minimize the time needed to get familiar with our system, we selected a keyboard layout fairly close to that of the IBM Selectric typewriter, with which most office workers are familiar. There are, of course, additional keys around the periphery of the keyboard for the enhanced capability of the computer, such as editing keys, cursor controls, and function keys (see **photo 1 on page 169**).

Our keyboard has a low profile and an adjustment mechanism to allow you to select from three different heights. Because it uses capacitive switches, the keyboard requires very little effort to operate and is very quiet. However, if you prefer audio response to your keystrokes, you can choose to have adjustable acoustic feedback provided from the system's speaker. We selected a standard coiled telephone cord and modular jack for the connection between the keyboard and the system. The modular jack presents a low visual profile for the inserted connector, which is at the front right-hand side of the desktop unit. Many machines have the keyboard connector on the *back* of the machine, but when the keyboard connector is on the front, near the normal location of the keyboard, the keyboard can be easily extended up to 6 feet from the system unit.

The Caps Lock key and the Numeric key (which turns the cursor control keys into a numeric keypad) have an electronic latching mechanism and include an LED (light-emitting diode) to indicate if they are activated or deactivated.

The Expansion Bus

In any computer system design, the selection of the bus structure is a critical issue. Initally, we considered using a structure that would be compatible with existing expansion cards designed for older 8088-based designs by providing an overflow connector to pick up the additional 8 bits of the 80186's 16-bit external bus. However, the high performance of the 80186 would be lost on several of the popular cards.

To avoid potential incompatibility, we elected to take a different route. We investigated several of the popular 16-bit industrial bus formats, but we were not satisfied with the size of the cards; we would have to split the system card (the only card in the minimum system) into two cards, a costly limitation. Even with the high level of integrated circuitry used on the system card we still have 160 chips in the design (see figure 1 on page 170). We selected a size of 14½ by 11 inches for our card, and we squeezed the entire system onto a double-sided card (see photo 2). This fairly large card size, combined with the 5-slot motherboard in which it resides, allows us to expand the system to include high-resolution color graphics, a full megabyte of memory, and a network interface card with one slot to spare, in a total size of 15.4 inches high by 6.3 inches wide by 11 inches deep.

As should be the case with any high-performance system, the motherboard is shielded and terminated. The short width of the motherboard (4½ inches) further reduces the possibility of noise. The total bus bandwidth is 4 megabytes per second.

The Color Graphics Option

We felt the color graphics option of the Pronto Series 16 should measure up to the high performance that the rest of the system provides. The resolution we selected is unusually high for a general-purpose system: 640 by 480 pixels with 8 simultaneous colors (see photo 3). We selected the vertical resolution (480) based on the highest possible resolution with the standard 15.75-kHz scan monitor. The horizontal resolution was selected to generate a square pixel based on the 4:3 aspect ratio of the color tube. The resulting video frequency is 13.33 MHz.

We based the graphics design on the newly introduced NEC 7220 graphics-display controller (GDC) because not only does the 7220 support the required resolution, but it contains hardware support for drawing basic graphic primitives, including lines, arcs, rectangles, and characters, and further supports very high performance area fills. The system provides the user with a vector-drawing rate of up to 400,000 pixels per second and an area-fill rate of up to 6,400,000 pixels per second. Another powerful feature of the graphics board is that it provides hardware-based panning along both axes and has the ability to zoom from 1 to 16 times normal size.

We added a RAM-based color table (which allows you to use 8 out of a possible 16 colors) and included an address line from a flash oscillator to allow individual pixels to be programmed to flash automatically or to alternate between two colors. The color table also provides animation capability by allowing alternating bit planes to be modified and displayed, making complex image transformations appear to be instantaneous.

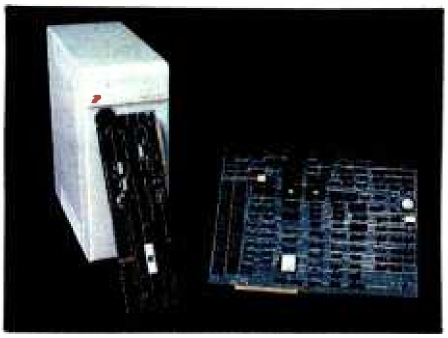

Photo 2: *The graphics adapter of the Pronto Series 16 leaning against the system housing, and large main system card.*

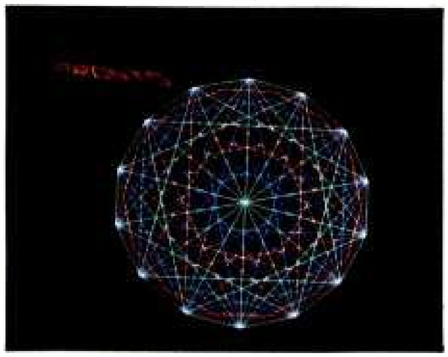

Photo 3: *An example of the graphics possible with the color-graphics option of the Pronto Series 16.*

To fulfill this high-resolution display's screen memory requirement of 113K bytes, we selected the same 64K-bit dynamic memory chips chosen for the system's main memory. Sixteen chips provide a graphics memory size of 128K bytes. This memory is isolated from the main processor bus by the GDC, so it does not affect the main processor. The three bit planes are contained in the same physical memory. The memory is cycled three times during one display cycle to read each bit plane.

When the graphics option is selected, the format in alphanumeric mode is 80 characters by 24 lines with a 7- by 9-dot matrix. The alpha characters may be positioned anywhere on the screen, limited only by pixel boundaries, and may be aligned at a 45-degree angle from either axis.

Summary

As I mentioned earlier, bringing out a new business microcomputer is quite a challenge. It must do more than any of its competitors, and it must do it at a reasonable price. Although the real test of a product is in the marketplace, I believe that the Pronto Series 16 computer, which combines the new Intel 80186 microprocessor with the MS-DOS 2.0 operating system, floppy-disk drives, 128K bytes of RAM, a high-resolution monitor, communications interfaces, and a bundle of applications software, has met this challenge. ■

Sales and Service for the Pronto Series 16

Pronto Computers is setting up a dealer network to market the Series 16. This network will include approximately 200 dealers and should be fully established by the fourth quarter of 1983.

Service for these machines will be provided by the dealers and by a third party that has not yet been named. You can obtain more information from Pronto Computers Inc., 3170 Kashiwa St., Torrance, CA 90505; (800) 634-6400. In California and outside continental U.S. call (213) 539-6400.

About the Author

Skip Hansen is vice-president of engineering for Pronto Computers Inc.

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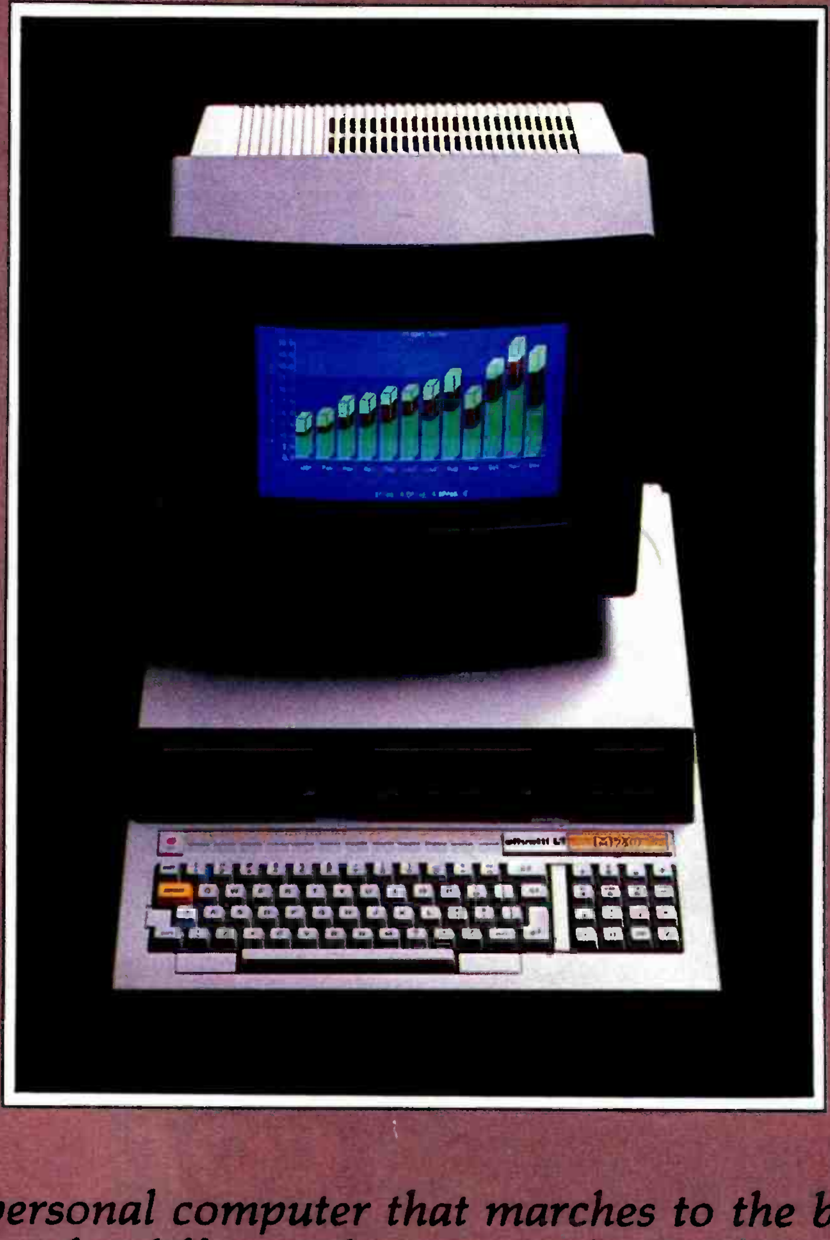


A personal computer that marches to the beat of a different drummer—the Z8000.

The Docutel/Olivetti M20 is the maverick of the second-generation personal computers. It has no function keys, an "unfashionable" microprocessor, and a 16-bit disk operating system that is incompatible with the rest of the micro world. A closer look at this machine, the company's initial foray into the microcomputer market, may shed some light on the reasoning that went into its intriguing design.

Olivetti is an industry giant in the office products arena, a market that has been changing rapidly since digital electronics invaded the business world. Not to be left behind, Olivetti aggressively converted its product line from electromechanical to electronic operation. The company's products ranged from intelligent typewriters and dedicated word processors to minicomputers, peripherals, and networks; a computer/workstation was an obvious addition. So in 1979, Olivetti's California-based Cupertino Advanced Technology Center began the design of the M20. The system was officially announced in the spring of 1982, and more than 50,000 units are estimated to have been shipped in its first year. Manufactured in Italy, the M20 is distributed in the United States by Docutel/Olivetti.

The M20 is based on the Z8001, Zilog's 16-bit microprocessor, and it runs a proprietary operating system called PCOS (Professional Computer Operating System). Although there is a rationale for taking such a nonstandard route, the reality is that software vendors have little use for the exotic. In a marketplace in which the IBM Personal Computer has become a de facto standard, the M20 suffers as a result of its uniqueness. In response to its compatibility problem, Olivetti has developed a coprocessor board based on the Intel 8086 chip, which offers the M20 owner access to software running under MS-DOS and CP/M-86.

System Overview

The M20 hardware is divided into two parts: the central unit and the video unit (see photo 3). The central unit houses the processor board, the keyboard, and the disk drives. This represents another interesting departure from the current industry trend toward detachable, low-profile keyboards.

Even more remarkable in an industry that deems function keys essential is the M20's apparent lack of general-purpose, user-definable function keys. Apparently the designers believe that an overcrowded keyboard will confuse the user and slow down user input. Once again, the manufacturer has hedged its bets: although the M20 has no discrete function keys, it is capable of providing alternate functions for some of its standard keys. Furthermore, two auxiliary keys can be redefined using an operating system utility.

Photo 1: *The M20's color graphics capability.*

Special functions are invoked by two color-coded keys. When either the orange key, Command, or the light-blue key, Control, is pressed along with another key, it creates a new output that can be assigned a logical function. Although the use of compound keys is hardly new, Olivetti has added one interesting twist to identifying key functions. Above the top row of numeric keys is a channel designed to hold a plastic strip that identifies the two additional user-defined functions for those keys. These strips, colored orange and light blue, match the correspondingly colored Command and Control keys, a scheme that effectively offers you 24 user-definable function keys.

The Delete, Tab, and Backspace keys are also conspicuous by their absence. But this deficiency is also surmountable. Two keys, marked S1 and S2, were apparently added in order to maintain keyboard compatibility with Olivetti's previous business systems. The default functions of S1 and S2 are equivalent to Return. If you don't need three Return keys, an operating system utility called Change Key lets you redefine the functions of these auxiliary keys. Typically, you would redefine S1 as Delete (or Backspace) and S2 as Tab. Change Key lets you define any of the 252 unique ASCII (American National Standard Code for Information Interchange) codes that can be generated from the M20's keyboard.

The alpha keys also double up their functions for prospective programmers. On the front of the keys are 26 BASIC statements that can be input by compound keying, as with the numeric keys. On the right of the keyboard is a 16-key numeric keypad that features the numbers 0-9 and 00 as well as the four arithmetic functions (addition, subtraction, multiplication, and division). This keypad also doubles as the cursor controls.

The Processor Board

Inside the central unit, a large motherboard holds the electronic components of the system (see photo 2). There are two reasons for the ample size of this board. First, a true 16-bit microprocessor requires additional data and address lines as well as "wider" memory (16-bit rather than 8-bit), which means more discrete chips. Second, the M20 includes all of the peripheral control functions on the board rather than use the add-on expansion boards. The

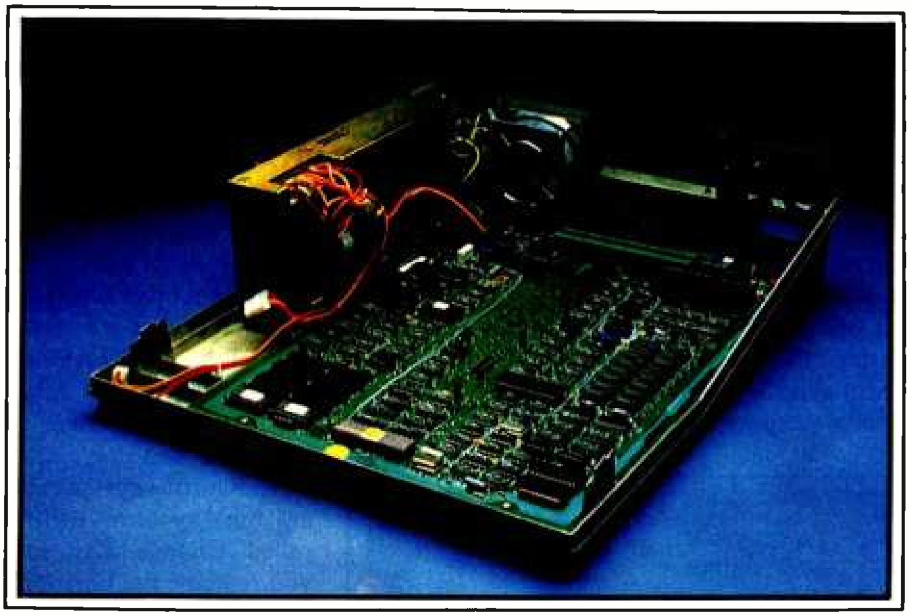


Photo 2: *The large motherboard (approximately 13 by 18 inches).*

standard M20 offers 128K bytes of RAM (random-access read/write memory), a parallel interface, a serial interface, a floppy-disk controller, and high-resolution graphics (black and white or color).

The heart of the motherboard is its microprocessor, a Z8001 that runs at 4 MHz. The Z8000 family offers an extremely advanced instruction set and the unique capability of redefining some of its internal 16-bit registers as 8-, 32-, or even 64-bit registers. This flexibility enables the Z8000 to carry out complex 32-bit arithmetic as well as perform compact byte-size operations.

The Z8001 is capable of addressing as many as 8 megabytes of memory in 64K-byte segments. The designers chose to limit the M20 to 16 of these segments, for a total (theoretical) memory of 1 megabyte. It is worth noting, however, that currently the system can be expanded only from its standard 128K bytes to 512K bytes because the expansion memory boards are limited to 128K bytes each. Presumably, when denser (256K-byte) memory boards become available, the M20 will be able to expand to its full megabyte capability.

Mass Storage

Initially, the standard M20 came with dual 5¼-inch floppy-disk drives with an unformatted storage capacity of 320K bytes (or 286K bytes formatted). Recently, Docutel/Olivetti introduced 160K-byte and 640K-byte drives in order to provide a broader range of system configurations; these can read programs or data from the original 320K-byte disk format, a feature that simplifies software distribution. The 640K-byte drive is particularly appropriate for backing up files from the optional hard-disk unit.

The 5¼-inch Winchester hard-disk drive can replace one floppy-disk drive in the central unit. This three-platter disk offers 9.2 megabytes of formatted storage and requires a separate add-on controller board. This board is inserted into one of the two I/O (input/output) expansion slots on the motherboard.

I/O Expansion

In addition to the hard-disk controller card, other optional cards can be mounted in the I/O expansion slots. Docutel/Olivetti offers both an IEEE-488 parallel interface that can daisy-chain up to 14 peripherals and a twin serial-interface card that can be configured as twin RS-232C ports, as twin 20-milliamp (mA) current-loop ports, or as one RS-232C interface and one 20-mA current-loop interface. Remember that these interfaces are in addition to the standard RS-232C serial port and the Centronics-compatible parallel port provided with the system.

Docutel/Olivetti is reported to be developing a local area network based on the Corvus Omninet CSMA (carrier-sense, multiple access) architecture. By the time that this article is published, a network may be available to connect several M20s together to share such resources as hard disks and high-speed printers.

Both color and black-and-white versions of the video unit are available. The video unit sits atop the central unit on a pedestal that adjusts to the user in three ways. The unit can tilt vertically, rotate horizontally, or move to either side of the central unit. It also has an antiglare screen to reduce eyestrain.

Both monochrome and color units have the same text and graphics characteristics and are completely software compatible. In text as well as graphics modes, the screen displays a high-resolution bit map of 512 pixels (horizontal) by 256 pixels (vertical). Unlike other systems that use a traditional character generator for text, the M20 creates text characters as it would graphics characters—pixel (picture element) by pixel. This approach allows users to modify the existing character fonts and has led to the development of several international character sets, including kanji and Arabic. In normal text mode, two display formats are available: 16 lines of 64 characters or 25 lines of 80 characters.

The system's extraordinary graphic capability emerges when you use the color display (see photo 1). An M20 with two additional memory boards (either the 32K-byte or the 128K-byte) can display eight colors simultaneously. With only one additional memory board, the M20 displays four colors simultaneously from a palette of eight. If you have a monochrome display, the colors are displayed as different shades of gray.

PCOS Operating System

By adopting the Z8001 instead of the more common 8088/8086, designers of the Docutel/Olivetti could not use off-the-shelf operating systems such as MS-DOS or CP/M-86, so they developed PCOS, a proprietary operating system. Essentially, PCOS is a single-user, single-tasking operating system. Like CP/M, PCOS is built on a nucleus and a set of resident commands that is enriched with a set of transient commands. When the computer boots up, the nucleus and the resident-commands module are loaded into RAM; together, they take up more than 20K bytes of memory. Also, 16K bytes of RAM are reserved for the screen memory; thus, of the original 128K bytes of RAM, about 90K bytes remain.

PCOS has some advanced features worthy of mention. First, it can be custom-made, so you can change transient commands into resident commands and easily modify the PCOS to "remember" such changes. To explain these features properly, we must define the terms "permanent memory" and "user memory."

Permanent memory is that portion of RAM in which you can store information that will not be overwritten or erased until the system is reset. User memory is that portion of RAM that's left over for program and data storage; this area can and will be overwritten in the course of using the system. The division between permanent and user memory is only logical; no physical boundary exists between the two.

For frequently used transient commands, you could spend much of your time waiting for disk accesses. Moreover, the system disk containing those commands must always be mounted on the drive. To avoid these problems, the PLOAD command transfers a transient command into permanent memory. Such a command will be executed immediately upon being called. Naturally, the more commands you transfer, the less user memory remains.

When you turn off the system or reset it, the previously transferred commands will be lost. To avoid a series of PLOADs every time the system is booted, the command PSAVE lets you create a personalized version of PCOS. Once you have performed a PLOAD on the commands you want resident (and have reassigned function-key values, etc.), you save a customized version of the operating system by using the utility PSAVE.

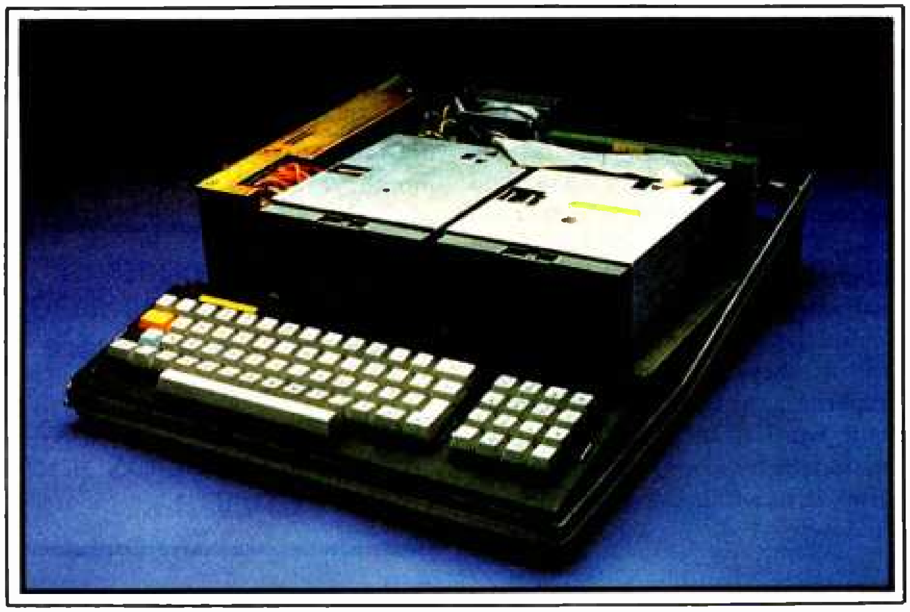


Photo 3: *The M20 with its cover removed. Note the modular construction.*

Memory Usage

In addition to flexibility, PCOS is unique in that its memory-segmentation design features dynamic allocation of memory—a concept that has been passed down from mainframes and minicomputers. PCOS (version 2.0) allows the software developer to use all of the available system memory without any difficulties created by the boundaries between the 64K-byte segments.

What this means to the programmer is that Pascal and Z8000 assembly-language code do not necessarily reside in contiguous memory. That's because the compiler and the assembler generate an intermediate z-code that is processed by the linker, which remaps the code in an effort to optimize memory usage.

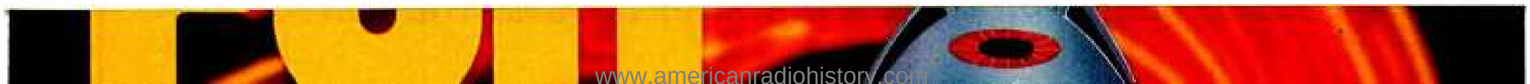
The drawback to this scheme is that you don't know where your code resides within memory. Some programmers, accustomed to direct access to memory to perform software tricks, won't appreciate the PCOS dynamic-allocation feature. As always, when the M20 creates an obstacle, it offers you some software wizardry to bypass it. The PCOS utility DCONFIG gives you a memory map showing where the various pieces of code are located, so you can find all the memory pointers you need.

BASIC

Obviously, the PCOS memory management cannot override the addressing limits of Microsoft BASIC. All computers using this popular BASIC are limited to 64K bytes. Because the M20 has no BASIC ROM (read-only memory), the whole interpreter (37K bytes) is loaded into RAM. Without memory management, you would have had only 20 to 25K bytes of user memory available. Even with memory management, the stock 128K-byte system has only about 40K bytes of usable BASIC memory. The serious BASIC user needs 32K bytes more RAM.

The M20's Extended BASIC features excellent graphics, control of the IEEE-488 interface, program segmentation by using the CHAIN and COMMON commands, and the ability to call and execute object code routines and PCOS commands.

The graphics statements take full advantage of the bit-mapped screen and let you manage multiple windows. You can also draw points, lines, boxes, circles, and ellipses.



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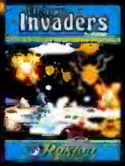

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Modular Architecture

Designing a modular computer around the IBM PC

Sudha Kavuru
Sritek Inc.
10230 Brecksville Rd.
Cleveland, OH 44141

IBM's Personal Computer (PC) has become a de facto standard for the personal computing industry. As the range of its applications programs expands, more performance in terms of powerful system software, multitasking and multiuser capabilities, and raw throughput will be required of the PC. Unfortunately, the IBM PC is limited by its 8088 microprocessor. As designed, the PC can neither adequately nor efficiently support the advanced and commercially successful multiuser operating systems such as Unix and RM/COS. These applications require a more powerful processor and a memory management scheme available in the advanced microprocessors. The combination of these facts prompted our design of a modular computer: a computer system using IBM's PC as a base but incorporating a variety of processors and memory options (see photo 1).

Photo 1: *The Sritek modular expansion system for the IBM Personal Computer. The center circuit card is the Versacard, a 256K-byte dual-ported memory card that fits in a single slot of the IBM's expansion bus. Above it are a RAM Module (left), with an additional 256K bytes of memory, and a 68000 Microcard. Below the Versacard is a Z80 Microcard and an 8086 Microcard.*

The Void

The 16- and 32-bit microprocessors have ushered in a new era in the design of commercial and engineering workstations. Recently introduced products show a definite trend toward systems configured around Intel's 8086-family of processors and Motorola's 68000. National Semiconductor's introduction of the 16032 microprocessor has created considerable enthusiasm among designers of computer systems.

The availability of this exciting hardware is paralleled by unprecedented software development. A recent survey indicates that more than 90 percent of software development efforts in the microcomputer industry are targeted toward 16- and 32-bit processors. The time is ripe for the 16-bit microprocessor marketplace to explode.

Designing with Modular Architecture

Because in a computer the cost of the processor is a small percentage of the cost of the total system, we decided that it would be most cost-effective to upgrade the processor, maintaining the rest of the PC—with its software, peripherals, and memory—as a onetime investment. This protects the user's investment in the PC and allows upgrading according to the user's needs.

Our goals were to allow maximum flexibility yet require the user to do a minimum of problem solving. Thus, if users required higher performance than is normally available from a PC, they could choose a higher-performance processor from the Intel family (i.e., the 8086 or the 80286) and run their existing software with no modifications. In this way, money and time already spent on software would not

Mom laughed, and said the Magic Machine can start by cooking dinner.

He said the computer would be a great addition to our family.

I think a computer must be like an elephant —it never forgets.

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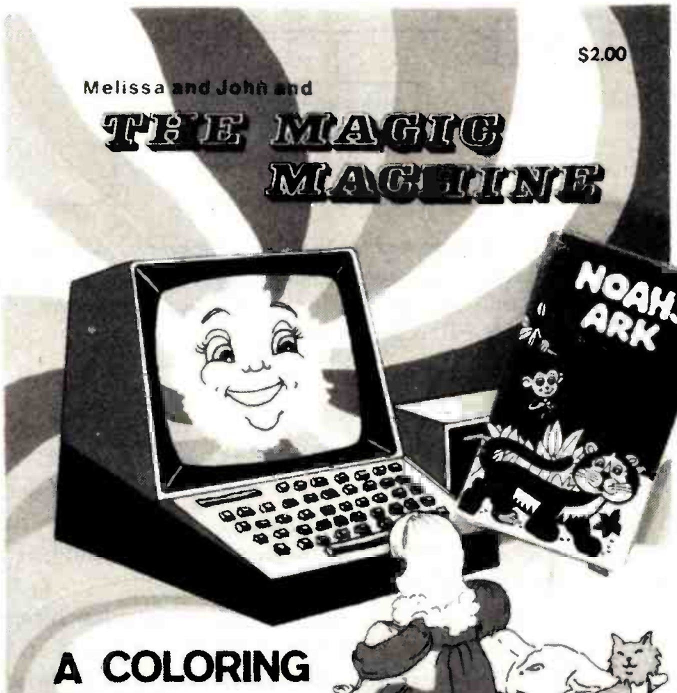

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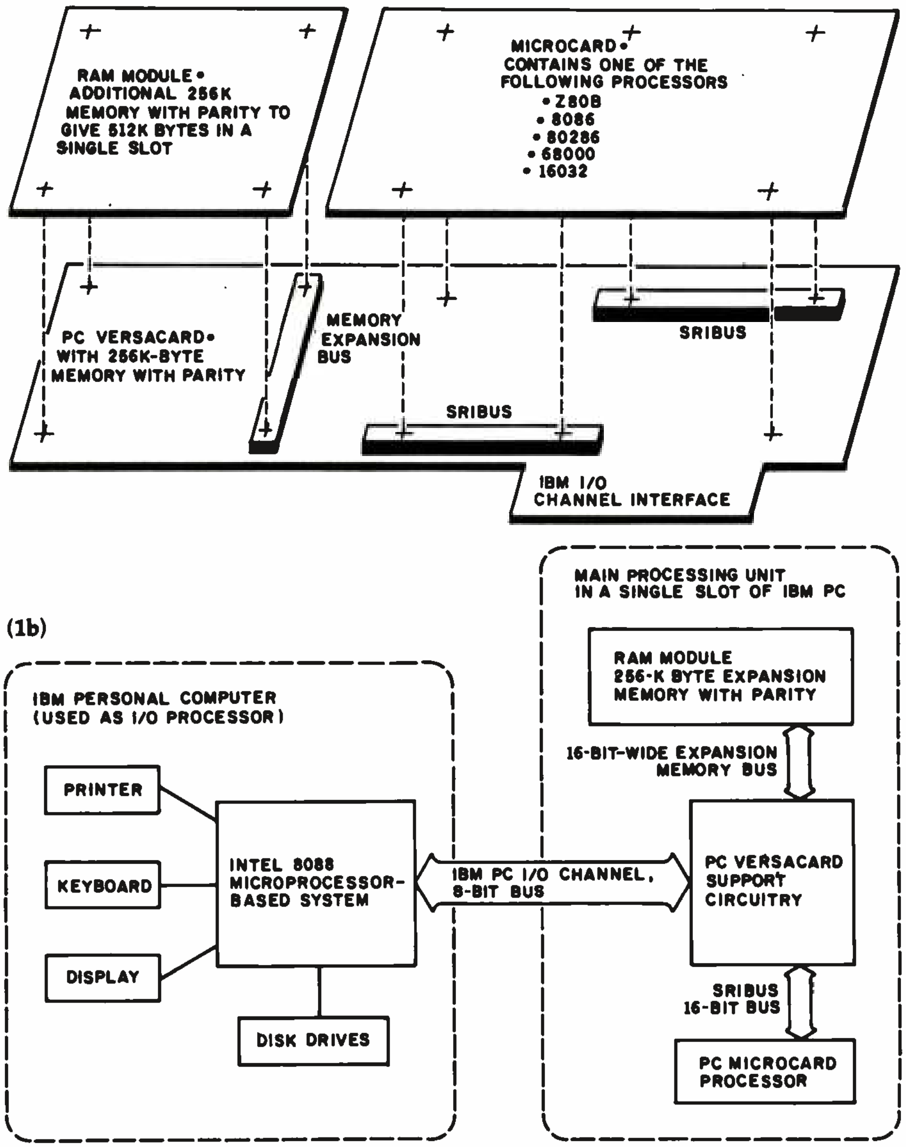

Figure 1: *Architecture and mechanical arrangement of the Versacard. The extra memory and the additional processor plug into the Versacard (figure 1a), so that the whole unit requires only one IBM expansion slot. The architecture of the complete system, including the IBM PC, is shown in figure 1b.*

be wasted.

On the other hand, we felt users who upgraded to another incompatible processor (i.e., the Motorola 68000 or the National Semiconductor 16032, etc.) should not be limited to software written only for those machines while their computer systems still had the original Intel 8088 processor intact. We had in mind making available a wealth of time-tested software, such as CP/M-80, Unix, RM/COS, the UCSD p-System, and others, while allowing programs that normally execute under IBM DOS to continue to run as special tasks. For example, consider Wordstar under Unix: though Wordstar actually runs on the 8088, this fact should be transparent to the Unix user.

Besides offering performance improvements and software compatibility, we decided that the ability to handle multiple users and multiple tasks is essential. It is particularly important in commercial applications in which sharing of databases is common. Further, any multiuser system must be efficient, reliable, and secure.

We felt the product should be convenient to install in any IBM PC and able to accommodate all possible add-on devices for the PC. The system should be able to use Unix, or any other operating system associated with the expanded processor, with all of the PC's facilities and without any modification to the hardware or software. This applies equally to local area networks, hard-disk drives, graphic terminals, and any other I/O (input/output) devices made to work with the PC.

And finally, we decided to consider the IBM DOS floppy-disk format as the standard format for software distribution, independent of the processor and the operating system. This encourages much-needed standardization in the personal computer industry and the exchange of information among users.

System Details

To meet the criterion of flexibility, we chose a building-block approach that would allow us to interchange processors at will, without having to redesign the complete computer. The system can be divided into four main units (or modules, see figure 1), each of which performs a specific function:

- I/O Processor: the IBM Personal Computer, the framework on which the system is built. It provides for all the physical needs of the system (electrical power, cooling, a cabinet, etc.) and is also the system's interface to the rest of the world. The PC's processor handles I/O between the user and the system, and between the system and other peripherals.
- The Versacard: a single-circuit card designed to fit in the PC's expansion slots. This card hosts the RAM (random-access read/write memory) Module, which is a dual-ported expansion memory, and the additional processor module (called a Microcard), and provides the support circuitry necessary to interface the two to the PC's bus. This card is required in order to use the processor Microcards.
- Microcard: contains any one of the processors previously mentioned and the necessary support circuitry to

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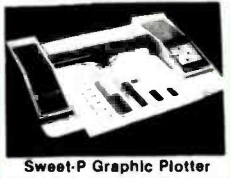

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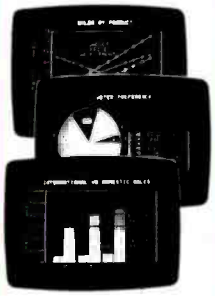

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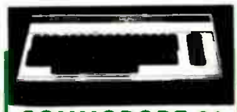

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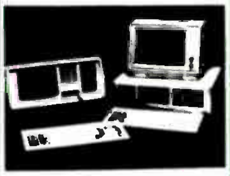

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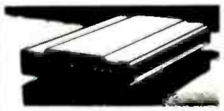

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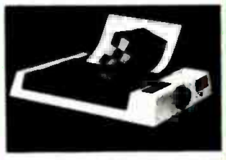

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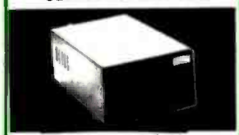

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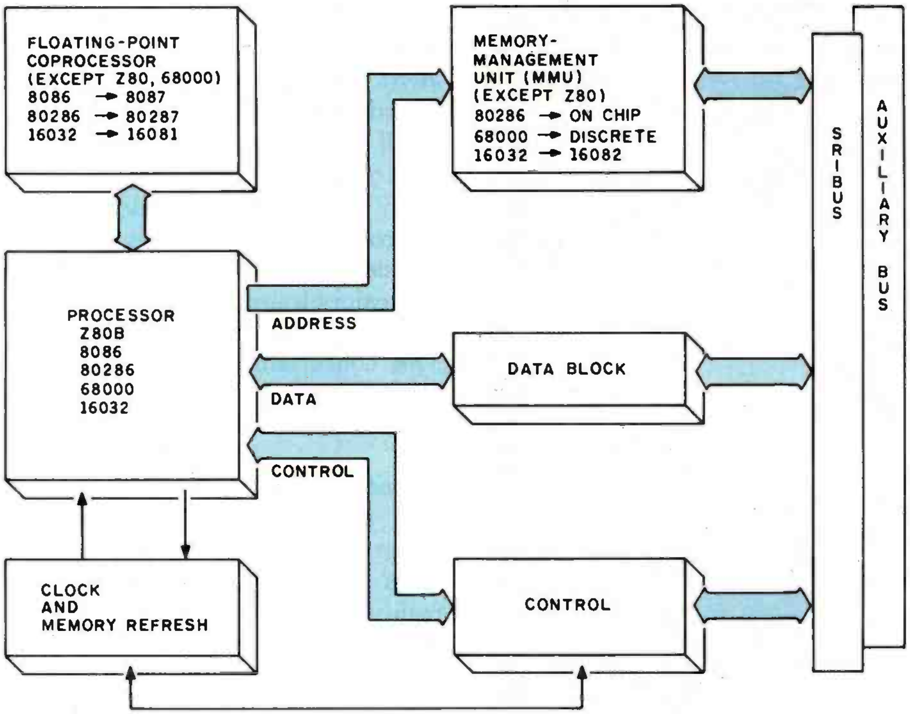

Figure 2: *Architecture of the Microcard.*

communicate with the Versacard. Its function is to execute the operating system and the user's applications programs. The Microcard does not directly interact with the I/O devices installed in the PC but employs the PC for that purpose.

- RAM Module: a simple circuit card containing 256K bytes of memory that may be installed on the Versacard for a total of 512K bytes.

A Microcard typically consists of the following: processor, data block, multiprocessor-control block, clock-and-memory refresh, MMU (memory-management unit), and floating-point coprocessors (see figure 2). The memory refresh circuitry provides the refresh timing to the Versacard memory when it is under Microcard control. The clock circuitry synchronizes all activity on the Microcard. The multiprocessor-control block comprises the communication registers necessary for dual-port control; this enables both the Microcard's and the PC's processors to access the Versacard memory without contention. The data block consists of a few simple buffers.

In short, the Microcard is a module that contains the "personality" of the system; replacing this module alters the essence of the system. There are five versions of Microcard currently available: The Z80 Microcard is the simplest and has neither an MMU nor a floating-point unit. The 8086 Microcard has an 8087 floating-point processor, within which is a simple memory-mapping scheme. The 68000 Microcard has a sophisticated paged MMU to support advanced multiuser and multitasking operating systems. Both the 80286 Microcard and the 16032 Microcard have advanced MMU and floating-point hardware support.

When the processor residing on the Microcard seeks an I/O transaction, it must create a message block in the shared memory. The block contains the I/O command and the appropriate parameters to direct the transfer of information between the processors. When the Microcard issues an I/O command, the PC is alerted by way of an interrupt; the message block is read by the PC, and the appropriate I/O process is in-

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itiated. Likewise, the PC creates a message block in the memory and alerts the Microcard via an interrupt in order to transfer information.

All I/O transactions are performed in blocks in such a way that the I/O delay is considerably reduced; to the Microcard, all I/O devices appear as fast devices, and all transactions occur at memory transfer rates. This reduces interrupt overhead on the Microcard. This concurrent processing arrangement increases the overall system performance.

Memory Management

In a multiuser system, the processor appears to attend to several users simultaneously, though, in reality, the processor's attention is being switched between the users several times a second. In order for this to be possible, each user's program must be in a form that can reside at any physical address and still run. This gives the operating system the freedom to determine where the program should be stored. The relocation facility in an MMU provides address translation by mapping the logical addresses into physical addresses, so that programs may be written as though they will be loaded starting at location 0, even though they may end up scattered throughout various portions of memory. The MMU is totally transparent to the user programs, and the processor appears as an exclusive resource to each user.

A memory management scheme is available for the 68000, 80286, and 16032 Microcards. The MMU on the 68000 uses a paging scheme and has the facility to handle 16 simultaneous processes or users. The MMU on the 80286 Microcard is incorporated on the processor itself, and no special hardware scheme is needed. The processor provides a segmented virtual memory with four-level hierarchical memory protection. The 16032 Microcard has a 16082 MMU, which is a VLSIC (very large scale integrated circuit) that uses a demand-paged virtual-memory scheme. These three Microcards support any multiuser and multitasking operating system, as they are functional replications of the

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MMU schemes available on minicomputers and mainframes.

I/O Architecture

Typical business application programs are limited more by I/O than by computation. In an office environment, it is important that the system's I/O performance be worthy of the processor's power. A multiuser system with four users, all actively performing screen-oriented editing, probably generates an interrupt approximately every 400 microseconds (μs). Servicing these interrupts would put a tremendous burden on a single processor, and very little processor time would be left for data processing. Such a system would have limited commercial appeal.

Minicomputers and mainframes have overcome this limitation by using special block-buffered I/O processors. In our modular system, the IBM PC takes over the I/O load, concurrently processing I/O tasks, while the Microcard processor takes care of operating-system and user business.

Mass-storage devices present a different type of problem: compared to the large hard-disk drives used with minicomputers and mainframe systems, the 5¼-inch Winchester drives likely to be found on IBM PCs are generally slow. In a multiuser system, disk accesses are frequent (especially in Unix, with its hierarchical disk directories); therefore, program swapping and file transfers degrade performance. The problem of slow hard-disk drives can be handled by a cache-memory scheme. The cache memory decreases apparent disk-access time by keeping frequently accessed disk sectors in memory.

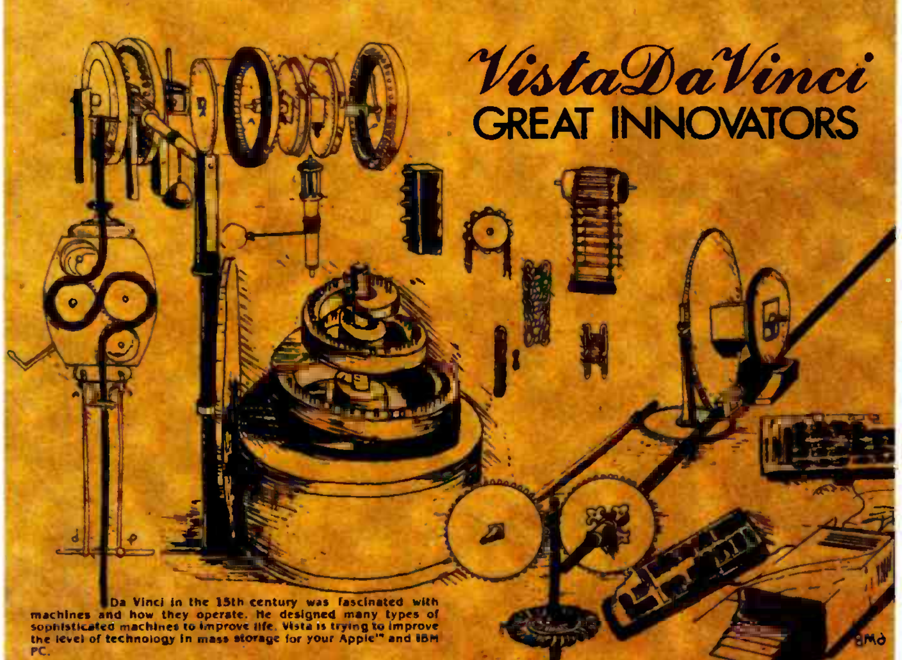
The IBM PC, functioning as an I/O processor, can significantly reduce the I/O burden on the Microcard processor by handling I/O-device interrupts and providing buffering. Printing a large file, for example, can consume enormous amounts of processor time, so a print-spooling mechanism is provided.

I/O Processor Software

The I/O Processor Monitor is a multitasking, interrupt-driven program, resident in the PC, that serves all I/O requests (see figure 3). The processor communicates via a well-defined data structure that is independent of the processor and operating system being used. The Monitor software is easily configurable, and the user can readily alter system parameters or add new device-specific routines without having to rewrite a lot of software.

The request types are character output, spooled-block output, unspooled-block output, character input, block input, and device status checks. All character-type I/O requests are for serial devices, and all block-type I/O requests are generally for mass-storage devices and network communications. Special-request types are assigned for setting protocols for serial devices, covering such things as data rate, number of bits per word, and number of stop bits. Other types include direct access to mass storage devices for device-formatting purposes and user-defined request types, which enable access to operating-system calls and user-installed hardware.

An internal polling loop in the I/O



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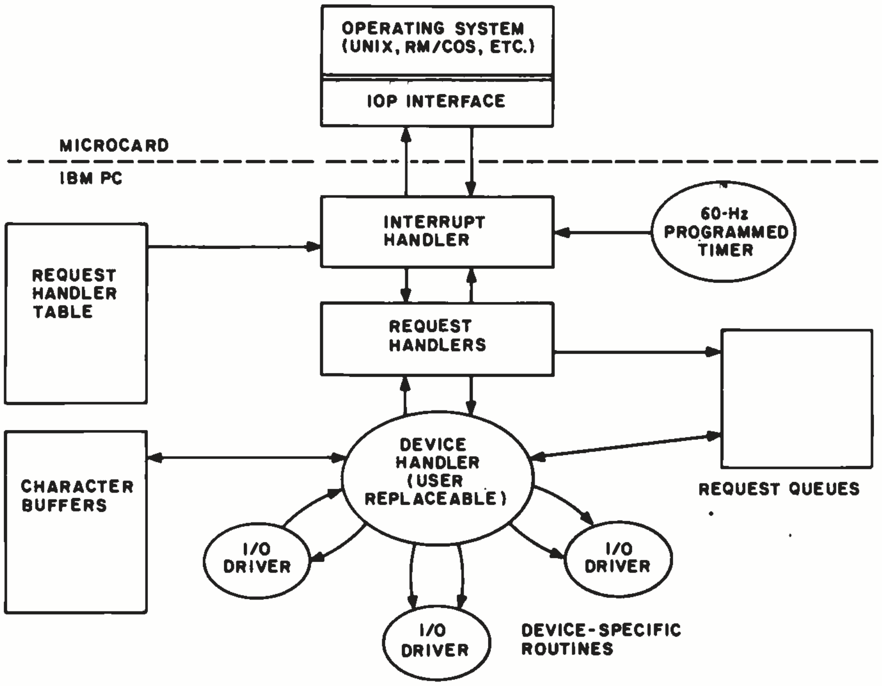

Figure 3: *Flow diagram of the I/O Processor software.*

Processor Monitor is controlled by a programmable timer set to 60 Hz. Whenever there is a block I/O in progress, this polling loop attends to character input or output. This concurrent processing scheme is used to improve I/O response. When an I/O task is finished, the Monitor will normally interrupt the Microcard processor; but if the Microcard is processing some critical section of a program, the I/O Processor keeps the message block number in a separate queue and interrupts the Microcard at a later time. The polling loop is used to keep track of this also. This feature not only prevents a "deadly embrace" condition (when two processors access the same resource at the same time) but also enhances overall system performance.

Final Remarks

The 8-bit microcomputer industry has had little success in creating a market for multiuser systems. Multiuser operating systems (such as MP/M from Digital Research and Oasis from Phase One) suffer when they are limited by 8-bit microprocessor architecture. The 64K-byte address limitation, lack of memory management, and limited processing capability are just some of the factors that have prevented the 8-bit microprocessors from making a dent in the multiuser market.

The Unix operating system has emerged as a de facto standard for 16-bit multiuser and multitasking systems. The elegant design and supreme flexibility offered by Unix provides individuals with a powerful single-user system and a lot of advanced application software. Unix, with its multitasking, electronic mail, and networking capabilities, also seems ideal for office automation applications. Other operating systems, like the 16-bit MP/M and RM/COS, offer efficient multitasking and multiuser facilities. But this advanced operating system software demands a sophisticated architecture. Critical elements in these systems are memory management and carefully designed I/O processing. The IBM PC, and the hard-disk-based IBM XT, properly enhanced, can set the trend in high-performance, cost-effective personal computer systems.■

About the Author

Sudha Kavuru is president of Sritek Inc.

Design Credits

The following members of the Sritek engineering staff were primarily responsible for the product design and implementation: Madhav S. Kavuru, formerly of IBM, for product definition and system design; lead engineer Jim Bias and Jeff Centanni, for the hardware design; Neal Somos and Scott Fluhrer, for the design and implementation of the systems software; and Mike Kapolka, for the mechanical and printed-circuit board design.

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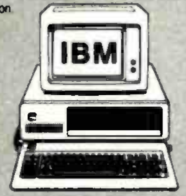

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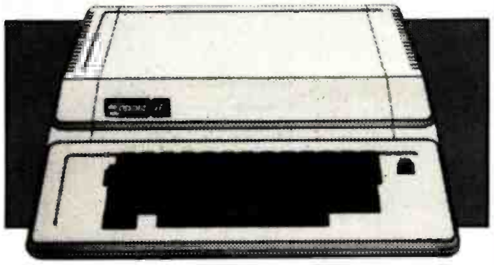

APPLE IIe 64K, 40 COLUMN $1,175
APPLE IIe 128K, 80 COLUMN $1,395
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	Duet, 5", Double Sided, 320K Half Height	$ 420	$ 329
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	Controller Card	$ 89	$ 75
	V1000 Dual 8", Std. Format w/Controller, Complete	$2195	$1495
	V1200, 5", 6MB Disk Pack System	$1549	$1199
TEAC	143K Disk Drive, 1/2 High	$ 379	$ 279
	Controller Card	$ 89	$ 69
C.P. SOFTWARE, Filer, Utility and DOS 3.3		$ 20	$ 15

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for Apple II

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★ **Apple**, RAM Card, 2 Yr. Wty.	16K	$ 179	$ 39
★ **Microsoft**, RAMCard	16K	$ 100	$ 79
★ **Saturn Systems**, RAM Card	32K	$ 249	$169
RAM Card	64K	$ 425	$319
RAM Card	128K	$ 599	$459
★ **Axlon RAM Disk System**	320K	$1395	$995

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ASTAR, RF Modulator	$ 35	$ 25
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Dan Paymar, Lower Case Chip	$ 50	$ 39
Don't Ask, DAO 003 S.A. Mouth	$ 125	$ 85
★ **Eastside**, Wild Card, copier	$ 130	$ 99
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Kraft, Joystick (Ap II/II+)	$ 65	$ 49
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MicroTek, Dumpling 64, Buffered 64K Spooler	$ 349	$239
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Joystick (II+)	$ 60	$ 45
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WICO, Trackball (Ap II/II+)	$ 80	$ 55

SOFTWARE

on disk for Apple II/II+/IIE

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SpellStar™		$ 250	$129
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Applewriter II preboot disk		$ 20	$ 15
Visicalc 80 col. preboot disk		$ 50	$ 39
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Cobol 80		$ 750	$559
Fortran 80		$ 195	$149
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Micro Lab, Miner 2049er	$ 40	$ 27
Muse, Castle Wolfenstein	$ 30	$ 23
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Microsoft, 16K RAMCard	$ 100	$ 89
Saturn Systems, 32K RAM Card	$ 249	$ 169
M&R, SupRterm 80 col.	$ 375	$ 199
Videx, Videoterm, 80 column card	$ 345	$ 229
CCS, Serial Interface 7710A	$ 150	$ 129
Calender Clock 7424A	$ 120	$ 95
MicroCom, Micro Courier	$ 250	$ 125
Micro Telegram	$ 250	$ 125
Anadex, DP8000, Dot Matrix Printer	$ 995	$ 495
ALS, Synergizer + Supercalc + Condor	$ 749	$ 499

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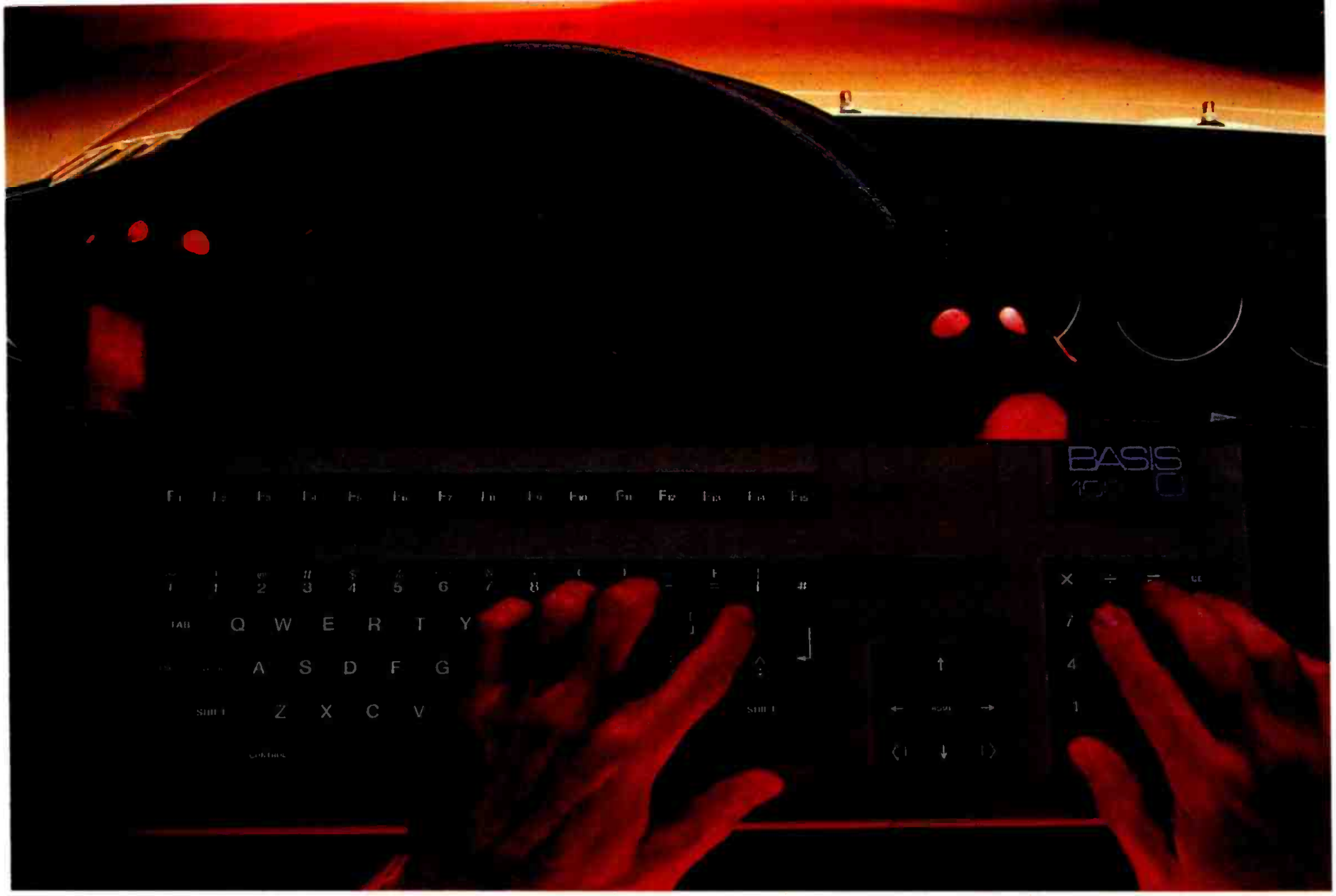
Logo for personal computers has been heralded by some as the beginning of a revolution in computer languages that promises to be as far reaching as the introduction of the personal computer itself. Yet many people think that Logo is not much more than a graphics language for children. Adding to this confusion is the fact that some commercial implementations of Logo are weak (somewhat akin to a version of English that contained no adjectives). Because of the confusion surrounding Logo itself, the appearance of a sophisticated version of this language on a professional microcomputer such as the IBM Personal Computer might be expected to raise some eyebrows. The development of a powerful Logo for 16-bit computers such as the IBM PC can change our way of thinking about programming.

DR Logo incorporates the list-processing capabilities of LISP with a syntax that can be learned by children. And Logo and LISP share other powerful features, too.

In this article we will show what makes Logo truly powerful, what it can be used for, and how Digital Research's DR Logo, with its powerful language, large workspace, and complete program-development environment, sets a new benchmark by which to measure the properties of useful computer languages.

To help you understand the power of Logo, we'll give you some background about the earlier language LISP. LISP, developed more than 20 years ago by John McCarthy, is overwhelmingly the language of choice for researchers in the field of artificial intelligence. Unlike many other languages, LISP lets users perform operations on several data types, including numbers, words, and lists. A list can consist of a collection of words, numbers, or lists themselves. Because the names of LISP primitives or procedures are also words, one can write LISP programs that automatically generate other LISP programs. It is the ability to manipulate this type of data that gives LISP its name (*LIS*t *P*rocessing).

LISP has been used to explore topics as diverse as image processing, the analysis of natural language, the computer solution of certain types of "intelligence" tests, and theorem proving. More mundane programs in LISP (such as word processors) have also been created. Viewed from any angle, it is a powerhouse of a language.



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Nodes, Bytes, and Bits

The popularity of personal computers has brought new words into our vocabulary, such as bits and bytes (that describe storage capacity). With the introduction of list-processing languages like Logo, yet another term to describe units of memory has been added—the node. *In Logo terminology you operate with a* workspace *that holds a certain number of nodes. Like bits and bytes, you want as many nodes in your Logo workspace as possible because your programs and data values are built from workspace nodes. Because nodes are themselves made up from a fixed number of bytes for any particular Logo interpreter, the exact number of nodes you have depends upon the brand of your computer and its memory size.*

When you write procedures, enter data values, and run Logo programs, you use nodes from your workspace. Some of these nodes are used permanently, perhaps to store a portion of your Logo program. Others are used to keep track of a temporary value, then later discarded when not of any use.

When you run out of nodes, Logo automatically searches your workspace for temporary nodes that have been discarded. This "garbage collection" reclaims nodes so that Logo can continue operating. If no nodes are reclaimed, Logo stops and tells you about the situation so that you can erase some of your permanent procedures or data values.

Eight-bit computers generally store fewer nodes than 16-bit computers because the Logo interpreter and workspace must coexist in the same 64K-byte memory area. Logo for the 8-bit Apple II computer gives you about 2800 nodes to work with.

Sixteen-bit computers, however, let you operate with more nodes because the memory size is not limited to 64K bytes, as long as you're willing to invest in more memory boards. An 8086- or 8088-based computer, such as the IBM PC, can potentially address up to 1 megabyte of main memory, giving you more than 100,000 nodes.

For the first-time Logo user, a 2800-node workspace is large enough to write simple procedures, work with turtle graphics, and learn the basics of list processing. When you become serious about your Logo programming, your requirements will increase because of the complexity of the procedures you write and the amount of data you want active in your workspace.

Now your local computer salesperson has one more term to confuse you. If the computer doesn't have enough bits and bytes for you, he'll throw in some nodes at no extra charge.

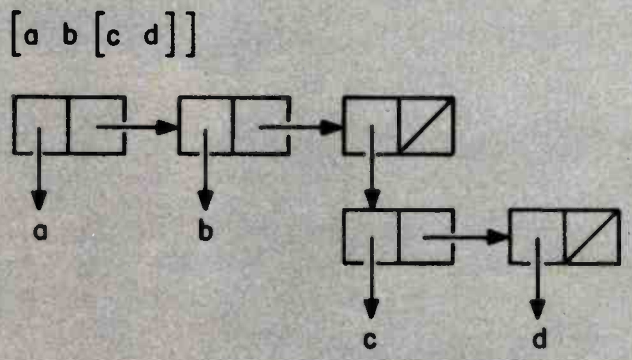

Figure 1: *The list containing the two atoms* ''a *and* ''b *and the list* [c d] *is shown above in its node representation. Each node consists of two 2-byte fields that can be used as data or pointers to more data.*

DR Logo incorporates the list-processing capabilities of LISP with a syntax that can be learned by children. More than the utility (and beauty and simplicity) of turtle graphics, it is this list-processing capacity that gives it so much power.

Other important characteristics are shared by Logo and LISP. Among these is the ability to extend the language through the creation of procedures that are treated just as if they were part of the language itself. As with some FORTH devotees, many Logo enthusiasts see themselves as not writing programs, but as creating new "words" in Logo tailored to the solution of their particular programming task. While this may appear to be a subtle distinction, it has a tremendous effect on programming style. This style affected the design of Digital Research's Logo in several ways, especially in the debugging and procedure-management tools.

The Power of DR Logo

Before showing what Logo procedures look like, we will list a few of the characteristics of DR Logo. To provide maximum power to the user, we designed the first implementation of DR Logo for the 16-bit IBM Personal Computer. The use of a 16-bit processor greatly increased the amount of workspace available to the user and also yielded a modest speed improvement over 8-bit versions of the language. A DR Logo user with 192K bytes of RAM (random-access read/write memory) has about 10,000 nodes available for use. (See the text box above.) For comparison, an Apple II user running Apple Logo has only about 2800 free nodes to work with. It goes without saying that sophisticated applications require comparably more workspace than simple ones, and it was important to its designers that DR Logo be able to handle sophisticated applications.

In addition to list processing and turtle graphics primitives, DR Logo can work with integers (30 bits long plus a sign) and both single-precision and double-precision floating-point numbers. A full set of transcendental functions (log, square root, etc.) allows this language to be used for scientific programs as well.

DR Logo is a superset of Apple Logo and more than just a language. A complete programming environment, it includes its own operating system, program editor,

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debugger, and a set of workspace-management tools designed to speed the successful implementation of even the most convoluted artificial-intelligence program.

The graphics system is designed to use either the color monitor alone or to use the color monitor for turtle graphics or mixed text/graphics applications and the monochrome monitor for procedure editing, debugging, and pure text programs. The color display uses the 320-by 200-pixel medium-resolution mode and supports 16 background colors (eight colors that are either bright or dim). It also supports two foreground color sets of four colors each.

A Brief Glimpse at Logo Procedures

Before describing the editor and workspace-management tools, we will examine what a Logo procedure looks like by illustrating the creation and manipulation of a list. A list in Logo is a collection of words, numbers, or lists that are enclosed in square brackets. Each item in the list is separated by a space. For example, [cow horse sheep snake] is a list; so is [1 1 2 3 5 8]. The first list consists of the words cow, horse, sheep, and snake; the second list consists of the first six numbers of the Fibonacci series. A more complex list would be [car [dump truck] airplane [railroad engine]], in which two of the elements are words (car and airplane) and two elements are lists of two words each ([dump truck] and [railroad engine]). Also, a list can have one word in it ([yellow]) or even be empty ([]).

In common with other computer languages, Logo allows values to be assigned to names. For example, you can assign a list to a name with the make command, e.g.:

```
make "friends [Pam Roy Pat George]
```

The quotation mark is used by Logo to indicate that friends is a word, a variable name in this case, and not a command. If we tell Logo to

```
print :friends
```

we will see

```
Pam Roy Pat George
```

on the screen. The colon in front of friends lets Logo know that we want to see what is bound to the variable rather than the variable name itself. If we had entered

```
print "friends
```

we would have seen

```
friends
```

on the screen instead.

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Logo, Turtles, and Kids

Anyone who has watched the personal computer industry for the past few years has probably seen the evolution of certain myths regarding computer languages. Many devotees of BASIC, for example, claim that it is the optimal choice for the home user because of its nearly universal adoption as the default language for personal computers. The fact that BASIC was the only high-level language that was readily available in compact form in the late 1970s is not considered to be relevant by many users. Fortunately, the recent availability of other languages on personal computers (Logo, Pascal, FORTH, and PILOT, to name but a few) has afforded programmers other choices. But some of these languages have myths of their own.

In the case of Logo, the common myth is that it is a turtle graphics language designed to be used exclusively by children. As evidence in support of this myth, one is pointed to Seymour Papert's book Mindstorms. *It is true that Papert devotes the bulk of his book to the use of turtle graphics as a powerful programming and discovery tool for children, and that he stresses the accessibility of Logo to the young and inexperienced.*

The problem with the Logo myth is that it suggests that Logo is exclusively for children's use. As with many myths, the reality of the situation is quite different. First, it is true that Logo supports turtle graphics. In this regard it is similar to some versions of Pascal, PILOT, and FORTH. Note also that, while turtle graphics is accessible to children, it also has applications of value to advanced programmers as well. Anyone who doubts this would benefit from reading Turtle Geometry *by Abelson and diSessa or* Discovering Apple Logo *by Thornburg.*

The point is that Logo is no more a "kid's" language than is English. Yes, English is the language of "Mary Had a Little Lamb," but it is also the language of Moby Dick *and Shakespeare's sonnets.*

At its base, Logo is a symbol-manipulation language in the finest sense of the word. Rooted in the artificial-intelligence language LISP, Logo allows the user to extend its vocabulary, to use recursion, and to manipulate various types of data in ways that are nearly impossible with languages like BASIC.

It would be a shame if the myth of Logo kept serious programmers from exploring a language whose foundation goes to the heart of computer science itself.

You can take lists apart in Logo with commands such as first, butfirst, last, and butlast. For example, if we enter

```
print first :friends
```

the screen will show

```
Pam
```

The command

```
print butfirst :friends
```

prints

```
Roy Pat George
```

Now that we know a little about lists, let's explore Logo's extensibility by creating a new command in the language. Suppose you did a lot of work with lists and you found that you would like to rotate a list by moving its first element to the rear end and pushing everything else up front. We can create a word (e.g., rotate) to do this for us. If we had such a procedure, we could make a rotated version of friends by entering

```
make "neworder rotate :friends
```

Because Logo doesn't have a primitive called rotate, we can create a procedure with this name that looks like the following:

```
to rotate :list
output sentence butfirst :list first :list
end
```

This procedure accepts a list (denoted by the local variable name :list) and makes a new list starting with all but the first word and then appending the first word to the end of the list. The sentence primitive (or native instruction) is used to assemble a list from two parts. The output command passes the new list back out of the procedure to any procedure that used rotate, or to the command level.

Once defined, Logo procedures are treated just as if they were part of the language's native vocabulary. For example, if you were to enter

```
print rotate :friends
```

the list

```
Roy Pat George Pam
```

would appear on the screen.

Logo's ability to manipulate lists by taking them apart, adding to them, examining their contents, and altering their order is central to the use of Logo in the creation of knowledge-based programs. For an excellent introduction to the use of lists in the creation of a knowledge "tree" that "sprouts" new nodes as the program gets "smarter," you should read Harold Abelson's discussion of the program animals in his book *Apple Logo*.

In addition to the ability to perform list processing and

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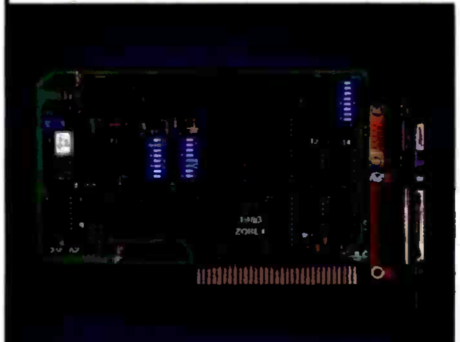

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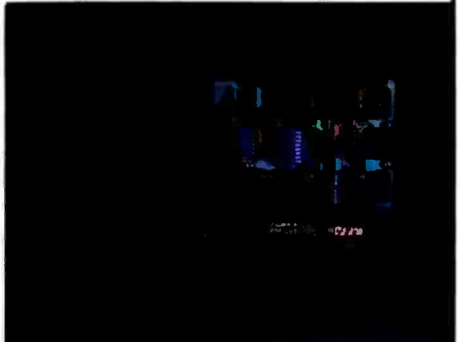

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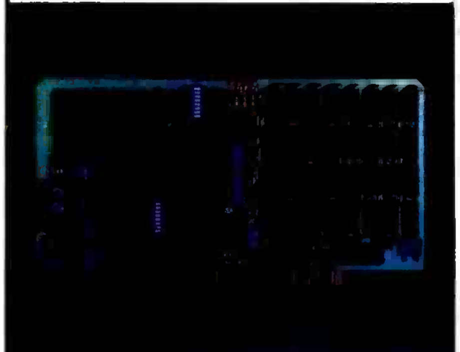

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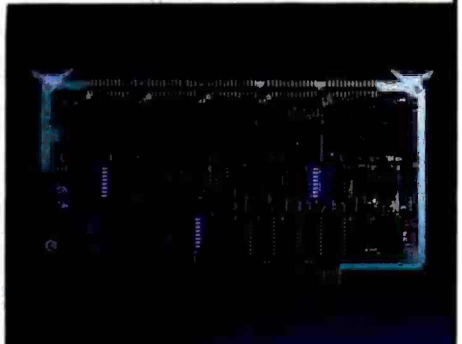

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arithmetic, DR Logo also supports an excellent turtle graphics environment. While much has been written about turtle graphics, especially on its use with children (see the text box on page 214), it is important to understand that turtle graphics is of tremendous value to expert programmers as well. The power of this graphics environment comes through its description of the shape of an object as a series of incremental steps that create it. Once a procedure describing an object has been written, the object can be displayed at any screen location, orientation, and size without having to tamper with the basic description. For example, the procedure

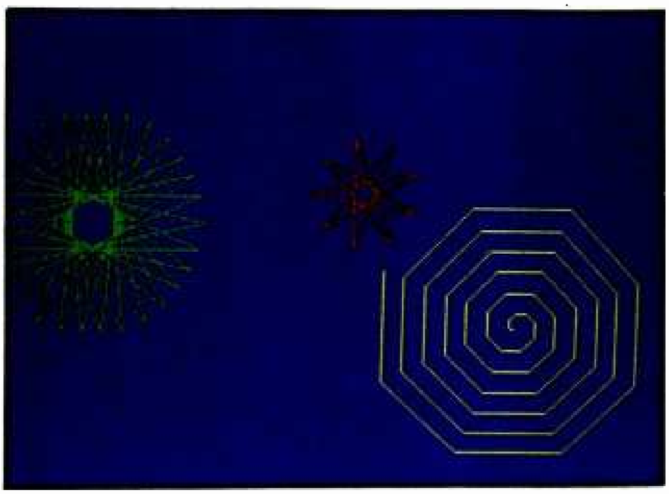

Photo 1: *An example of turtle graphics with DR Logo.*

```
?trace
?island [gosper 60 3] 6
```

```
[1] Evaluating island
[1] times is 6
[1] list is [gosper 60 3]
[2] Evaluating gosper
[2] limit is 3
[2] size is 60
[3] Evaluating gosper
```

Photo 2: *Multiple text windows in the debugging mode, with the* trace *function turned on. The upper left window is the Logo interpreter where you enter Logo commands. The debug window in the upper right displays information on the current program that is running. Output from the program and input that it requests are handled by the program window at the bottom. The* trace *function follows the program as it runs, showing the level at which a procedure is called, the name of the procedure, and the values of variables as they are defined. The* island *procedure being traced has two inputs: a list and a number. This shows up as level 1 in the debug window. The* gosper *subprocedure is called and begins to execute at level 2 with its variables, size and limit. The* gosper *subprocedure is recursive and calls a copy of itself that begins executing at level 3.*

```
to square :size
repeat 4 [forward :size right 90]
end
```

can be used to create a square at any screen position, angular orientation, or size. To draw a square at a given place, you first instruct the turtle (a cursor that has both position and orientation) to move to a specific *x-y* coordinate and heading (angle). Next you type square 50, for instance, to create a square with sides 50 units long. This property of turtle graphics procedures, coupled with Logo's capacity to run recursive programs, has allowed the easy exploration of geometrical shapes and their properties. See photo 1 for an example of turtle graphics.

Programming Tools

DR Logo provides many tools to assist the programmer. While smaller Logo systems can adequately survive with a rudimentary procedure editor, larger Logo environments benefit from some of the extra tools that make program analysis and debugging less tedious. DR Logo's procedure editor allows the use of both uppercase and lowercase letters for programs and data. Two primitives, uppercase and lowercase, allow the conversion of a word from one case to the other. Also, procedure listings can be indented to make decision branches and nesting easier to see. While not essential to the creation of good programs, such formatted listings are easier to read.

While Logo's syntax generally makes procedures easy to read, it is valuable to have comments appended to certain program lines. This ability is provided in DR Logo, along with the ability to strip these comments from procedures with the noformat primitive if more workspace is needed. If the name or syntax of a Logo primitive or editing command is forgotten, online help is available.

Once procedures are created, DR Logo has several primitives that help show how procedures interact with each other. This is especially important for those Logo enthusiasts who experiment with several coexisting versions of procedures before settling on the final choices. Most versions of Logo will print the names of resident procedures on receiving the pots command (*p*rint *o*ut *t*itle*s*). If, in DR Logo, you enter potl, the workspace will be examined for all top-level procedures (those not called by other procedures) and their names will be displayed on the screen. If you enter pocall followed by the name of a procedure, DR Logo will examine the calling structure of the named procedure and print the names of the procedures used by the one mentioned, as well as the names of the procedures used by these secondary procedures, and so on until the calling sequence is complete. This gives a great deal of information on the internal organization of the Logo workspace. If, on the other hand, you enter poref followed by a procedure name, all the procedures that reference this name will be found and displayed.

Many Logo programmers create procedures in a haphazard sequence. Because a listing of multiple procedures follows the sequence in which they were entered, large listings can be hard to assimilate. By using the DR Logo follow command, procedures can be resequenced in any order, thus allowing large listings to be more easily scanned.

Once you are ready to try a Logo program, DR Logo provides additional tools to assist in debugging. One of these tools allows the text screen to be split into windows corresponding to the command level, a user I/O (input/output) port, and the debugger (see photo 2). The trace command traces the procedure and displays what is happening and at what level the procedure is relative to the top (command) level. Because a single recursive procedure (that calls a copy of itself) may oscillate through many levels, knowing the level at which an error occurs is helpful when fixing the fault. The command watch allows single-step execution of a procedure with the ability to change values and see the effect of each statement. See photo 3 for an example of the watch function.

The use of multiple text windows in debugging is only one application for this powerful tool. The development of good window-management tools can, by itself, increase the simplicity, flexibility, and power of this programming environment.

Photo 3: *The* watch *function lets you interact with a program line by line as opposed to the* trace *function that runs continuously. The* animal *procedure is being run while the* watch *function is on. (The question mark on the first line is the Logo prompt.) The name of the current procedure being called is given at the beginning of each line. This is followed by a line from the procedure that is about to be executed. You can hit the return key to execute that line or you can type in a Logo command to display values that the procedure is using. Program input and output occur separately on their own lines.*

Applying DR Logo in Education

Perhaps because of its historic use as a discovery tool for children (and because of the typically small workspace found with most implementations), Logo is not generally perceived as an applications language. It is anticipated that DR Logo will prove to be an exception in this regard.

The educational applications for Logo have typically focused on the use of turtle graphics. The beauty of turtle graphics is that children simultaneously acquire skills in programming, geometry, and art. Many children who are "turned off" by math have discovered it to be an exciting field through their exploration with turtle graphics. Furthermore, it has been found that once a child uses Logo to discover new ways of thinking about mathematics, this new way of thinking continues to produce beneficial results—even if the child is no longer exposed to Logo.

In the physical sciences, Logo can be used to construct *microworlds* in which bodies obey different natural laws, such as gravitation. By exploring these artificial microworlds, children can develop better intuitions about the properties of their own corner of the universe. (See "Designing Computer-Based Microworlds" by R. W. Lawler on page 138 of the August 1982 BYTE devoted to Logo.)

Given Logo's powerful list-processing capability, one would expect it to be of value in the language arts as well. To pick one simple example, suppose a child created several lists called nouns, verbs, adjectives, articles, etc., and assigned appropriate words to each list. The word order in each list can be randomized with the shuffle command, and a random sentence can be constructed by assembling words from each list in a syntactically valid order. Legitimate nonsense sentences can be automatically generated in this fashion (e.g., No yellow toad smells tall people.) while bringing the child to look at and solve the structure of English.

The educational value of this program can be seen on several levels. First, if the child creates the lists of words, a misplaced word will show up as a misplaced part of speech. Having a verb appear when a noun is expected results in an obviously invalid sentence structure. The result is a self-reinforcing mechanism for learning the parts of speech. Second, the student can learn to identify valid sentence forms without sample words (sort of the reversal of the traditional parsing process). This helps to cement sentence structure concepts as well. Finally, the student learns some of the challenges awaiting those who want to create natural-language interfaces between people and computers.

DR Logo in Business

While Logo is not usually thought of as a language for business applications, DR Logo has several characteristics that may change this perception. The creation of an interactive illustration generator using an inexpensive graphics tablet is quite easy in DR Logo. Photo 4 shows a possible display of business graphics, and listing 1 is the program that produced it.

In addition to business graphics, the list-processing capability of DR Logo makes it suitable for database management. In fact, one might envision incorporating some of the results of research in natural-language understanding to generate a query system that responds to questions such as: "If we increase our salaries by 10

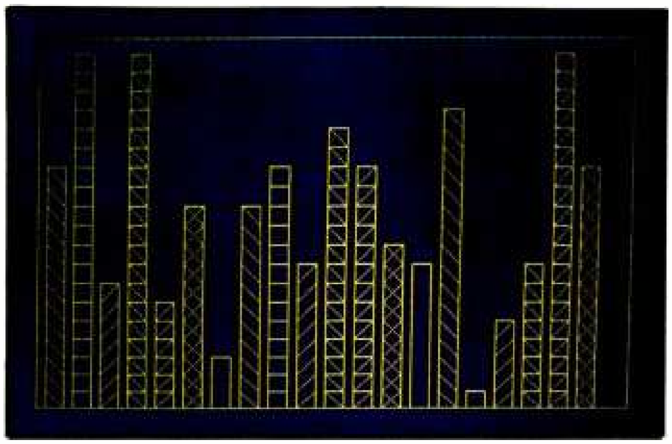

Photo 4: *An example of business graphics possible with DR Logo. The program that produces this picture is in listing 1.*

percent this year and increase our sales by 20 percent next month, what will our profit be in the fourth quarter?"

There is no question that many business applications will be found for DR Logo, but it is premature to set limits on the scope of these applications.

DR Logo in Artificial Intelligence

There has been much talk lately about knowledge-based or "expert" systems. The noble efforts of personal computer software experts notwithstanding, sophisticated microcomputer programs that can adapt to various queries are few and far between. The major reason for this is the inadequacy of most computer languages for dealing with the types of data and operations natural to adaptive systems. Because of DR Logo's close connection with LISP, we expect to see artificial-intelligence techniques appearing in personal computer software rather than being limited to university and large industrial research centers as they have in the past.

This movement is valuable for several reasons. First, it will help to demystify artificial-intelligence research. Second, it will result in the application of advances in artificial intelligence to the development of practical programs. To pick one example, suppose you had a computer program (called car repair) that allowed the following dialogue:

> User: I hear noises when I steer the car.
>
> Computer: Do you think the problem is in your steering mechanism?
>
> User: Yes, I think so.
>
> Computer: Do you have power steering?
>
> User: Yes.
>
> Computer: Is the noise loudest when you turn the steering wheel?
>
> User: Yes, but I hear it when the car is idling too.
>
> Computer: You should check the level of your steering fluid before proceeding. Do you know how to do that?
>
> User: Yes.
>
> Computer: Fine. Check the fluid level. If it is low, fill the reservoir and see if the problem is fixed, otherwise we will continue to explore other causes.

Programs that allow this type of interaction can be used for many diagnostic applications and might be far more valuable applications for home computers than checkbook balancers or recipe files.

Domestic applications for artificial intelligence represent a sleeping giant. The list-processing capability and large workspace of DR Logo will allow this giant to be awakened and will enable the creation of a whole new class of applications software.

DR Logo is the first of a new family of languages that promises not only to change our programming style, but to alter the way we think about computing itself. ■

About the Authors

David Thornburg is an author and lecturer who has been actively involved in the development and support of user-friendly programming environments. His most recent book, Discovering Apple Logo, *shows how Logo can be used to explore the art and patterns of nature.*

Gary Kildall is the president of Digital Research Inc. He is active in research and was the developer of CP/M, Digital Research's version of PL/I, and DR Logo.

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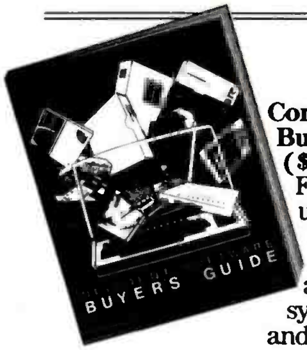

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BM 683

DISCOUNT SOFTWARE

Listing 1: *A DR Logo business-graphics program. See photo 4 for an example of the screen display. Note the indentation and embedded comments possible with DR Logo.*

```
to graphics
; A sample business graphics program for bar graphs
make "screen.height 198
make "yfactor .25
make "zfactor .575
make "zdeg 22.5
make "xmin -139
make "xmax 139
make "ymin -79
make "ymax 119
make "return char 13
get.request
end

to get.request
(local "reply "h.or.v "s.or.o "2.or.3)
cleartext
make "reply prompt [Horizontal or vertical bars (h or v)] "char
if :reply = "h
    [make "h.or.v "h]
    [make "h.or.v "v]
if :reply = :return
    [stop]
make "reply prompt [Solid or open bars (s or o)] "char
if :reply = "s
    [make "s.or.o "s]
    [make "s.or.o "o]
if :reply = :return
    [stop]
make "reply prompt [2 or 3 dimensional (2 or 3)] "char
if :reply = 2
    [make "2.or.3 2]
    [make "2.or.3 3]
if :reply = :return
    [stop]
make :reply prompt [Values to be graphed] "list
if "reply = []
    [stop]
bar.graph :h.or.v :s.or.o :2.or.3 :reply
get.request
end

to prompt :text :type
local "reply
(type :text ": char 32)
if :type = "char
    [make "reply readchar print :reply output :reply]
    [output readlist]
end

to bar.graph :h.or.v :s.or.o :2.or.3 :values
cleartext
(local "max.value "min.value "origin "width "depth "axis "reply
    "graph.width "graph.height "proc "spacing)
if emptyp :values
    [stop]
make "max.value 0
```

Listing 1 continued on page 224

Don't let price get in the way of owning a quality printer.

Adding a printer to your computer makes sense. But deciding which printer to add can be tricky. Do you settle for a printer with limited functions and an inexpensive price tag or buy a more versatile printer that costs more than your computer? Neither choice makes sense.

Here's a refreshing option—the new, compact STX-80 printer from Star Micronics. It's the under $200 printer that's whisper-quiet, prints 60 cps and is ready to run with most popular personal computers.

The STX-80 has deluxe features you would expect in higher priced models. It prints a full 80 columns of crisp, attractive characters with true descenders, foreign language characters and special symbols. It offers both finely detailed dot-addressable graphics and block graphics.

And, of course, the STX-80 comes with Star Micronics' 180 day warranty (90 days on the print element).

The STX-80 thermal printer from Star Micronics. It combines high performance with a very low price. So now, there is nothing in the way of owning a quality printer.

*Manufacturer's suggested retail price.

star™
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THE POWER BEHIND THE PRINTED WORD.

Computer Peripherals Division, 1120 Empire Central Place,
Suite 216, Dallas, TX 75247 (214) 631-8560

The new STX-80 printer for only $199.*

Listing 1 continued:

```
make "min.value 999999999
if :h.or.v = "h
    [make "origin list :xmin :ymax make "graph.height :screen.width
    make "graph.width :screen.height make "axis 90]
if :h.or.v = "v
    [make "origin list :xmin :ymin make "graph.height :screen.height
    make "graph.width :screen.width make "axis 0]
if :2.or.3 = 2
    [make "spacing (:graph.width / count :values) * :yfactor]
    [make "spacing (:graph.width / count :values) * :zfactor]
if :2.or.3 = 2
    [make ":width (:graph.width / count :values) * (1 - :yfactor)]
    [make ":width (:graph.width / count :values) * (1 - :zfactor)]
make "depth :width * :zfactor
minmax :values
make "values scale :values :graph.height * .8 / :max.value
cleanup
penup setpos :origin pendown
if :h.or.v = "h
    [line [] list :screen.width ycor]
    [line [] list xcor :screen.height]
penup setpos :origin pendown
draw.bars :axis :width :spacing :2.or.3 :values
splitscreen
setcursor [0 23]
type [Return to continue]
make "reply readchar
end

to minmax :list
if emptyp :list
    [stop]
if first :list > :max.value
    [make "max.value first :list]
if first :list < :min.value
    [make "min.value first :list]
minmax butfirst :list
end

to scale :list :factor
if emptyp :list
    [output []]
output sentence (:factor * first :list) scale butfirst :list :factor
end

to cleanup
hideturtle
setbg 6
penup
home
clean
pendown
end
to draw.bars :axis :width :spacing :2.or.3 :values
if emptyp :values
    [stop]
setheading axis
draw.1.bar :s.or.o :2.or.3 first :values :width :depth :zdeg
```

Listing 1 continued on page 226

"TI's Home Computer. This is the one."

A lot of computers offer a lot. Only one in its price range offers the most. The TI Home Computer.

Better to begin with. Anyone can start right away with our Solid State Software™ Command Cartridges. Dozens of programs are available in home management, education and entertainment.

Easy to expand. Our Peripheral Expansion System gives you plug-in cards for memory expansion, P-Code capabilities, a disk drive controller and the RS232 Interface. You can also add a modem, speech synthesizer, disk drive and 80 column dot matrix printer.

Programming flexibility. TI BASIC is built into the Home Computer. But it can also handle TI Extended BASIC, UCSD Pascal* Version IV.0, TI LOGO II, TMS 9900 Assembly Language and TI PILOT. Programs can be stored in the optional Mini Memory Command Cartridge.

High-Tech specs. 16-bit microprocessor, 16K bytes RAM (expandable to 52K). 26K bytes internal ROM, up to 30K bytes external ROM. 3 simultaneous tones from 110 HZ to 40,000 HZ. High resolution video. U. & l.c. Single line overlay for 2nd function. Control & function keys. 16 color graphics with 4 modes & sprites.

Sound impressive? Compare a TI Home Computer with the competition and really be impressed. You won't even need a computer to tell you this is the one.

TEXAS INSTRUMENTS

*UCSD Pascal is a trademark of the Regents of the University of California

Listing 1 continued:

```
setheading :axis + 90
forward :spacing + :width
draw.bars :axis :width :spacing :2.or.3 butfirst :values
end

to draw.1.bar :s.or.o :2.or.3 :height :width :depth :zdeg
(local "origin "direction)
make "origin pos
make "direction heading
if :s.or.o = "o
    [make "proc "open.bar]
    [make "proc "solid.bar]
run (list :proc :height :width)
if 2.or.3 = 2
    [stop]
forward :height
right 90 - :zdeg
forward :depth
right :zdeg
forward :width
right 180 - :zdeg
forward :depth
back :depth
left 90 - :zdeg
forward :height
right 90 - :zdeg
forward :depth
penup setpos :origin pendown
setheading :direction
end

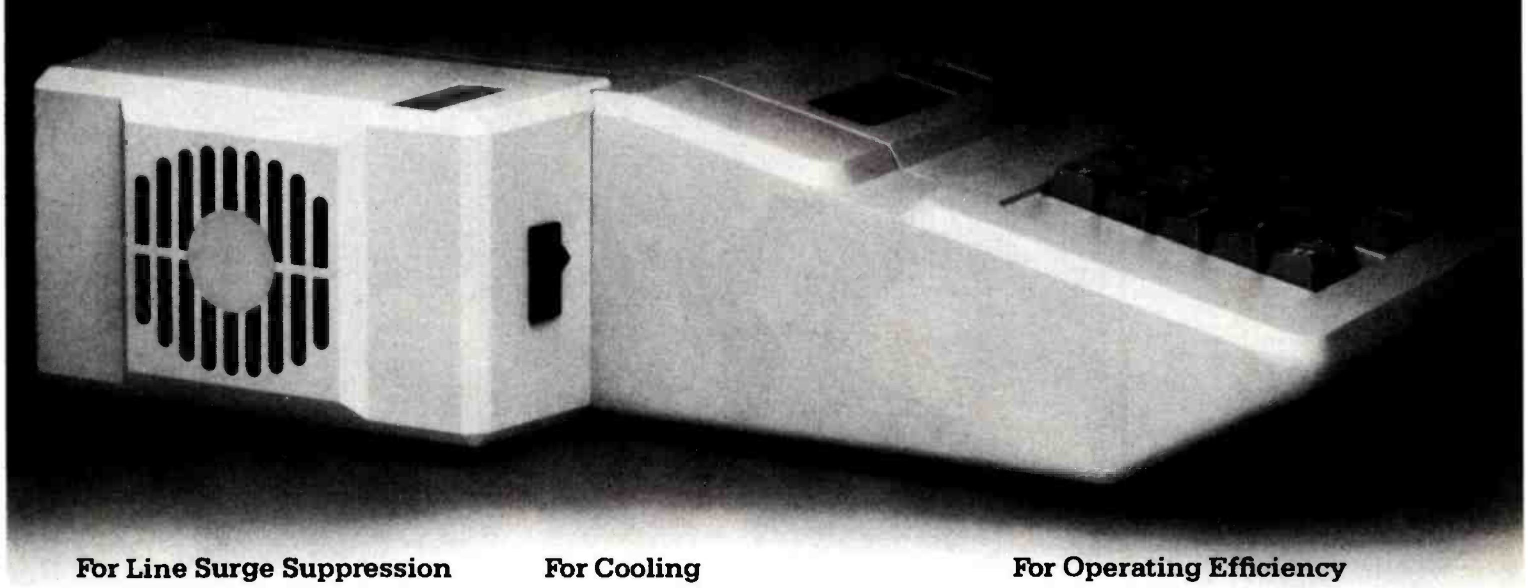
to open.bar :height :width
repeat 2 [forward :height right 90 forward :width right 90]
end
to line :pos1 :pos2
if not emptyp :pos1
    [penup setpos :pos1 pendown]
make "pos1 pos
setheading towards :pos2
forward sqrt sum
    sq ((first :pos1) - (first :pos2))
    sq ((last :pos1) - (last :pos2))
end

to sq :num
output :num * :num
end

to solid.bar :height :width
(local "course "origin)
make "course heading
make "origin pos
repeat :width / 2 [forward :height right 90 forward 1 right 90
    forward :height left 90 penup forward 1 pendown left 90]
if remainder :width 2 = 1
    [forward :height]
penup setpos :origin pendown
setheading :course
end
```

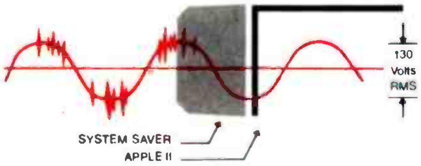
System Saver™

The most important peripheral for your Apple II and IIe.



For Line Surge Suppression

The SYSTEM SAVER provides essential protection to hardware and data from dangerous power surges and spikes.

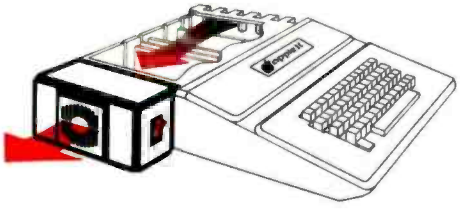


By connecting the Apple II power input through the SYSTEM SAVER, power is controlled in two ways: 1) Dangerous voltage spikes are clipped off at a safe 130 Volts RMS/175 Volts dc level. 2) High frequency noise is smoothed out before reaching the Apple II. A PI type filter attenuates common mode noise signals by a minimum of 30 dB from 600 khz to 20 mhz, with a maximum attenuation of 50 dB.

For Cooling

As soon as you add 80 columns or more memory to your Apple II you need SYSTEM SAVER.

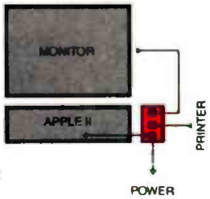
Today's advanced peripheral cards generate more heat. In addition, the cards block any natural air flow through the Apple II creating high temperature conditions that substantially reduce the life of the cards and the computer itself.



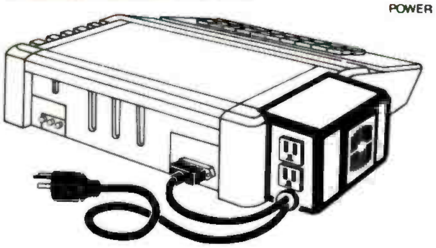
SYSTEM SAVER provides correct cooling. An efficient, quiet fan draws fresh air across the mother board, over the power supply and out the side ventilation slots.

For Operating Efficiency

SYSTEM SAVER contains two switched power outlets. As shown in the diagram, the SYSTEM SAVER efficiently organizes your system so that one convenient, front mounted power switch controls SYSTEM SAVER, Apple II, monitor and printer.



Available In 220/240 Volt. 50 Hz



The heavy duty switch has a pilot light to alert when system is on. You'll never use the Apple power switch again!

Easy Installation

Just clips on.
No mounting or
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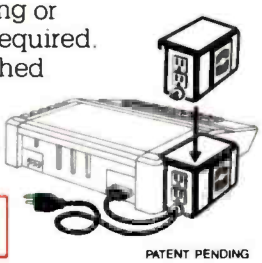
Color matched
to Apple II.



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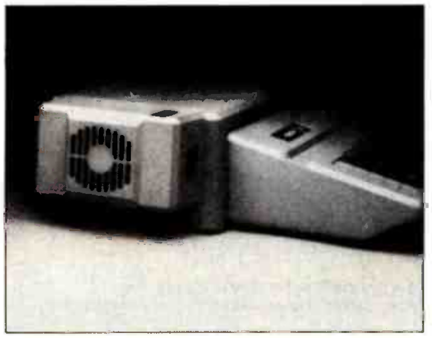
PATENT PENDING

Compatible with Apple Stand



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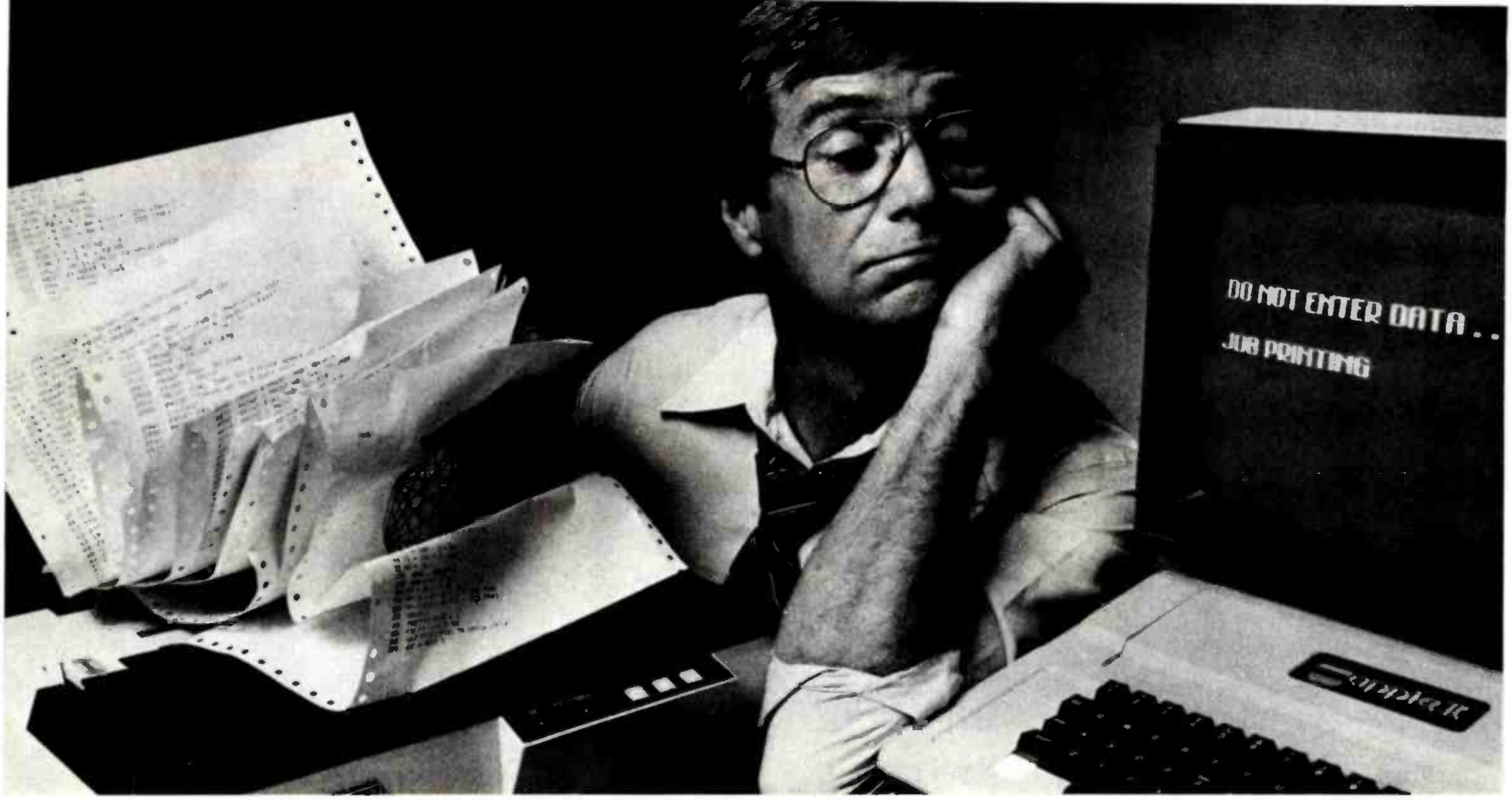
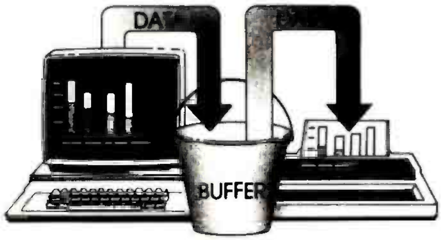


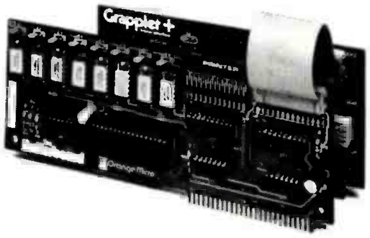
If your printer uses your Apple® more than you do, you need The Bufferboard.™

If your Apple is locked into the "PRINT" mode so much that you've taken up solitaire to kill the boredom, you need a buffer. And if your computer is the Apple II or III, the only buffer for you is The Bufferboard. Expandable to 64K of storage, The Bufferboard stores an instantaneous **bucketful** of print data from your computer. Then it feeds the data to your printer at its own printing rate. Your Apple is set free from driving your printer and is ready for more data from you.



Take your existing interface— and buffer it!

Only The Bufferboard has a simple Interface-Docking System. No bulky boxes or expensive power supplies are needed because The Bufferboard fits right into your Apple—and **docks** onto your existing printer interface. The result is convenient and economical buffering of most popular printer interfaces, including the Grappler +™ interface, Epson interface, and Apple printer interface. Thirty seconds and a single hook-up are all you need to end the printer waiting game forever.



Up to 20 letter-size pages stored at a time.

The Bufferboard comes standard with 16K, and is expandable to 32K or 64K of buffering capacity with the addition of memory chips. This "bucket" will hold up to 20 pages of a print job, allowing you freedom to use your Apple.

The Bufferboard—designed exclusively for the Apple Computer.

Specifications:

• Versions for Grappler + interface, Epson interface, Apple interface, and other popular printer interfaces • 16K buffer standard • Upgradeable to 32K or 64K • Automatic memory configuration • Automatic self test • Includes interface docking cable.

The Bufferboard is made by Orange Micro, Inc.; the same people who brought you the popular Grappler + printer interface. Both the Grappler + and The Bufferboard are now available at your local Apple dealer.

Orange Micro Inc.

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The Bufferboard™
For Apples and Printers

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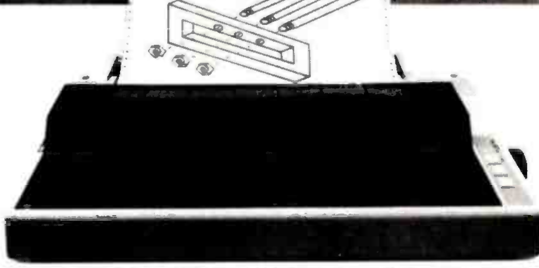

ACTUAL APPLE II PRINTOUT USING GRAPPLER AND EPSON MX100

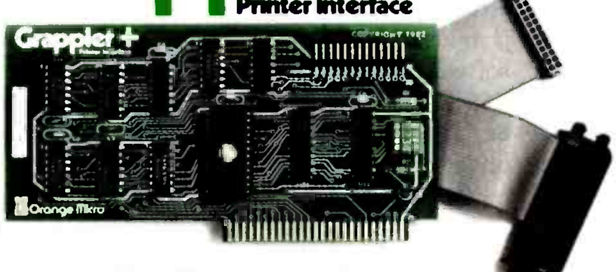
COMPLETELY REDESIGNED.
NOW, THE GRAPPLER + .

The original Grappler was the first graphics interface to give you hi-res screen dumps from your keyboard. The new Grappler + adds flexibility with on-board printer selection and 23 different commands for text and graphics. Exclusive *Dual Hi-Res Graphics* allow a side-by-side printout of graphics pages 1 and 2.

The Grappler + is compatible with the Apple II, II +, IIe and III* computers. Its extensive printer menu has been expanded to include the Apple Dot Matrix, Okidata 84 and Star Gemini, along with most popular printers. In addition, the IDS Grappler + is currently available with color capability, including color graphics screen dumps.

UP TO 64K BUFFER OPTION
An optional Bufferboard can now be added to all existing Grappler and Grappler + Interfaces. See your Apple Dealer for details.

With The Grappler™ + Printer Interface



NOW AVAILABLE THE BUFFERED GRAPPLER +

The best of both worlds . . . the Buffered Grappler +

All of the popular Grappler + features with the time-saving benefits of a printer buffer.

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- Expandable to 64K
- Interfaces with all popular dot matrix printers

Make the most of your Apple and printer, with the Grappler + or the Buffered Grappler + .

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*Requires additional software driver.

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An Inside Look at MS-DOS

The design decisions behind the popular operating system

Tim Paterson
Seattle Computer Products
1114 Industry Dr.
Seattle, WA 98188

The purpose of a personal computer operating system is to provide the user with basic control of the machine. A less obvious function is to furnish the user with a high-level, machine-independent interface for application programs, so that those programs can run on two dissimilar machines, despite the differences in their peripheral hardware. Having designed an 8086 microprocessor card for the S-100 bus and not finding an appropriate disk operating system on the market, Seattle Computer Products set about designing MS-DOS. Today MS-DOS is the most widely used disk operating system for personal computers based on Intel's 8086 and 8088 microprocessors.

MS-DOS Design Criteria

The primary design requirement of MS-DOS was CP/M-80 translation compatibility, meaning that, if an 8080 or Z80 program for CP/M were translated for the 8086 according to Intel's published rules, that program would execute properly under MS-DOS. Making CP/M-80 translation compatibility a requirement served to promote rapid development of 8086 software, which, naturally, Seattle Computer was interested in. There was partial success: those software developers who chose to translate their CP/M-80 programs found that they did indeed run under MS-DOS, often on the first try. Unfortunately, many of the software developers Seattle Computer talked to in the earlier days preferred to simply ignore MS-DOS. Until the IBM Personal Computer was announced, these developers felt that CP/M-86 would be *the* operating system of 8086/8088 computers.

Other concerns crucial to the design of MS-DOS were speed and efficiency. Efficiency primarily means making as much disk space as possible available for storing data by minimizing waste and overhead. The problem of speed was attacked three ways: by minimizing the number of disk transfers, making the needed disk transfers happen as quickly as possible, and reducing the DOS's "compute time," considered overhead by an application program. The entire file structure and disk interface were developed for the greatest speed and efficiency.

The last design requirement was that MS-DOS be written in assembly language. While this characteristic does help meet the need for speed and efficiency, the reason for including it is much more basic. The only 8086 software-development tools available to Seattle Computer at that time were an assembler that ran on the Z80 under CP/M and a monitor/debugger that fit into a 2K-byte EPROM (erasable programmable read-only memory). Both of these tools had been developed in house.

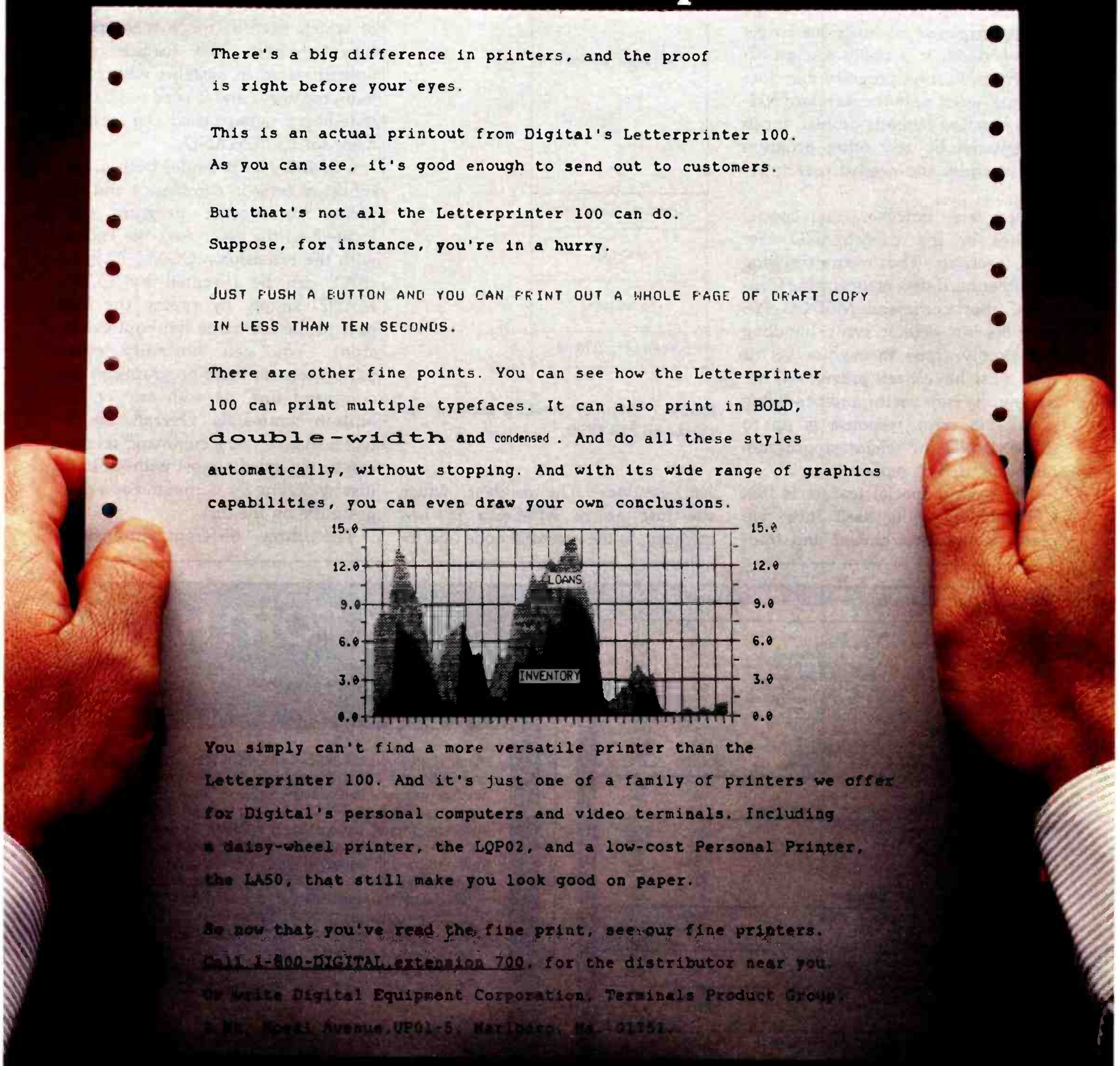
MS-DOS Organization

The core of MS-DOS is a device-independent input/output (I/O) handler, represented on a system disk by the hidden file MSDOS.SYS. It accepts requests from application programs to do high-level I/O, such as sequential or random access of named disk files, or communication with character devices such as the console. The handler processes these requests and converts them to a very low level form that can be handled by the I/O system. Because MSDOS.SYS is hardware independent, it is nearly identical in all MS-DOS versions provided by manufacturers with their equipment. Its relative location in memory is shown in figure 1.

The I/O system is totally device dependent and is represented on the disk by the hidden file IO.SYS. It is normally written by hardware manufacturers (who know their equipment best, anyway) with the notable exception of IBM, whose I/O system was written to IBM's specifications by Microsoft. The tasks required of the I/O system, such as outputting a single byte to a character device or reading a contiguous group of physical disk sectors into memory, are as simple as possible.

The command processor furnishes

Before you buy a printer look at the fine print.



There's a big difference in printers, and the proof is right before your eyes.

This is an actual printout from Digital's Letterprinter 100. As you can see, it's good enough to send out to customers.

But that's not all the Letterprinter 100 can do. Suppose, for instance, you're in a hurry.

JUST PUSH A BUTTON AND YOU CAN PRINT OUT A WHOLE PAGE OF DRAFT COPY IN LESS THAN TEN SECONDS.

There are other fine points. You can see how the Letterprinter 100 can print multiple typefaces. It can also print in **BOLD**, double-width and condensed. And do all these styles automatically, without stopping. And with its wide range of graphics capabilities, you can even draw your own conclusions.

You simply can't find a more versatile printer than the Letterprinter 100. And it's just one of a family of printers we offer for Digital's personal computers and video terminals. Including a daisy-wheel printer, the LQP02, and a low-cost Personal Printer, the LA50, that still make you look good on paper.

So now that you've read the fine print, see our fine printers. Call 1-800-DIGITAL, extension 700, for the distributor near you. Or write Digital Equipment Corporation, Terminals Product Group, 2 Mt. Royal Avenue, UP01-5, Marlboro, Ma. 01751.

digital

the standard interface between the user and MS-DOS and is contained in the visible file COMMAND.COM. The processor's purpose is to accept commands from the console, figure out what they mean, and execute the correct sequence of functions to get the job done. It is really just an ordinary application program that does its work using only the standard MS-DOS function requests. In fact, it can be replaced by any other program that provides the needed user interface.

There are, however, two special features of the COMMAND file. First, it sets up all basic error trapping for either hard-disk errors or the Control-C abort command. MSDOS.SYS provides no default error handling but simply traps through a vector that must have been previously set. Setting the trap vector and providing a suitable error response is up to COMMAND (or whatever program might be used to replace it).

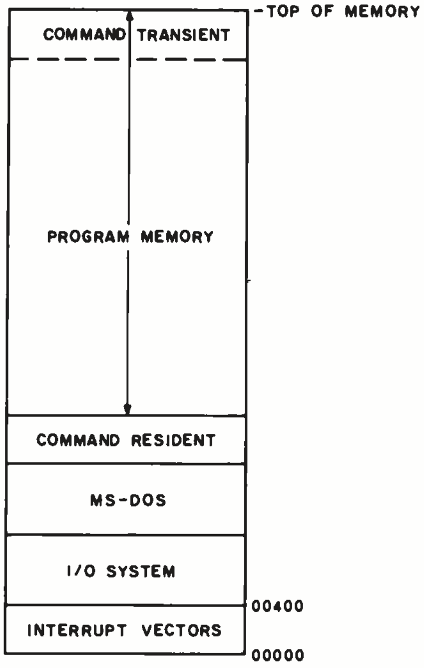


Figure 1: *Map of memory areas as assigned by MS-DOS.*

The second special feature is that COMMAND splits itself into two pieces, called the *resident* and *transient* sections. The resident, which sits just above MS-DOS in low memory, is the essential code and includes error trapping, batch-file processing, and reloading of the transient. The transient interprets user commands; it resides at the high end of memory where it can be overlaid with any applications program (some of which need as much memory as they can get). This feature is of limited value in systems with large main memory, and it need not be imitated by programs used as a replacement for COMMAND.

COMMAND provides both a useful set of built-in commands and the ability to execute program files located on the disk. Any file ending with the extensions .COM, .EXE, or .BAT can be executed by COMMAND simply by typing the first part of the file name (without extension). You can normally enter parameters for these programs on the command line, as with any of the built-in commands. Overall, the effect is to give you a command set that can be extended almost without limit just by adding the command as a program file on the disk.

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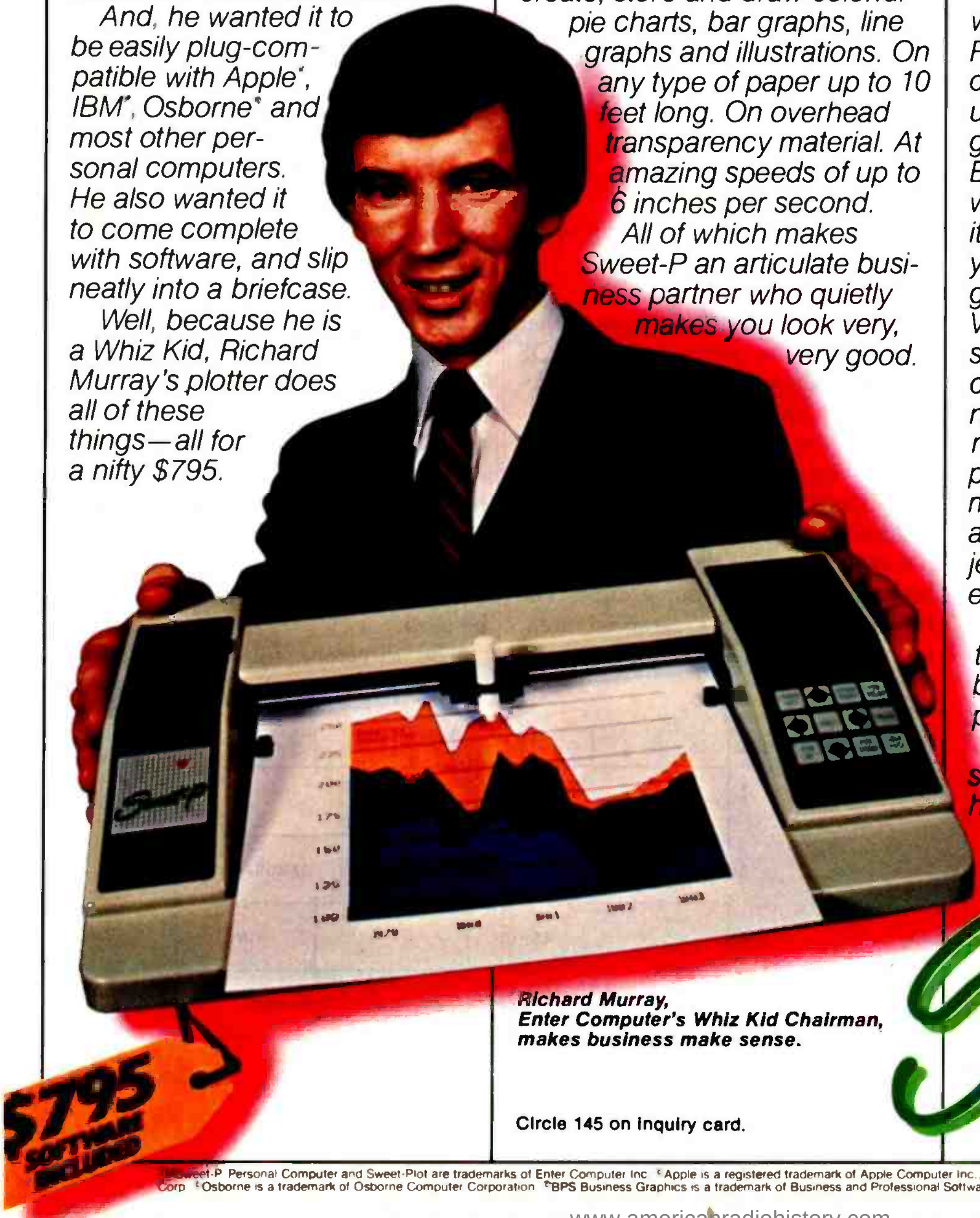

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allowed on program files represent different internal file formats.

- .COM files are pure binary programs that will run in any 8086 memory segment; in order for this to be possible, the program and data would ordinarily have to be entirely in one 64K-byte segment.
- .EXE files include a header with relocation information so that the program may use any number of segments; all intersegment references are adjusted at load time to account for the actual load segment.
- .BAT (batch) files are text files with commands to be executed in sequence by COMMAND.

File Structure

Disks are always divided up into tracks and sectors, as shown in figure 2. To access any particular block of data, the program first moves to the correct track, then has you wait while the spinning disk moves the correct sector under the head.

A somewhat more abstract view of disks was taken in developing MS-DOS. MS-DOS views the disk, not in terms of tracks and sectors, but as a continuous array of n logical sectors, numbered from 0 to $n-1$. Figure 2 shows the usual method of numbering the logical sectors. Logical sector 0 is the first sector of the outermost track; the rest of the track (and the next, etc.) is numbered sequentially. Logical sector $n-1$ is the last sector on the innermost track.

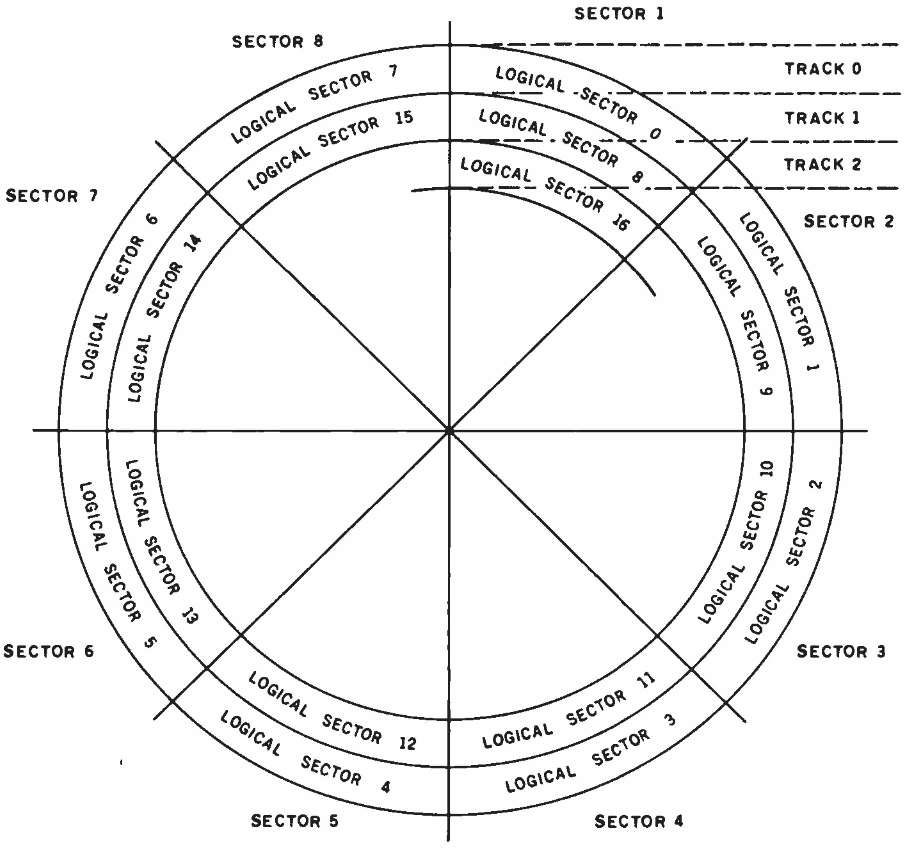

Figure 2: *Placement of disk sectors in IBM Personal Computer (single-sided) format.*

The mapping of logical sectors to physical track and sector is done by the hardware-dependent I/O System and is completely transparent to the MS-DOS file system. Any other method may be used, and MS-DOS wouldn't know the difference. Having a standard mapping, however, is essential for interchanging disks between computer systems with different peripheral hardware.

As shown in table 1, the MS-DOS file system divides the linear array of logical sectors into four groups. The first of these is the reserved area, whose purpose is to hold the bootstrap loader. Because the loader is usually very simple, only one sector is normally reserved.

The FAT (file allocation table), a map of how space is distributed among all files on the disk, comes next. Because it is so important, two copies are usually kept side by side. If one copy cannot be read because of a failure in the medium, the second will be used.

The directory follows the FAT.

Logical Sector Numbers	Use
0	Reserved for bootstrap loader
1—6	FAT 1 } file allocation
7—12	FAT 2 } tables (FATs)
13—29	Directory
30—2001	Data

Table 1: *Map of disk areas on an 8-inch single-sided, single-density floppy disk.*

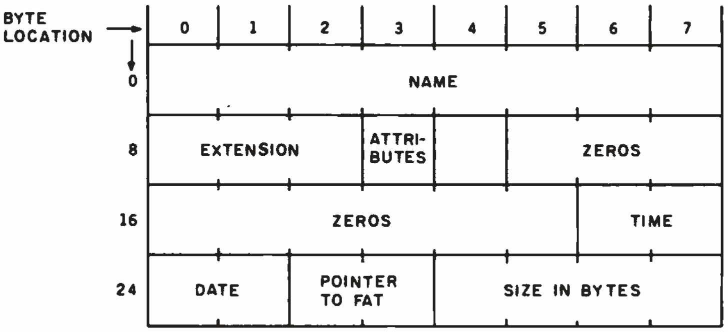

Figure 3: *Arrangement of bytes in disk directory entry.*

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Logical Sector Numbers	Allocation Unit Number
30—33	2 (first allocation unit)
34—37	3
38—41	4
42—45	5
•	•
•	•
•	•
1998—2001	494

Table 2: *Allocation unit numbering for the 8-inch single-density format. To compute the logical sector number of the first sector in an allocation unit, you use the following equation: sector number = 4 × allocation unit number + 22.*

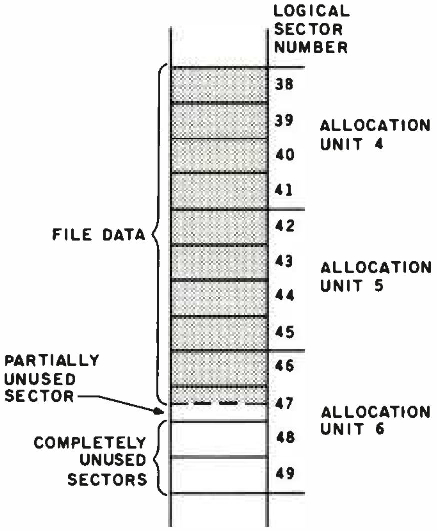

Figure 4: *Assignment of logical sectors to allocation units. Note that, in the file shown, more than two sectors are wasted because they are in an unused part of the last allocation unit.*

Each file on the disk has one 32-byte entry in the directory, which includes the file name, size, date and time of last write, and special attributes. Each entry also has a pointer to a place in the FAT that tells where to find the data in the file. Figure 3 shows the layout of a directory entry.

The rest of the disk is the data area. It is divided into many small, equal-sized areas called *allocation units.* Each unit may have 1, 2, 4, 8, 16, 32, 64, or 128 logical sectors, but the number is fixed for a given disk format. Allocation units are numbered sequentially. The numbering starts with 2; the first two numbers, 0 and 1, are reserved. Table 2 shows this numbering system applied to the 8-inch single-density disk format.

The allocation unit is the smallest unit of space MS-DOS can keep track of. The amount of space used on the disk for each file is some whole number of allocation units. Even if the file is only 1 byte long, an entire unit will be dedicated to it.

For example, the standard format for 8-inch single-density disks uses four 128-byte sectors per allocation unit. When a new file is first created, no space is allocated, but an entry is made in the directory. Then when the first byte is written to the file, one allocation unit (four sectors) is assigned to the file from the available free space. As each succeeding byte is written, the size of the file is kept updated to the exact byte, but no more space is allocated until those first four sectors are completely full. Then to write 1 byte more than those four sectors worth, another four-sector allocation unit is taken from free space and assigned to the file.

When writing stops, the last allocation unit will be filled by some random amount of data (figure 4). The unused space in the last allocation unit is wasted and can never be used as long as the file remains unchanged on the disk. This wasted space is called *internal fragmentation,* because it is part of the space allocated to the file but is an unusable fragment. On the average, the last allocation unit (regardless of size) will be half filled and, therefore, half wasted. Because each file wastes an average of one-half an allocation unit, the total amount of space wasted on a disk due to internal fragmentation is the number of files times one-half the allocation unit size.

The phenomenon called *external fragmentation* occurs when a piece of data space is unallocated yet remains unused because it is too small. This cannot happen in the MS-DOS file system because MS-DOS does not require files to be allocated contiguously. It is, however, present in more primitive systems, such as the UCSD p-System.

It would certainly seem desirable to minimize internal fragmentation by making the allocation unit as small as possible—always one sector, for example. However, for any given disk size, the smaller the unit, the more there must be. Keeping track of all those units can get to be a problem. Specifically, the amount of space required in the file allocation table would be quite large if there were too many small allocation units. For every unit, 1.5 bytes are required in the FAT; there are normally two FATs on the disk, each of which is rounded up to a whole number of sectors.

Now take a standard 8-inch single-density floppy disk that has 2002 sectors of 128 bytes. To minimize internal fragmentation, choose the smallest possible allocation-unit size of one sector. Two thousand allocation units will require 3000 bytes (24 sectors) per FAT, or 48 sectors for two FATs. If the average file size is 16K bytes (128 sectors), the disk will be full when there are 16 files on it. Waste due to internal fragmentation would be

16 files × 64 bytes per file =
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Far more space is occupied by the FATs on the disk than is wasted by internal fragmentation!

To provide maximum usable data space on the disk, both internal fragmentation and FAT size must be considered because both consume data area. The standard MS-DOS format for 8-inch single-density disks strikes a balance by using four sectors per allocation unit. Two sectors per unit would have been just as good (assuming a 16K-byte average file size), but there is another factor that always favors smaller FATs and larger allocation units: the entire FAT is kept in main memory at all times.

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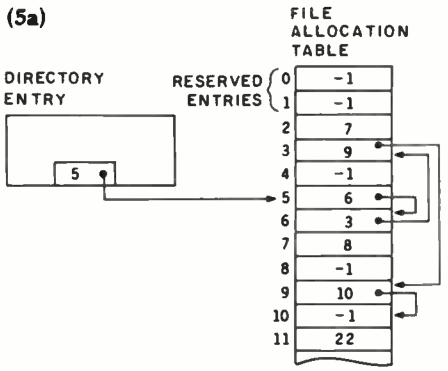

(5b)

```
FF   FF   FF   07   90   00   FF   6F

00   03   80   00   FF   AF   00   FF

6F   01
```

Figure 5: *Finding data via the directory and the file allocation table. Figure 5a shows how pointers are used to direct the operating system to the sequential parts of a file. The data stored in the sample file-allocation table is displayed in hexadecimal in figure 5b.*

or randomly without going to disk except for the data access itself. Schemes used in other operating systems (including CP/M and Unix) may require one or more disk reads simply to find out where the data is, particularly with a random access. In an application such as a database inquiry, where frequent random access is the rule, this can easily make a 2 to 1 difference in performance.

How the FAT Works

The directory entry for each file has one allocation unit number in it: the number of the first unit in the file. If, as in the previous example, an allocation unit consists of four sectors of 128 bytes each, then just by looking at the directory you know where to find the first 512 bytes of the file. If the file is larger than this, you go to the FAT.

The FAT is a one-dimensional array of allocation unit numbers. As with any array, a given element is found with a numeric index. The numbers used as indexes into the FAT are also allocation unit numbers. Think of the FAT as a map, or translation table, that takes an allocation unit number as input and returns a different allocation unit number as output. The input can be any unit that is part of a file; the number returned is the next sequential unit of that file.

Let's look at the example in figure 5a. Suppose that the directory entry for a file specifies allocation unit number 5 as the first of the file. This locates the first four logical sectors (512 bytes). To find the next allocation unit of the file, look at entry 5 in the file allocation table. The 6 there tells you two things: first, the next four logical sectors of the file are in allocation unit number 6; and second, to find the unit after that, look at FAT entry number 6.

This process is repeated as you locate each allocation unit in the file. After number 6 comes number 3, then number 9, then number 10. In each case, the allocation unit number returned by the FAT tells you both

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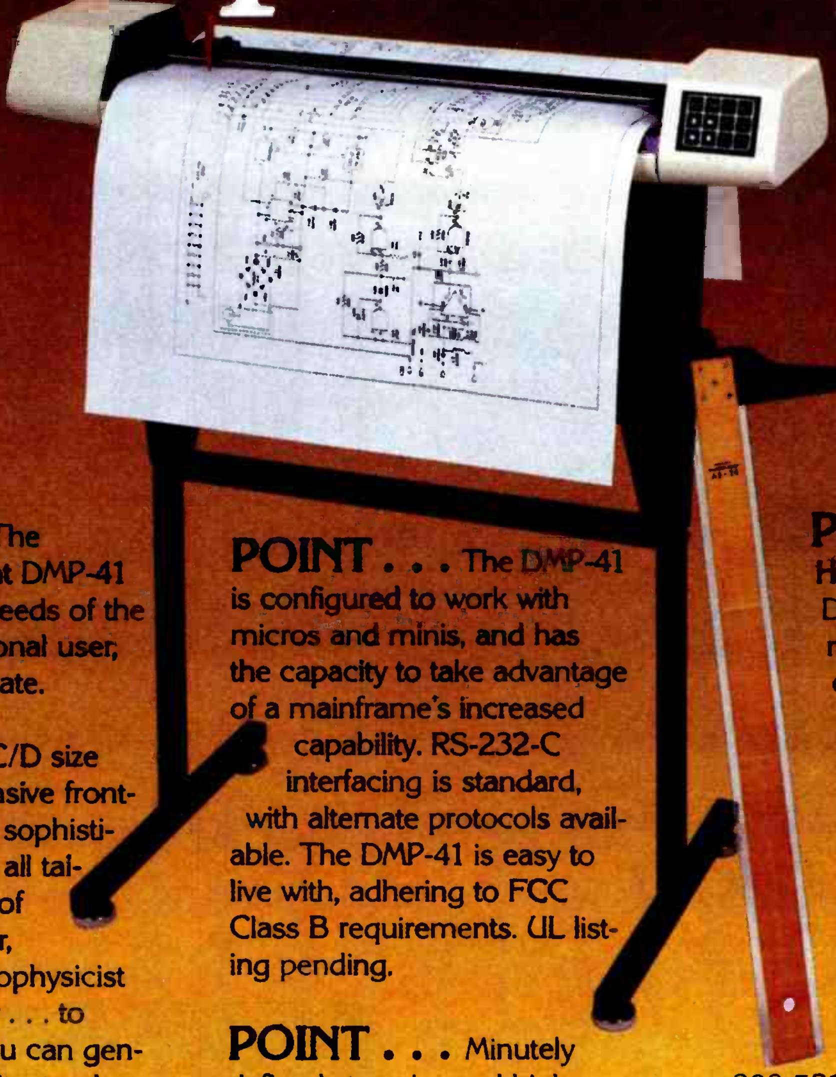

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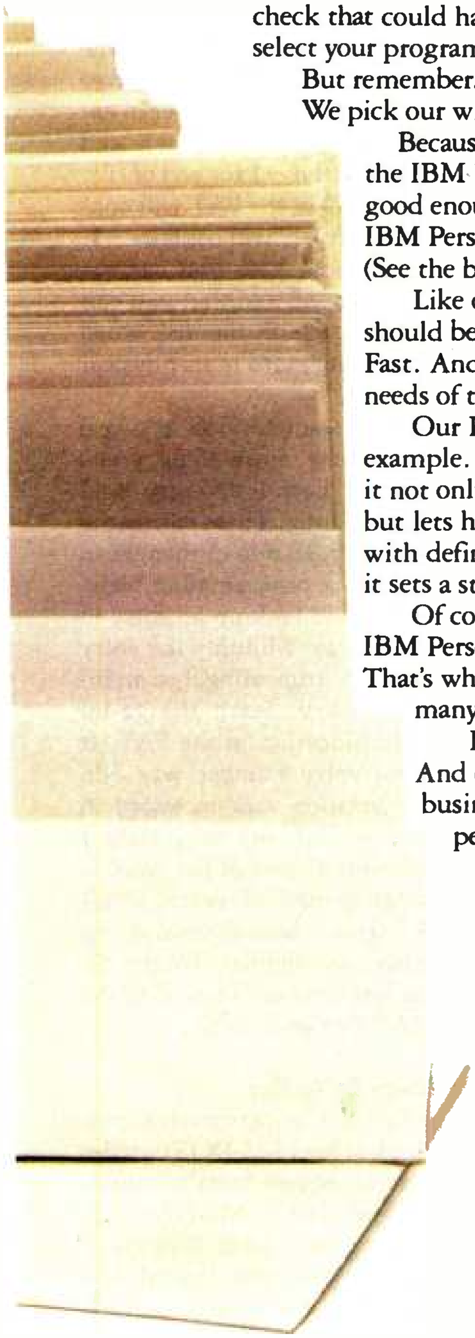

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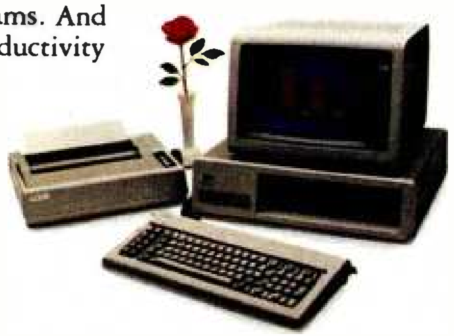

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where the data is (i.e., in which unit) and where to look in the FAT for the next allocation unit number.

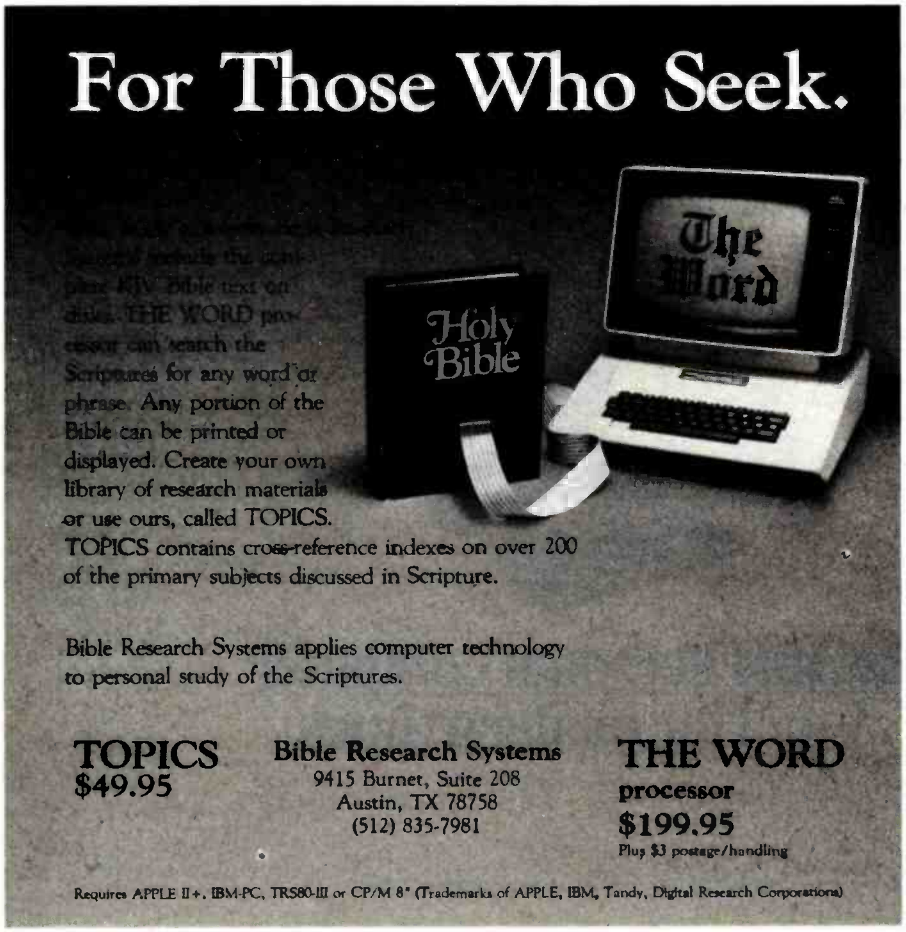
If you followed the example all the way through, you should have noticed that entry 10 in the FAT contains a −1. This, as you might have guessed, is the end-of-file mark. Allocation unit number 10 is last in the file, so its entry contains this special flag. (Another special value in the FAT is 0, which marks a free allocation unit.)

Now you know that this file occupies five allocation units, numbers 5, 6, 3, 9, and 10 in order. The file could be extended by finding *any* free unit, say 27, putting its number in entry 10 (where the −1 is now), and marking it with the −1 for end of file. That is, entry 10 in the FAT will contain 27, and entry 27 will contain −1. This demonstrates how you can extend any file at will and that you can use any free space on the disk when needed, without regard to its physical location.

If you ever want to look at a real FAT, there's one more thing you'll need to know. Each FAT entry is 12 bits (1.5 bytes) long. These entries are packed together, so two of them fit in 3 bytes. From a programming viewpoint, you would look up an entry in the FAT this way: Multiply the entry number by 1½, truncating it to an integer if necessary. Fetch the 16-bit word at that location in the FAT. If the original entry number was odd (so that truncation was necessary in the first step), shift the word right 4 bits; the lowest 12 bits of the word is the contents of the FAT entry. Reading a FAT from a hexadecimal dump isn't nearly as simple! Figure 5b shows the hexadecimal version of the sample FAT I've been using.

File System in Action

To put all this in perspective, you need to look at how MS-DOS handles a file-transfer request from an application program. With MS-DOS, application programs treat files as if they were divided into logical records. The size of the logical record is entirely dependent on the application and may range from 1 byte to 65,535 bytes. It is not a permanent feature of



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(6a)

$$\frac{\text{byte position 1200}}{128\,\frac{\text{bytes}}{\text{sector}}} = 9\text{, remainder 48}$$

Therefore, first byte to transfer is sector 9, byte 48

128 − 48 = 80 bytes to transfer in first sector
1200 − 80 = 1120 bytes left after first sector

$$\frac{\text{1120 bytes}}{128\,\frac{\text{bytes}}{\text{sector}}} = 8\text{, remainder 96}$$

Therefore, transfer 8 whole sectors, then 96 bytes of last sector

---

(6b)

$$\frac{\text{9 sectors}}{4\,\frac{\text{sectors}}{\text{allocation unit}}} = 2\text{, remainder 1}$$

Therefore, first sector to transfer is allocation unit 2, sector 1.

Figure 6: *Calculating physical, byte-level operations from logical definitions. The process outlined in figure 6a shows how the amount of data is calculated in physical terms. The actual position of data on the disk is computed in figure 6b.*

a file but in fact may vary from one file-transfer request to the next. The logical record size currently being used is passed to MS-DOS for each transfer made. It is, of course, completely independent of the physical sector size the disk uses.

To read a file, an application program passes to MS-DOS the size of a logical record, the first logical record to read, and the number of sequential logical records to read. Let's follow an example of how MS-DOS uses this information. Assume the application program is using 80-byte records and is set up to read a file 15 records at a time. Let's pick things up on its second read, that is, after it has already taken the first 15 records and is about to read the second 15. The request will be for an 80-byte record, the first record is number 15, and you want to read 15 records. Now pretend you're MS-DOS and analyze this request.

You immediately convert the request into byte-level operations. First multiply the logical record size by the record number, to get the byte position to start reading (80 × 15 = 1200). Then multiply the record size by the number of records, to get the number of bytes to transfer (also 1200).

Next, these numbers must be put in terms of physical disk sectors. This requires some divisions and subtractions involving the physical sector size and results in the breakdown of the transfer into three distinct pieces: (1) the position in the file of the first physical sector and the first byte within that sector to be transferred, (2) the number of whole sectors to transfer after the first (partial) sector, and (3) the number of bytes of the last (partial) sector to be transferred. The calculations and their results are shown in figure 6a. It is quite common for one or two of these pieces to be of length 0, in which case some of the following steps are not performed.

At this point, there is still no hint as to where the data will actually be found on the disk. You know that you want the tenth sector of the file (sector 9 because you start counting with 0), but you're not yet ready to check with the FAT to see where it is. The sector position in the file must be broken into two new numbers: the allocation unit position in the file and the sector within the allocation unit. For this example with single-density 8-inch disks (four sectors per allocation unit), this would be the third unit from the start of the file and the second sector within the unit (figure 6b).

What you need to do now is skip through the FAT to the third allocation unit in the file. If your file is the same one shown in figure 5, then from the directory entry you learn that the first unit is number 5. Looking at entry 5 of the FAT, you see the second unit is number 6. And finally, from entry 6 of the FAT, you find the third unit of the file, number 3. Table 2 reminds you that allocation unit number 3 is made up of physical sectors 34, 35, 36, and 37; therefore, physical sector 35 is what you are looking for.

Now the disk reads begin. Physical sector 35, only part of which is needed, is read into the single buffer kept in MS-DOS solely for this purpose. Then that part of the sector that is needed is moved as a block into the place requested by the application program.

Next, the whole sectors are read. MS-DOS looks ahead in the FAT to see if the allocation units to be transferred are consecutive. If so, they are combined into a single multiple-sector I/O system transfer request, which allows the I/O system to optimize the transfer. This is the primary reason why MS-DOS disks do not ordinarily use any form of sector interleaving: a well-written I/O system will be able to transfer consecutive disk sectors if told to do it in a single request. The overhead of making the request, however, would often be too great to transfer consecutive sectors if it were done on a sector-by-sector basis.

Back to the example. MS-DOS will request that the I/O system read sectors 36 and 37 directly into the memory location called for by the application. Then, noting that allocation units 9 and 10 are consecutive, the corresponding sectors 58, 59, 60, and 61 from unit 9 and sectors 62 and 63 from unit 10 will be read by the I/O system in a single request. This completes the transfer of the eight whole sectors.

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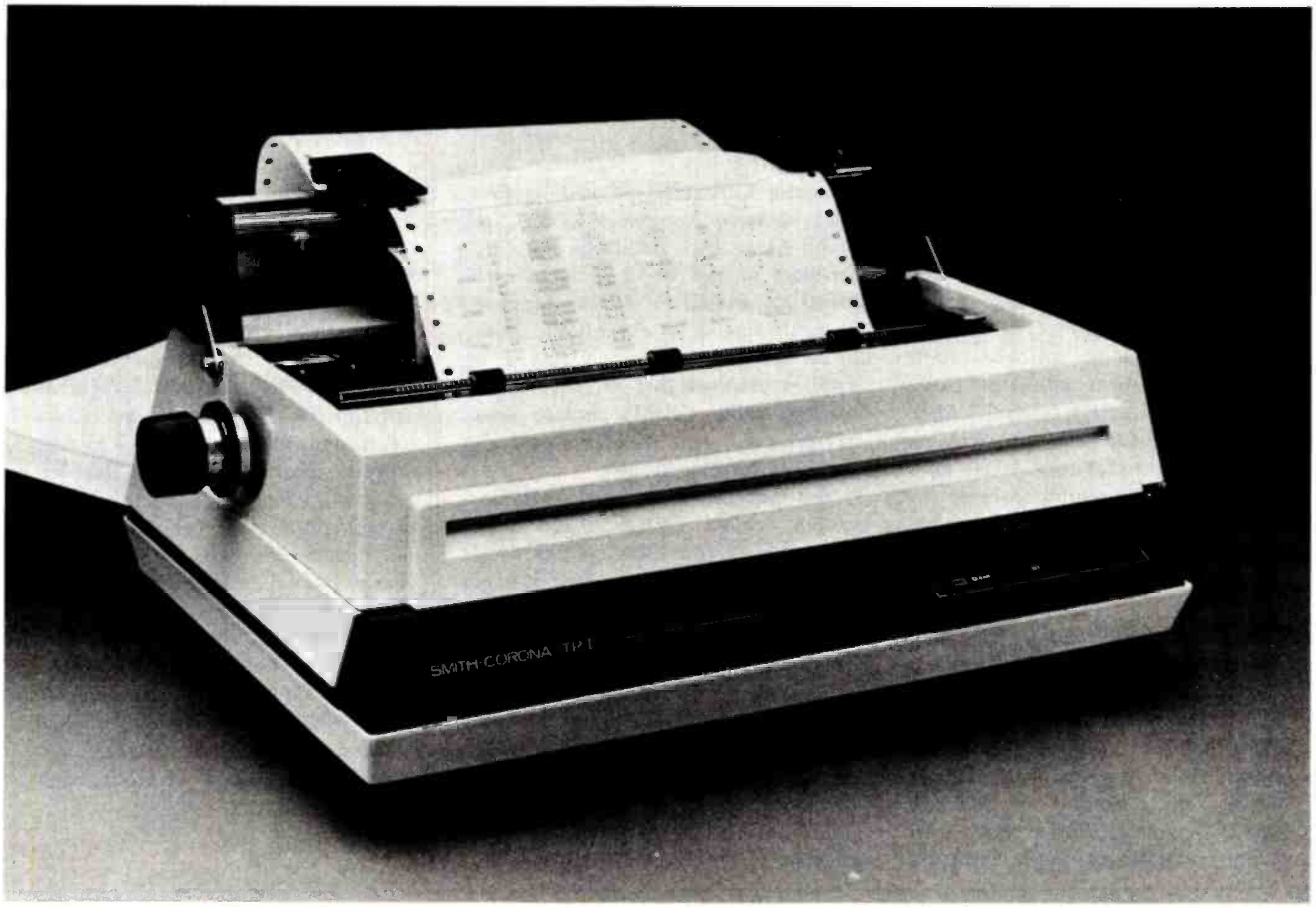

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A Short History of MS-DOS

Known variously as Seattle Computer 86-DOS, IBM Personal Computer DOS, and Zenith Z-DOS, MS-DOS was developed by Seattle Computer Products for its 8086-based computer system. The MS-DOS history is intertwined with the general development of software for 8086-based computers.

In May 1979, Seattle Computer made the first prototype of its 8086 microprocessor card for the S-100 bus. There were brief discussions with Digital Research about using one of Seattle Computer's prototypes to aid in developing CP/M-86, which was to be ready "soon." Although Seattle Computer was considering using CP/M-86 when it became available (expected no later than the end of 1979), there were only two working prototypes of the 8086 processor card, and it was felt that both were needed in house. Therefore, there wasn't one free for Digital Research.

Microsoft had already started a strong 8086 software-development program. The firm was ready to try the 8086 version of Stand-Alone Disk BASIC, which is a version of its BASIC interpreter with a built-in operating system. During the last two weeks of May 1979, this BASIC was made completely functional using the hardware that Seattle Computer provided for Microsoft. Seattle Computer Products displayed the complete package (8086 running disk BASIC) in New York the first week of June at the 1979 National Computer Conference. (This was the first-ever public display of an 8086 BASIC and of an 8086 processor card for the S-100 bus.)

Seattle Computer shipped its first 8086 cards in November 1979, with Stand-Alone Disk BASIC as the only software to run on it. The months rolled by, and CP/M-86 was nowhere in sight. Finally, in April 1980, Seattle decided to create its own DOS. This decision resulted just as much from concern about CP/M's shortcomings as from the urgent need for a general-purpose operating system.

The first versions of the operating system, called QDOS 0.10, were shipped in August 1980. QDOS stood for Quick and Dirty Operating System because it was thrown together in such a hurry (two man-months), but it worked surprisingly well. It had all the basic utilities for assembly-language development except an editor. One week later, Seattle Computer had created an operating system with an editor, an absurdity known as EDLIN (editor of lines). A primitive line-oriented system, it was supposed to last less than six months. (Unfortunately, it has lasted much longer than that as part MS-DOS.)

In the last few days of 1980, a new version of the DOS was released, now known as 86-DOS version 0.3. Seattle Computer passed this new version on to Microsoft, which had bought non-exclusive rights to market 86-DOS and had one customer for it at the time. Also about this time, Digital Research released the first copies of CP/M-86. In April 1981, Seattle Computer Products released 86-DOS version 1.00, which was very similar to the versions of MS-DOS that are widely distributed today.

In July 1981, Microsoft bought all rights to the DOS from Seattle Computer, and the name MS-DOS was adopted. Shortly afterward, IBM announced the Personal Computer, using as its operating system what was essentially Seattle Computer's 86-DOS 1.14. Microsoft has been continuously improving the DOS, providing version 1.24 to IBM (as IBM's version 1.1) with MS-DOS version 1.25 as the general release to all MS-DOS customers in March 1982. Now version 2.0, released in February 1983, has just been announced with IBM's new XT computer.

To finish the job, sector number 64 is read into the internal MS-DOS sector buffer. Its first 96 bytes are moved to the application program's area.

The Sector Buffer

This example shows the internal MS-DOS sector buffer being used in a very simple way. In reality, MS-DOS would normally perform the disk read in the example more efficiently than described here due to its optimized buffer handling. By keeping track of the contents of the buffer, disk accesses are minimized. The resulting speed improvement can be dramatic particularly when the requested transfer size is small (a fraction of a sector).

In the example, I assumed the application program was sequentially reading 15-record chunks (at 80 bytes per record) and had already completed the first such read. This would mean that sector 35 (the first one read in this example) would already be in the sector buffer because its first 48 bytes were needed for the previous read. MS-DOS would not reread this sector but instead would simply copy the remaining 80 bytes into the area designated by the application.

The presence of only one sector buffer in MS-DOS is a design inadequacy that is difficult to defend.

Likewise, when the application is ready to read the third chunk of the file, MS-DOS will find sector 64 already in the sector buffer. The last 32 bytes of the sector will be moved into place without a disk read.

For its own internal simplicity, MS-DOS has only one sector buffer. Between the 15-record reads, should the application request some other transfer that requires use of the buffer, then the buffer contents will be changed, and these optimizations are not possible. In this particular case, in which most of the disk transfer does not need the buffer, there will be very little difference in speed either way. Let's look at a different case where this optimization is practically essential.

Suppose the application wishes to write a file sequentially, one 16-byte record at a time. When the first record is written, MS-DOS simply copies the 16 bytes into the first part of the sector buffer. As each of the next seven records is written, it too

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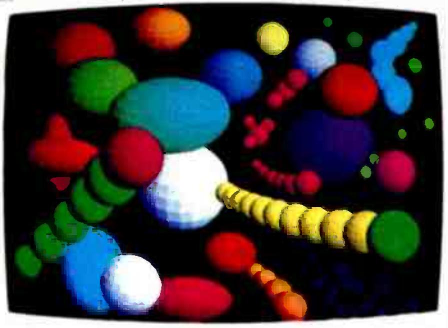

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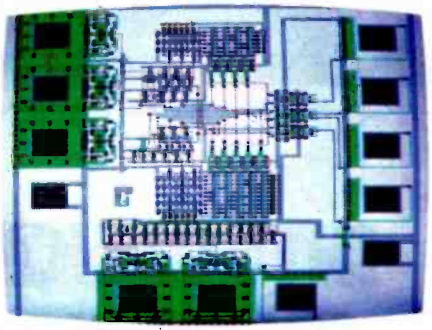

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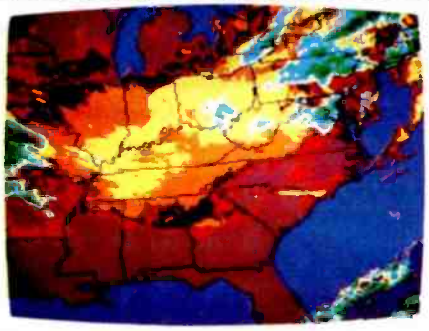

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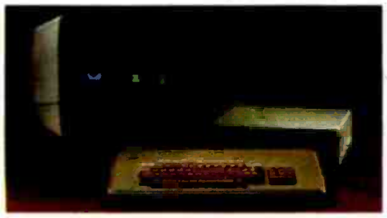

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is just copied into the appropriate position in the sector buffer. Again with a 128-byte sector of an 8-inch single-density format, the sector buffer would be full at this point. Upon attempting to write the ninth record, MS-DOS would find it needs to put the record in a different sector from the one currently in the buffer. The current buffer contents are marked "dirty," meaning they must be written to disk rather than discarded. MS-DOS does this and then moves the ninth 16-byte record into the buffer.

Note that MS-DOS did not write the sector buffer automatically after 128 bytes had been written to it. This is because the DOS has no notion of a sequential file: every disk transfer has an explicitly specified record position and record size. Thus, it does not think of the buffer as "full"—for all it knows, the application program might back up and write the first 16 bytes over again. So the data is simply kept in the buffer until the file is closed or until the buffer is needed for something else.

Another optimization was taking place here that may have gone unnoticed. MS-DOS is always aware of the exact size of its files, and the assumption in the previous example was that this file was being newly written. Had it already existed, MS-DOS would have been forced to preread each sector into the sector buffer before copying any records into it. This is essential in case the program does random writes, intending to change only selected portions of the file. When the file is being extended (as in this case), the preread is not performed.

The possible outcome of this approach to buffer handling is that when the application program requests a write and is told it was successfully completed, the data may, in fact, not yet be written to the disk. The alternative approach is called *buffer write-through*, in which the data in the sector buffer would be written to disk each time the application requested a write. This would mean, in the example, eight rewrites of the same sector before moving on to the next, requiring a minimum of 1.2 seconds to write just 128 bytes! As

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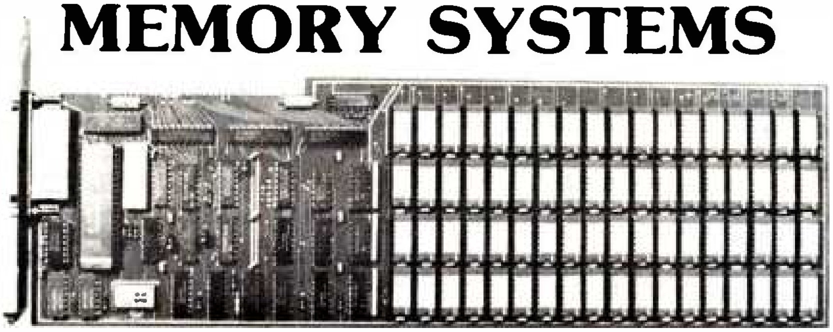

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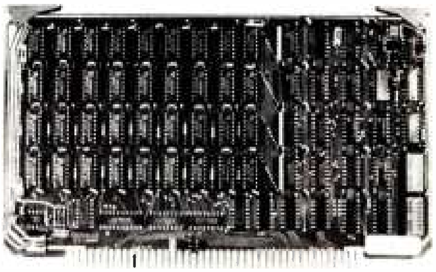

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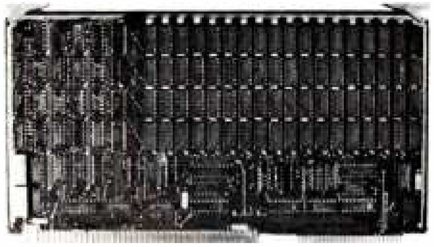

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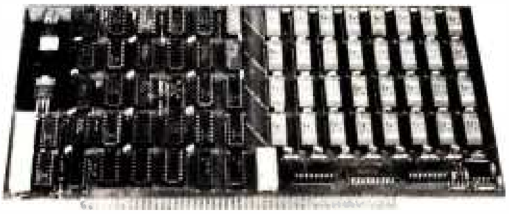

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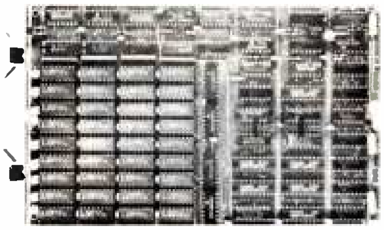

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the logical record size gets smaller, the time required to write becomes greater.

The presence of only one buffer does bring about the definite possibility of buffer "thrashing." Take the example of an application such as a compiler that will alternately read a small amount from one file and write a little bit to another. If both the reads and writes consist of a single 16-byte record, then the following sequence will be performed for each pair of records:

- read input file, get record from buffer
- read output file, put record into buffer
- write output file

For each record pair, three disk transfers are required. The result would be unbearably slow. The presence of only one sector buffer in MS-DOS is a design inadequacy that is difficult to defend (but it does help keep the DOS small). The practical solution is for applications that must access more than one file at a time to provide their own internal buffering. By requesting transfers that are at least half as big as the sector size, thrashing can be substantially reduced.

MS-DOS 2.0

Microsoft has now made available MS-DOS version 2.0 to all OEM (original equipment manufacturer) customers of previous versions. The 10 months put into version 2.0 by the MS-DOS team probably exceeds the total effort behind the previous 1.25 release, including the original development at Seattle Computer Products. While the changes have been substantial, the basic structure is still recognizable. I have been discussing the DOS at such a low level that most of what I've talked about applies directly to version 2.0 as well. Here are the three main differences, along with my personal comment as original author of the DOS. I was not involved in the MS-DOS 2.0 project.

MS-DOS 2.0 allows multiple-sector buffers. The number is determined by a configuration file when the DOS is loaded. It can be easily adjusted to the user's needs: for example, to accommodate more buffers to prevent thrashing (this is the ideal solution to the buffer thrashing problem previously discussed) and fewer buffers to make more system memory available.

The new MS-DOS does not keep the file allocation tables in memory at all times. Instead, the tables share the use of the sector buffers along with partial-sector data transfers. This means that at any one time, all, part, or none of a FAT may be in memory. The buffer-handling algorithms will presumably keep often-used sectors in memory, and this applies to individual sectors of the FAT as well. This change in the DOS goes completely against my original design principles. Memory is getting cheaper all the time, so dedicating a few thousand bytes to the FATs should be completely painless. Now we're back to doing disk reads just to find out where the data is. In the case of a random access to a large fragmented file (for example, when accessing a database that fills half of a small Winchester disk), it is possible that several sectors of the FAT would need to be visited, in random order, to find the needed allocation unit.

While MS-DOS retains the original fixed-size main directory, it now can have files as subdirectories. This hierarchical (tree-structured) directory system may be extended to any depth. This approach is nearly essential for users to keep track of all the files that might be on a hard disk.

MS-DOS version 2.0 is, on the whole, a substantial upgrade of the previous releases. The three preceding paragraphs are intended only to point out the way the 2.0 file structure differs from the file structure I've discussed, not to give you a complete product description. ■

About the Author

Tim Paterson worked for Seattle Computer Products on the design of its 8086 computer system and the operating system now called MS-DOS. He then worked for Microsoft for about a year. Since returning to Seattle Computer Products as director of engineering, he has been prinarily involved with new hardware development.

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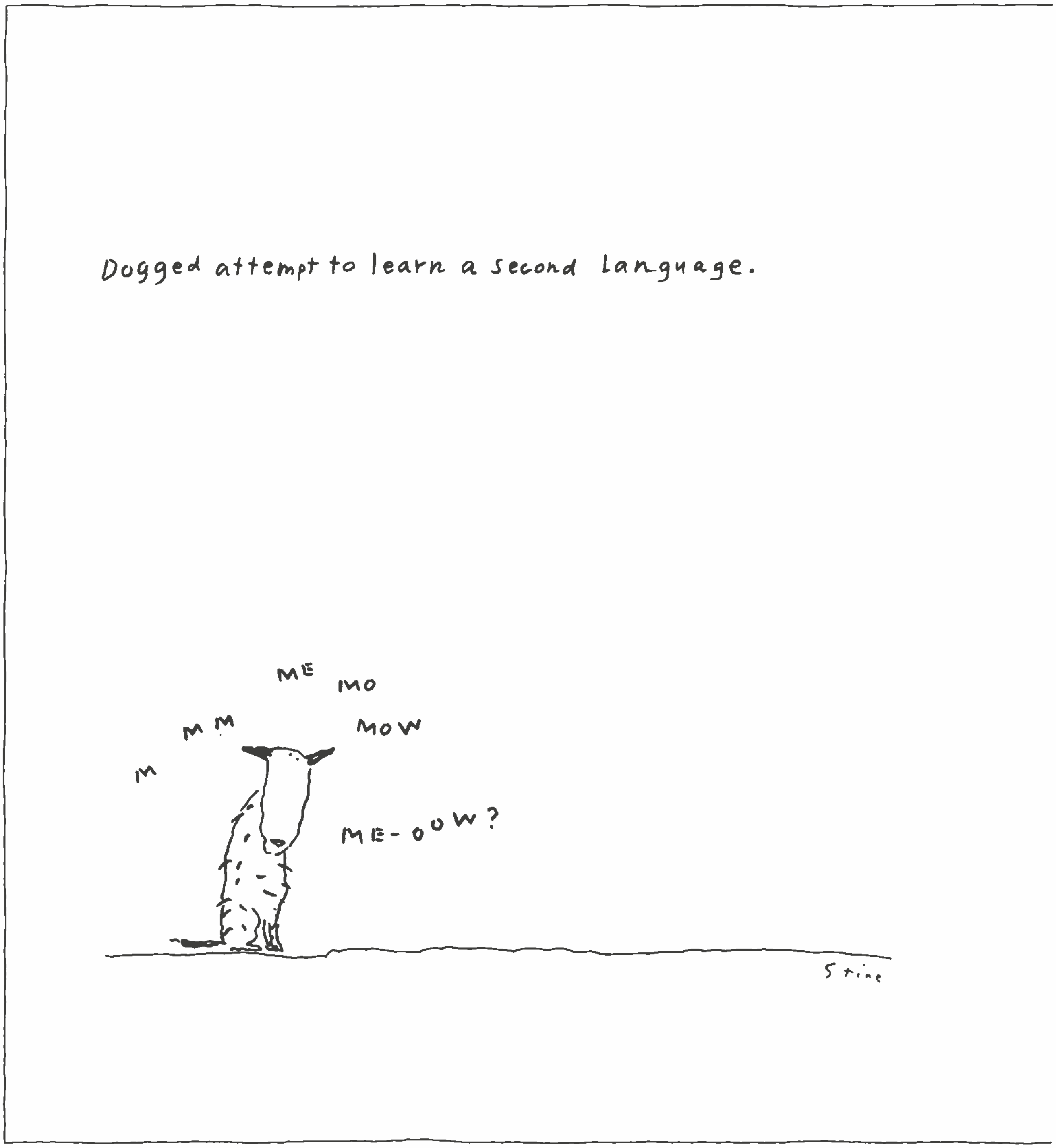

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BYTE West Coast

A Guided Tour of Visi On

William T. Coleman, a group manager at Visicorp, is responsible for Visi On and the applications programs that run under it. He started work on the Visi On project soon after joining Visicorp less than three years ago. Prior to that he served as a consultant for Visicorp.

He has also been a department manager at GTE, where he managed development of minicomputer and microcomputer systems that automated the use of analog equipment to collect, analyze, and disseminate information. Before that, he worked at the artificial-intelligence lab at Stanford University, where he did graduate work. A graduate of the Air Force Academy, Coleman served in the Air Force as a programmer at the Satellite Test Center.

Bill Coleman talked with BYTE's West Coast Editor Phil Lemmons in March at Visicorp's headquarters in San Jose, California. Lemmons' questions are in bold; Coleman's responses follow in lightface.

Phil Lemmons
West Coast Editor
Byte/McGraw-Hill, 4th Floor
425 Battery St.
San Francisco, CA 94111

When did you decide to do applications software that uses mice?
The original decision wasn't necessarily to involve mice. It was to develop an environment in which users could run applications programs. We started in the first quarter of 1981. We came up with three overall requirements for a system that we wanted to develop, and those requirements were the appearance of multiple product activation . . .

What does that mean?
To give the users the impression of actually having multiple applications programs available to them at any time. Users were to believe that they could use and interact with multiple products very generally. We were seeking the appearance of multiple-product interaction as opposed to actual multiprocessing.

So you're not "timesharing" the central processing unit?
In reality, when you get down to the depths of what we've done, there is a concurrent operating system. That's what the Visi On layer of Visi On is. The Visi On layer keeps the mouse up to date all the time, keeps one application program running, always keeps interacting with one program, or one activity, as we call it, and can also do background processing for handling output devices, whether they're printers or plotters or communication lines.

So while it is in some sense multitasking, it's not a multiprocessing environment, meaning that you can actually tell one program to start computing here and immediately switch to another one and watch the first program computing while you're interacting with the second. You can do that only in the context of output processing of the background.

What were the other two requirements for your system?
The second requirement was ease of learning and use, which we called "ELU," and the third requirement was simple transfer of data between products. That meant not a procedure-oriented transfer. In brief, we wanted users to be able to have multiple programs on the screen at one time, ease of learning and use, and simple transfer of data from one program to another.

From that we've developed a whole series of objectives. The key ones were that programs be installable. That differs from Smalltalk, which lacks a concept of programs or products and uses a concept of objects. Objects make up classes, and the class provides a set of methods that tell what will happen to an object in the class when an object receives messages. You can increase the methods in a class. There are also objects that are communications between classes and subclasses, and it's the class and subclass that have a method, etc. But our products had to be installable. (See "The Smalltalk-80

William T. Coleman

System," August 1981, page 36.)

We also wanted to live with the vendor-supplied operating system. We wanted our system to be portable across a series of machines, portable to many personal computers. We wanted the system to have a consistent user interface. And a series of other objectives don't come to mind at the moment.

Basically we've gone through four development phases. Phase one was specification of the system and development of the human factors—those were two separate projects that we happened to call Quasar and Nova. During the specification of the system we decided to develop four different external product specifications so that we could approach the problem from four different angles, and we approached it from as wide and diverse a set of angles as we could. We developed all four. One was a Smalltalk system, one resembled a Xerox Star system, one was a virtual-terminal system, and one was a split-screen system. We developed about 15 or 20 pages of specifications for each of the four different approaches.

The second project was human factors, and for that we built two models. One was a model of the user, and the second was a model of the product. We wanted to answer the question, What should a product look like conceptually to the user? And from those two models we developed a set of interactions between the user and the product model.

We drew on all of Visicorp's experience in customer support and on problems we had with building previous products. From that we derived two things. One was a set of principles of design that are applied to the system. Their names might sound a little funny. There are 16 of them. They're things like the principle of display inertia, the principle of the illusion of direct manipulation, the principle of guidedness, etc. We said, okay, these are the principles upon which we want to build systems from now on.

Could I get a list of those principles?

It's a proprietary document. I just want to mention it because we've been going through phase one of the development of Visi On, and this was part of phase one.

Next we said, okay, now we have these principles of design and we have this user and this product; now let's classify the interactions between the user and the product. So we developed the concept of what we called BITs, (basic interaction techniques). We specified 16 of these; they are basically the atoms of the interaction of human factors in the system. Each BIT encapsulates and specifies one kind of interaction between the user and the system. There's a menu BIT, an error BIT, a forms BIT, a list BIT, a sound BIT, a BIT for giving confirmation, etc. The BITs are the smallest atoms of things that we want to use consistently in any product.

At the end of phase one, we did a review and we came out of it with an overview of our external product specification. That consisted of a drawing and a set of descriptions of the functions. If I showed you that today, you'd see that what we had in the mid-summer of 1981 looks very much like the system we have now.

So there weren't any major reversals of course?

Well, no. There was quite a bit of tuning because we evaluated each of the four designs and said what we liked and didn't like about each. We tried to put the best things into one system, guided by our principles of design.

Did you come to a time when you had to make trade-offs between functions in the programs and ease of use?

That's what the whole month of July and August was, until we came out with this specification. That was the end of the first phase.

The second phase was a prototype phase, and we actually built the system from scratch. We built the front end of the system as fast as we could on an Apple III and got it working on an Apple III, just the front end. You could actually interact with most of the commands that are on the global menu line. Only about five people were working on this project full-time then, and we brought it up and got it working. We had to modify the motherboard of the Apple to use 160K bytes of memory, and we had to use an Apple II with a graphics tablet over an RS-232C line to simulate the mouse, but we actually got it so you could play with it and simulate using the mouse and open windows and frame them and things like that.

At the end of the prototype phase, in November 1981, we entered phase three. We went through a three-month period in which we analyzed and respecified the system. We changed a fair number of things in the system at that time and began building it at the end of the first quarter of last year.

Phase four, what we're in right now, is the development phase. I made a big point of the human factors throughout. This is a very layered architecture, as required by our needs for portability and compatibility with an operating system. In the upper layer, we not only have all of the calls—the Visi Ops, we call them—the operations that you would expect if you were using a very high level windowing system, but we also have the BITs. The BITs are actually implemented in the upper layer. When someone is developing a program for Visi On, he or she calls something named "menu" and just passes it a bunch of the data structures, and all the interaction is taken care of. So when we say if you've learned to use one product, you've learned to use them all, the location of the BITs means that's true. The programmer still has to design the actual algorithms for all the interaction, of course.

That's the history of Visi On's development. We're in the process of finishing the coding in some areas of Visi On and developing the products, the applications programs. They are in different stages of testing and quality assurance so that we can get Visi On out this summer.

Are you producing two sets of all the applications programs, one to go into Visi On and one to go outside?

Yes. Every product under Visi On and under my group is being developed from scratch to work with Visi On and to take optimal advantage of the use of the mouse in the environment, and they'll all be introduced for Visi On. They'll be much upgraded from our current products. We hope we've learned something in the last four years about where we have deficiencies.

> **We're in the process of finishing and coding in some areas of Visi On so we can get it out this summer.**

Will Visiword be very different from the demonstration that I saw a few months ago? It looked easy to use.

From an appearance point of view, it won't be very different. I think it's much easier to use with the mouse added to it, to begin with, and we've done some restructuring to take advantage of the features. For example, it will let you put pictures and graphs into the document anywhere, and it doesn't just bring the pixel representation in, it brings in the line representation of the actual drawing and draws it to scale. You know, there are a fair number of upgrades for things like that. But as far as when you physically see the interface and use the rulers and whatever, there won't be a lot of changes. There are a couple of other upgrades that it's a little premature to talk about.

The User Interface

What, in general, are you aiming for in the human interface?

We were looking for something that was intuitive to use, very guided, and consistent across all products. What we ended up having to do in all of the definitions of BITs was to try to break down the interaction to its lowest possible common denominator and determine what's appropriate.

Consistency and intuitiveness are very important. We also wanted to provide very obvious ways to do things but not necessarily provide multiple ways to do the same thing. We developed a motto early on that "Two is much, much greater than one." The motto means that any time you offer somebody two ways of doing a task, he has to decide which way to do it. That becomes an *n*-factorial problem—2 times 2 times 2 to the second power, etc. In designing products we believe that there are so many ways of doing things that people get afraid to try anything. They don't know at a given time just what using this key or doing some other specific action will do.

On the other hand, in certain instances we didn't want to restrict the product to be able to use only the mouse or to require the user to do something only in an arcane and difficult manner.

The human factors involved in product design is probably the most underrated issue. Everybody claims to have ease of learning and use. Not everybody is qualified to design a product, but everybody in the world is qualified to say whether they like or don't like some aspect of using the product. The hardest issue is not necessarily coming up with something that's good, but finding an approach that everyone involved agrees is the best. There have been deep philosophical issues here as in other companies in the valley for years.

About the number of buttons on a mouse, for example?

We really haven't had a problem with the number of buttons on a mouse, but about what special keys to allow.

I should go into my mouse diatribe here for a minute. We specifically decided that we wanted only one button on the mouse for selection, and that's all we have. A two-button mouse is confusing, because you don't know when to use one and when to use the other. The only reason for our second button is that we didn't like to have lots of little modes that you have to look at to

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```
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                 ---------------------------
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                                             Balance 60+  :     .00
Last Name:       ....................

Family Members:
      Code       First/Middle Name
      ----       -----------------
       1         .................
       2         .................
       3         .................
       4         .................

Address:     .........................
City:        ...............      State: ..     ZIP: .....

Phone (O):   ........
      (H):   ........             Date Registered:  ........
-----------------------------------------------------------
Search for Account Number:  ....
Search for Home Phone    :  ........
```

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   4  Post Daily Transactions
   5  Post Aged Balances
   6  Print Procedure Codes
   7  Print Patient Registration List and Age Balances
   8  Print Daily/Monthly Transaction List
   9  Print Monthly Summary of Account Balances
  10  Print Billing Statements

 Press RETURN to exit
 OPTION (1-10): █
```

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```
$select account name balance where balance

   1   1001:Disk, Floppy F.        : 25.00
   2   1003:Printer, Dot M.        : 25.00

Total number of records read:     2

$select service fee from practice

   1   Office Visit               : 20.00
   2   Physical                   : 75.00
   3   X-Ray                      : 45.00
   4   Consultation               : 25.00
   5   Therapeutic Injection      : 60.00
   6   Urinalysis                 : 35.00
   7   Throat Culture             : 55.00
   8   Mono Test                  : 35.00
   9   Stool C[illegible]         : 25.00
  10   Office Surgery             : 95.00

Total number of records read:     10
$█
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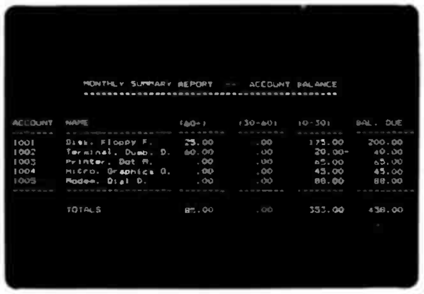

```
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           -------------------------------------------

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1002     Terminal, Dumb. D.     60.00      .00     20.00-     40.00
1003     Printer, Dot M.          .00      .00     65.00      65.00
1004     Micro, Graphics G.       .00      .00     45.00      45.00
1005     Modem, Dial D.           .00      .00     88.00      88.00
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determine how you scroll and how you move the window around. You know, if you push on this part of the window or you push here, one thing happens, and if you push twice the program does this, and so on. Those things are all nonstandard. Apple just came out with a one-button mouse. The trouble is there are so many modes on the mouse that you don't know whether you hold down the button or release it or whatever.

You just click our mouse, and that's the only thing you'll ever do. On the other hand, there's a scrolling button, and any time you want to scroll, you push that down, and the direction you move the mouse is the direction it will scroll; the farther you move it the faster it will scroll, so you have direct control of scrolling. The metaphor is that of a sheet of paper on the table; you're just pushing the paper in different directions.

The concept of our mouse came from part of our product model, which started with the model of a typewriter. The model said that there are keys on a typewriter, and each key does only one thing. It either deposits text on the paper or it repositions where you're going to deposit text in some way or another. When you extrapolate that to a computer keyboard—to a monitor instead of paper—you now have two dimensions, and you have some intelligence behind the keyboard. So we have keys that deposit things on the screen, position the cursor, and actually perform functions.

When you go further than that, you have problems. Because there aren't enough keys to do all the functions, each programmer and the functions in his program decide what the keys will do. So, first, you end up with the same key doing different things in the program, depending on the context or the mode, as Xerox is fond of saying. That's a barrier for the user, who asks, "Oh, what happens if I do this?"

Second, when you go from one program to another, the keys inevitably do different things, so there's a barrier for the user in learning different programs. We wanted keys to do one of two things: either drop text on the screen or do a single other function, and to do it the same way in every program. That's the basic concept, and we've had to violate it very little. That means function keys aren't portable from one machine to the next. You don't see those on the Lisa and you don't see those used on our machine, but it really does limit what you can do with keys.

But you have a Delete key and. . .

Yes, we have a small subset of keys—the cursor keys, Delete key, Backspace key, etc.—that always work the same way whenever you hit them. There's only one function for those keys, the same in every product.

Visi On's Data Structures

Let's look at another issue in integration, transfer of data. Can you say anything about Visi On's data structures?

It might be easier to give you an overview of the architecture, but I'll try to explain. At the lowest level of Visi On we use the native file structures. And they must also read and write and open and close MS-DOS files. Above that we built something we call an archive, for storing all the data. Internally we also call it an object store; it's where we store all our data objects.

The object store is three layers deep. On the top is the volume layer, in the middle is the object layer, and on the bottom is the files layer. From a programmer's point of view, he's actually manipulating all three of these layers to manage a hierarchical file structure. The reason for volumes is obvious: we want to go across volumes that can be on Winchester disks or on remote file servers or whatever.

The idea of objects is not so obvious, but the idea is that users will be manipulating objects. They'll think they're manipulating a spreadsheet, but a spreadsheet may be multiple files. You may have one file that's the formulas, and so on. Users want to know only about the composite object. I don't ever want to show them a

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74LS10	.23	74LS136	.45	74LS247	.75
74LS11	.25	74LS137	.85	74LS248	.85
74LS12	.25	74LS138	.50	74LS251	.55
74LS13	.45	74LS139	.52	74LS253	.55
74LS14	.40	74LS147	1.95	74LS257	.55
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74LS28	.45	74LS158	.65	74LS283	.65
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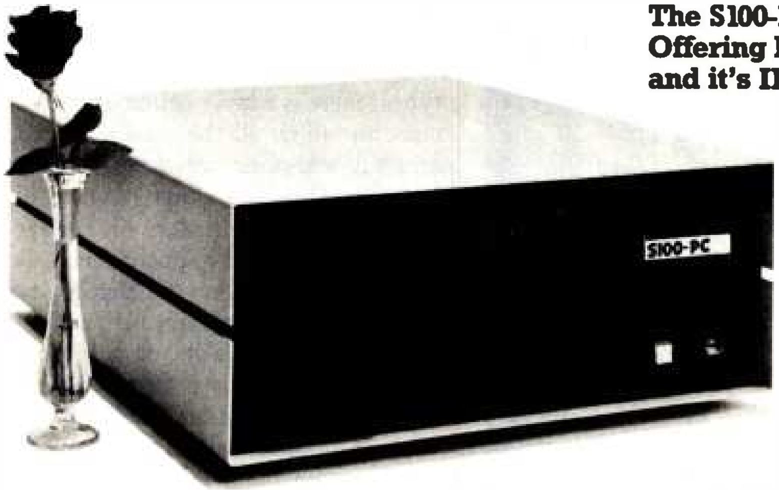

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whole bunch of DOS files with arcane 8-character names with 3-byte trailers on them. I want to show them a name in the context and the way it's defined in the context of the kind of product.

Now, above this, the volume layer knows about password protection/encryption, so a user can password protect/encrypt, and the object layer knows about file types. We have multiple file types, but I won't go into them.

Simply, we have multiple file types, there is a layer called the object store in which all the data is stored, and all transfers are done through Visi On. Products don't have to do anything about transfers or conversion of data. What happens when the user selects Transfer and points at a source object to transfer, be it a block of data in the middle of a Visicalc spreadsheet or some abstraction of that—like pointing at the name of a Visicalc spreadsheet—is that Visi On will transfer the whole spreadsheet. Or if you're pointing at two column headers, Visi On will transfer all the columns between those two points, something obvious like that.

Once the user points at that and points at the destination location, Visi On takes over. First, it actually queries the product: "In the context in which data was pointed at, what types of data can you pass?" And the program or product will say, "I can pass type X, X, and X." And then Visi On will query the destination product the same way and do a match.

Then Visi On will actually physically transfer the highest-order pairing, meaning that the higher the order, the more context is transferred with it. The highest-order data type actually is called "owned," and that means the data will probably be transferable only to another instance of the same product. For a spreadsheet that will have all the formulas underneath it, all the formatting information, column widths, the whole nine yards. But if you're transferring that into a word processor that doesn't know anything about calculating formulas, all it's going to want is enough data to know whether it's character, numeric, and what the precision is.

That gives you some idea of how

the transfer actually takes place. Therefore, as far as the product is concerned, transfer is a general process. All the product has to do is respond, "I can give you this and this," and then when the other product says, "Okay, give it to me," that passes the data. Visi On takes care of everything else.

And the objects you described are like the objects in Smalltalk—they carry some information about how they can be handled?

An object in Smalltalk basically is a message, yes, that carries with it something that says what can be done to it. Visi On objects are not that complex. They're objects . . . yes, they do have context of what their formatting is, but they aren't Smalltalk objects. We just call them an object store. The lowest level of the system is an object-oriented system, though.

Visi On's Architecture

Could you talk about Visi On's architecture?

Sure, I don't have any problem with that. Visi On basically is composed of three levels. The lowest layer is called the Visihost. That's the machine-dependent code. At completion time, it will be approximately 35K bytes of code, of which two-thirds is C and one-third is assembly language. Now, the Visihost and the host operating system in the first version of Visi On, which is for MS-DOS 2.0, must always be resident. So you're talking about 50K bytes that must always be resident. That's the base system.

Visihost is an object-oriented operating system, and it's composed of 10 object types. A better description would be abstract data types. The objects or types include things like file device, keyboard, soundmaker, raster, segments, ports, etc. But what they actually implement is a layer above which is the Visihost interface. The Visihost interface is machine independent and provides the services that are required by Visi On itself.

Visihost uses the concept of objects to implement above it what look to the user like a lot of concurrently processing activities. You can establish

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instances of the objects by just sending messages to them on a Smalltalk message-class type interface. You end up with a process ID or an object ID, which is very similar to a concept in Smalltalk.

The whole concept here is that everything is machine dependent, and the whole virtual machine upon which Visi On rests is isolated. Above that sits Visi On itself; internally we call it the Visi On Operating System, VOS.

The Visi On Operating System

Visi On, or VOS, is an activity to Visihost, as are all products—applications programs. As far as Visihost is concerned, everything that sits above it is an activity to it. What's special about VOS to Visihost is two unique capabilities. First, VOS is the only activity that actually does direct Visihost calls. All other calls come through VOS itself. In other words, VOS does a pass-through, so a product thinks it's doing all calls to VOS. Second, VOS is the only activity that communicates with the user, meaning the only activity that directly receives keystrokes and mouse points. So the VOS is a very key activity; it's the one that sits in the middle of everything. It's the one that is really the concurrent operating system.

Now, what VOS implements is all of the Visiops, the basic operations for reading and writing the files and all the things you'd expect an operating system to do. Included in that is also all of the device layer. That is a layer in itself, because we have not only developed this archive, but also a Graphics Kernel Standard (GKS) Virtual Device Interface. And we extended that to include alpha text, so it's not just the GKS. We can handle, from the same interface, total device-independent printing to output devices.

The other thing that Visi On implements directly is the BITs, which a product merely calls and says, "Do it, and here's what I need," and then Visi On handles the whole thing. Visi On will even replace its screen, its part of the window, and then put back the initial contents when it's done.

Something else that looks to a

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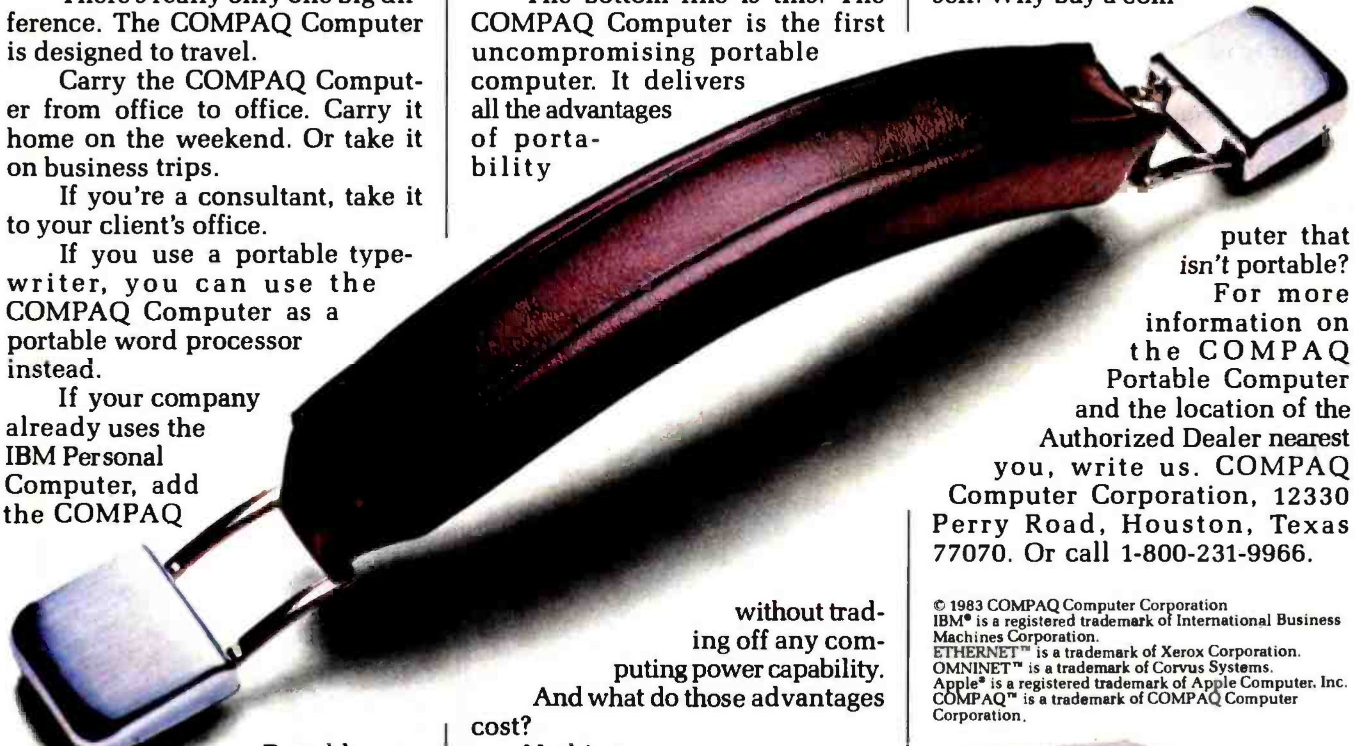

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product as if it's part of Visi On is a series of activities which are really separate. That series includes the files window, the workspace window, the scripts window, and the services window. Even though they might appear to be part of Visi On, they really sit on top of Visi On and use the services that happen to . . .

Just as applications do?

Just as applications do.

So all the applications go to these same services?

All the applications use these services, but they do so through Visi On. What you have above Visi On or VOS itself is an interface we call the Visimachine interface. That is all of the calls that you need as a product designer to use all of the facilities provided by Visi On.

This is the virtual machine?

For product designers, this is the virtual machine.

What's the relation to Visihost?

It's much more extended than Visihost. The whole idea of this architecture is that of nested abstract machines. The concept originated with Edsger Dijkstra back in his THE (Technische Hochschule Eindhoven) operating system in the early 1960s. You have a low-level machine that implements all the very very basic functionality, and that's Visihost. That does the reading and writing of basic files. But the archive does a lot more—and that's in Visi On. It will do your basic device puts and gets—whatever it takes to read and write to a device—but it doesn't know anything about this whole virtual device interface above it. You have to have a driver that knows in between the two.

So what you have is a very low-level machine that provides just basically a virtual memory machine. That's very important. All these products run in the pseudovirtual memory that we developed in software. You have this low-level machine, and above that is Visi On itself, which is much higher level services for products, and it's machine independent. We've nested the greatest amount of coding in the smallest possible area.

The Visimachine spec is the specification for all of these high-level services: the Visiops, the BITs, and all of the higher-level functions that Visi On provides through the services windows. For a product sitting on top of the Visimachine, it is as if the product is running all by itself in its own virtual machine, in its own virtual memory, so it has as much memory as it wants, and all the product is doing is communicating with Visi On.

The theory of the interface comes from Brinch Hansen's concept of concurrent processes, which he calls "communicating sequential processes." What it means to us is that as far as calls are concerned, the Visimachine and the activity interface look to each other like two big programs with dual entry points.

Every call that Visi On makes—remember, Visi On is the only thing that gets a keystroke or listens to the user—every time the user does something that causes an input to the product, Visi On says to the product, "Here, do this," and then Visi On's blocked for I/O (input/output).

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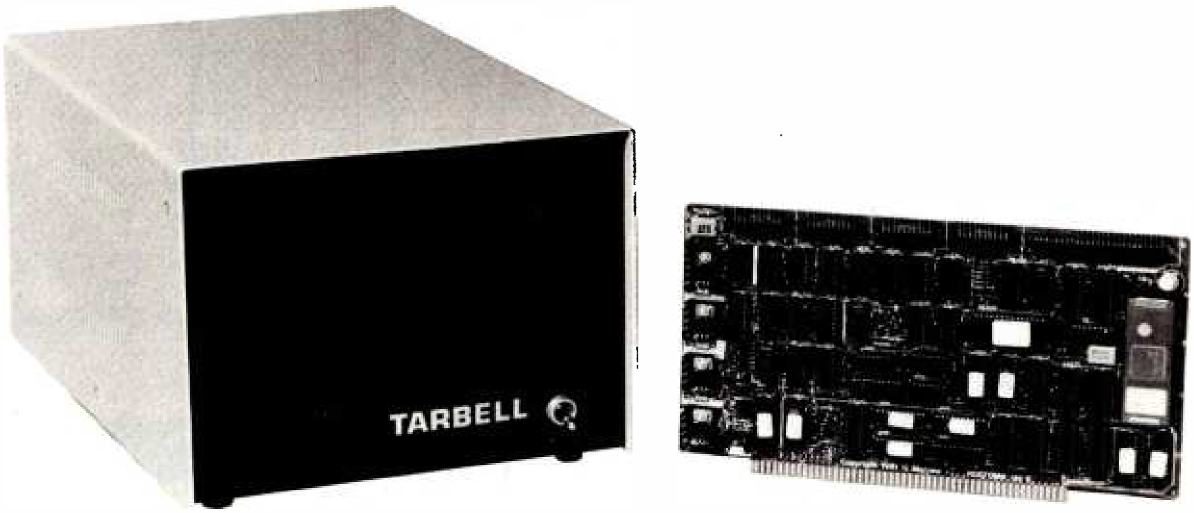

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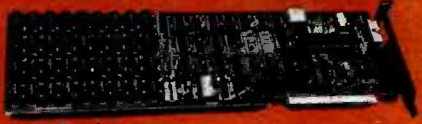

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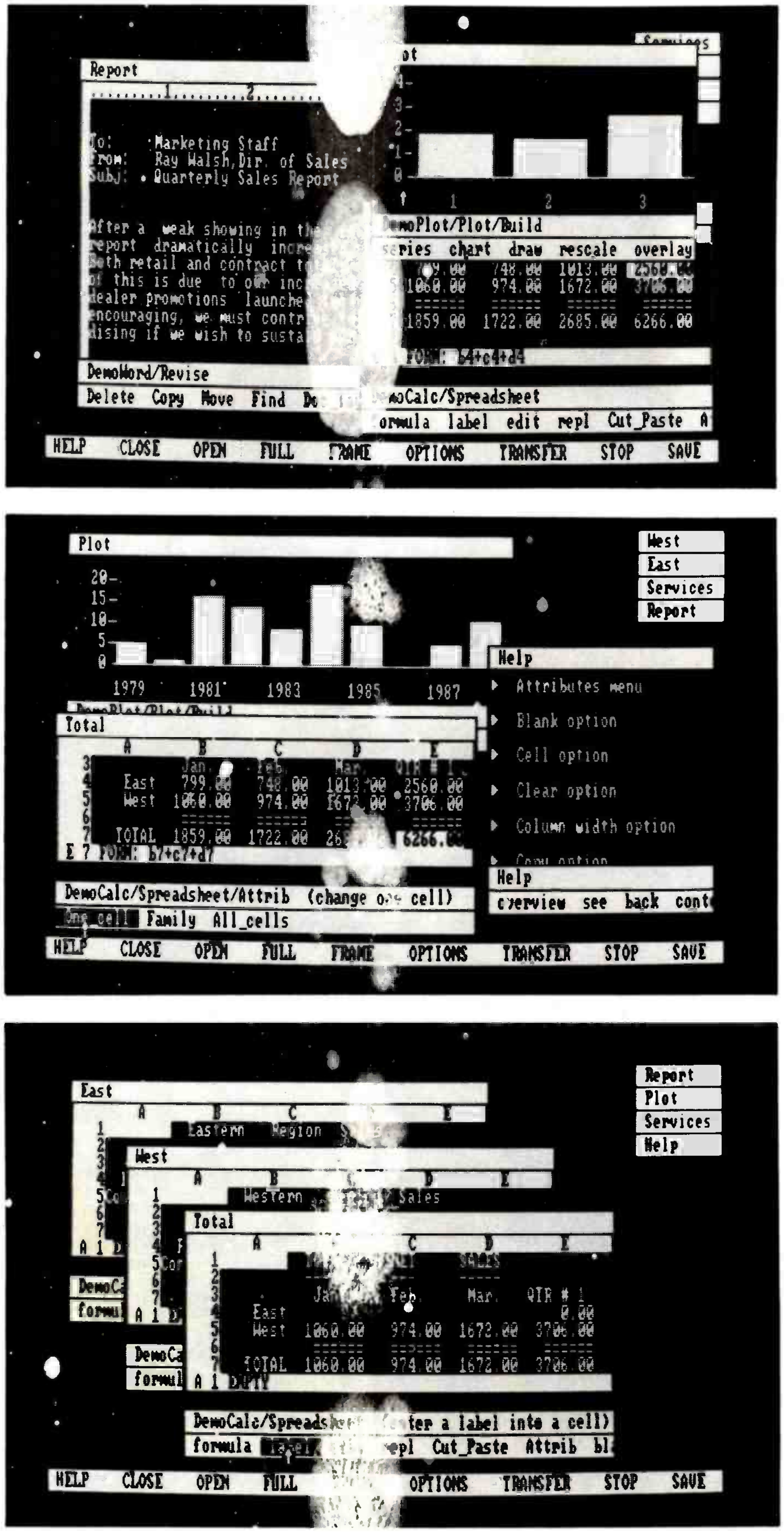

To: Marketing Staff
From: Ray Walsh, Dir. of Sales
Subj: Quarterly Sales Report

Sample screen displays of Visi On windows.

You'll see the hour-glass come up; Visi On can't do anything. The product will execute whatever processing it has to do and will say to Visi On, "Here, here's your response." Then Visi On will come to life, and the product is blocked. That's the communicating sequential processor.

The real idea of making this into a concurrent process is that as far as Visi On is concerned, it has a lot of those products or processes going on, and in its tightest inner loop, Visi On is also keeping track of the mouse and keeping this background printer printing or whatever happens to be going on.

The Programs under Visi On

At the top end, you have the applications activities themselves. They're programs that have been developed for this high-level operating system, running in their own memory, using these very high level calls. When these programs are compiled, they have this large header file that you have to include at compile time. This header has all the definitions of all those calls and all the definitions of all the data types and so on, so that now all you have to do is develop your routines underneath that. It's a fairly complex architecture.

You're doing this all in C, you say, or two-thirds in C?

VOS is about 100K bytes of C, plus about 20K bytes of data. . .

It's compiled C, 100K bytes?

Yes, this is really 100K bytes of object code, but it's from C. Plus about 20K bytes of data space. Visi On itself and the products are all in virtual memory, so only a part of that has to be resident at any one time.

Visi On requires 256K bytes of RAM?

256K minimum. With MS-DOS 2.0, that only leaves us about 230K bytes to use, and we're going to need between 128K and 150K bytes to efficiently run multiple activities. In reality, our concept of virtual memory means you could run in less memory, but not with high performance, and if the system isn't very interactive, you lose everything. We did a lot of testing when we were going through our prototyping phase,

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and there is a threshold under which, if the system doesn't respond fast enough, you just may as well not have the system at all.

It doesn't look as if having a lot of memory will be a problem in most systems for much longer.

That's one of our hopes. A significant part of this system is the virtual memory, which is quite a bit of work for us to implement. The virtual memory requires that, at least early on, all of the programming development will have to be done in C. We have to use our linker because we've created a concept of segments of memory that can be paged in and out. It's obviously not real virtual memory because we don't have hardware support to do virtual pages. But a segment looks like a virtual object page in Smalltalk with what they're trying to do, which says that a segment is more like an overlay than it is a page. It includes a whole bunch of objects that should be run together. As far as we're concerned, a segment can be of adjustable size. You can have both code segments and data segments. Data can be swapped in and out and paged as well. Everything will be in virtual memory, of course, but only so much will be resident at any one time. The whole memory manager is down in Visihost.

Complicating this, of course, is the need for all the code to be position independent. That's one of the things we had to do with our linker. Everything can be relocated to any position. Another complication in this architecture is that we have to contend with the segmented architecture of the 8086 family and those chips' idea of long calls (outside a 64K-byte segment) and short calls (within a 64K-byte segment). We have to straighten up all of those calls at load time and at run time. But the memory management does work rather efficiently.

Porting Visi On

You wanted to talk about how we port the system. The concept is a two-phase portation, where we actually do the portation of Visi On to any new architecture. To us, a new architecture is a combination of any change in operating system or any change in the central processing unit. That's the major portation, when the Visihost has to be rewritten. Visihost is actually assembly language. So we will have different versions of it. Initially we have one for the 8086/8088, 80186 family with MS-DOS. The new one we're intending is a 68000 version, probably with Unix, maybe with MS-DOS as well, but we will extend those versions. That's number one. We'll do that work in-house.

Let me back up. The second part of the portation is the target conversion, where we actually take the adaptation for one processor and one operating system and put it on a specific target machine. We configure it to the bit map of the screen, to any calls that are different for the keyboard, any changes in how they handle fonts, and so on. We do allow loadable fonts.

What we do on the second part of the portation is sort of like doing your BIOS (basic input/output system) for CP/M, but we're going to provide to the OEM (original equipment manufacturer) the source for the Visihost, a specification, and a test program to assure that all the calls work. And the idea is that the OEM would do that part of the conversion. It could target to its machine. There will be small changes. If its mouse is different from our mouse, it will have to change a driver to take advantage of that, and so on.

You've talked about MS-DOS so far, and not CP/M-86. Your announcement said you were going to do Visi On for that as well.

We do intend to do it for CP/M-86.

But not until the second version. What about CP/M-68K or the other Digital Research operating systems?

We do intend to do it across CP/M lines. The number one objective is to get one version out late this summer. We have announced on DEC, we have announced on TI, and there'll be other announcements coming.

More on Applications Programs

Can you talk a little more about the applications programs themselves? Are they being managed as a separate project?

Well, they're all managed as separate projects, but they're all under my group. Right now, we intend to release all five—one product for each of the five applications that we consider major: spreadsheet, word processing, business graphics, database, and communications. Most of those five programs will be released right at ship time or within a few weeks of the Visi On system itself.

They're being developed totally independently. I mean they'll be developed as independent projects, from scratch. They're being designed to take full advantage of the system and all the utilities provided by the system. And they are significantly upgraded in features and functions above our stand-alone product line. We hope we've learned quite a bit about what our competition has taught us and what the marketplace has taught us.

I will tell you that one of the major things we're trying to do is adapt to our conception of human factors—context, guidedness, the principle of direct manipulation where users directly manage the data and receive immediate responses to their actions. We think that's very important. Visicalc was the first product out that let users do that. They could build very complex models by building them one number at a time and seeing that something was right or wrong and changing it and actually not have to go through a series of steps to rebuild it. We think that's important throughout all the products. Users don't want to have to learn some pseudoprogramming technique to get to an ending, to go through lots of steps and not necessarily see if something is right or wrong. So we're making a heavy effort on that.

As a matter of fact, we not only have this Visimachine specification and a lot of tools to go with it, but our human factors project—the Nova project, which still has resources devoted to it—produced a manual we call the *Designer's Guide to Well-Behaved Products*. That not only details the whys and wherefores of

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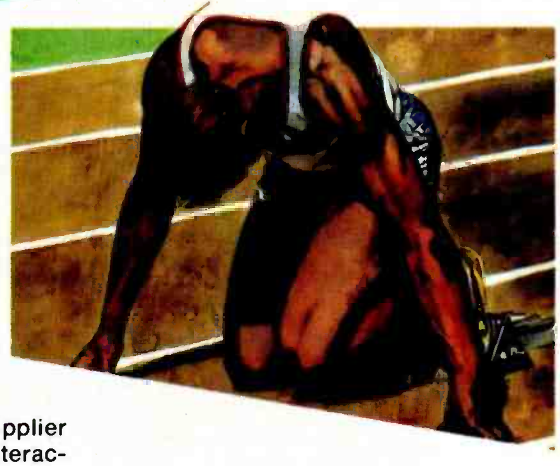

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our product model and our user model and all the principles of design, but goes through all the usages and all the BITs. It also explains all of the functionality of Visi On, how to use it and why to use it, and the preferable and less preferable things to do with it. We're designing right to that guide. It's been an evolutionary document over two years.

There could be a trade-off between consistency in the user interface and tailoring each program to a specific application. How have you resolved that?

There absolutely is a conflict, and resolving it is an ongoing process. We have an evaluation lab set up and we try to mock up and evaluate things. Each product has a working team that includes marketing, technical writing, and development that works out the issues. Then we have a weekly meeting of what we call the Quasar product working group—Quasar was our original name for this product. There we actually confront issues as they become problems and attempt to come up with some solutions. Anything that can't be done at that level comes up to my level, and we work it out between the director of product marketing and me. And as I said, it is not something that is easy. Where you might find 80 percent of the things easy, the last 20 percent affect the other 80 percent anyway, so you end up having to revise it and revise it. And you have to have voices that speak all sides of the problem, and you have to be able to interact with that and evaluate it.

So it's case by case. . . there's no other way?

At this point it is. We set up our overall principles of design and we actually held hard and fast from January 1982 until the end of that year, trying to design as well as we could without any violations of the principles. We made one mid-course correction, an update of the guide in the fall of last year, and now that we're in the end throes of trying to interact with these products, to get them up, we're finding things that are bothersome, and so now we're at the point where it really is a case-by-case basis.

Are you trying this out on naive users? How do you test it?

Internally so far.

On people you've hired?

People we hire, but we brought in some naive users from the outside, and beyond that we do intend to do a significant beta testing of it, but that will be later on. We don't want to do it until enough things are stable that people can really. . . if the system gets in the way of using it, it doesn't matter whether it gets in the way because it's not complete or it has a bug or it isn't good.

Can you say more about installing applications?

As far as users are concerned, all they'll do is use this services window and select the Install button. This is how we install them today in our development environment. The window will prompt users to insert the floppy disk. Once users have done that and confirmed it, the code will actually be read onto the Winchester disk itself.

Basically, the loader will set up all the appropriate addresses in each segment. So all the segments are initialized and loaded on the disk. Then all of the appropriate indexes and overview pages are updated. An item is added to the services window indicating that this product is now installed; there is an overview table for what is available in the help files. The help files are loaded from this disk into the Winchester disk. The help window's overview will show that there's a new series of things here.

Copy Protection in the Mouse

Finally, the serial number of the machine is appropriately encrypted and stored on the floppy disk itself, so at that point you can use that program. You can load it on the Winchester disk as many times as you want or on as many Winchesters as you want. The program will run only for the appropriate serial number, which for us happens to be in the mouse. Anywhere you take your mouse, you can run that program.

How will you adapt Visi On to run with different printers? How much of that are you going to do? Or will you let the computer manufacturers do

Coleman on the Future of Microcomputer Software

Looking at the next generation of software beyond Visi On, and I know that's very far to look ahead, when do you think voice will become a factor in the user interface? When do you expect to have to deal with that?

Voice input . . . in some ways I guess you can consider it a factor today.

Because of TI's announcement of the Professional Computer?

Well, because there are several things that can take very limited amounts of voice but not a general function. I think we're going to see much further integration over the next 10 years.

Where will the integration increase?

In the underlying data structures, so that you really do have common data. Each program understands all the context at some level or another of every other program's data.

What stands in the way of that now?

Basically a definition of the underlying data base. It's a broad subject, not just to understand that something is of a certain type, numeric and alpha and so on, but also to understand all the semantics and all the metadata that go with that type, that say, for example, that this program is a spreadsheet and therefore it has the following kinds of information as far as formulas and recalculation orders; or the program is a word processor and therefore it understands all the semantics about justification and margining and the rest.

If you look ahead somehow, if you could develop an underlying context that understood all of that, there's no reason why the tools that go on top of it can't be—boy, am I talking ahead—much smarter than such tools are today. Therefore you really can do what the 1-2-3s and Context MBAs are trying to do: make one product that does everything. What MBA and 1-2-3 do is integrate some functions very problematically and nonextensibly. But if you had something that could understand all of this kind of structure then, you really would approach Smalltalk's objective. You would have lots of classes and subclasses of data that understand all the manipulations that are done on them, and all you would have to do would be little processes to change that. Therefore you really could be just typing along and in the middle of your text have a spreadsheet, which will recalculate any time and will understand any time you make a change in this model over here that this document must be updated the next time you look at it or print it out. Those things are obviously an extension of where we are trying to go with Visi On, but they aren't here now.

Voice input and the next levels above that could be much more highly interactive. The problem with voice input is that you've got to deal with the office, and in many offices you can't do a lot of talking. The real technical problem, of course, is just getting the computer to understand voice.

That's sort of coupled with knowledge-based systems as well. If you start looking at the concepts of artificial intelligence, somewhere along the way we're going to start seeing voice input in inference processing, and use of artificial intelligence will work its way into these systems. But I see a highly usable system like that as about 10 years away. You are going to see special cases of that all the way along. After all, we've seen special cases of windowing systems for 15 years.

When do you think the features of expert systems will begin to appear?

You're just asking my personal opinion?

Yes.

In the next couple of years, you're going to see people coming out with expert systems that have some utility. I don't think you're going to see the Visicalc of expert systems for five to seven years—that is, an expert system that is so conceptually easy to use that it will be generally adapted by a large group of people. The expert systems that come out sooner will be special-purpose, will involve special training, and will do a very small segment of a problem. But we aren't close enough there in the technology. That's just my opinion.

What about progress in languages? Do you think that we're going to see languages that incorporate features like the new applications? Is Smalltalk going to become popular? Do you think people will ever program with languages? Will languages reach the necessary stage of ease of use, or do you think that's just fantasy?

I don't think that people will generally write programs in the sense we're talking about writing programs today because I don't think many people easily think at the level of logic it takes to do a program. Even concepts of iteration are hard for people to understand. I do think that people will be able to develop programs by interacting with systems that are being developed now, maybe inference processing systems.

But I don't think people will sit down and learn languages even as simple as BASIC or Smalltalk to do much programming on a general basis. The potential world market for the computer/personal computer/desktop workstation is an inverted pyramid—this is an Apple model, by the way—and we've seen only the first couple of percent of the tip of that pyramid. To get farther into the pyramid, you have to get farther and farther from the actual need for people to understand computers and programming.

that for the printers they sell?

The manufacturers can do them, and we'll have at least 10 printer drivers available when we first ship Visi On. You see, to develop a driver with enough capability to handle the GKS, we're talking about drivers that are about 8K to 15K bytes. The first year we'll support probably three to four plotters and a whole line of printers.

But the idea is that these drivers are very sophisticated, because they have to interpret calls in context to what kind of device is attached to the other end and make the appropriate tradeoff. If the device doesn't allow superscripting or subscripting, the driver won't do it. But we will be providing a lot of drivers and there will definitely be information to write drivers. Fortunately, it turns out that a lot of the manufacturers are already signing up to develop or have developed and will provide GKS drivers. Digital

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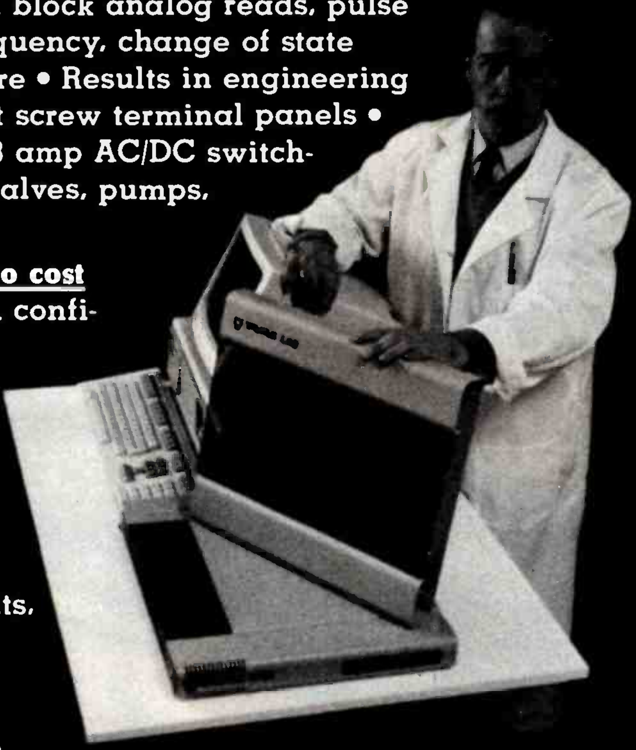

Research is already part of that.

One of the concepts of Visi On is to get people, once they've learned to use the system—which is very easy to learn to use—to a state of no longer having to pay attention to the use of the software tool, but only to solving the problem. The system should not distract people from the problem. No one is turning on the system in order to run Visi On or to run a spreadsheet under Visi On, or a word processor, graphics, whatever. People will turn the system on because they have a goal to get something done by the end of the day. Visi On is nothing more than a toolkit. We want to make sure that users can learn how to use it, not be afraid of it, get in and work quick, and get out. Users should not be concerned about where they're getting their data from. It should be possible in the future for users just to ask for some data and not worry about whether the data comes from a remote system over a telephone line, or from a local system, or from their buddy's personal computer.

The scripts capability is another important aspect of ease of use. It's a learn mode. It has a window that you can interact with. You can stop that learn mode at any time and tell the system to accept a variable. You open a scripts window and say, "learn." Then the system prompts you for a name, you type in the name, and that will be the name of a script. Maybe you go through a consolidation of three models and you combine data and you're loading models, etc. As you're going through that, you might tell the system—by reaching up and pointing into the middle of the scripts window—that something there is a variable.

When you replay that script, let's say once a month, you want to consolidate your East Coast, West Coast, and international sales plans. So once a month you can call up the script and go through it and it will stop at different points and you can type in specific items, and then the system will use the script to do the rest all by itself and print it out. The system has learned from you, and it has let you do what amounts to a form of rudimentary programming. ■

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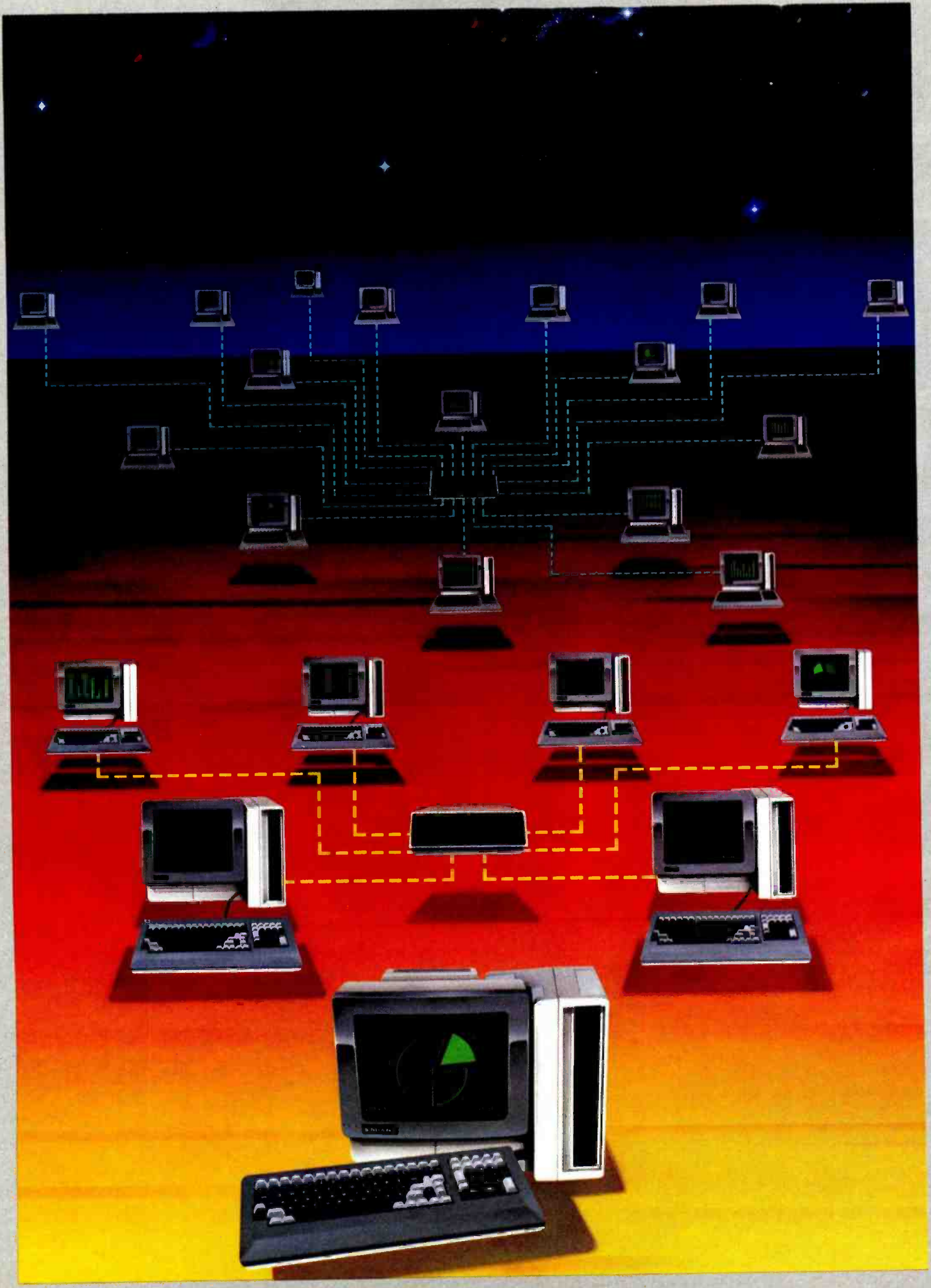

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NEC PC-8201 Portable Computer

A new contender with Tandy's Model 100

Stan Wszola
Technical Editor

With its PC-8201, Nippon Electric Company has introduced another contender in the fight for a place in the executive briefcase. Scheduled to be released in the U.S. this summer, the PC-8201 (see photo 1) is expected to compete directly with Tandy's new Model 100. Among other similarities, both machines use the 80C85 microprocessor, a low-power CMOS (complementary metal-oxide semiconductor) version of the 8085 running at 2.4576 MHz. But, and this is an important difference, the PC-8201's 16K bytes of CMOS RAM (random-access read/write memory) can be expanded to 64K bytes internally. And the machine can accept an optional 32K-byte CMOS RAM cartridge. The list price converted into U.S dollars is about $675 at the time of this writing.

The 8201's 32K bytes of CMOS ROM (read-only memory) contain the operating system, Microsoft BASIC, a simple text-editing program, and a telecommunications program. As with the RAM, the internal ROM can be expanded to 64K bytes, and NEC provides an optional 64K-byte ROM cartridge.

Looking at the rear of this machine (see photo 2), you can see that NEC tried to include connections for all necessary options. An interface for a cassette tape recorder, a Centronics-type parallel printer port, an RS-232C serial port, an interface for an optional bar-code reader, and connectors for as yet unannounced RAM modules and a floppy-disk drive are all there. Additionally, the reset switch, the memory-protection switch, and power input jack were squeezed in. On the right side of the case, you'll find the power on/off switch and an adjustment for the display's viewing angle.

Battery-powered and light (about 3.8 pounds), the 8201 uses four alkaline AA batteries, a rechargeable nickel-cadmium battery pack, or an AC adapter. It's housed in a red, white, or silver case that's 11.8 inches wide by 8.4 inches deep by 1.3 to 2.4 inches high, just slightly larger and approximately three times as thick as the copy of BYTE you're now holding.

Photo 1: *The NEC PC-8201 Portable Computer features a 40-character by 8-line LCD, software in ROM, and your choice of a red, white, or silver case.*

Display

The liquid-crystal display (LCD) has 8 lines of 40 characters with each character comprising a 6 by 8 matrix (see photo 1). The 8201 can display the full 128-character set of the American National Standard Code for Information Interchange (ASCII), the Japanese katakana character set, and 61 user-definable characters.

The 8201 display is the minimum practical size; anything smaller (e.g., Epson HX-20) becomes too difficult to work with. Even in the simplest writing task, you need to see a certain amount of text. This amount may vary, according to individual preferences or the type of material you are working on. While the 8 by 40 display is adequate for writing or programming, it is too small for use with tabular information or spreadsheet programs.

The display, suffering from the same faults that plague all devices using LCDs, is visible only at an ideal viewing angle of about 60 degrees. A bright light or sunlight obscures the display because of the reflections on the

Photo 2: *Rear view of the NEC PC-8201. From left to right are the AC power input jack, memory-protection switch, reset switch, and connectors for the floppy-disk controller (not yet released), memory-expansion modules, and bar-code reader. The Centronics-type parallel printer port is located above the RS-232C serial port, which is next to the cassette tape input/output port. An optional RAM cartridge is shown plugged into the side of the computer.*

cover. LCDs can't be easily used in low-light conditions because they function by reflecting ambient light rather than by producing a lighted display as does a standard video monitor. For most office use, however, the 8201's display is effective and poses no problems when used under average lighting conditions. If necessary, the contrast can be adjusted using a control on the right side of the case.

Keyboard

Surprisingly, the 8201 has a very usable keyboard for such a small package. It has 55 keys in the popular Selectric-style layout (see photo 3) and five programmable function keys, initially defined for use with the text-editing and telecommunications programs. The four triangular-shaped cursor-control keys form a square on the right side of the keyboard, an excellent arrangement.

Two special keys, Paste/Insert and Delete/Backspace, provide text-editing functions. As its name implies, the first inserts characters in text or a program. A Shift-Paste inserts the contents of a Paste buffer (more on this later) into the text or program at the cursor location. The Delete key deletes the previously entered character and Shift-Delete deletes a character indicated by the cursor. A third special key, Stop, generates a Control-C and halts program operation.

Admittedly, the keyboard is a little cramped for my fingers, but the tactile response is fine. The only annoyance was with the confusing combination of English/katakana legends on the keytops. The American version of the computer will have only the English letters on the keytops.

Memory

NEC provided the 8201 with an impressive capacity for memory expansion. The evaluation unit had 32K bytes of ROM (standard) and 32K bytes of RAM, both of which could be expanded with optional memory modules. With the addition of both internal and external RAM, the 8201 gives you a total of 96K bytes. The ROM can also be increased internally to 64K bytes and, with plug-in cartridges, to 128K bytes.

Managing that amount of memory presents an interesting problem, which NEC solved by giving the 8201 a BANK command. A programmer can specify which 32K bank of both RAM and ROM the processor must look at. This method enables the 8201 to store very large programs in memory with enough memory left over to use other programs.

The plug-in cartridges offer you an alternative to program storage on floppy disks. Because the cartridges include battery power for the CMOS RAM, you could load a program into a cartridge, remove the cartridge, and plug in a different cartridge in order to use or store other programs. This is hardly an inexpensive solution, but it is convenient and portable.

Although the 8201 manual does not mention what programs will be available to fill 128K bytes of ROM, the needs of the market suggest a simple electronic spreadsheet and executive software such as a daily appointment record and phone/address records. Software developers have the opportunity to develop custom ROM cartridge programs.

Software

A characteristic feature of most microcomputers is the required loading of software through cassette recorders and floppy-disk drives. The NEC PC-8201 is a true portable because it eliminates this dependence on peripherals by having programs in ROM or saved in RAM.

When the 8201 switches on, the operating system's main menu appears, showing the date, the time, a directory of all programs in memory, and which bank of memory is being accessed. In the directory, extensions indicate the type of information in the file. Text files use the extension DO for document, BASIC programs have the

Photo 3: *Screen display and keyboard layout of the PC-8201. Note that the keytop legends show both English characters and Japanese katakana characters. The special-function keys are labeled by the last line of the display.*

At a Glance

Name
NEC PC-8201 Portable Computer

Use
Portable general-purpose computer

Manufacturer
NEC Home Electronics (U.S.A.) Inc.
Personal Computer Division
1401 Estes Ave.
Elk Grove, IL 60007
(312) 228-5900

Price
Approximately $675 (depending on exchange rates)

Dimensions
11.8 inches wide by 8.4 inches deep by 1.3 to 2.4 inches high

Weight
3.8 pounds

Software
Microsoft BASIC, telecommunications program, and text-editing program in ROM

Audience
Anyone needing a portable computer for telecommunications, word processing, and general-purpose applications

BA extension, and machine-language files use CO. You can identify applications programs such as BASIC, TEXT, and TELCOM by the lack of an extension. The bottom line of this initial display presents labels for the special-function keys and indicates the amount of free memory. (The similarity between the display of the 8201 in photo 3 and the Tandy Model 100's shouldn't be surprising because Microsoft designed the software for both systems.)

The user interface makes ease of use as strong an asset as portability with this computer. To choose a program to run or a file to edit, you simply position the cursor over the file name and press the return key. With a BA file extension, the system enters BASIC, and with DO, the text editor is invoked. Even machine-language programs with a specific execution address run automatically if selected from the menu. Another simplifying feature is available when you finish any application program or file. Just by typing "MENU," you close the files and return to the menu display.

One bundled application, TEXT, is a simple editing program for text or BASIC files and will probably be the most used program. To invoke the TEXT program, you choose the program from the main menu, select a document file that automatically invokes the editor, or use the EDIT command while in BASIC to edit a program.

The special-function keys make the TEXT program especially easy to use. For example, you search for text strings with FIND, locate the next occurrence of the string with NEXT, select text to be cut or copied with SELECT, and transfer copy to a Paste buffer with either CUT or COPY.

A safety feature prevents you from typing over previously entered copy. Whenever you want to insert text, you must first press the Insert key. The Paste buffer lets you put all or part of your text into a buffer with the COPY or CUT commands. Then, with the PASTE command, you reinsert that copy elsewhere in the text. An

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added benefit of the Paste buffer is that it saves any entered text. With a little bit of effort, you can combine this benefit with the FIND and NEXT commands to perform operations similar to search and replace operations found in more powerful text-editing programs.

The same easy-to-use features of TEXT are in the TELCOM program, a fairly simple telecommunications program. Designed primarily to access online databases or information services (The Source, Compuserve, Dow Jones, etc.) or to exchange programs between two computers, it uses the special-function keys and Escape/character key sequences to control the program's operation. A two-page memory buffer, totaling 16 lines, lets you halt the display in order to refer to previously received information. You can set the program for half- or full-duplex operation and "echo" the screen display to a printer.

The UPLOAD and DOWNLOAD commands transfer files through the RS-232C port. The telecommunications program asks for the name of the file to send or receive, performs the operation, indicates the task's completion, and finally asks if you want to disconnect. With the STAT command, the 8201 provides a simple method of setting the data rate, parity, bit length, stop bits, and XON/XOFF sequence.

BASIC

The implementation of Microsoft's BASIC ensures an easy transference of programs to the 8201 without costly translation. Additionally, this interpreted BASIC includes the statements and functions needed to write almost any type of program. By integrating BASIC with the TEXT program, you get two editing methods—a line-oriented program or the character-oriented TEXT program.

Peripherals

Several related peripherals are due to be released with the computer. Of most interest are the floppy-disk controller (PC-8233) and disk drives. Apparently, the controller regulates several different types of drives (PC-8031-1W, PC-8031-2W, and PC-80S31), one of which is probably some version of the 3½-inch microfloppy. Another useful peripheral is the PC-8240 video monitor adapter, which enables you to connect the 8201 to a video monitor.

Peripherals in the planning stage include an intelligent telephone, an acoustic coupler modem, and a bar-code reader.

Summary

With the portable computer market becoming crowded with contenders, more functions are being squeezed into smaller packages. The 8201 takes its place as a transition machine designed to determine just what features people want in a portable computer.

Overall, it looks as if NEC has developed an effective integrated package of hardware and software useful to anyone with a need for a computer to go. ■

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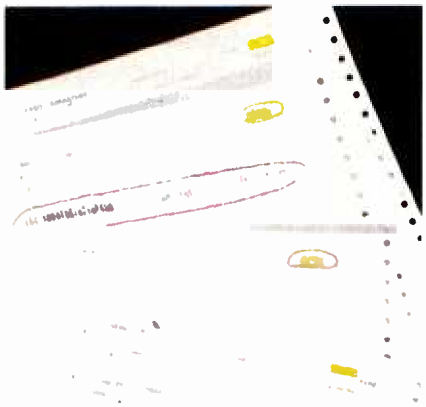

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HMS3264 EPROM Programmer

Marvin L. De Jong
Department of Mathematics-Physics
The School of the Ozarks
Point Lookout, MO 65726

The HMS3264 EPROM (erasable programmable read-only memory) programmer package lets an Apple II computer handle the programming tasks for a broad range of software-development tasks. The Hollister Microsystems product (see photo 1) includes the peripheral card, a DOS 3.3 disk with the necessary software to program an EPROM, and a manual. This peripheral package lets you program Intel-compatible EPROMs, including the 2716, 2732, 2732A, 2764, and 27128. (Note that the Texas Instruments' TMS2716 is *not* compatible with the Intel 2716, whereas the TMS2516 is compatible with the Intel 2716.)

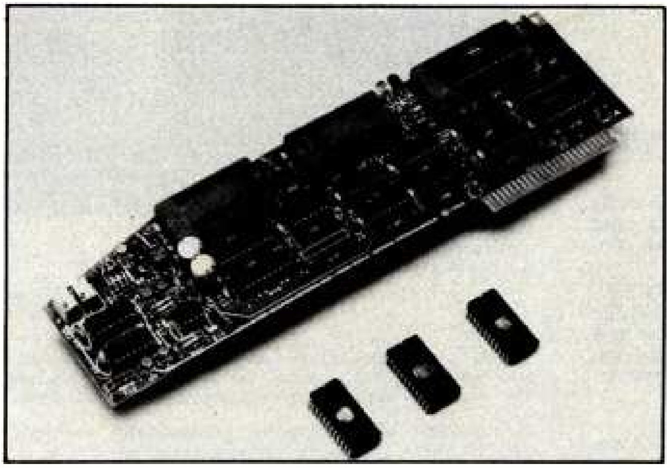

Photo 1: *The HMS3264 programmer card for the Apple II.*

The Hardware

Mounted on the HMS3264 EPROM programmer card are three Textool ZIF (zero insertion force) sockets with gold-plated contacts. Each socket, marked to indicate the type of EPROM device it is designed to hold, contains a lever that removes the force of its contacts on the pins of the installed EPROM, allowing an EPROM to be inserted in the socket with no effort. You push the lever down to hold the EPROM in place during programming. When you raise the lever, the EPROM can be easily removed without prying or damage to its pins.

Many EPROM programmers use plug-in "personality modules" to handle a variety of EPROM types, but the HMS3264 card has all the programming sockets on board. Software is used to identify the EPROM type and modify the programming parameters when necessary. These features eliminate the need for jumper wires and personality modules, which are easily misplaced or lost.

EPROMs can be inserted or removed from the EPROM programmer while the HMS3264 card is installed in an Apple II peripheral-card slot and power to the Apple II is turned on. Two switches on the card control power to the Textool sockets. One switch controls the 5-V (volt) power supply that is required to read an EPROM. The other switch controls the programming voltage that is applied to the EPROM during the programming process. Setting the latter switch, called the write switch, in its off or "protect" position prevents the occurrence of an undesirable Write. A red LED (light-emitting diode) indicates the status of the EPROM power switch; a yellow LED indicates a programming voltage being applied to an EPROM. Two on-board DC-to-DC converters provide the 21 V and 25 V required to program the EPROMs.

In order to insert or remove EPROMs, you must first remove the cover of the Apple II. Moreover, to prevent harm to your fingers, other circuit boards in the Apple II, or both, you must isolate the HMS3264 card with empty peripheral-card slots.

I found it convenient to install the EPROM programmer card in slot 3, leaving one blank slot on the left next to the printer-interface card and two blank slots between the EPROM programmer card and the disk-drive controller. Furthermore, be aware that a small but finite probability exists that you will drop an EPROM chip while attempting to insert or remove it from the EPROM programmer. In addition, a corresponding probability exists, guaranteed by Murphy's Law, that the EPROM will fall and produce a short circuit, smoke, and perhaps

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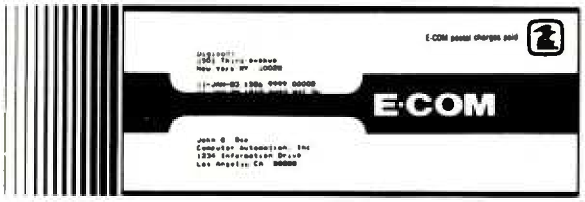

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At a Glance

Name
HMS3264 EPROM programmer for the Apple II computer

Manufacturer
Hollister Microsystems Inc.
1455 Airport Blvd.
San Jose, CA 95110
(408) 293-3900

Price
$395

Computer
Apple II or Apple II Plus with Applesoft BASIC, 48K bytes of user memory, and Apple II disk drive and controller

Hardware
Single-circuit board for peripheral-card slots 1 through 7; no other circuits or personality modules are required; it programs Intel-compatible 2716, 2732, 2732A, 2764, and 27128 EPROMs

Software
Single DOS 3.3 copyable disk handles all EPROM programming tasks, including editing, saving, and moving binary files before they are burned in the EPROM

Documentation
A 25-page manual includes detailed instructions for using both the hardware and the software

Audience
Apple II owners who use their computer as a development system, manufacturers of controllers who require a production EPROM programmer, and hobbyists who wish to program their own EPROMs

damage to components on the main logic board of the Apple II. However, a reasonably alert person can avoid these difficulties.

A third switch on the HMS3264 board is called the CFFF switch. The EPROM programmer uses the hexadecimal C800 through CFFF block of memory that the Apple II reserves for expansion ROM. The *Apple II Reference Manual* suggests that each peripheral card using this space should contain a flip-flop that disables its on-board ROM whenever location hexadecimal CFFF is referenced. This component prevents several ROMs from competing for the data bus with uncertain and undesirable side effects.

With the CFFF switch in its Norm position, the HMS3264 board becomes disabled when location hexadecimal CFFF is referenced with a read or write instruction. However, if you want to program all the locations in a 2716, you need to disable this feature in order to program location hexadecimal CFFF. In that case, place the CFFF switch in its Write position. Then make sure that other cards are not competing for control of the data bus by removing the cards that use the hexadecimal C800 through CFFF ROM space.

Of course, these details are mentioned in the manual. The intent here is to describe various aspects of the HMS3264 EPROM programmer so that you get a feeling for its features and qualities. For example, it is likely that an inexpensive programmer board would omit the CFFF feature. The HMS3264 is not an inexpensive board, and no shortcuts were taken in its design. All its ICs (in-

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Circle 160 on inquiry card.

```
********* HMS3264 EPROM SYSTEM *****V0.2

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..NOW LOADING HMS3264 BINARY PROGRAM..

********* HMS3264 EPROM SYSTEM *****V0.2
  EPROM TYPE.. UNDEFINED
  EPROM START.0000
  EPROM END...????
  WORK START..0000
                         SLOT...

============= SELECT SLOT =============


ENTER SLOT NUMBER (1-7)
                                3


============== EPROM TYPE ==============
   ENTER EPROM TYPE.... (1-5)

1)  2716 SINGLE VOLTAGE ONLY
2)  2732 INTEL COMPATIBLE
3)  2732A INTEL COMPATIBLE
4)  2764 INTEL COMPATIBLE
5)  27128 INTEL COMPATIBLE



              2716 SINGLE VOLTAGE ONLY
```

Figure 1: *Printed output from the software supplied with the HMS3264.*

```
********* HMS3264 EPROM SYSTEM *****V0.2
  EPROM TYPE..2716 SINGLE VOLTAGE ONLY
  EPROM START.0000
  EPROM END...07FF
  WORK START..0000
                         SLOT...3

============== MAIN MENU ==============


0.  LOAD & BURN SINGLE BINARY FILE
1.  BURN FROM WORKSPACE TO EPROM
2.  LOAD BINARY FILE TO WORKSPACE
3.  SAVE WORKSPACE TO FILE
4.  COPY EPROM TO WORKSPACE
5.  COMPUTE WORKSPACE CHECKSUM
6.  COMPARE WORKSPACE TO EPROM.
7.  DISPLAY EPROM/WORKSPACE

8.  EDIT WORKSPACE   9.  EXIT

A.  EPROM TYPE       B.  SELECT SLOT
C.  CALIBRATE        D.  CLEAR WORKSPACE
         SELECT--
```

Figure 2: *The main software menu of the HMS3264.*

tegrated circuits) are socketed; you do not have to ruin the board in order to replace an IC.

The lack of unusual components in the analog circuitry, namely the DC-to-DC converters, means that a failure here is easy to correct. Each of the 11 74LS-series ICs has its own bypass capacitor. Obviously, careful attention was paid to the location of the power bus, ensuring noise-free and consistent operation. You are even provided with a location for a spare 16-pin DIP (dual-inline pin) socket, which might be used with jumper wires to program a special EPROM.

The Software

The floppy disk provided with the HMS3264 contains software, partly in BASIC and partly in machine code, for performing the various functions. To illustrate some of the software, the output of the program was directed to a printer, and the results are reproduced in figure 1. Note that the first task is to select the slot number. Any peripheral-card slot number except 0 is acceptable. Next, you choose the type of EPROM you intend to program. In this application, I chose to program a 2716. The software confirms the choice, as shown in the last line of figure 1. After selecting the EPROM, you are presented with the main menu, as illustrated in figure 2.

The software uses a block of memory in the Apple II, called the *workspace*, to load, store, and edit the binary files that will be read from, or burned in, the EPROM.

The workspace starts at location hexadecimal 4000 in the RAM (random-access read/write memory) address space of the Apple II and extends upward as far as necessary for the particular EPROM being programmed. For instance, a type-2716 EPROM requires 2K bytes of RAM extending from location hexadecimal 4000 through 47FF; a type-27128 EPROM requires 16K bytes of memory extending from location 4000 through 7FFF. But to ease the translation to the EPROM, the workspace is *identified* by addresses hexadecimal 0000 and upward, even though the binary information is stored in locations 4000 and upward. For example, if you are dealing with a type-2716 EPROM, its 2K bytes of memory are identified both in the EPROM and in the workspace by addresses 0000 through 07FF. At the other extreme, the memory locations in a type-27128 EPROM are identified in the EPROM and in the workspace by addresses 0000 through 3FFF. Because a programmed type-2716 EPROM was available, I placed it in the 2716's socket on the EPROM programmer card and selected option four from the menu (copy EPROM to workspace).

After selecting an option, you are given a chance to return to the main menu before proceeding. The software then asks you to identify the starting address, default value = 0000, and the ending address, default value = 07FF, of the portion of the EPROM you wish to copy into the workspace. (I selected the default values because I wanted to copy the entire EPROM into the workspace.) You are next asked to identify the address in the workspace where you wish to begin copying the EPROM's contents. (I chose the default value, which is hexadecimal

0000.) The software then prompts you to turn on the EPROM power switch.

Upon switch activation, the EPROM's contents were copied into the workspace, but I received an error message. The software calculates a checksum for both the EPROM and the workspace to make sure that the copy program executed successfully. The error message puzzled me until I realized that the CFFF switch was in its Norm position; in this switch position, the software does not copy location hexadecimal CFFF in the EPROM into location hexadecimal 07FF in the workspace. Placing the CFFF switch in the Write position (no pun intended) allowed all the EPROM's contents to copy correctly into the workspace.

This procedure was the only one where a note in the documentation might have prevented a problem. Otherwise, the documentation is excellent. Each program in the menu is carefully explained in the manual, and the prompts on the video monitor make operation of the various programs idiot-proof.

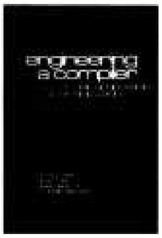
After copying an EPROM to familiarize myself with the style of the software, I decided to do some programming. First, I selected item number two in the main menu. This program allows reading a binary file from a disk and storing the file anywhere in the workspace. You input the address in the workspace where you want the binary file to begin. After the file is loaded, you return to the main menu.

Next, I selected item number one in the menu. Here, you are asked to enter the EPROM addresses where you want to start and end programming. These addresses have default values, but you would probably want to enter the appropriate values for the binary file you are burning into the EPROM. You also input the workspace address where the binary file starts. This address would have a default value corresponding to the binary file just loaded into the workspace. Having done this, I was almost ready to operate.

Before starting, the Apple II will query whether you wish to suppress audio. During programming, the software causes the speaker to emit a series of audible clicks that can be eliminated by a positive response to this question. You are also reminded to set the switches properly. Finally, you have a last chance to abort and return to the main menu or to go ahead.

To keep going, you press the * key. An estimate of the time needed to accomplish the task next appears on the screen, and then programming begins. Each EPROM address appears on the screen as the programming continues. After each byte is programmed, it is compared with the corresponding byte in the workspace. Programming stops if this test fails; otherwise, it proceeds until the entire binary file has been burned into the EPROM. Finally, programming returns to the main menu.

Item number zero in the menu is a combination of item numbers one and two. The other items in the menu are not covered in this discussion. Their functions are obvious from their names, and the manual describes the operation of each program in detail. With the exception



of item number nine (Exit), the successful completion of each routine returns you to the main menu. Programming an EPROM thus becomes a smooth operation with minimal chance for error. In fact, the software permits novice computer users to easily handle the EPROM programming tasks on a production-line basis.

You can tell from this review that I am favorably impressed with the hardware, software, and manual. I recommend this package to anyone who is programming EPROMs. If you want to change any features, you can easily modify the BASIC software for your own purposes by making a listing. The machine-language subroutine might be more difficult to modify, but it can be located, disassembled, studied, and modified if you wish. The EPROMs that can be programmed are all 5-V devices; that is, they can be used as ROM when powered by one 5-V supply. (The 2716 EPROM provides 16K bits of memory in a 2K by 8-bit format; that is, it has 2K bytes of memory. The 2732 stores 4K bytes of information, the 2764 stores 8K bytes, and the 27128 stores 16K bytes.)

One important criticism of the documentation is that it does not include a circuit diagram. For example, if you want to use the card as an EPROM card in the Apple II's hexadecimal C800 through CFFF ROM space, it might be possible to discover how the type-2716 EPROM is switched into this part of the address space. Also, it would be useful to know the bank-switching techniques used to access larger EPROMs. With additional documentation, the card could perform a secondary function as a regular EPROM card. However, this deficiency in the documentation should not be regarded as serious. ■

About the Author

Marvin L. De Jong is the author of two microcomputer books, Programming and Interfacing the 6502 *and* Apple II Assembly Language. *He teaches mathematics and physics at The School of the Ozarks in Point Lookout, Missouri.*

BYTE's Bits

New York to Host World Computer Chess Championship

New York will be the host city for the Fourth World Computer Chess Championship. This match, held during the annual conference of the Association for Computing Machinery (ACM), will pit the reigning champion, Belle, against challengers from England, Germany, the Soviet Union, and the United States. Belle will square off against Cray Blitz, Nuchess, and Chaos, which finished second, third, and fourth in performance rating versus opponent's strength behind Belle last October at the ACM's Thirteenth North American Chess Championship. Play in this five-round tournament is expected to approach the master level.

The ACM's annual conference will be held in the Sheraton Center on October 22 to 25. Anyone interested in further information may write to Professor Monroe Newborn, School of Computer Science, McGill University, 805 Sherbrooke St. W, Montreal, Quebec H3A 2K6, Canada. ■

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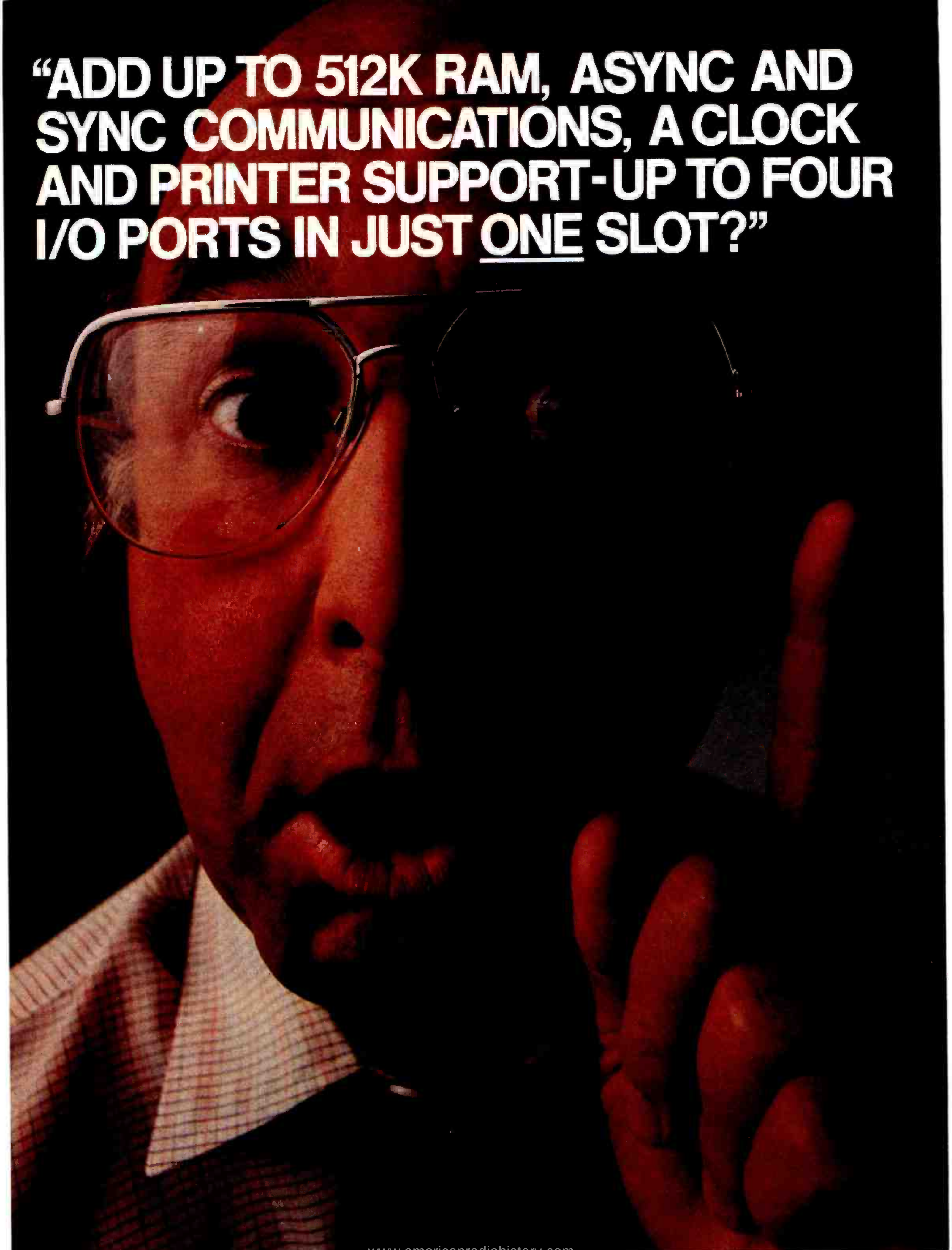

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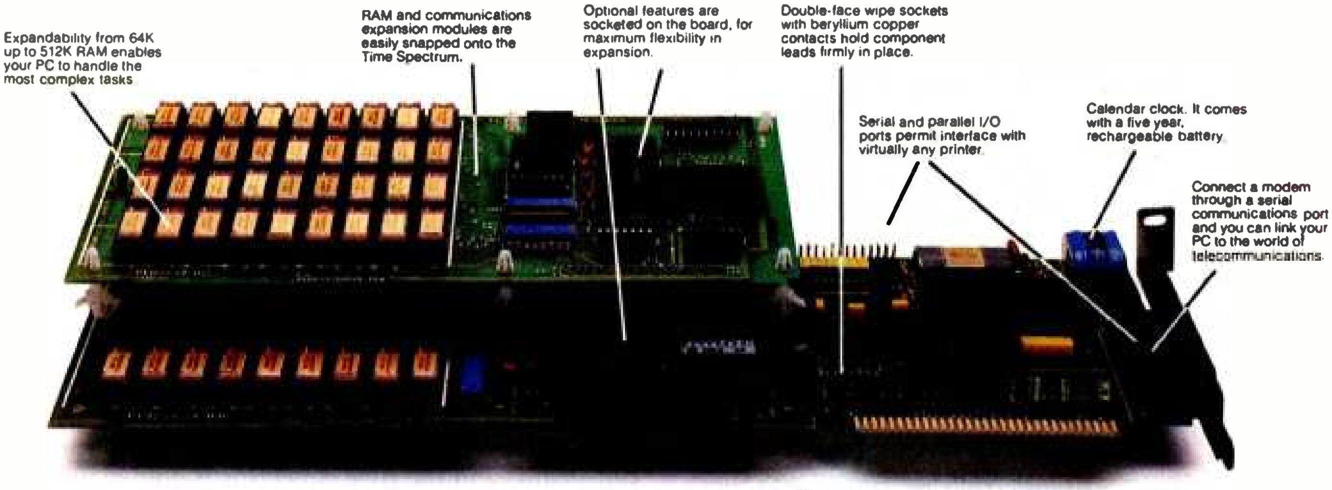

THE TIME SPECTRUM™ BY PERSYST.

Electrohome Supercolor Board and Color Monitor

Jon N. Swanson
Drafting Editor

Electrohome's Supercolor Board is a video interface that enables the Apple II to drive a professional color video monitor. The board sends three separate signals that directly control the amount of red, green, and blue seen on the monitor's screen. Without the board, the three signals would be combined with several others into a single *composite video* signal that a TV receiver must decode. The Supercolor Board eliminates these combining and decoding steps, thus producing an extremely clean high-resolution display.

Photo 1: *The Electrohome high-resolution monitor and Supercolor Board.*

Background

The normal video signal output by the Apple II, referred to as composite video, is a mixture of image and "sync" (synchronization) signals. This signal is designed for use with a normal television set via an RF (radio-frequency) modulator (a device that converts the signal so that it may be received on a television channel) or with a composite-video monitor. Unfortunately, some signal components and resolution are lost in this process.

A conventional digital RGB (red-green-blue) video interface, which turns any or all of the three color guns in the monitor's picture tube fully on or fully off, offers some improvement over composite video. Only eight colors can be produced by a digital interface, however, because tints and shades require intermediate levels of the three colors. An analog interface like the Supercolor Board, on the other hand, can turn on the guns at varying intensities and produce many different colors.

Hardware

The Supercolor Board uses 22 ICs (integrated circuits) that draw 365 mA from the Apple's +5-V power supply. All ICs are socketed on the double-sided, glass-epoxy circuit board, and the edge connector is gold-plated. Two cables are provided, one to connect to an RGB monitor,

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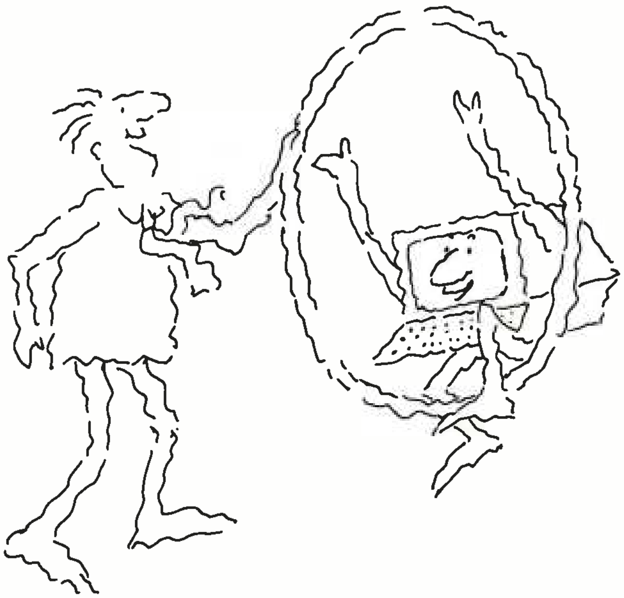

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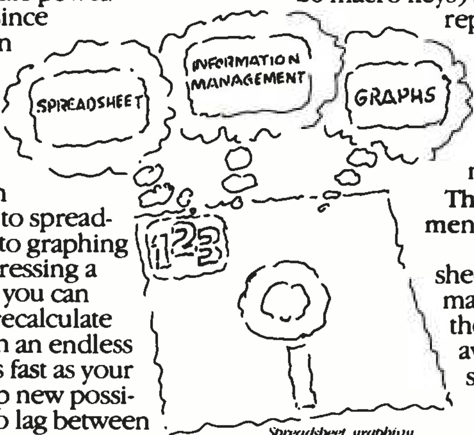

Spreadsheet, graphing, information management all-in-one.

The spreadsheet function.

If 1-2-3 were just a spreadsheet, you'd want it because it has the largest workspace on the market (2048 rows by 256 columns). To give you a quick idea of 1-2-3's spreadsheet capabilities: VisiCalc's spreadsheet for the IBM PC offers 15 arithmetic, logical and relational operators, 28 functions and 32 spreadsheet-related commands. 1-2-3 has 15 operators, 41 functions and 66 commands. And if you include data base and graphing commands, it actually has 110!

In addition, 1-2-3 is up to 50 times as fast as established spreadsheets. With all the features you've ever seen on spreadsheets. 1-2-3 also gives you the capability to develop customized applications (with 26 macro keys) and lets you perform repetitive tasks automatically with one keystroke. If 1-2-3 were just a spreadsheet, it would be a very powerful tool. But it's much, much more.

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Add to 1-2-3's spreadsheet a selective information management function, and the power curve rises at an awesome rate. Particularly since 1-2-3's information management capability reads files from other programs such as WordStar, VisiCalc and dBase II. So you can accumulate information on a limitless variety of topics and extract all or pieces of it for instant spreadsheet analysis. Unheard of before. Specific 1-2-3 information management features include sorting with primary and secondary keys. Retrieval using up to 32 criteria. 1-2-3 performs statistical functions such as mean, count, standard deviation and variance. It can produce histograms on part or all of the data base. 1-2-3 also allows for the maintenance of multiple data bases and multiple criteria.

The graphing function.

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For a full demonstration of 1-2-3's remarkable power, visit your nearby 1-2-3 dealer. For his name and address, call 1-800-343-5414 (in Mass. call 617-492-7171).

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At a Glance

Name
Electrohome Supercolor Board and high-resolution RGB monitor

Use
RGB color monitor interface for the Apple II

Manufacturer

Electrohome Limited
809 Wellington St.
Kitchener, Ontario N2G 4J6
Canada
(519) 744-7111

Tech Plus Inc.
35 Marsh Rd.
Needham, MA 02192

Price
Low-resolution monitor, $550; high-resolution, $950; Supercolor Board, $249

Dimensions
Supercolor Board: 7¾ by 2¾ inches; ECM Monitor: 18 by 13 by 15½ inches deep; screen: 13 inches (diagonal measure)

Features
Apple hardware board, RGB analog monitor, connecting cables, software contained on a 5¼-inch disk, users manual

Capabilities
Display of 256 colors or pure white text with color, compatible with existing and future Apple II software

Hardware Required
Apple II with 48K bytes of memory; must use slot 7

Audience
Any Apple II owner

Warranty
One year, limited, for board and monitor

the other to obtain two signals from other parts of the Apple via a four-pin Molex plug and a component clip. The board must be installed in slot 7 on the Apple II motherboard because that is the only slot that provides the sync signal from the Apple's video circuitry.

Unlike some other video boards that use extra memory in the Apple, the Supercolor Board uses only the memory assigned to slot 7 and thus does not interfere with normal Apple II functions. The board adds 16 new memory locations to the Apple II, from decimal 50944 through 50959. The contents of these locations determine the values of low-resolution graphics colors 0 through 15 and high-resolution colors 0 through 7. These contents can be altered by using the Colorset program provided in the software package.

The Supercolor Board was developed in Canada by Electrohome. (Tech Plus Inc. is now licensed to sell Electrohome products in the United States.) The board comes with a seven-pin male DIN-type connector wired for use with Electrohome RGB analog monitors. Although the board will work with any RGB monitor, it offers 256 colors only on analog-input RGB monitors.

The Electrohome ECM 1302-2 high-resolution RGB monitor has a 13-inch black-matrix color CRT (cathode-

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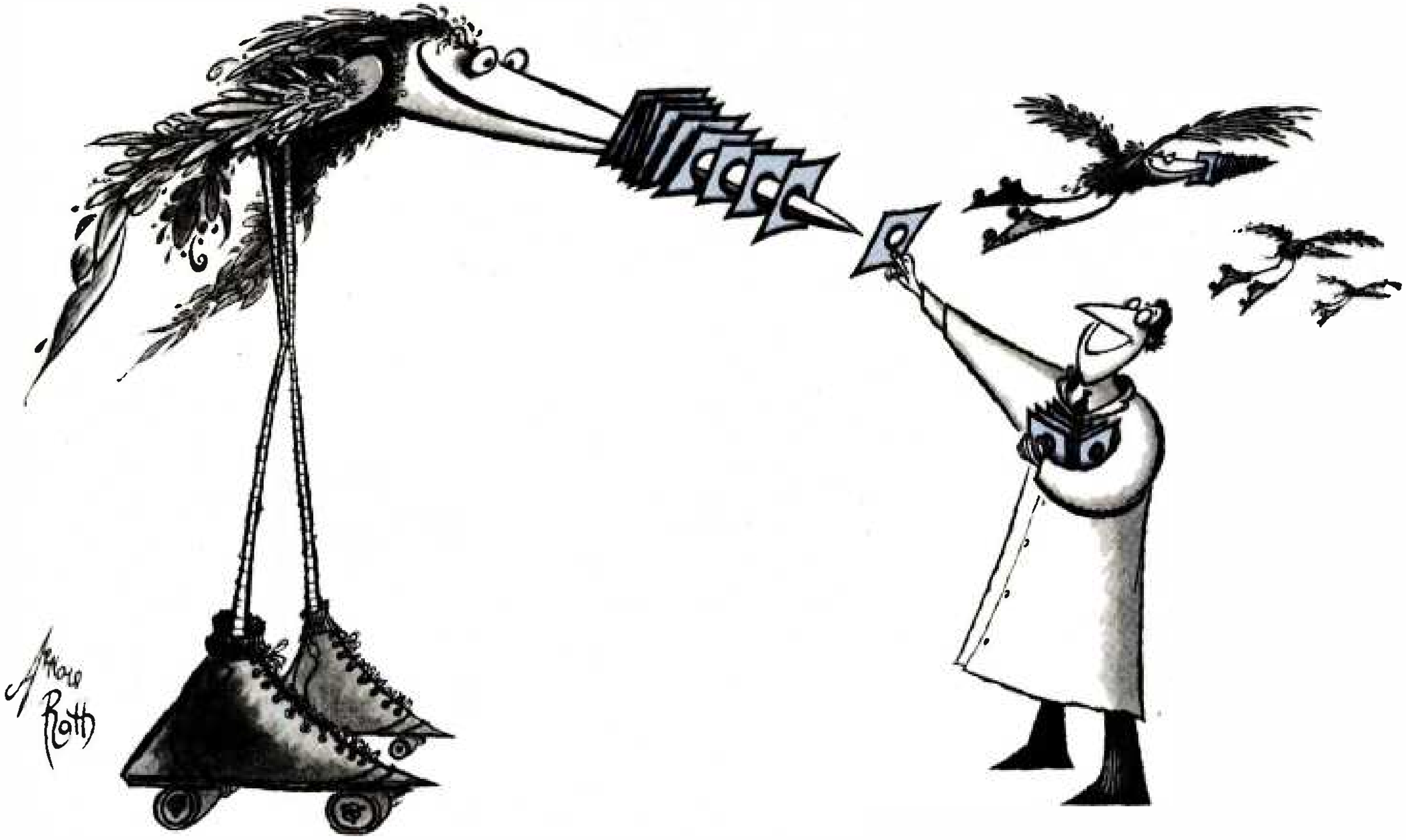

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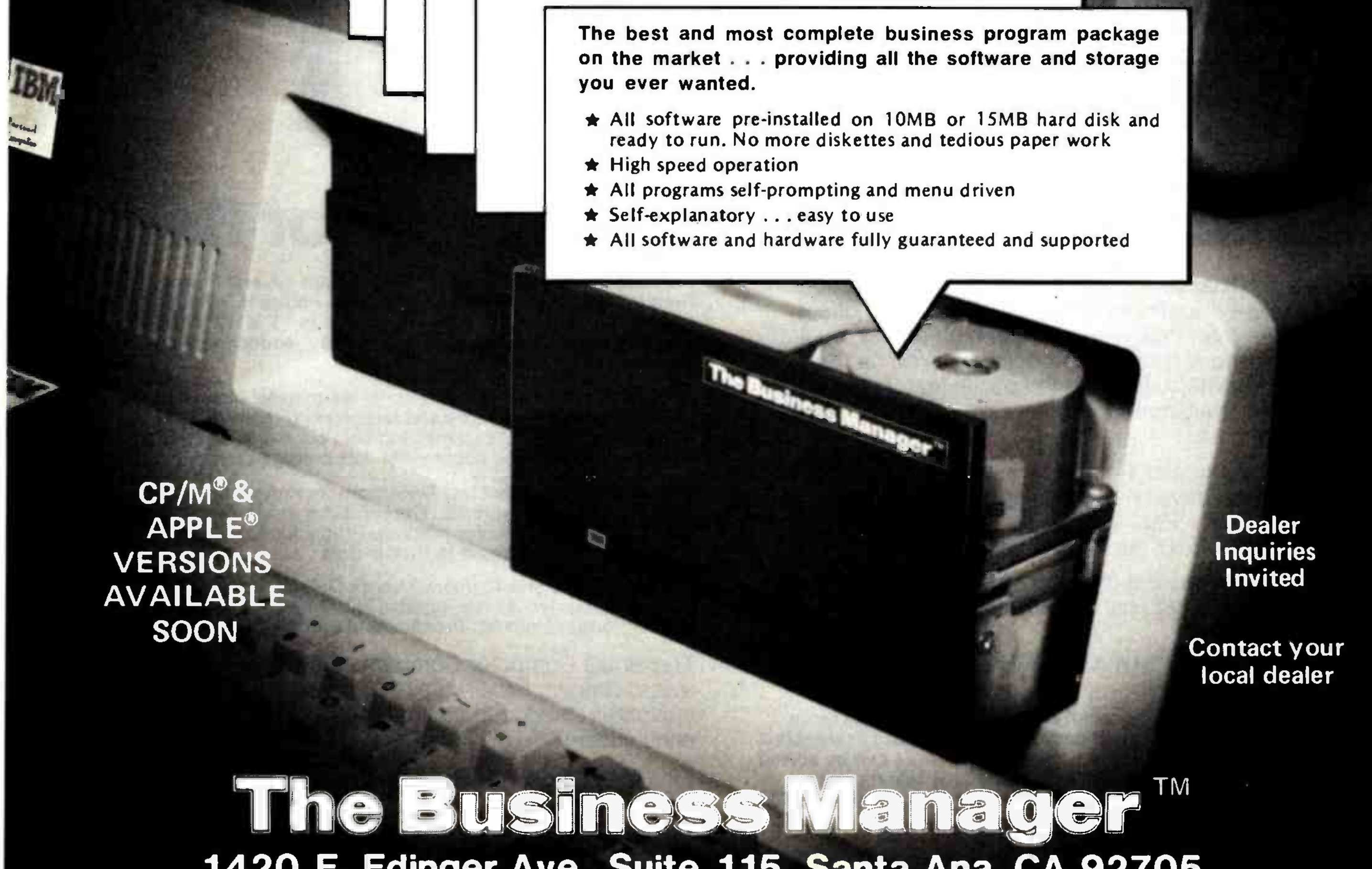

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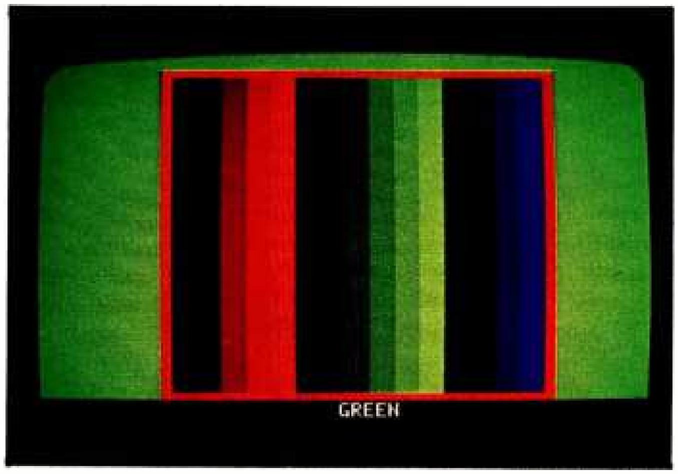


Photo 2: *Red, green, and blue shades created with the Boardtest program.*

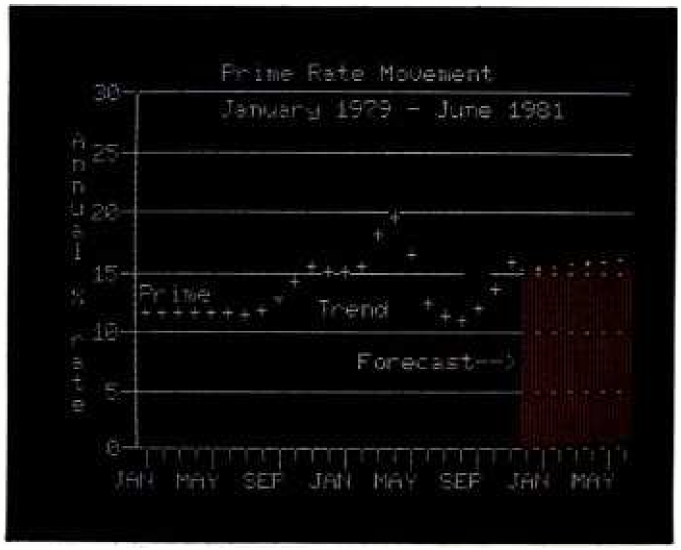


Photo 3: *Pure white high-resolution text.*

ray tube), RGB analog input at TTL (transistor-transistor logic) levels, 10 MHz bandwidth, 580- by 235-pixel resolution, and separate connectors that allow direct connection to the Supercolor Board or the Apple III computer (which has built-in provisions for digital RGB output). The monitor's Apple III input port is a 15-pin subminiature "D" connector that accepts RGB data. In another version (the ECM 1302-1 low-resolution monitor) Electrohome provides a bandwidth of 6 MHz and 370- by 235-pixel resolution. A 120/240 line voltage option is available for both versions, as well as a module that enables the monitor to accept composite video signals.

Software

A 5¼-inch floppy disk with demonstration, testing, and color-programming software is included with the Supercolor Board. Because the disk is not copy-protected, the software is easily customized by the user. Of particular interest is the Colorset program. By blending varying amounts of red, green, and blue, this program allows you to create with simple keystrokes a palette composed of any 16 of the 256 possible low-resolution colors or any 8 of the 256 possible high-resolution colors. Any set of colors you create can be stored on disk and accessed from a program.

A PROM (programmable read-only memory) on the Supercolor Board contains color settings for normal Apple II operation (default mode) and for an enhanced mode that offers pure white text in high-resolution mode. When creating text in high-resolution mode without the aid of the board, the locations on the screen where the six available colors can appear are restricted by whether an adjacent dot is on or off, whether the dot is in an odd or even column, and which color is selected. Any two adjacent dots produce white, but most letters require single, isolated dots. This is why text constructed dot-by-dot using high-resolution graphics is tinged with color.

When the enhanced PROM color set is entered, the Supercolor Board rewrites the tinged colors as white, producing pure white text. However, two of the six high-resolution colors are lost in this mode, so you may choose to put up with "confetti" text. Six-color mode is available with pure white text if you can fit all of your text into the four-line text window at the bottom of the screen. Letters in this window are always pure white, as is all text in TEXT mode.

Installation

The Supercolor Board is advertised as being compatible with any version of the Apple II to date, but I could get it to work only on Apples that have the auxiliary four-pin connector between locations B and C on the motherboard. You should check with your Apple dealer to make sure the board will work with your version. The instructions are very straightforward and installation takes only about 15 minutes, reading included. One cautionary note—the board must be installed in slot 7 right next to the disk-drive interface, and it's a pretty tight fit for all of the various cables. Route your cables neatly, being careful not to puncture the disk-interface cable's insulation with the back of the circuit board. Inserting a thin piece of cardboard between the boards lessens this danger.

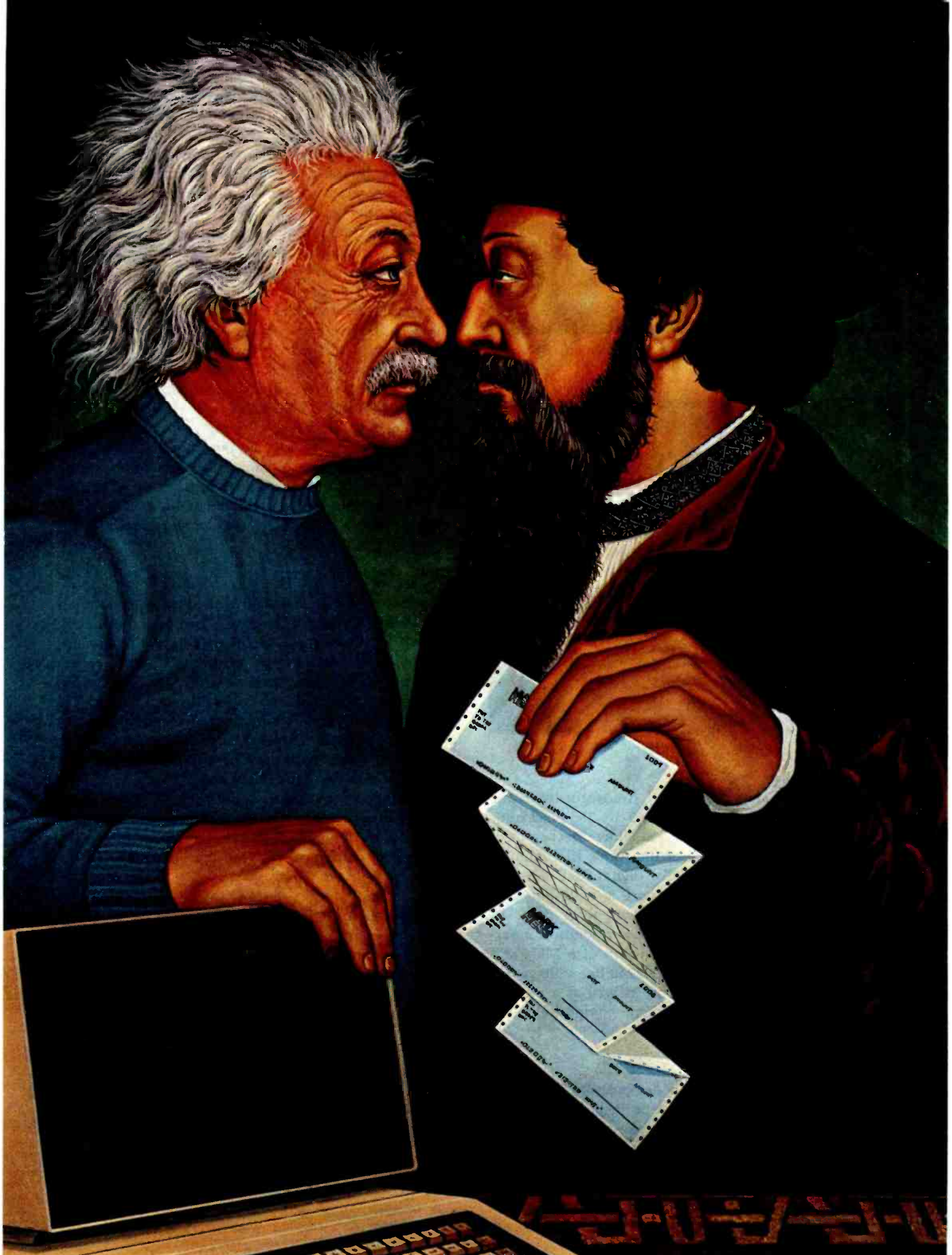
Conclusions

My only complaint is the lack of a user-accessible contrast control on the monitor. When using high-resolution graphics, increased contrast is needed at times to brighten some of the thinner lines in the display. A spokesman for Electrohome said the firm will be adding a contrast control on its next model.

The hardware and software of the Supercolor Board and Electrohome RGB monitor are excellent, with all operations fully supported and documented.

The color output is very clean, and pure white text is definitely easier on the eyes than the rainbow-edged characters commonly seen on Apple IIs.

No modification to your Apple II is required, making this truly a "plug-and-go" interface.■



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The User Goes to the Faire

Our redoubtable critic journeys from Chaos Manor to the Eighth West Coast Computer Faire.

Jerry Pournelle
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This year's Faire report is different: I was there both as observer and participant. I'm afraid I can't separate the experiences . . .

The West Coast Computer Faire remains my personal favorite of the computer shows. There was a time when it was the most important show in the microcomputer industry, but I think that's no longer true. In the old days many companies announced new products at the Faire; now that tends to happen more at Comdex and NCC. For users, though, the Faire remains one of the best shows of the year, and a lot of exciting things still happen there. You just have to dig for them.

For example: at this year's Faire you could (at last!) buy a copy of WRITE, the text editor I'm using to write this report. I also saw the precursor to what I believe will replace both WRITE and my own computer.

I played with a copy of Niklaus Wirth's personal computer.

There's an APL interpreter for the Z80 microcomputer.

If that isn't enough of a teaser, I

The main floor of the show—it was one of three floors the exhibitors occupied.

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also saw the first computer with ventricles. Read on . . .

It's nearly impossible to write a brief overview of the West Coast Computer Faire. There's just too much going on. That in itself is significant; it means that the microcomputer field has gotten too big even for someone as frantically determined as I am to keep up. It used to be that I could follow the mainstream. Now, I'm not even sure there *is* a mainstream. That probably won't last. Improved communications will bring the branches together again, but a lot of mistakes are going to be made first. Meanwhile, fair warning: given the number of panels, talks, and exhibits, no one could cover the whole Faire.

Second warning. I can't pretend total objectivity. My son and one of my closest friends had a booth at the Faire. They not only sold programs I've written, but also WRITE, which I've been using (and talking about) for several years. While I have no financial interest in Workman and Associates, I can't divest myself of my friends and relations—nor would I if I could. Thus, this is the Faire as I saw it. Others probably saw a show that only partially overlaps mine.

First, let's set the scene. The Eighth West Coast Computer Faire was held the weekend of 18 through 20 March in the San Francisco Exposition Center. In previous years booths were set up on Wednesday, so that on Thursday the exhibitors had a chance to see each other's wares before the public arrived Friday morning. For some reason that didn't happen this year, and Thursday was setup day.

I had planned to fly up Thursday at noon and get a good night's sleep. It didn't work out that way. Wednesday afternoon there were big rainstorms. My son Alex and his friends had planned to use Barry Workman's Ford Escort to tow an overloaded trailer filled with computer equipment and Workman and Associates catalogs from Hollywood to San Francisco. The storms got worse. The weather reports got worse. Next thing I knew, I'd volunteered to drive with them in my International Harvester truck, and we were leaving well after midnight Wednesday.

Dante's Ninth Circle

We arrived Thursday afternoon. It was raining in San Francisco. The Exposition Center was surrounded by cars, trucks, trailers, pushcarts, and every other conceivable means of transporting computer equipment. Dealers everywhere were bent on getting their stuff inside out of the rain.

Trailer unloading ought to be an Olympic event. Two men and one woman seemed to be the average team makeup. Some of the big companies cheated with professional help.

As the afternoon went on, the entire Exposition Center was covered with piles of rugs, boxes, boards, disassembled furniture, signs, computer components, and angry dealers trying to find out what happened to their electric power. *Compute!* magazine sponsored a very nice party in the exhibitors' lounge Thursday

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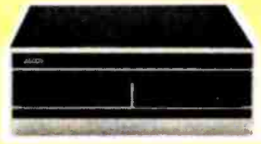

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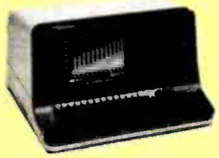

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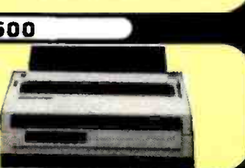

afternoon, and I much enjoyed the hospitality. The party was largely attended by the press and the lucky few exhibitors who'd gotten their booths set up. Most hadn't, and when I left the Center Thursday evening, the scene resembled one of the less pleasant circles of Dante's Inferno.

Somehow by the time the show opened Friday morning, everything *looked* organized. Most of the dealers were exhausted, having worked all night under trying circumstances. That's not a big problem for large outfits with professional staffs, but it can be pretty serious for firms of owner and spouse, who have to work like donkeys all night and be charming the next day.

Friday morning the crowds came. Eventually there were 50,000 attendees. At least 25,000 were there Friday morning when I took my tape recorder and went racing past the exhibits while dictating notes. I always do this; the idea is to locate everyone. (I'm tempted to bring my roller skates. Jim Warren, who founded the Faire, always wears his.)

There were an astounding number of booths. Last year, the meeting rooms to each side of the main hall were devoted to convention conferences. This year they had become the Apple and IBM PC halls respectively. In addition, every corridor was jammed with booths. In past years booths have filled the corridor outside the rest rooms, but this year they extended into the chair storage area, a place more like the Black Hole of Calcutta than a computer exhibit site.

As usual, the halls are filled with 6 by 6 microbooths and the downstairs area contains innumerable 8 by 10 minibooths. You can't ignore them. They often have the most exciting stuff in the show.

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One wants to be careful about bandwagons. In 1919, Lincoln Steffens, American writer and social critic, went to the newly created Soviet Union, and after a brief visit to what was then called Petrograd, cabled: "I have been over into the future, and it works." He might have a different view today.

Similarly, at the tiny Logitech booth I saw Lilith, the computer used by Niklaus Wirth. This is a rather powerful machine capable of concurrent processing. That means that it can run a number of programs, or more important, a number of parts of the same program, at the same time. Lilith was operated by Brigham Young University professor Richard Ohran, who was there as one of the principals of the nonprofit Modula Research Institute, as well as vice-president of the commercial firm Diser Inc.

I saw graphics better than arcade games. There was a game of billiards, in which you could use a mouse to move the cue around. The balls had spin after being hit, and not only showed it by visibly "spinning" as they moved, but behaved accordingly as they bounced off each other and the "table."

More interesting, though, was a text editor that would format almost anything you wanted onto the screen,

Continued on page 315

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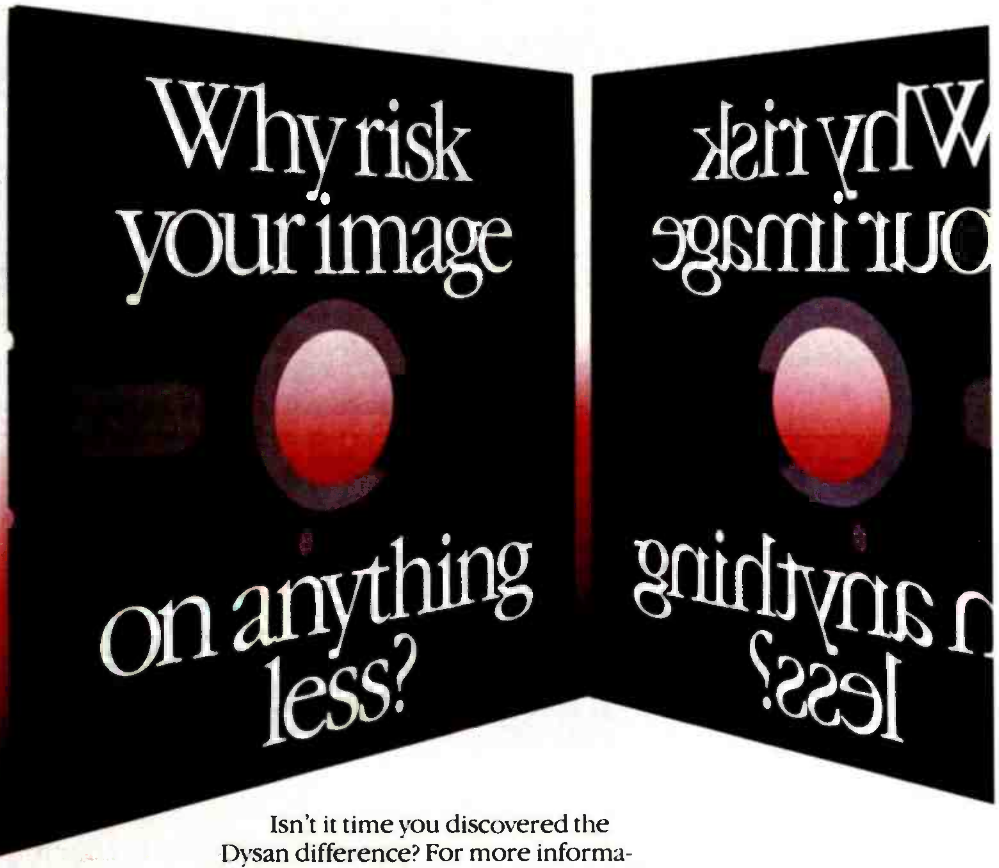

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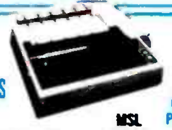

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putting it in nearly any typeface and size you could imagine. It was also controlled by a mouse, and worked something like Apple's Lisa, but *much* faster.

The editor was coupled to the compiler and a debugger. A program could be written with the editor, compiled, and executed in the debugger. While the program was running, Ohran halted it. Then, using the mouse, he displayed the segment of source code corresponding to what the machine was doing when halted. Code could be altered quickly, and the program module could then be recompiled. (Modula uses very modular compilation, so you seldom need to recompile large parts of a program.)

I was impressed. This is the first editor I've seen that's probably better for text creation than WRITE, as well as certainly better for program writing. Moreover, it's written in a language I understand, or at least could understand, meaning that it can be changed, altered, and customized to fit my idiosyncrasies.

This whole system of editor, debugger, and compiler was written in Modula-2, Niklaus Wirth's new language. Modula-2 is sometimes described as "grown-up Pascal," and I'll be reporting on it frequently. I already have a version running on my Sage. The exciting news is that Logitech has a version of Modula-2 that compiles to 8086 native code.

This means that programmers can soon have Modula-2 for the IBM PC (and its work-alikes such as the Eagle and Victor), as well as for CP/M-86 machines such as the 8085/8088 dual processor and the new 10-MHz 8086 card Compupro had at the Faire.

There's even better news for PC owners. The Logitech mouse will plug into the IBM PC keyboard. It should also work with the Eagle and any other PC work-alike whose keyboard can be plugged unchanged into the IBM PC.

You can see why I was tempted to use Lincoln Steffens' line. This does look like the future, and it seems to work.

Alas, there may be more to the story.

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You've heard the good news. The not so good is that it's just not certain how much of this will work properly on the 8086-chip machines. Possibly a lot. Possibly not. Pierluigi Zappacosta, vice-president and spokesman for Logitech, didn't want to commit himself. Although Modula-2 is a transportable language—considerably more so than Pascal—there are some machine-dependent features of the editor/compiler/debugger system Ohran was demonstrating, and while Lilith isn't *that* much more powerful than the 8086 machines, it does have some unusual features.

According to Ohran, there are only about 75 copies of the Lilith machine in the world. You can buy the computer for something like $15,000. And the laser printer needed to take advantage of the fancy graphics, print formats, and character fonts Lilith can generate costs another $12–15,000.

We may not soon see those graphics and print formats on any existing PC or work-alike. They just don't have large bit-mapped screen systems like that. Lilith's display uses half a million bits of memory for screen mapping. I have seen similar bit-mapped graphics on the LISP machine at MIT, and Lisa has about two-thirds the resolution of the Lilith machine.

Zappacosta was a great deal more optimistic about transferring the debugger and many of the editing features to the IBM PC. The PC's 8086 chip can do concurrent processing, so the only real uncertainty is speed. Even that's not likely to be a problem for my 10-MHz Compupro 8086 board.

Beyond the 8086 is the 2-86, which most of us agree is as powerful as Lilith (although Ohran would argue the point). The 2-86 will accept 8086 instructions, meaning that the Modula-2 compiler will work instantly and can then be used to write a better compiler making more use of the 2-86's capabilities.

Meanwhile, a number of advanced firms, including Compupro, are looking at designs for the memory-mapped graphics board we'd need for that billiards game. Dennis Hunter of the Swiss-backed firm Diser Inc. tells me that a commercial version of Lilith itself will be at the Atlanta Comdex show. That machine, complete with graphics and the software I've described, will be available as a package deal for around $22,000.

There are some problems with Modula-2; it lacks features I'd have thought it should have. Even so, I *know* you can write nifty programs and operating systems with it, because I've seen them running. I guess the bottom line is that I've seen, if not *the* future, then a future I like, and I think I know how to make it work.

APL

More good news. There's an APL for the Z80 machines. For those who don't know, APL (A Programming Language) is very strange. It makes use of about a zillion little special symbols, such as a "T" lying on its side, and squashed boxes, and diamonds, and stuff like that. Each symbol stands for something interesting, such as "take the natural logarithm" or "raise to a power." It's *interpreted*, like MBASIC, and works much like BASIC; and it has all the commands that a top-quality desk calculator has, including logs, trig, factorials, inverses, etc. In addition, there are matrix operations.

In fact, if the various APL keys had names like "Absolute value of Y" and "Pi times Y" instead of the symbols |Y and 0Y, APL probably wouldn't scare so many people because it works a lot like a fancy scientific desk calculator.

At least that's what my readers tell me. I don't get a lot of mail from APL enthusiasts, but every month there's one or two letters. The interesting part is that whereas enthusiasts of some languages are hostile, APL people *know* most people think their language is weird; instead of threatening, APL enthusiasts plead. "Just try it," they say.

Until now that's been irrelevant, because I had no machine on which I could try it. Now, though, Easi APL Systems Inc. has a real live APL running on Z80 machines. I saw it operate on an Osborne and a Victor. It is said to work with any CP/M

Z80, but there's the problem of generating and displaying those strange APL symbols. According to David Saunders of Easi, I'll have this running on my Osborne in a few days, because they already have a ROM (read-only memory) chip that can plug directly into the Osborne to reprogram its keyboard and displays.

I know almost nothing about APL, but I confess I was impressed with Saunders' demonstration. He set up a 10 by 10 matrix with about three commands, inverted it with a single command, and multiplied it by its inverse with one more. This took only a few seconds. Saunders thought that inverting a 50 by 50 matrix might take half an hour. When I get APL installed on one of my machines, I'll try the matrix multiplication benchmark I invented.

Meanwhile, I can't imagine writing large programs in APL, but as a quick calculator it has some really wonderful potential. If I could just learn it, and get it on the Osborne or the Otrona, I'd have a portable machine with really powerful capabilities. I'll bet that within the year at least one portable machine will offer APL as a standard option.

Ada, Now and Later

The booth next to Barry Workman's was run by R&R Software. They're the people who have implemented both 8080 and 8086 versions of Ada. They're honest to a fault, so they call their language Janus; but it's more nearly Ada than any other microcomputer implementation I know of.

The Department of Defense hopes Ada will save the government a lot of money. At the moment, though, there's no full Ada compiler for any machine in the world, and the "official" system compiles at tortuously slow rates. The R&R version compiles quite rapidly.

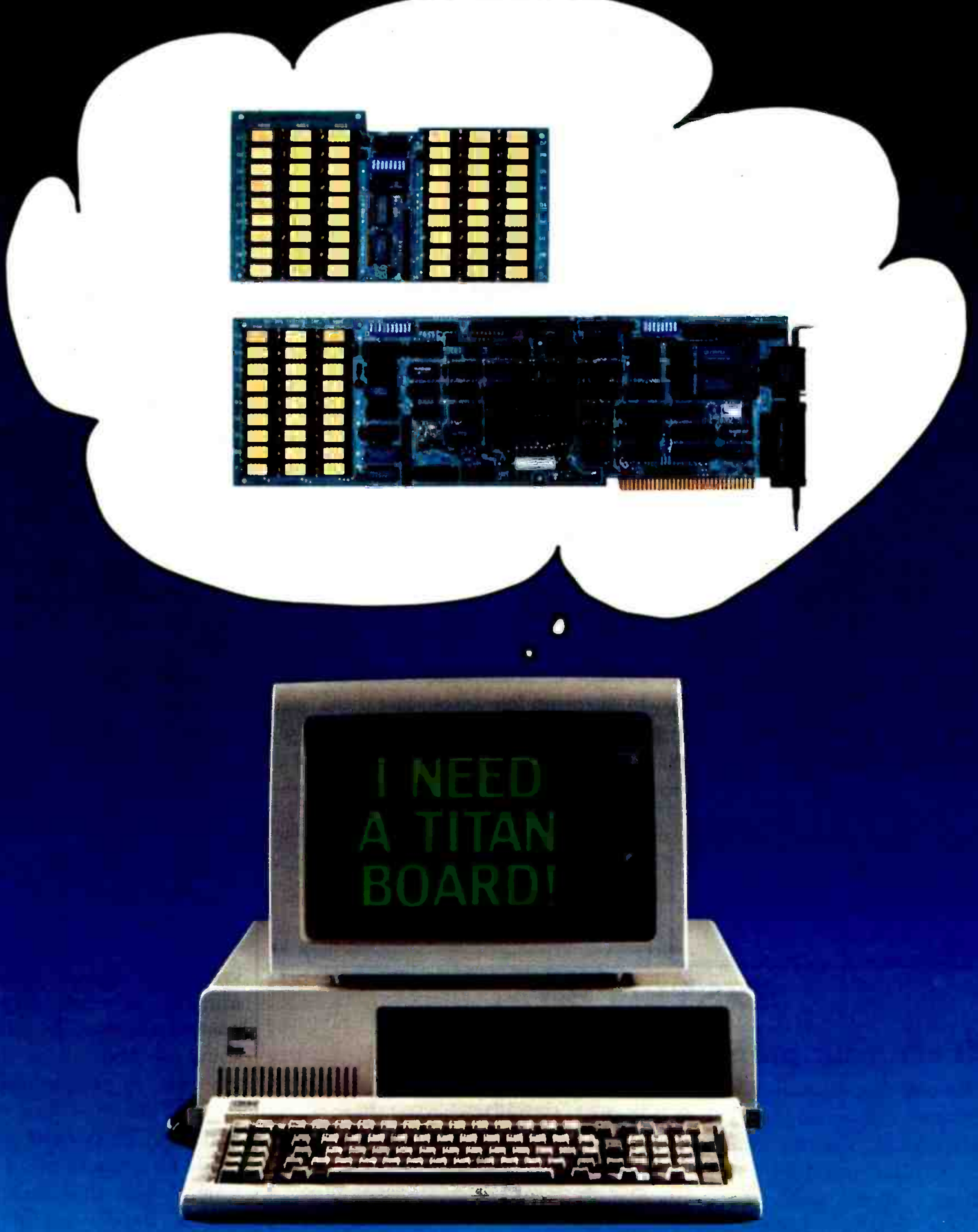
It's not a full Ada; but as Randy Brukhardt, one of the Rs in R&R, told me, it's certainly complete enough to write practical programs in. He knows, because it compiles itself. I watched some of the demonstrations, and it works. As I've said before: if you want an assured income, learn Ada. You don't have to *like* the language to profit from it, and the government will be hiring Ada programmers for a long time.

On that score, I can recommend a new book, Narain Gehani's *Ada: An Advanced Introduction*. It's just out in the Prentice-Hall Software series. I read part of it on the plane home (at least I didn't have to drive *back*). As the title says, it's an advanced introduction, meaning that it assumes the reader has some familiarity with computers and programs. It's fairly complete, and the writing isn't too obscure, although I have found myself reading some paragraphs more than once.

Down with the Prices!

There were a number of bargains at the Faire. Priority One had 16-megabyte Morrow hard-disk drives, with S-100 bus controller, for $1595; the same disk drive without controller could be had for $1295.

There were so many exhibits at the Faire that Priority One, along with



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Eagle Computers and Micropro, found themselves beyond the main building doors in a basement area that used to be a garbage collection area. It took Bill Godbout an hour to find the Priority One booth. When he finally did, he announced that his new Disk Three Controller will work with the Morrow hard-disk drive.

One hundred dollars a megabyte is a low price.

Meanwhile, down in the Black Hole of Calcutta, Micromate offered a full CP/M single-board system, with Z80 processor, disk controller, 64K bytes of memory, two input/output ports, and a single 8-inch disk drive, for $695. Before you could use it you'd need a terminal, of course.

Lobo offers its Max-80 with keyboard but no screen—and no disk drives—for $800. Matchless Systems, whose owner Mike Connor is a real disk whiz (a couple of years ago he solved several of the problems we had with our TRS-80 disk drives), has a two-drive full Z80 CP/M single-board system at a reasonable price, as well as reliable add-on drives in single-sided and double-sided configurations.

Priority One will sell you a floppy-disk drive for $255.

George Morrow's Decision One system was going for bargain prices.

These are just things I noticed. There are lots of others. Good CP/M components and full systems, capable of business-quality work, are now competitive with similarly configured "home computers." You still have to shop around, and note that this is a show report, not an evaluation column; except for Barry Workman's Lobo Max-80 (which he still loves after six weeks), I've had little to no experience with any of those systems.

Furthermore, I still recommend S-100 bus systems to those who can afford them: it remains true that "Iron is expensive, but silicon is cheap." You can update an S-100 bus system at reasonable costs. For the budget-minded though, there are some real bargains if you're careful. More on this in future issues.

Ventricles in the Frammistan!

The Jonos computer is by all reports a good little machine. It makes use of the Sony-format vest-pocket (3¼-inch) disks. The Jonos is very portable, employs the STD bus, and has about the nicest keyboard I've seen on any portable computer. I've never worked with one myself, but people I respect who have them report great satisfaction, and I have no negative information about the machine itself.

I *do* wonder about the people demonstrating it.

When I first saw the Jonos last fall at the Mini/Micro show, Amos Jones, the company's owner, sat in a tiny booth personally explaining his machine. He answered all my questions patiently and sensibly.

I'm told he was present at the Faire, but I never saw him. When I went by the booth, there was a chap in a three-piece suit who seemed eager to answer questions. The Jonos has a key outboard of the Shift and below Control, which is in my judgment a terrible place for a key because it's so easy to strike it accidentally. On the Jonos it's inscribed "Funct," and I wanted to know what it does.

I asked the demonstrator. I should have waited for Amos Jones.

I don't mind when people don't know the answer to a question. I mind a lot when they give me an answer anyway. In this case I got a shine job about how wonderful that key was for programmers.

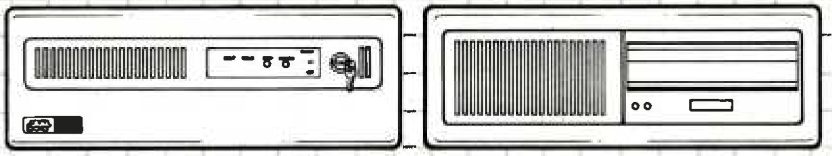
"Yes, but what does it do?" I asked patiently. There came more jargon. It made no sense to me. I asked a third time. I was told that the key sent special signals useful to programmers. Hmm, thought I. Could this be the equivalent of the "meta" key on some advanced machines? That really would be interesting.

"Does it set the eighth bit?" I asked.

"Yes, yes, these are 8-bit machines," came the answer.

Never mind if that makes no sense to you; it shouldn't. It makes no sense to *anyone*.

At this point I understood. I was going to get an answer to any question I asked, regardless of whether or not the question was rational. I must



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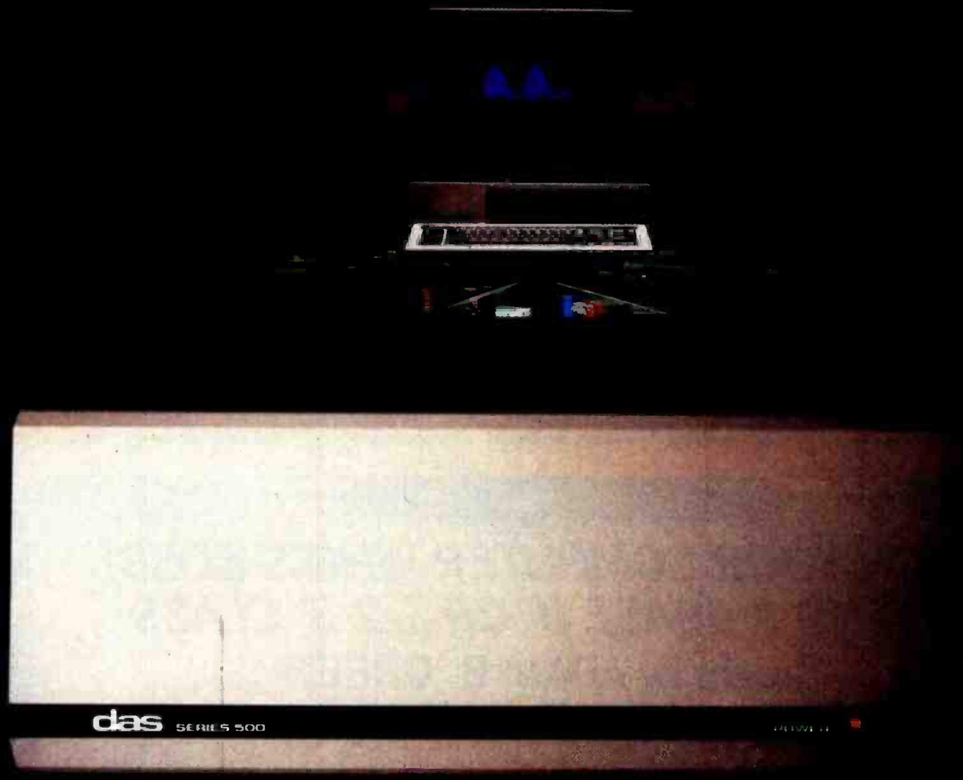

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have been tired, for a wicked scheme came unwanted into my head.

"I've noticed," I said in my most puzzled voice, "that some of the competition has ventricles. Do you have them?"

"Yes, yes, we have the most features of any portable machine on the market."

"But," I continued, "do you have them in the frammistan where they belong?"

"Yes, yes," he began. Sudden comprehension flashed across his face. He realized he'd been had. The frammistan was just too much.

Please, Fellows . . .

The moral of the story has nothing to do with Jonos computers, which remain good machines. (I've since learned what the Funct key does, and indeed it is very useful for programmers, because it allows you easily and simply to reprogram the special-function keys; this is a highly desirable feature.)

The moral of the story is, if you're selling computers, make all your salespeople learn the words "I don't know." I'm told it's "good sales technique" for salespeople to act as if they know more than they do. Certainly it will work quite a bit of the time because the public doesn't know an awful lot about computers. Sooner or later, though, there'll come along someone like me.

I may never again catch anyone with ventricles in his frammistan, but I'll bet I can think of something equally absurd and not quite so obvious.

Comes the Epson

Barry Workman's booth probably had as much new and different equipment and software as anyone at the show. One of his attractions was the Epson QX-10. If he'd been an Epson dealer, he could have sold a dozen of them. Everyone stopped to look at it.

What he had (with Epson's permission) was my beta-test machine. What made it really unusual was that Chris Rutkowski and Roger Amidon, respectively the president and software development manager of Rising Star Industries, came by and updated our Epson software.

Rising Star is in charge of the Epson QX-10 software, and a couple of days before Faire time I called Roger Amidon for a quick conference on problems I was having with the test software. Roger worked on it overnight and brought the update to the Faire. That's *service*.

Alas, he didn't have the documentation completed in time, so I can't really report on the Epson QX-10. We did run some of the graphics package, and it's both very nice and quite easy to use. Some of the visitors to Barry's booth tried the Epson text editor and liked it, and a couple of them wouldn't accept that the machine wasn't for sale until Barry himself confirmed it. It wouldn't be fair to say more until I have the final version of the Epson software.

It was pleasant to meet Chris and Roger, but I didn't have long to talk with them, because they came just before my big speech.

The Pascal Project

Some time ago, weary of the limits of Pascal, I conceived a bright idea: if all the compiler writers would get together, maybe they could agree on a standard set of extensions to the language. That would make it much more useful.

Thus was born what I rather pretentiously labeled "The Pascal Prime Project." Since I hate to waste good ideas, I immediately telephoned a number of compiler people. "We all go to the West Coast Computer Faire," I said. "Let's get together and see what we can agree on." Most of those invited said they'd show up at the meeting, although few (other than me) thought there'd be much accomplished.

They were right, of course. Nothing specific was accomplished. On the other hand, we all agreed that the meeting had been worthwhile. Certainly I thought so. I learned a lot, most of which will have to be reported in another place.

The meeting was chaired by Carl Helmers, former editorial director of BYTE. Present were Bob Wallace, the Microsoft Pascal designer, Al Irvine of Softech Microsystems, Mike Lehman of Digital Research, James Tyson of JRT Systems, and Mike Haggarty, chairman of the IEEE Pascal Standards Committee. Conspicuously absent was Paul McQuesten of Sorcim. Everyone agreed that Pascal needs extensions, and there ought to be agreement on which ones and how to implement them.

McQuesten wasn't there because Sorcim didn't want to be committed to revisions; its resources are going into other work at the moment. He needn't have worried.

All the major companies except JRT stated their intention to implement "standard Pascal." There the agreement ended, and there, I fear, it will remain ended.

A Ray of Hope

For a while I saw hope loom. Mike Haggarty announced publication of the IEEE Pascal Standard, and when I asked, plaintively, just what I should write programs in if I wanted some hope of both convenience and program portability, he held up his standards book to universal laughter and applause.

Unfortunately, that was a better gesture than advice. No one uses "standard Pascal." You have to have *some* extensions or you'll never get any practical programs done.

Then Haggarty read the "proposed extensions" that have been "almost accepted" by the IEEE committee. They sounded like the answer to a prayer. An "otherwise" exception to the case statement. An exponentiation operator. An "open file" statement. Nonnumeric labels. Structured function results, with functions able to return any reasonable type. A whole mess of other stuff, all desirable.

There was also a list of proposed features that had been rejected, either because there was no agreement among the committee on how to accomplish them, or because a majority of the committee felt they weren't desirable anyway. Two of the rejected proposals, strings and separate compilations, were pretty important. Others weren't.

The list of "agreed" extensions was longer and far more important than the list of "rejected" ones.

Terrific, I thought. There is progress, and by the people who are supposed to be making it. I have foolishly set myself a task that I need not have begun.

Then I had to ask: have these "standards" been published? No. They haven't even been adopted. They're merely proposed, "agreed" by some subset of the committee. Most of the compiler people present had implemented several of them, but no one had added all of them—and there had been no consultation about how they were implemented, either.

We're as far from portability as ever.

During the course of the discussion, I argued that Modula-2 will replace Pascal (and have a go at the C programming language as well). I may or may not believe that, but it did seem an interesting thing to say to a room full of Pascal enthusiasts. As expected, my view wasn't accepted by the panelists. Al Irvine of Softech

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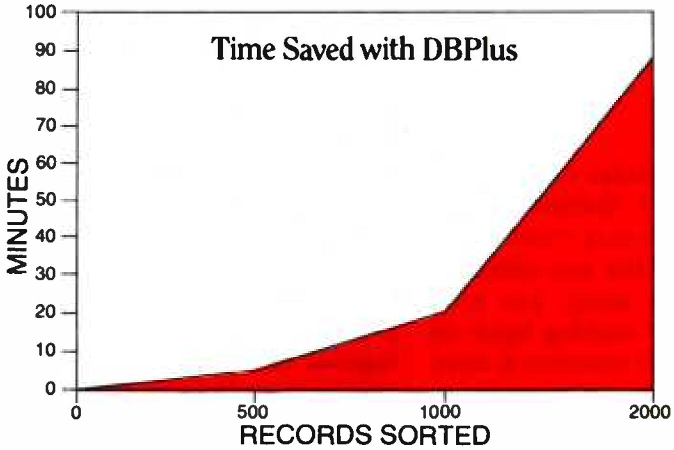

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was particularly lucid in his objections: too many people know Pascal, and there's too much invested in existing Pascal programs.

He's probably right. Still, Modula-2 does seem to offer some clear advantages, and it's very easy for Pascal programmers to learn it. It all depends really on just how good an implementation of Modula-2 we get, and when. Meanwhile, Pascal is alive, and if not well, at least not critically ill.

Fun and Games

The most spectacular display at the show was Perfect Software's laser light show. It was in a room of undiscernible size. After you entered a black maw on a ramp, you were guided by lines of flashing lights on either side, with TV monitors at intervals. A breathless voice spoke in hushed tones about the future.

Once inside there was a Futureworld atmosphere. Green laser beams flashed overhead. (I'm told it was one laser and lots of mirrors.)

As marketing hype it was awesome, at least to me. Alex's friend Jenny says it wasn't as effective as I thought: she went into the display and returned not knowing what it was Perfect Software sold.

Meanwhile, all over the Faire were arcade-style games. There weren't too many creatures eating dots, because Atari's lawyer was there to discourage that; he told H.A.L. Labs president Greg Autry that its game Taxman violates Atari trademarks. It seems that H.A.L. Labs uses a circle with a slice cut out of it, even though its Taxman creature doesn't eat dots. (It eats dollar signs and leaves a trail of cent signs.)

I wonder if this trade protection stuff hasn't gone too far. Eating dots was awfully popular last year, but I'd think the market is nearly saturated now. I certainly wouldn't want to be Atari's lawyer against H.A.L. Labs, which consists of a bunch of teenaged computer whizzes working out of their garage. Its games are nice, with excellent graphics. My kids prefer the Apple versions of Taxman to any of the other chase-in-a-maze games we have at the moment. I suspect any jury would begin with considerable sympathy for H.A.L. Labs; I know I do, but then you must realize they're all science-fiction fans and like my books.

According to patent law, you can't patent an idea. Literary copyright law is a little more tricky. I served as an expert witness in the suit between *Star Wars* and *Battlestar Galactica*, and was given a fairly extensive briefing; but neither I nor anyone else could write a definitive statement of just what combination of common-knowledge elements constitutes an idea worthy of protection by the public authorities. Take *any* element: mazes, eating dots, creatures changing character after eating something special, and you can find many past precedents. How many must be put together before you can justify having the taxpayers pay the police and judges to protect your exclusive rights?

H.A.L. Labs has already had one bout with Atari, and as a result it changed its maze, changed dots to dollar signs, and made other changes in graphics. It's now being told that Atari has exclusive right to a circle with a wedge cut out.

Gosh, I'd swear CornNuts used to use circles with a slice cut out . . .

Don't Lean on Shirley

For months now I've heard rumors that Compupro was going to build a machine that didn't use the S-100 bus. Compupro gave it the code name "Shirley."

A model of Shirley was on display at the Compupro booth. It's certainly smaller than the usual Compupro machines: a low-profile box about the size of the electronics part of an IBM PC. It holds two half-height 5¼-inch floppies and a 5-inch Winchester hard-disk drive; the rumor is that there'll be about 20 formatted megabytes on the Winchester. Given that Bill Godbout started in this business by selling memory boards, and that he had hanging on his wall the new 64K-byte memory chips, you can expect plenty of memory aboard Shirley.

The display model was only a plastic case with drives in it. The real

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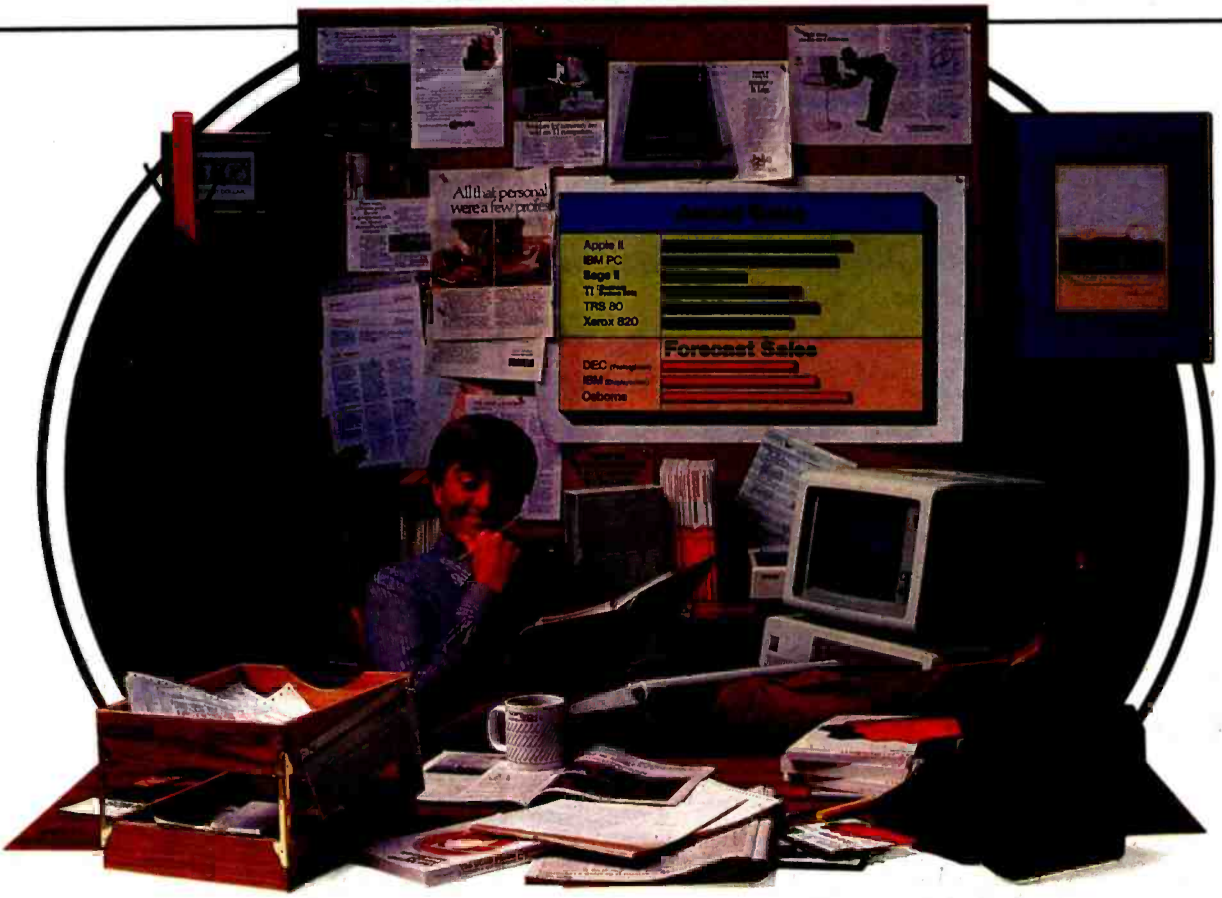

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Computer Control			
FABS (B-TREE file access)		195	146
Ultrasort II		195	146
Computer Development, Inc.			
Image		495	356
Comshare Target Software			
Plannercalc		50	38
Masterplanner		325	263
Condor Computer Corp.			
Condor 1		195	147
Condor 3		650	488
Designer Software			
Palantir		425	319
Dictronics			
Random House Electronic Thesaurus		150	113
Digital Research			
Access Manager		300	225
MAC (macro assembler)		90	75
SID (symbolic debugger for 8080)		75	63
ZSID		100	88
CBASIC (language)		150	94
CB80		500	395
CIS COBOL		800	595
Oisplay Manager		400	295
Pascal Mt+ w/SPP		500	395
DJR Associates			
FMS 80		995	625
FMS 80-1		495	312
FMS 80-2		495	312
Ecosoft			
MicroStat (stat package)		295	248
Epic Computer Corp.			
Supervyz		150	94
Faircom			
MICRO B+ (Keyed file accessing)			
For CBASIC 2		260	211
For MBASIC, COBOL, PL1/80, FORTRAN, Pascal MT+, CB 80		260	211
Fox and Geller			
dGRAPH		295	195
Quickscreen		149	125
Quickcode		295	195
dUTIL		99	59
FYI			
Superfile		195	129
Infocom			
Deadline		60	43
Zork I, II, III (ea.)		50	38
Star Cross		50	38
Human Soft			
D B Plus		125	95
ISM			
Mathemagic		99	72
Lexisoft			
Spellbinder		495	281
Lifeboat			
T-Maker II		275	215
Mark of the Unicorn			
Mince (text editor)		200	136
Final Word		300	229
Micro Pro			
Infostar	[5]	495	327
Report Star		350	231
Wordstar	[4]	495	327
MailMerge		250	165
Wordstar/MailMerge	[4]	695	426
Spellstar	[4]	250	165
Wordstar/Spellstar	[4]	695	426
Word/Spell/Mail	[4]	845	558
Calcstar		145	96
Datastar		295	195
MicroSoft			
BASIC 80		350	252
BASIC Compiler		395	284
FORTRAN 80		500	360
COBOL 80		750	540
MACRO 80		200	156
EDIT 80		120	94
μ Math/μ Simp		250	194
μ LISP/μ Star		200	156
M-Sort		195	151
Multiplan		275	179
Microstuf			
CrossTalk		195	119
Northwest Analytical			
Statpak		495	369
OASIS			
The Word Plus		150	112
Organic Software			
Datebook		295	229
Milestone		295	229
Peachtree			
Series 4 Peach Pak (GL,AR,AP)		595	359
Pearlsoft			
Personal Pearl		295	184
Pickles and Trout			
CP/M TRS 80 Mod II		185	169
Select Information Systems			
Select with Superspell		595	369
Software Dimensions			
Accounting Plus™			
GL, AR, AP, Inv each		645	402
All four		2580	1435
Sorcim			
Pascal/M (Z80 or 8080)		395	284
Pascal/M (8086, 8088)		495	356
ACT 80 (Z80, 8080, 8085)		175	126
ACT 86/88 (8086, 8088)		175	126
TRANS 86		125	90
Spellguard		195	146
SuperCalc		295	185
Superwriter		395	249
Supersoft			
C Compiler		250	188
Ada Compiler		300	225
Woolf Software Systems			
Move it		100	66

Formats for CPM 8", Apple 5¼ & others. Price the same in most cases.

HARDWARE

		List	Now
Corona			
5MB Hard Disk	[6]	2495	1895
Daisywriter			
Printer	[10]	1395	1235
Hayes Microcomputer Products			
Datacom Pascal Package		50	36
Hayes Stack Chronograph (RS-232)	[4]	249	199
Hayes Stack Smart-Modem (RS-232) 300 Baud	[4]	279	209
Hayes Stack Smart-Modem (RS-232) 1200 Baud	[4]	699	509
NEC			
12" Green Hi-Res CRT	[10]	285	167
7710 Printer	[10]	3085	2295
3530 Printer	[10]	2290	1735
8023 Printer	[10]	795	520
Novation			
J-Cat	[4]	149	119
Smart-Cat 103	[4]	259	207
Smart-Cat 103/212	[4]	595	476

® =Manufacturer's trademark.

APPLE DOS

	List	Now
Applied Software Technology		
Versa Form:		
VS-1 Apple II/64K	389	249
VH-1 (Corvus)	495	360
VP-1 Versaform Pascal/Interface	245	180
ARTSCI (Softape)		
Magic Window II (40/70/80)	150	109
Magic Window	100	75
Magic Mailer	70	49
Magic Words	70	49
Magic Pack Combo (Contains all 3)	225	156

Avant-Garde Creations		
Ultra Plot/D.I.F./Data Graph	99	71
Beagle Brothers		
Alpha Plot	40	28
DOS Boss	24	17
Utility City	30	22
Apple Mechanic	30	22
Broderbund Software		
General Ledger (with A/P)	495	305
Payroll	395	275
Computer Station		
Combined Enhanced Graphics Software	55	40
Station Master	175	136
Comshare Target Software		
Image Maker	175	126
Continental		
Home Accountant	75	52
1st Class Mail	75	54
CPA #1 — GL	250	159
CPA #2 — AR	250	159
CPA #3 — AP	250	159
CPA #4 — PR	250	159
All four [5]	1000	609
CPA #5 — Property Management	495	352
Crane Software		
Menu Generator	40	29
Creative Curriculum. Inc.		
Speed Reading Courseware	99	75
Dakin 5/Level 10		
Depreciation Planner	395	299
Budget Planner	150	112
Business Bookkeeping System	395	299
Datamost		
Write On II	130	90
Real Estate Analysis Program	130	90
Tax Beater	130	90
Datasoft. Inc.		
Micropainter (48K)	35	25
BASIC Compiler (32K)	100	75
LISP Interpreter	125	94
Decision Support		
The Accountant	129	97
• with OBCalc	149	107
Delta Software		
Bookkeeper Master Program	90	68
Bookkeeper Check Writer	40	29
Denver Software		
Pascal Tutor	125	97
Pascal Programmer	296	223
Financial Partner	250	188
Eastside		
Wildcard	130	109
Eduware		
Compu-Read	30	22
Statistics	30	22
Spelling Bee with Reading Primer	40	30
Compu-Math/Fractions	40	30
Compu-Math/Decimals	40	30
Compu-Math/Arithmetic Skills	50	37
Algebra 1	40	30
Fractions (New version)	49	37
Decimals (New version)	49	37
Algebra 2	40	30
Counting Bee	30	22
Compu-Spell/System	30	22
Compu-Spell/Data Disk Levels 4 thru 8 (ea)	20	15
Metri-Vert	16	12
Uni-Solve	25	19
PSAT Word Attack Skills	49	37
SAT Word Attack	49	37
Hayden Software		
Pie Writer/Standard	150	108
• Double Vision	150	108
• Multi 80-col (for Smarterm, Videoterm. & Superterm)	150	108
Hayes		
Terminal Pgm.	100	75
Highlands Computer Services		
E-Z Ledger	60	37
Howard Software		
Creative Financing 1983	195	149
Real Estate Analyzer II	195	146
Information Unlimited Software (IUS)		
Datadex	150	108
Datadex/Hard Disk	300	216
Professional Easywriter	175	126
Professional Easymailer	150	108
Easy Mover	100	75
Tellstar Level I	40	30
Tellstar Level II	80	58
FORTH Development System	140	101
Insoft		
GraFORTH II	75	56
Electric Duet	30	23
TransFORTH II	125	94
ALD System II	75	56
International Software Marketing		
Mathemagic (Advanced programmable calculator package)	90	65
Graphmagic	90	65
Kensington Microware Ltd.		
Format II	250	169
Lightning Software		
Mastertype	40	30
Link Systems		
Datafax	199	149
Datalink	100	75
Link Index	195	149
Link Video	55	41
Link Disk	70	51
LJK Enterprises		
Letter Perfect with Mail Merge	150	112
Data Perfect	100	78
Lower Case Character Generator (accessory)	25	19
Lotus		
Executive Briefing System	199	149
Micro Lab		
The Invoice Factory	200	144
The Merger	50	37
The Learning System	150	108
Painter Power	40	30
US Constitution Tutor	30	22
English SAT #1	30	22
VisiBlend	50	37
VisiFactory	75	54
The Asset Manager	200	144
The Tax Manager	180	129
Data Factory 5.0	300	216
Wall Streeter	300	216
Payroll Manager	300	216
Microsoft		
TASC (Applesoft compiler)	175	119
Typing Tutor II	25	19
Time Manager	150	116
Adios μMath-80	125	97
Adios μMath/μSimp	250	194
M-Sort	195	151
μLisp/μStar	200	156
Multiplan	275	179
MUSE		
Supertext 40/56/70	125	79
Supertext 40/80	175	126
Form Letter Module 48K	100	72
Data Plot 48K**	60	43
The Voice 48K	40	29
**Requires Applesoft. ROM or Apple II Plus		
Omega		
Locksmith	100	75
Inspector	60	49
On-Line Systems		
The General Manager	230	168
Screenwriter II	130	85
The Dictionary	100	70
Expeditor II+ (Applesoft compiler)	135	94
LISA	80	56
EPFIV (Extended Programming Facility IV)	80	56
LISA Educational Package	120	83
Optimized Systems Software. Inc.		
Speed Read Plus	60	43
Peachtree		
Series 40 GL. AR. AP. Inventory. Payroll (ea)	400	239
Penguin Software		
Complete Graphics System	70	50
Special Effects	40	30
Graphics Magician	60	45
Additional Fonts and Character Sets	20	15
Complete Graphics System II (Apple Tab Ver.)	120	86
Special Effects (Apple Tab Ver.)	70	50
Program Design. Inc.		
The New Step-by-Step	80	58
Quality Software		
GBS-DB Apple Dev. Prog.	700	504
Sensible Software		
Super Disk Copy III	30	23
Multi Disk Catalog III	25	19
Disk Recovery ("The Scanner")	30	23
Applesoft Plus Structured BASIC	25	19
Disk Organizer II	30	23
DOS Plus	25	19
Quickloader	25	19
Image Printer-Letter Quality	40	30
Image Printer-Epson	40	30
Image Printer-NEC Dot Matrix	40	30
The Bug	50	37
Build Using	30	23
Edit Soft	30	23
Quadrant 6112	35	26
Sensible Speller	125	94
• for Supertext	125	94
• for Apple CP/M	125	94
• Pascal	125	94
BEST (Applesoft Program Optimizer)	40	30
Select Information Systems		
Select (with Superspell)	595	356
Silicon Valley		
Word Handler	199	145
List Handler	90	68
Dictionary	125	94
Sirius		
Pascal Graphics Editor (48K II/II+)	100	69
Sof/Sys. Inc.		
Executive Secretary	250	169
Executive Speller	75	56
Softech Microsystems		
UCSD P-System Software Set [4]	625	450
BASIC Compiler and Runtime Package	225	169
Xenofile	50	39
Softeach	125	90
Software Dimensions		
Accounting Plus™		
GL. AR. AP. Inv ea	395	239
All four	1250	699
Software Publishing		
PFS:File	140	99
PFS:Report	125	79
PFS:Graph	140	99
Southeastern Software		
Data Capture 4.0	65	45
Data Capture 4.0/Videx. Smarterm, Superterm	90	65
Southwestern Data		
Z-Term Professional	150	99
ASCII Express	80	59
ASCII Express Professional	130	89
STC		
Professional Time and Billing	395	284
Language Reading Development Program	175	126
Apartment Manager	325	234
Stoneware		
DBMaster	229	148
Utility Pak #1	99	65
Utility Pak #2	99	65
OBMaster/Hard Oisk	499	359
Stat Pac	99	71
Micro Memo	40	30
Electronic Price Sheet	100	72
Compucube	30	22
Graphics Processing System (Standard)	60	45
Graphics Processing System (Professional)	179	129
Synergistic Software		
The Linguist	40	30
The Directory Manager	25	19
The Star Gazer's Guide	30	22
Higher Graphics II	35	26
Mailing List Data-Base	50	37
Program Line Editor	40	30
Modifiable DataBase	80	59
The Data Reporter	220	158
Integer BASIC Compiler	150	108
Global Program Line Editor	65	49
Data Reporter—Hard Disk	220	158
Versa Computing		
VersaWriter Expansion Pac-I	40	30
VersaWriter Expansion Pac-II	40	30
VersaWriter Graphics Tablet (accessory)	299	252
VisiCorp (Personal Software)		
VisiCalc	250	169
VisiFile	250	169
VisiLink	250	169
Desktop Plan II	250	194
VisiPlot	200	156
VisiTrend/Plot	300	234
VisiDex	250	194
VisiTerm	100	65
VisiSchedule	300	234
Business Forecasting Model (req. Visi Calc)	100	78

APPLE HARDWARE

Hayes		
Micromodem II [4]	379	259
• with terminal pgm	409	289
Kensington		
System Saver (Fan)	90	65
Micro-Sci		
A2 35T Disk Drive [5]	479	329
Microsoft		
RAMcard (memory board)	100	69
Softcard (CP/M board)	345	219
Premium System: Softcard. 16K RAMcard. Videx Videoterm 80 col. Card. Softswitch. CP/M User Guide [5]	695	489
Personal Computer		
Appli-Card (6MHz)	595	429
Videx		
Keyboard Enhancer II	149	99
Videoterm w/Soft-Switch	375	239

APPLE ///

Applied Software Technology	**List**	**Now**
Versa Form VS-3	495	371
DataMost		
Write On	130	99
Denver Software		
EASy (Executive Accounting System)	725	562
Insoft		
TransForth ///	125	94
ALD System ///	75	56
Link Systems		
Link Index	195	146
Link Video	55	42
Link Sampler I	60	45
Datafax	249	187
Datalink	149	112
Micro Lab		
Data Manager ///	750	562
Software Publishing Corp.		
PFS: File	175	120
PFS: Report	125	86
PFS Graph	175	120
VisiCorp		
Desktop Plan ///	300	234
Visischedule ///	300	234
Visicalc Advanced III	400	312
Business Forecasting Model	100	78

APPLE IIe

Most Apple II products also run on the IIe (call for details). Products below are specially designed for the IIe.

Software Publishing		
PFS File	125	99
PFS Report	125	99
PFS Graph	125	99
VisiCorp		
Visicalc Enhanced		202

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Compupro Systems *Oakland Airport, CA 94614-0355* *(415) 562-0636*	*Shirley*
Diser Inc. *POB 70* *Orem, UT 84057* *(801) 224-7444*	*Lilith*
Eagle Computers *983 University Ave.* *Los Gatos, CA 95030* *(408) 395-5005*	*Eagle*
Easi APL Systems Inc. *10 Jackson St. #115* *Los Gatos, CA 95030* *(408) 354-3274*	*APL for Z80*
H.A.L. Labs *Suite 23* *4074 Midland Rd.* *Riverside, CA 92505* *(714) 359-8480*	*Apple and Atari games*
Heath Company *Benton Harbor, MI 49022* *(616) 982-3200*	*Heath/Zenith Hero robot*
Logitech Corporation *165 University Ave.* *Palo Alto, CA 94301* *(415) 326-3885*	*Modula-2 compiler*
Matchless Systems *18444 South Broadway* *Gardena, CA 90248* *(213) 327-1010*	*Add-on disks and small computers*
Micro Peripherals Inc. *4426 South Century Dr.* *Salt Lake City, UT 84107* *(801) 263-3081*	*Print-Mate 99*
Rising Star Industries *24050 Madison St. #113* *Torrance, CA 90505* *(213) 378-3994*	*Epson QX-10*
R&R Software *POB 1512* *Madison, WI 53701* *(608) 244-6436*	*Ada for 8085 and 8086*
Sorcim *2310 Lundy Ave.* *San Jose, CA 95131* *(408) 942-1727*	*Superwriter and Supercalc*
Workman and Associates *112 Marion Ave.* *Pasadena, CA 91106* *(213) 796-4401*	*WRITE*

thing will be solid metal. It was amusing to watch the Compupro people nervously asking Faire-goers not to lean on the display model. They don't much care if you *stand* on the real machines.

They weren't saying much on the record about what Shirley's innards would be. Bill Godbout did tell me that it would have at least five CPU (central processing unit, or brain) chips for four users. Given that the Compupro team invented the dual processor and MPM-8/16, it's a good guess that it will have both 8- and 16-bit capabilities and will be able to take advantage of most existing software.

While I was at the Faire, I introduced Logitech's Pierluigi Zappacosta to Bill Godbout and Mark Garetz, his chief of research. Maybe something will come of that, and they'll have some hardware to take advantage of Modula-2. I sure hope so.

All they'd tell me about Shirley, though, was that they've taken what amounts to an S-100 bus system and squashed out the bus idiosyncrasies, making the whole thing faster and more reliable. Given Bill Godbout's reputation for advancing the state of the art, I won't be the only one looking forward to Shirley.

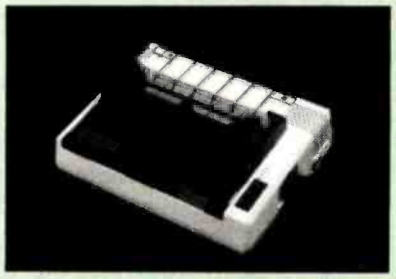
WRITE

On the Monday before the Faire, Tony Pietsch, my engineering genius friend who constructs and maintains my computers, made arrangements to release WRITE and have Workman sell copies at the Faire. I'm not certain precisely how that works, but Ashton-Tate isn't going to be selling this version of WRITE, Tony will be, through Workman. I've written at least enough about this editor in the past, and I don't intend a full review here.

What's relevant is that I'd promised Tony I'd do the front end of his manual if he ever released WRITE. That hadn't been done. On Tuesday morning I was told about this. Tuesday afternoon was eaten by locusts: telephone calls, answering mail, and such like. Tuesday evening I sat down to write a manual.

Wednesday dawn saw 11,000 new words done and edited. There had already existed a "reference manual" about 10,000 words long; we went over that quickly and stuck it on the back end of what I'd done. By Wednesday noon there was an analytical table of contents. We for-

Star Micronics
GEMINI-10
Features Epson code compatability



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C. Itoh Prowriter 2	$734.88
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C.Itoh F-10 Printmaster, 55 cps Parallel or RS-232C	$1679.88
F-10 Series Tractor	$289.88

Diablo

Diablo 620	$1029.88
Diablo 630	$1969.88
Diablo 630 Tractor	$289.88

Epson

FX-80	$CALL
FX-80 F/T	$CALL
MX-80	$CALL
MX-80 F/T	$CALL
MX-100	$CALL
Com-Riter (Letter Quality) Parallel or RS-232C	$CALL

IDS

IDS Prism 80	$1079.88
above w/graphics	$1139.88
above w/sheetfeed	$1249.88
above w/4-color	$1539.88
IDS Prism 132	$1229.88
above w/graphics	$1309.88
above w/sheetfeed	$1419.88
above w/4-color	$1699.88
IDS Microprism	$574.88

Mannesmann-Tally

MT-160-L	$789.88

NEC

NEC 3530	$1759.88
NEC 7730	$2399.88

PRINTERS

Okidata

Microline 82A	$419.88
82A Okigraph ROM	$49.88
82A Tractor	$59.88
82A Roll Paper Holder	$49.88
Microline 83A	$679.88
83A Okigraph ROM	$49.88
Apple Okigraph II	$59.88
Microline 84 w/graphics & tractor Parallel, 200 cps	$1024.88

Microline 92	$524.88
Microline 93	$884.88

Qume

Qume Sprint 11+	$1539.88

Smith-Corona

Smith Corona TP-1	$CALL

Specify either 10 or 12 cpi, & parallel or RS-232C interface

Accessories

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64K Microfazer	$219.88
128K Microfazer	$319.88

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Hayes 1200 Baud	$539.88

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103 SmartCat	$199.88
103/212 SmartCat	$499.88
Novation D-Cat	$159.88
Novation J-Cat	$139.88

Anchor Automation

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Amdek

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300A	$159.88
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Color 3 (Comp.)	$379.88

Princeton Graphics

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Quadram

Quadchrome (RGB)	$529.88

USI

PI-3 (12" Amber)	$189.88
PI-4 (9" Amber)	$159.88

PC PERIPHERALS

RAM Chips

16K (9/pkg)	$29.88
64K (9/pkg)	$79.88

AST Research

MegaPlus has a parallel port, two serial ports, a clock & software.

MegaPlus 64K	$359.88
MegaPlus 256K	$509.88
MegaPack	$329.88

I/O Plus has a parallel port, serial port & clock—no memory.

I/O Plus	$199.88

Maynard Controllers

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w/RS-232C Port	$259.88

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Quad 512 «/256K	$399.88
Quad 512 « 512K	$599.88

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QuCeS

Big Blue	$479.88
12mB Hard Disk	$2059.88
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THE BOTTOM LINE

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MILFORD, NH 03055-0423 ☐ TELEPHONE (603) 881-9855 matted the whole mess and printed it on my NEC 7710. To salvage my pride, we stuck in a notice saying this was done in haste and guaranteeing a free copy of the revised version. Then it was off to the printer.

There's not enough money to have hired me to do that much work in so short a time. The interesting thing is that it was possible; that's probably the best testimonial WRITE will ever have.

Alas, WRITE was not well demonstrated at the Faire. One of the machines Barry Workman had with him was my Z-100; it has that big screen, making it an eye-catcher. They put it on a stand in front of the Workman booth.

That was a mistake. We didn't have a version of WRITE configured for the Z-100. We did have a version installed on the Z-19 terminal, and that worked on the Z-100, but just barely. For example, the special-function keys weren't implemented. These keys are one of the joys of WRITE, making it at least as powerful as any dedicated word processor I've seen. The editor will work without them—my first keyboard didn't have any—but if there are such keys and they don't do what they say they will, users tend to be confused.

The Z-100 when run in 8085 mode has *slow* disk access; at least it's slow compared to what I'm used to. We should have hooked up some 8-inch double-density disks to the machine, but there wasn't room, and Workman hadn't taken any extra drives along. Most of all, though, we should have configured WRITE for the machine it was running on.

Finally, I'd intended to put some text—say the WRITE manual itself—into the machine, so that people would have something to play with. I didn't do that, and in the frantic pace of the show it never got done. Thus, those who stopped to look at WRITE saw only a pale shadow. My fault, and my apologies to those who came by.

One last point: I have no financial stake in WRITE. The editor was originally written to suit Larry Niven and myself. Tony added a number of nifty features. Some new editorial

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features that Larry and I want will go into the next revision.

I've written my part of the WRITE document as "payment" for getting the text editor I want. I will do at least one more revision of that manual; probably two. I will not be paid for doing them. You couldn't pay me enough to do that much work, especially now when I'm up to my clavicle in assignments and contracts.

If I were marketing the program, I'd cut the price a lot. I understand there are some legal complications arising from the previous contract, and at the moment the price *can't* be cut. Anyone who buys the current version of WRITE will receive at least one free revision of both manual and program as part of the price. They'll also get an Install program that's already written, but which wasn't documented for the show. It should have been.

In other words, they weren't ready to sell WRITE, and I probably should have been more adamant about that.

Still in all: when, as, or if I find an editor I like better for what I do—which is creative writing—I'll use it, and I'll tell my readers. Sol Libes tells me that there are better text-formatting editors. I believe him. Sol is one of the good guys. However, WRITE is the best thing I know (including dedicated word processors) for getting a lot of text written, edited, and polished, and it's pretty darned good for printing it, as I discovered when we formatted and printed the WRITE manual.

Moving Right Along

There were more than 600 booths at the Faire. If I'd stopped 5 minutes at each one, it would have taken me more than 50 hours (and I'd have been even more of a nervous wreck than I was). I can only give quick impressions.

There are many good text editors. I'm fond of the Sorcim Superwriter, and I may change over to it for programming; but it has competition from Vedit, which was also on display here and there at the Faire (including on my own Z-100). I've regained contact with Micropro, and Charles Stevenson, its chief research and development programmer, tells me it's doing a lot of interesting things, both with text editors and data management.

Micropro was out in the garbage area along with Priority One and Eagle. The Eagle computer looks very nice. It's a super-fast IBM PC workalike, with (in my judgment) a better keyboard.

Texas Instruments was out in force, with some really excellent graphics. Its people were always busy with Faire-goers, so I'll have to find out details later.

John Matlock had a new small printer, the MPI Print-Mate 99, which we liked a lot. He handed one to Barry Workman for evaluation, and Barry's very happy with it. Everything I've seen of the MPI line is good stuff.

Matlock and MPI were in the Heath/Zenith area, as was Walt Bilofsky and his Software Toolworks. Zenith was drawing attention with the Z-100 and its dramatic color graphics, but its most spectacular exhibit was the Hero robot. Carl Helmers has a kit model; if Zenith wants an evaluation from me (and I hope it does), it will have to send a fully assembled and tested model. My kit-building days are long gone. I was quite impressed with the Hero demonstrations. I'd be even more interested in what my brilliant friend John McCarthy (of Stanford's Artificial Intelligence Laboratories) thinks. Maybe I'll know soon.

Caxton, a British firm, had a nice program called Cardbox, which impressed both Alex and Jennifer as well as me. It's what amounts to a computerized box of 3 by 5 cards. Caxton's sending me a copy, and we'll have more on it in an upcoming column.

The bottom line is that there's more to see at a Faire than any one person can manage. I'm happy, though: every week there's another interesting development in microcomputerland, and the big outfits haven't yet sewed up the market. I hope they never will.■

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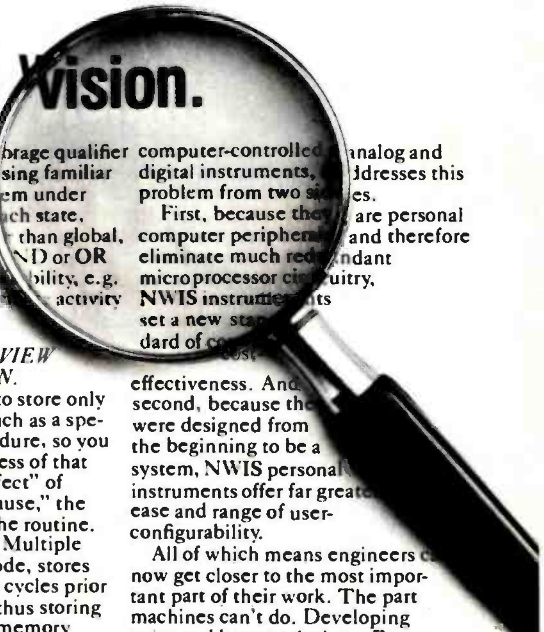

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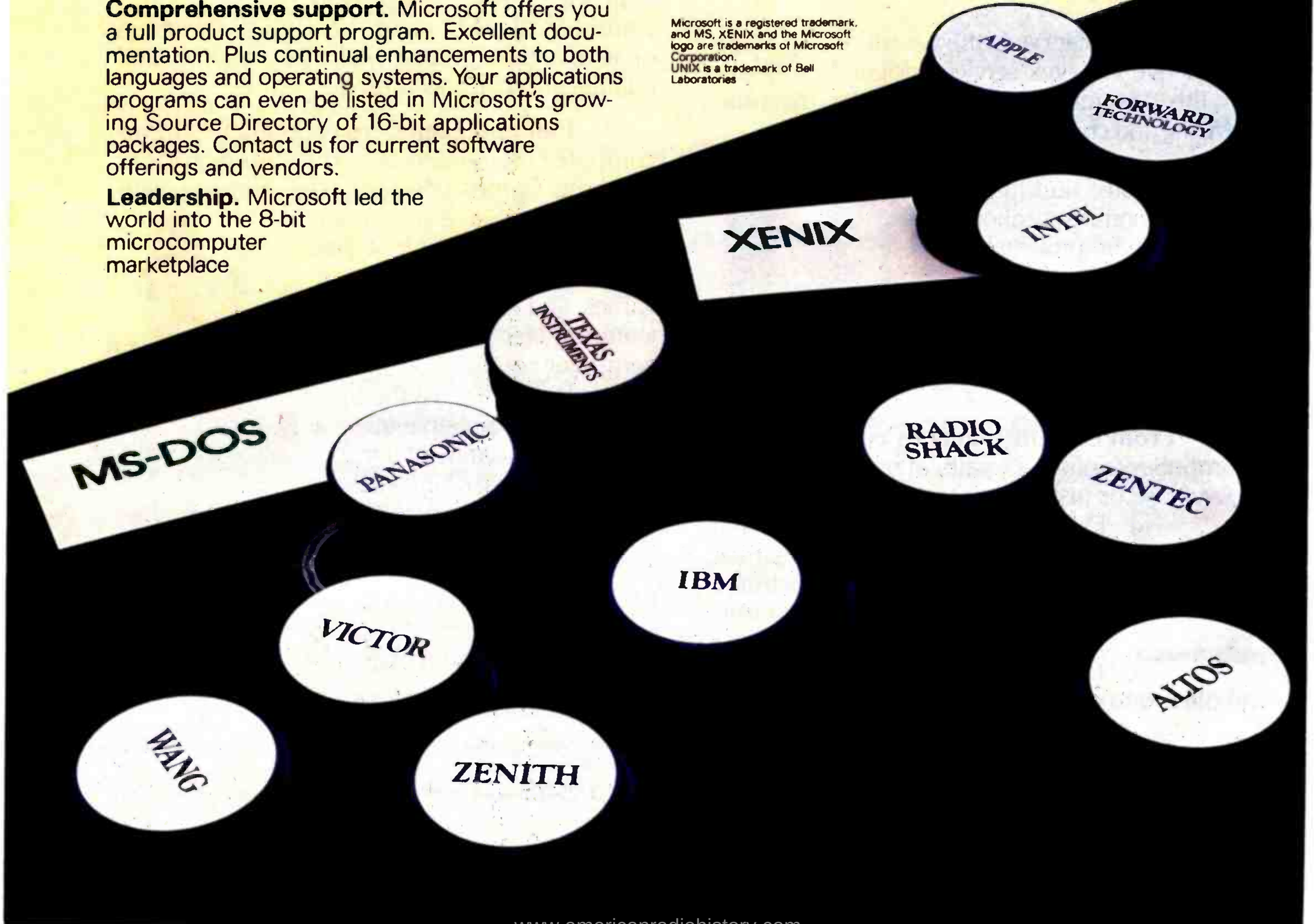

Design Philosophy Behind Motorola's MC68000

Part 3: Advanced instructions

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Last month (May BYTE, page 342), I discussed the data-movement, arithmetic, and logic instructions of Motorola's MC68000 family of microprocessors (sometimes referred to as MACSS—Motorola's Advanced Computer System on Silicon). I examined a useful set of instructions based on a philosophy of *orthogonality*, which eliminates duplication of effort by similar instructions (thus making the microprocessor easier to understand and use). In this final part of the series, I will discuss branching, jumping, error-trapping, supervisor-mode, and other advanced instructions of the MC68000.

Branching and Jumping

Data-movement, arithmetic, and logic instructions do most of the computational work in programs, but computers would be little more than adding machines without *program-control instructions*. These instructions give computers the capability to make decisions by executing nonsequential areas of code based on conditions tested at the time of execution. Branch instructions enable the microprocessor to transfer control to portions of code relative to the instruction being executed—that is, to transfer control to the effective address, which is the sum of the current contents of the program counter and a given offset. You use branch instructions extensively when writing position-independent code. Jump instructions differ from branch instructions in that the jump instructions transfer control to absolute locations in memory, are unconditional, and can use any of the MC68000 addressing modes to specify the destination.

The MC68000 has a flexible conditional branching instruction, referred to as a *Bcc instruction*, in which the letters cc denote a variety of conditions that can be specified. There are 14 different conditions, including such things as greater than (BGT), less than or equal to (BLE), equal (BEQ), overflow (BVS), and low or same (BLS); a complete list is given in table 1. The BRA instruction is not conditional but always forces the branch to occur.

You cause branching by the addition of some value to the program counter (PC). Branch instructions include an 8- or 16-bit signed displacement value that you add to the program counter. Because the displacement is a signed number, it can cause either a forward or backward branch. If the condition being tested evaluates to "true," the MC68000 will take the branch; if it is not, it will execute the next instruction in sequence.

Even though all MC68000 instructions are multiples of 16 bits and must be aligned on word boundaries (i.e., start on even addresses), the MC68000 interprets the displacement in all branching operations to be a byte count, not a word count. This is done to give the machine maximum flexibility, while still providing the most opportunity for future growth. Limiting the machine to word offsets would have prevented any future MC68000-family processor from having instructions that could be misaligned (i.e., did not start on a word boundary) or be multiples of 8 bits. Since the flexibility to have misaligned instructions still exists, it makes sense to follow the natural byte-oriented addressing of the MC68000. A 16-bit offset gives an addressing range of −32,768 bytes to +32,767 bytes, not the puny 8-bit computer range of −128 to +127 bytes.

Versions of the jump and branch instructions also exist for subroutine calls. You can branch to a subroutine (BSR) with a displacement value, or you can jump to the subroutine (JSR) by specifying the absolute address. Subroutine calls save the return address (the current value of the program counter) on the system stack before transferring control to the subroutine; the return address is

Mnemonic	Condition Description	Flags Tested
T	true	1
F	false	0
HI	high	$\overline{C} \wedge \overline{Z}$
LS	low or same	$C + Z$
CC	carry clear	$\overline{C}$
CS	carry set	C
NE	not equal	$\overline{Z}$
EQ	equal	Z
VC	overflow clear	$\overline{V}$
VS	overflow set	V
PL	plus	$\overline{N}$
MI	minus	N
GE	greater or equal	$(N \wedge V) \vee (\overline{N} \wedge \overline{V})$
LT	less than	$(N \wedge \overline{V}) \vee (\overline{N} \wedge V)$
GT	greater than	$(N \wedge V \wedge \overline{Z}) \vee (\overline{N} \wedge \overline{V} \wedge \overline{Z})$
LE	less or equal	$Z \vee (N \wedge \overline{V}) \vee (\overline{N} \wedge V)$

Table 1: *Conditional tests for the Bcc and DBcc groups of instructions. By substituting the letters in the first column for the letters cc, you can construct as many as 16 Bcc (branch on condition) and DBcc (test condition, decrement, and branch) instructions; for example, BHI branches if both the carry and zero bits in the status register are cleared. The third column indicates that the branch will take place if the expression evaluates to "true"; "∧" indicates a logical AND operation, while "∨" indicates a logical OR operation. The same conditions are available to another instruction group, Scc, which sets or clears all the bits of a given byte based on the condition being evaluated.*

removed from the stack and restored to the program counter when the MC68000 executes the RTS (return-from-subroutine) instruction.

Sometimes you will want to save and restore the condition codes that existed just before the subroutine was called. This is easy enough to do with the MOVE SR,−(A7) instruction, which pushes the status register onto the system stack (pointed to by register A7). You can also save selected registers with a single MOVEM instruction (discussed last month). At the close of the subroutine, you can use a MOVEM instruction to restore the saved registers and then use an RTR instruction (return and restore condition codes) to return and restore the saved condition codes in one operation.

Looping and String Constructs

Many times, a backward branch is used to create a *programming loop*, which is a very important part of programming because it allows operations to be repeated until a desired state or condition is reached. Although the looping constructs that most people are familiar with provide for a loop that ends with a given condition or one that ends after a certain number of iterations, a loop that can end by *either* means is often very useful. The double condition allows a loop to be performed until a given condition is met while ensuring that the loop does not process invalid data (in the case of, say, a string operation that reaches the end of the data without meeting the condition) or run forever (in the case of a numerical analysis algorithm that never converges to a given minimum tolerance).

The MC68000 has just the instruction for this kind of loop. The *decrement-counter-and-branch-conditionally* instruction (DBcc) uses any data register as a counter and branches based on both the evaluated condition and the data-register value. A DBcc instruction causes the following sequence of events. First, the MC68000 checks to see if the stated condition is met; if so, execution continues with the *next* instruction, thus ending the loop. If the condition is not met, the specified register is decremented by 1. If the resulting value is −1, the loop is again ended by having the execution continue with the next intruction; otherwise, the branch to the top of the loop occurs.

Note that the DBcc instruction tests the register for a value of −1. At first, this might seem odd, but there is a very good reason for it. Most looping constructs require extra steps to ensure that the loop can execute zero times when needed *and* that the loop tests for the desired condition *before* executing a given iteration. By having the loop entered just before the DBcc instruction (at the end of the loop) and by designing the DBcc instructions so that they end the loop on a value of −1 instead of 0, you create a loop that meets both of the above conditions without being burdened by an explicit second test. As an added bonus, a simple conditional branch instruction (using the same condition as the DBcc instruction) enables you to determine whether the program exited the loop because of the iteration counter or the condition.

The DBcc instruction provides a huge set of string operations, especially in conjunction with the predecrement and postincrement addressing modes. By using the appropriate MOVE instruction, for example:

```
   MOVE Dn,(An)+;
   MOVE (An)+,(An)+;
   MOVE −(An),−(An);
or MOVE (An)+,−(An)
```

followed by a DBRA instruction, you can have the MC68000 fill a block of memory, copy strings, and reverse strings. CMPM −(An),−(An) with DBNE compares two strings, while CMP Dn,−(An) with DBEQ searches a string for a pattern match. (See part 2, May BYTE, page 342, for an explanation of this address mode notation.) Multi-instruction loops can make very powerful string operations quite simple.

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Listing 1: *A string translation program that uses the DBEQ instruction to end a loop based on either of two conditions: end of string (as determined by the string length, given in register D3) or discovery of a termination character (stored in register D4). This program translates a string character by character according to the character values stored in TABLE. For a given character, its value (stored in register D0) is used as an index into TABLE (pointed to by register A2); the actual translation takes place at LOOP.*

```
      MOVEQ    #$13,D4           load termination character into register
      MOVE     #COUNT,D3         load string length
      MOVE.L   #STRING,A1        load string beginning
      LEA      *+TABLE,A2        offset to conversion table
      CLR      D0                prepare index for word
      BRA      POOL              start translation
LOOP  MOVE.B   0(A2,D0),(A1)+    translate and store result
POOL  MOVE.B   (A1),D0           load next character
      CMP.B    D4,D0             termination character found?
      DBEQ     D3,LOOP           if not and not end of string, branch
  Execution time where n bytes are translated:
  72 + (40 • n) clocks = 649 µs for 128 bytes at 8 MHz
```

DBcc instruction in the assembly-language program of listing 1, which translates a string of characters until a terminating character shows up or the end of the string is reached. Register D3 has the string length in it, while register D4 contains the terminating character you're looking for. Register A1 points to the string, while the translation table (which is found some distance from this code) has its location placed in register A2. The routine in listing 1 runs very quickly and demonstrates the power that results from a combination of versatile instructions and various addressing modes.

High-Level Language Aids

Many high-level languages, such as Pascal, use sophisticated programming concepts that can be enhanced by the use of reentrant and recursive programming and subroutines with local variable areas. The MC68000 has the facilities to support these techniques.

You can enter reentrant code at any time by several execution processes, and it will return correct results to all of them. This is very important for interrupt routines that may interrupt themselves before completion. Only reentrant code will correctly execute the interrupt routine the second time, then return to its interrupted version and correctly execute it. The MC68000 instruction set makes reentrant programming easy.

Recursive programs are those that can call themselves. An example of such a program might draw a straight line between two points by repeatedly plotting the midpoint of the line, then calling itself to operate on the two line segments created by the new point. Recursive programs are created to solve complex algorithms with relatively small amounts of code. Their disadvantages include slow execution and heavy use of the stack (or some other area) for storing each level's set of temporary variables. Of course, the MC68000 designers included special instructions to make this task easier, LINK and UNLK (unlink).

LINK and UNLK allow subroutines to allocate part of the stack for the storage of local variables quickly and easily. Often, a programmer needing to refer to variables associated with a given subroutine call will decrement the stack pointer to reserve an area of memory for such use ("decrement" because stacks usually "grow" downward in memory) and save the address of the top edge of this area as a reference point; this address is called a *frame pointer* (FP) and is a value that, on the MC68000, is stored in one of the seven address registers A0 through A6. The stack pointer, of course, will move up and down during the execution of a subroutine as stack operations are performed. The stable frame pointer always gives a good reference point to the variables, while the stack pointer would give a wildly varying reference to those same variables. Now let's look at a good method for going into a new routine.

To show how the LINK and UNLK instructions help give the programmer access to local variable areas, let's look at the example of figure 1. (Remember that the frame pointer is actually an address register that is designated by the programmer for this use.) Assume that you are in subroutine A, which has its own local variable area, pointed to by the frame pointer. Before subroutine A calls subroutine B, it first places parameters on top of the stack; see figure 1a. After the subroutine call to B, the return address to A is pushed onto the stack (figure 1b). The LINK instruction contains the name of an address register that is to be taken as the frame register and a displacement that indicates the amount of memory to be saved for local variables. When it is executed, three things happen (figures 1c-1e): the contents of the frame pointer (pointing to a stack location containing the previous frame pointer) are pushed onto the stack, the frame pointer itself is made identical to the stack pointer, and the stack pointer is changed by the displacement given in the instruction. (The displacement is a signed value and must be negative to save local variable space—if it is positive, you will lose information from the stack.) As shown in figure 1e, the stack pointer points to the top of the stack, and the frame pointer points to one word below the subroutine B local variable area. When the UNLK instruction is executed, the process is reversed (figure 1f), leaving subroutine B ready to execute an RTS instruction and return control to subroutine A.

Address Calculation in Hardware

Most microprocessor operations deal either with data or program control. Most also use memory addresses and, in the case of the MC68000, have some rather sophisticated means of generating those addresses. But the addresses are used by the instruction only to get to the data or program location; the address itself is never available to the programmer and is

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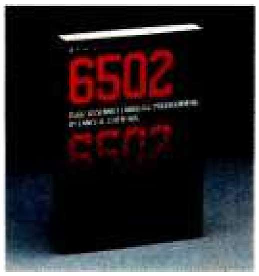

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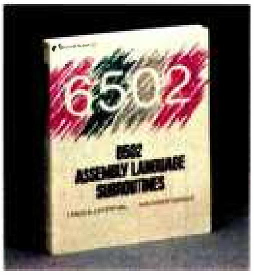

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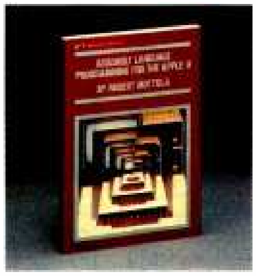

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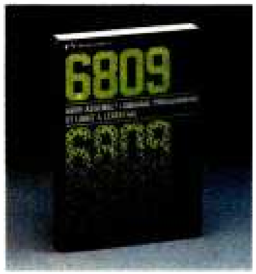

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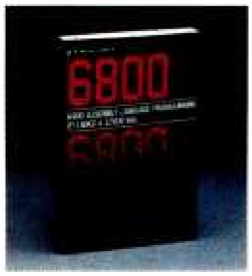

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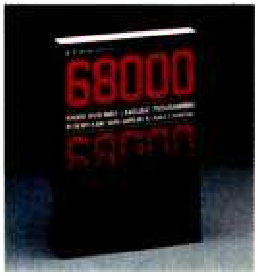

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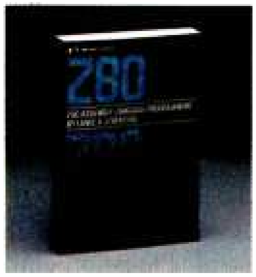

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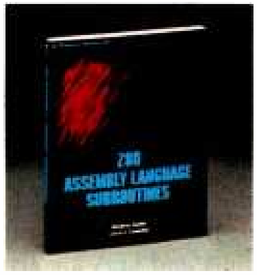

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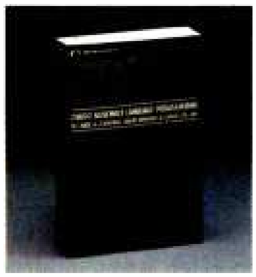

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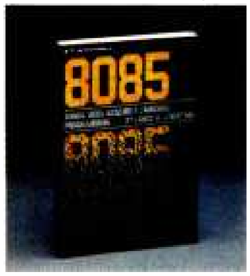

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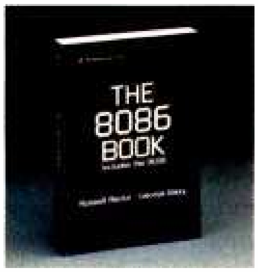

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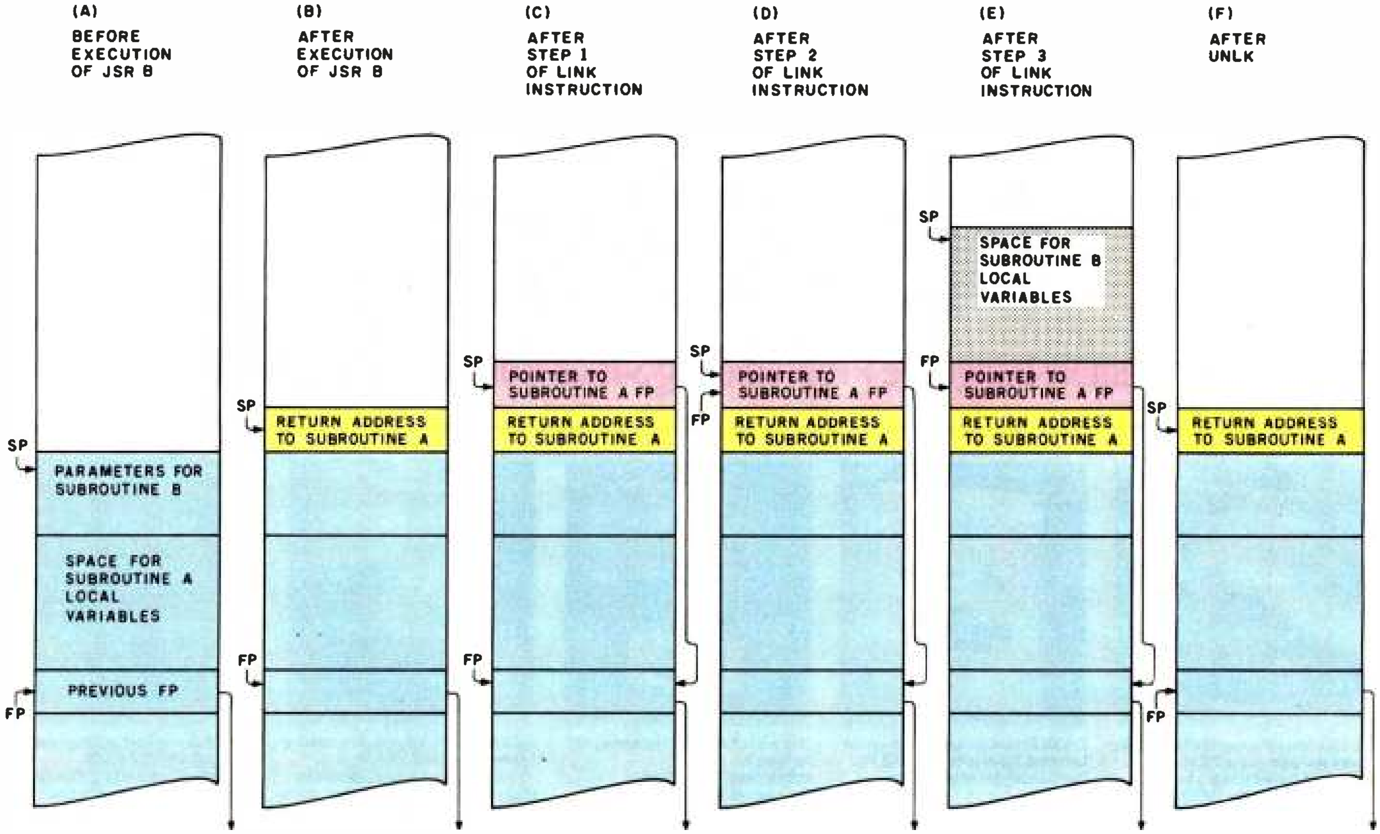

Figure 1: *Use of the LINK and UNLK (unlink) instructions, both of which help the assembly-language programmer manage memory areas to be used for local variables in subroutines. See text for details.*

often lost by the end of the instruction. However, it is sometimes the address itself that you need in your program. The MC68000 has two instructions that help you to get just the address, without using it to fetch any data. By having the MC68000 calculate the address itself (instead of writing a sequence of assembly-language instructions to do the same), you can do the calculation much faster without tying up either memory or registers.

The load-effective-address (LEA) and push-effective-address (PEA) instructions calculate a given effective address and place it either in any address register (LEA) or on the stack (PEA). You can calculate the effective address by using any available addressing mode with any of the appropriate registers. The LEA and PEA instructions can be useful when you are running position-independent code. Sometimes to take advantage of an addressing mode that runs more quickly than, say, the program-counter-relative addressing mode, you may want to calculate the address using LEA and access that area of memory by addressing indirectly through the address register in which the LEA instruction left the calculated address. PEA and LEA are also useful for passing pointers of data to other routines or placing them in memory. Sometimes, it's helpful to verify that an effective address is correct or at least in range. Without these two instructions, it would be extremely difficult to use processor-generated addresses.

Instructions for Shared Resources

Systems with more than one microprocessor running at a time are often designed to share some resources, e.g., memory, buffers, I/O, tasks, and so on. For this to happen, the programs running on the microprocessors must have a secure method of determining which processor has rights to a certain part of memory, a buffer, I/O, or a task. The MC68000 has an instruction, TAS (test and set), that makes such allocation of resources between multiprocessors simple and secure.

The key to this instruction is that it is *indivisible*, i.e., it can lock out all accesses to the designated addressing location until work on the location is complete. The test-and-set instruction tests a given byte, sets the negative (N) and zero (Z) status register bits accordingly, and then sets the most significant bit of the byte to 1.

In most cases, the microprocessor uses the TAS instruction as follows: It chooses a given byte to represent the status of a shared resource (this byte is often called a *semaphore*). If the TAS instruction shows the byte to be negative (if its most significant bit is 1), the querying microprocessor knows that the resource is in use. The processor can then either retest the semaphore byte until it shows the resource is available, or it can go about some other task. If the TAS instruction shows the byte to be positive (most significant bit is 0), the microprocessor knows the resource is free. Because the TAS instruction im-

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mediately sets the most significant bit to 1 (and because the instruction cannot be interrupted before completion), all the microprocessors with access to the semaphore byte have correct information about the shared resource. The microprocessor that has access to the shared resource has the responsibility of clearing the most significant bit when it is finished.

The only reason this process can work effectively is that the indivisible read-modify-write bus cycle (a special bus cycle) that accompanies the TAS instruction prevents, with hardware signals, any other device from accessing the semaphore byte between the time the TAS reads it and the time it is through setting the bit in it. This means that no two processors can read a semaphore byte and both be told that the resource is available. Thus, a secure way exists for software to determine the availability of shared resources in a multiprocessor MC68000 system.

Supervisor and User Modes

The MC68000 executes instructions at one of two operating or privilege levels. The upper level, called the *supervisor level*, provides a protected environment for the operating system to run in, isolating it and its resources from the less trustworthy user code. After a reset operation, the MC68000 begins running in the supervisor mode, in which the operating system and all interrupt routines are also running. The lower level, called the *user* level, is where most application programs execute and, therefore, where the processor usually spends most of its time.

The only controlled way to get from the supervisor level to the user level is by changing the S/U (supervisor/user) status bit (bit 13) in the processor status register. This is how the operating system switches to begin a user-level program. Should an interrupt be handled in the middle of a user-level routine, the interrupt routine will run at the supervisor level, but upon return to the interrupted routine, the MC68000 will return to the user level.

User-level programs are guaranteed to go to the operating system only through one of the 16 TRAP number *n* instructions. You can view these instructions as supervisor calls; they immediately transfer control to a specific routine. Upon completion of the TRAP routine, the processor will usually return to the original user-level routine to continue. Thus, there are 16 different supervisor trap instructions, which, along with other types of trap instructions, are listed in table 2.

Many other means of getting to the supervisor level of execution exist, but they are either conditional (like error traps) or asynchronous (like interrupts). Regardless, all traps are handled similarly by the supervisor. Any trap causes the processor to save the old program counter and status register on the supervisor stack. Then it will go to its external vector table and get a value, appropriate for the cause of the trap, to load into the program counter. This allows each type of trap to have a separate handling routine to correct the problem causing the trap and return to the original program.

Some of these other trap forms are intentionally conditional. Depending upon whether the overflow (V) condition bit is set, one instruction, TRAPV, either does nothing or causes a trap to occur, which forces the MC68000 into the supervisor state. This enables the program to handle all overflow conditions uniformly in a single operating-system-level routine. Another such instruction is the check (CHK) instruction, which verifies that the contents of any data register is greater than 0 but less than a specified bound. If it is within the limits, then nothing happens and the next instruction is run. If it is outside the bounds, then program control jumps indirectly through the vector table to a certain trap routine for handling. This gives the programmer an easy way to check whether an array index is within the proper bounds for that array. In addition, attempts to divide by 0 and access misaligned data (words or long words in memory on odd-byte addresses) will cause trap routines to be executed.

Type of Trap	Cause
address error	word or long-word access to an odd address
illegal instruction	no valid instruction exists for this op code (op codes starting with "1010 . . ." and "1111 . . ." generate other traps; see below)
zero divide	attempt to divide by zero
CHK instruction	CHK instruction failed (operand out of bounds)
TRAPV instruction	overflow has occurred (V bit set)
privilege violation	attempt to execute a privileged instruction while in the user mode
trace	an instruction has just ended and the T status register bit is set
line 1010 emulator	attempt to execute an op code that starts with "1010"
line 1111 emulator	attempt to execute an op code that starts with "1111"
TRAP *n* instruction	TRAP *n* instruction executed (*n* = 0,1, . . . ,15)

Table 2: *Supervisor trap types and their causes.*

STOP
RESET
RTE
MOVE (when moving a word to the status register)
MOVE USP
AND, EOR, or OR (when combining an immediate value with the status register)

Table 3: *Privileged instructions in the MC68000.*

Handling Illegal and Unimplemented Op Codes

To allow room for future expansion of the MC68000, designers did not use all of the possible bit patterns of the 16-bit op codes. Other microprocessors try to execute undefined op codes, often with disastrous results that cause you to lose control of the computer or even lose valuable work. To assure a completely foolproof system in the face of undefined op codes, the MC68000 refuses to execute any illegal instruction and, instead, executes a specified trap routine for corrective action.

To enable programmers to add whole blocks of new instructions to MC68000 processors, designers left two subgroups of possible op codes unimplemented. Any 16-bit op code beginning with binary 1010 or 1111 was left without definition in the MC68000. Attempts to execute either of these categories of op codes, even though they could be considered illegal instructions, are trapped separately. They cause either a line-1010-emulator or a line-1111-emulator trap routine to execute, enabling the programmer to emulate in software functions that are not implemented in the processor chip of the system. Currently, the 1111 op codes are defined mostly as floating-point instructions and so could be emulated on the MC68000. The 1010 op codes are still reserved for use in processors beyond the MC68020.

Privileged Instructions

Privileged instructions have a special characteristic—they can be executed only while the processor is running at the supervisor level. Attempts to run them at the user level force privilege-violation traps to occur, allowing the supervisor to take whatever action it thinks suitable.

The privileged instructions are listed in table 3 and are mostly self-explanatory. These instructions are restricted because they modify or control resources or services that must be under the control of the operating system. Many of these instructions modify the upper portion of the status register (SR), which contains the S/U supervisor bit, the interrupt mask, and a trace-mode switch. Such resources are not meant to be in the hands of the users, but maintained by the supervisor; this is why they are restricted.

Another supervisor-privileged resource is the *supervisor stack pointer* (SSP). This pointer is visible (as address register A7) only when the MC68000 is running at the supervisor level, just as the *user stack pointer* (USP) is visible (as register A7) only when the MC68000 is running at the user mode. However, when the operating system is ready to pull in a new user-level task, it needs to be able to access the hidden USP to initialize it. This is done with a special, privileged MOVE USP instruction.

The STOP instruction halts processor execution of further instructions, while waiting for an interrupt, a trace exception, or a reset to initiate new activity. The instruction also loads the status register with an immediate 16-bit value, allowing the programmer to enable certain interrupts before stopping the microprocessor. Only the supervisor can initiate this type of operation because, in a user's hands, the operation might throw off all sorts of operating-system timing integrity (such as time-slice clock signals) and generally brings the system to an irrecoverable halt. Also, the instruction must be restricted because it affects the entire status register.

The RESET instruction is a unique and powerful operation. Its execution pulses the reset line on the MC68000 without resetting the processor itself. You use this instruction typically after a catastrophic failure, from which the operating system is trying to recover on its own. It enables the operating system to initialize its external environment (i.e., reset the entire system except for the microprocessor) without forcing itself into a complete restart. Obviously, this instruction's power makes it inappropriate for the user level.

One final privileged instruction is the RTE (return-from-exception) instruction. An exception is anything that causes the microprocessor to perform an operation other than the next normal instruction. Interrupts and traps, then, are exceptions. The RTE is similar to the return-from-interrupt instruction of most microprocessors. It basically reloads both the program counter and the status register with the values from the top of the stack. Because all exceptions force the processor to execution in the supervisor mode, the RTE instruction will be executed only in that mode; this makes it a privileged instruction.

Note, once again, that privileged instructions can be executed from only the supervisor level of operation, where the operating system usually resides. The two different levels of privilege and the restricted use of privileged instructions allow you to build systems that prevent user-level application programs from, inadvertantly or otherwise, running rampant through operating-system code and data.

Conclusion

As you have seen in previous installments of this article, the MC68000 architecture is really designed with the programmer in mind. The MC68000 branch and jump instructions give you complete control over program flow and simplify often-used looping and string-movement constructs. The link and unlink instructions make it easier for you to create modular programs that use local variables. Other instructions carry out complex address calculations quickly, help mediate the use of shared resources, provide for the data integrity of the operating system, and allow recovery from errors under program control. In addition, planners designed the architecture and instruction set with far greater things in mind and made the set easy to expand to more powerful and more comprehensive functions. And all this has been done with a processor for which performance was a primary criterion.

Once you learn a few general concepts of programming the MC68000, coding an application comes easily. Pick up an MC68000 user's manual and a similar guide for any other 16-bit microprocessor. Then spend an hour or two learning each. Code a short program or two, and compare just how easy the MC68000 is to work with. And if you choose to write code for a larger program, you will find your task to be simple regardless of program size.

The MC68000 was designed to be a programmer's instrument through which programmers and system designers could use their creativity to engineer a system to fit the application instead of having to figure out some trick to get the microprocessor to perform the needed task. We at Motorola believe that using the right tool gets a job done faster with fewer mistakes, and the MC68000 is such a tool. ■

About the Author

Thomas Starnes is an electrical engineer who has spent the last five years helping to plan the direction of the MC68000 family of processor products for Motorola.

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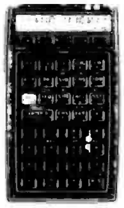

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The Bazeries Cylinder

A Cryptographic Challenge

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In 1618, a French mathematician named Antoine Rossignol deciphered a secret message for the forces of the King of France. It enabled the King's forces to capture the city of Réalmont without resorting to battle. This feat was the beginning of Rossignol's long and outstanding career as court cryptanalyst to Louis XIII and later to Louis XIV. During his tenure, Rossignol created a complicated cipher system for the exclusive use of the King. When Louis XIV died in 1715, he left behind messages written in the Great Cipher—but not the process to decipher them. For more than a century, the Great Cipher stood against all assaults at its secrets. It was finally broken by Commandant Bazeries of the Black Chamber, the French Army's cryptographic department. Bazeries went on to create the cylindrical cipher system that became the de facto standard used throughout the world.

The principles used in many of today's sophisticated cryptographic systems are based on the Bazeries cylinder. This article describes the cylinder, analyzes the security of the ciphertext produced, and illustrates its use with a computer simulation.

It is hoped that readers who must exchange private information over public facilities will find such a system useful. Needless to say, the Bazeries cylinder has survived the testing of several decades; during that time, it has been used worldwide by many security agencies.

The Rubber Stamp Model

The easiest way to think of a Bazeries cylinder is to recall the familiar date stamp, where month, day, and year bands are separately rotated to set the correct date. The Bazeries cylinder uses the same principle. It consists of 20 sections, or disks, each of which can be separately rotated. Each disk contains a permutation of letters on its rim. By rotating the disks, you can align any sequence of 20 letters, just as you set the date stamp to any date.

Figure 1 depicts how the Bazeries cylinder would look if it were slit lengthwise and laid flat. Note the alignment of the plaintext sequence SPEAKTOTHELADYINBLUE in the bottom row. Twenty-five other sequences are above it. Any one of them, say the top row, can be used as the corresponding ciphertext. To decipher text, simply align the scrambled disks of a cylinder to the ciphertext; the plaintext will set in one of its rows. If the text contains more than 20 characters, simply process it in blocks of 20.

For further security, the order in which the 20 disks are to be loaded in the cylinder can be specified by a key. For example, you can load the disks in the order

4-17-1-19-11-2-6-9-12-15-8-20-10-16-14-5-18-13-7-3

The key for this sequence is the phrase

BEWARETHEIDESOFMARCH

The numbers correspond to the position of the phrase's letters in alphabetical order.

Analysis of Security

Each disk of the cylinder is the equivalent of a 26-cycle substitution cipher on 26 characters. More than 1.55×10^{25} (i.e., 155 followed by 23 zeros) possible settings exist. That works out to about 7.75×10^{15} settings for every man, woman, and child in the country! A 20-disk cylinder can thus be configured in approximately 6.5×10^{503} ways, an immensely large number. For example, the combined memory capacities,

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A	F	Y	T	Z	X	J	N	Y	F	O	G	U	O	R	B	D	H	Q	V
O	X	R	H	S	Q	L	W	E	K	W	N	A	G	T	Y	A	Z	D	Q
G	I	U	N	R	P	H	X	Q	W	V	I	X	P	H	U	N	E	Z	X
R	D	F	C	A	V	G	E	P	N	E	J	T	Z	A	M	J	D	T	Y
J	L	N	Z	B	J	A	G	G	P	P	V	O	L	Q	Q	T	I	A	G
B	E	W	X	N	C	P	S	N	A	U	O	R	T	G	X	W	P	L	C
U	T	A	W	O	B	T	C	B	Z	X	H	V	A	F	A	H	G	G	D
Z	V	D	U	U	N	Z	U	R	M	S	K	W	B	D	W	M	U	N	O
D	Z	L	O	P	R	R	P	T	I	K	Y	K	U	P	V	F	O	S	Z
F	Y	Z	G	C	A	X	Y	F	G	D	Z	H	N	S	G	S	S	W	W
M	H	J	S	Q	D	S	A	V	H	R	C	P	E	M	L	G	M	Y	T
X	U	K	V	W	S	B	D	O	U	G	L	Z	J	L	J	U	F	J	P
Y	B	M	Y	D	K	Q	L	W	O	J	U	N	S	Y	S	Z	B	M	J
C	Q	Q	B	I	H	D	Z	S	S	Y	X	L	F	K	I	E	R	P	R
V	N	S	Q	J	I	V	Q	C	L	Z	E	I	V	X	K	Y	X	H	H
Q	W	C	F	V	Y	K	J	Z	Y	B	S	M	K	Z	P	X	J	V	I
W	A	X	P	M	O	U	K	X	C	N	F	B	R	W	O	R	C	O	B
E	G	H	J	G	G	N	O	D	D	Q	W	Q	W	J	D	V	Y	X	K
I	M	V	D	H	U	Y	I	L	J	H	T	C	M	O	T	I	W	R	A
T	S	P	E	X	L	E	B	M	V	C	R	J	I	N	Z	C	N	I	M
H	K	T	R	L	M	W	R	I	Q	F	P	F	H	C	C	O	V	F	S
N	C	G	I	E	Z	F	M	K	X	A	Q	G	C	B	R	L	Q	K	U
P	R	I	K	T	F	M	F	U	B	M	D	E	X	U	F	Q	K	B	N
L	O	B	L	Y	W	I	H	J	T	T	B	Y	D	V	H	K	T	E	F
K	J	O	M	F	E	C	V	A	R	I	M	S	Q	E	E	P	A	C	L
S	P	E	A	K	T	O	T	H	E	L	A	D	Y	I	N	B	L	U	E

Figure 1: *The Bazeries cylinder if it were slit lengthwise and laid flat.*

whether disks, tapes, or RAMs, of all the computers in the world would not come close to it; neither would the number of electrons in the universe.

Furthermore, if one 20-character message were enciphered, using each of the possible cylindrical configurations, every 3 seconds, it would take 2.3×10^9 centuries to do them all. Clearly, such a cryptographic system provides a great deal of security in sheer numbers alone.

However, the real world of cryptanalysis contains circumstances under which the best of cipher systems might be broken. To do this, an expert cryptanalyst would accumulate as much information about the cipher-system correspondence as possible, including prior plaintext messages. Analysis is also made using various frequency tables. Knowledge about the cipher system is another useful insight. The larger the body of ciphertext, the better the chances it can be deciphered. Two other important factors are doggedness and luck.

No matter how good the cryptanalyst, no matter how much computer power is used, no matter how much time is spent—in some situations the messages cannot be deciphered. Such systems are said to be *unconditionally* secure.

Even if a system is not unconditionally secure, it might still be *effectively* secure. Although such systems might possibly be broken, they usually entail such great expenditures of resources as to make them not worth the effort. Or even if worth the effort, it might require so much time to decipher them that their informational content is no longer of any value. In the seventeenth century, Rossignol put it more succinctly with his Law of Secret Writing: "A secret message must be safe enough so that by the time an enemy gets to solve it, it is too late to be of aid to him."

A Bazeries system is unconditionally secure in most instances over the short run. Even over the longer run, it can be made effectively secure if com-

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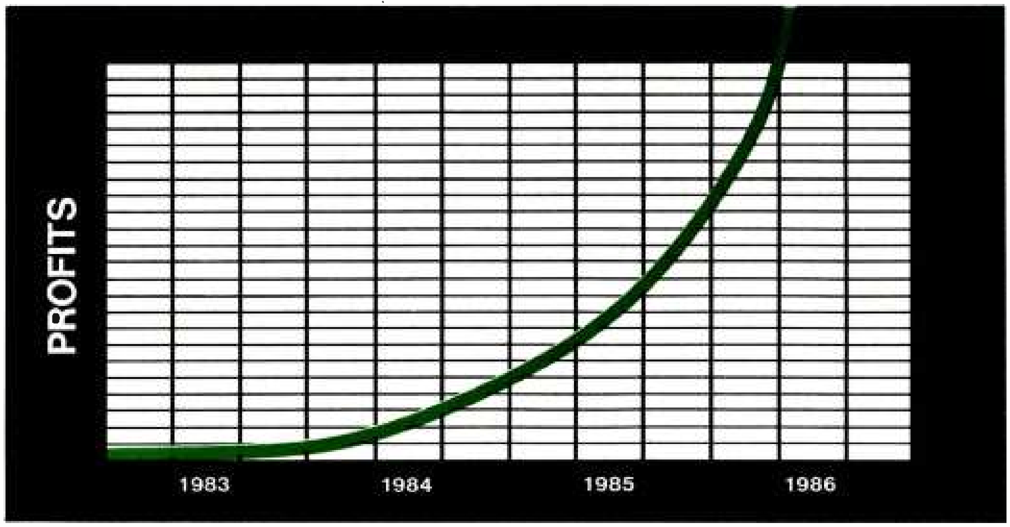

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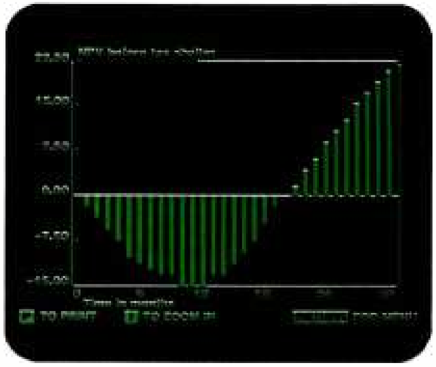

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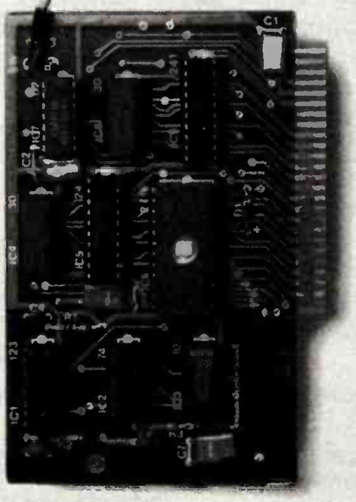

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Challenge to the Reader

Challenge #1

To illustrate the security of the ciphertext produced by the Bazeries cylinder, the reader is invited to try to decipher the text below. To make it feasible, the text is enciphered using the program in listing 1 without any changes in the DATA statements. The use of the correct key when running this program will decipher the text.

A check for $10 for a bottle of French wine will be sent to the person who sends the correct plaintext with the earliest postmark. Address correspondence to R. F. Prisco, RD #7 Edgebrook, Oswego, NY 13126.

```
OSUZKMTKLZYFYVTMDHKTQWWIBDMZJA
NZNTWDBVBHWGPDDHBPZCRJMDSWNZTH
FPBOVMVERUATTHCIYLNTYXSDOYZKXU
YPSWBUHZXJKRYVYHANNGQZVLMCRHIJ
VBZOIHBVCEFPMCCOPISGXMBLCZMCTO
XTWDGYECVUUWYIQQFYHWMDZPKAUURT
KSNZOCSSDZJBPMNDBPPWSCFFBLADXK
DPHOADEEBAGKNBGLELNDJBAZMOJUDO
```

Challenge #2

A much more secure ciphertext is offered below. It is also enciphered by the program in listing 1. However, in this case, a completely new set of DATA statements are used, making the text effectively secure. No reward is specified for the corresponding plaintext in this case because it is anticipated that there will not be any need for one.

```
OJIJPJMPUDAHDJXTUXNJUEDLGYQSIL
NUOESXFHUXJGODFBOTAOJZDLFHNNYC
KSJIXIKRUJECXGZBIQXMYFJIXUJMMQ
GZLYJOIMRMIMFSLTNAEHGBYUCODERP
QPEOIFYGZSABINADRSERUXURAQJAWQ
MRBEWKKSYKCTELIXFSHMUZRFVOSAKU
JOBNBEGVTAGYHZKAUQXGGXZAXQHKJG
RFHSCKCRWLJFXLZEFIGLQNDDDTSBIP
```

mon techniques of security are used. These techniques include frequent changes of the key and the set of disks.

For historical reasons, 26/20 Bazeries systems, consisting of 26-character disks and 20-disk cylinders, have been used as examples. With the computer power of today, however, 64/64 Bazeries systems are feasible. Such systems are much more secure than those previously discussed. In fact, a one-shot 64/64 Bazeries system could be used to send a 4032-character message with unconditional security as opposed to 500 characters for a 26/20 system. In addition, 64-character disks would be capable of including numerals, punctuation marks, spaces, and control characters.

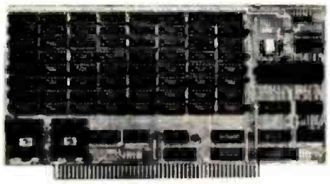
Program Description

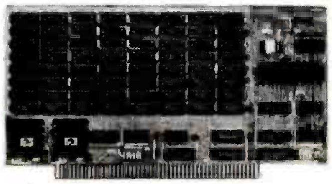
Listing 1 is a faithful simulation of the historic 26/20 Bazeries cylinder. (A run of this program is shown in listing 2.) Care has been taken to document it with the foregoing terminology.

It is written in the most commonly used dialect of BASIC. The only function that might not be allowed in some of the other common BASICs appears in line 1460. The instring function INSTR(*n*,A$,B$) returns the first position of the string B$ in the string A$ beyond the ($n-1$)st character of A$. This function can be replaced by a loop in those BASICs that do not have it.

The program also uses specific rows of the cylinder when transforming text. The first row used is specified by the first character in the key (lines 1140 and 1390). Subsequent rows are used in cyclical numerical order where the direction depends on whether the text is to be enciphered or deciphered (line 1510).

The simple bubble sort (lines 1210–1320), which is used to load the cylinder as specified by the key, is not very fast but does load the cylinder as described above. The Shell-Metzner sort, although faster, is not consistent when the key contains several instances of the same character.





Extensions

As noted earlier, a 26-character disk is equivalent to a 26-cycle substitution cipher on 26 characters. Such ciphers contain only 1/26 of the substitution ciphers on 26 characters. For example, such ciphers do not include any that substitute B for A, C for B, and A for C. With virtually no additional overhead, general substitution ciphers can be used in place of the disk substitution ciphers.

If the disk ciphers are retained, the method of choosing the rows for the transformation of text could be specified by some permutation contained in a DATA statement or key. Patterns should be avoided for added security.

Finally, routines for mass-storage devices can be added to buffer extensive amounts of text for future processing.■

About the Author

Rinaldo Prisco is an associate professor of mathematics at the State University of New York, College at Oswego. His interests include combinatorial group theory, discrete mathematics, and mathematical applications to computing. He has written several articles on microcomputing and is currently working on a mathematics text for computer programmers.

Listing 1: *This program is a simulation of the 26/20 Bazeries cylinder.*

```
1000 '     BAZERIES CRYPTOSYSTEM
1010 '
1020 '     Copyright (c) 8/1/81
1030 '
1040 '      Rinaldo F. Prisco
1050 '  Department of Mathematics
1060 '       SUNY at Oswego
1070 '      Oswego, NY 13126
1080 '
1090 CLEAR 1500
1100 DEFINT I,J,F,L,R,P,K,N
1110 DIM D$(20),P(20)
1120 FOR I=1 TO 20:READ D$(I):NEXT I
1130 PRINT "ENTER KEY: ";:LINE INPUT K$
1140 K=ASC(K$)
1150 ' ELIMINATE SPACES IF ANY
1160 S$=K$:GOSUB 1700 :K$=S$:PRINT
1170 ' RESTRICT KEY TO LENGTH <= 20
1180 IF LEN(K$)>20 THEN K$=LEFT$(K$,20)
1190 ' USE SORT ON KEY TO PERMUTE DISKS
1200 PRINT "Loading cylinder, ready shortly ..."
1210 FOR J=LEN(K$)-1 TO 2 STEP -1
1220   F=0
1230   FOR I=1 TO J
1240     L=I+1
1250    IF MID$(K$,I,1)<=MID$(K$,L,1) THEN 1300
1260      T$=MID$(K$,I,1):MID$(K$,I,1)=MID$(K$,L,1)
1270      MID$(K$,L,1)=T$
1280      T$=D$(I):D$(I)=D$(L):D$(L)=T$
1290      F=1
1300   NEXT I
1310   IF F=0 THEN 1330
1320 NEXT J
1330 ' CYLINDER IS NOW LOADED
1340 PRINT
1350 PRINT "ENTER TEXT: ";:LINE INPUT T$
1360 PRINT
1370 INPUT "<E>ncode or <D>ecode";Y$:Y$=Y$+" "
1380 IF LEFT$(Y$,1)="D" THEN F=1 ELSE F=0
1390 N=K-65
1400 ' ELIMINATE SPACES FROM T$
1410 S$=T$:GOSUB 1700 :T$=S$:PRINT:PRINT T$
1420 ' PROCESS AT MOST 20 CHARACTERS AT A TIME
1430 L=LEN(T$):IF L>20 THEN L=20
1440 ' ORIENT THE DISKS TO THE TEXT
1450 FOR I=1 TO L
1460   P(I)=INSTR(1,D$(I),MID$(T$,I,1))
1470 NEXT I
1480 ' SET R TO PROPER ROW NUMBER
1490 N=N+1:R=N-20*INT(N/20)
1500 IF R=0 THEN R=1
1510 IF F=1 THEN R=26-R
```

Listing 1 continued on page 360

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Listing 1 continued:

```
1520 ' SET POINTERS TO ROW R
1530 FOR I=1 TO L
1540   P(I)=P(I)+R
1550   IF P(I)>26 THEN P(I)=P(I)-26
1560 NEXT I
1570 ' PRINT NEW TEXT
1580 FOR I=1 TO L
1590   PRINT MID$(D$(I),P(I),1);
1600 NEXT I
1610 ' IS THERE ANY·MORE TEXT TO PROCESS?
1620 IF L=LEN(T$) THEN 1640
1630 T$=RIGHT$(T$,LEN(T$)-L):GOTO 1430
1640 PRINT
1650 PRINT
1660 INPUT "FURTHER TEXT";Y$:Y$=Y$+" "
1670 PRINT
1680 IF LEFT$(Y$,1)="Y" THEN 1350
1690 END
1700 ' REMOVES BLANKS FROM S$
1710 S$=" "+S$
1720 FOR I=2 TO LEN(S$)-2
1730 IF MID$(S$,I,1)<>" " THEN 1750
1740 S$=MID$(S$,1,I-1)+RIGHT$(S$,LEN(S$)-I)
1750 NEXT I
1760 S$=RIGHT$(S$,LEN(S$)-1)
1770 RETURN
1780 DATA FNWADLZJKMQSCXHVPTGIBOEYRU
1790 DATA ETXQPVJCBNRADSKHIYOGULMZFW
1800 DATA LEVQXYGCDOZWTPJRHIBKAMSUNF
1810 DATA XYCVQWEITHNPLKSAOGRJBUZDFM
1820 DATA ODTZCRFHENBYUMQXAWVGLJSIKP
1830 DATA VKUNYEWFMICOJLHGAPTZRXSVQD
1840 DATA JMPHVOXRIFKBECUQDZTALGNSWY
1850 DATA RGJYZBNQHCFAMTILOWVEPUXSKD
1860 DATA ZQJKOIBRMFHVTNWXEGSCUPYADL
1870 DATA UAXTORVWKHPZNLIMVQCJFGEYSD
1880 DATA MGHXLETYFKZSRABNOUPCQWDIJV
1890 DATA PGNBRTFVOWSCZXDLMIKUJAHYEQ
1900 DATA ZEDIPGUOSMFBRXJCYWNVQKTALH
1910 DATA FDPSMLYKXZWJONCBUVEIRTHAQG
1920 DATA MIGHUOSLYCDJVQXBTREFKWNPAZ
1930 DATA GPZLTABUNEJSFVKRWMIHCXDQYO
1940 DATA XIDLETVZYHUBQNWAGMSKCROJPF
1950 DATA WHMFSGUZFYXRVICOLQKPBDANJT
1960 DATA IKLMATHNCZXWUOGSVYBQFPJDER
1970 DATA JVOHKYZCLUXESFWTRPQDBMAGNI
Ok
```

Listing 2: *A run of the program in listing 1.*

```
RUN
ENTER KEY: BEWARE THE IDES OF MARCH

Loading cylinder, ready shortly ...

ENTER TEXT: ANTICIPATE MERGER IN TWO WEEKS STOP PURCHASE SHARES

<E>ncode or <D>ecode? E

ANTICIPATEMERGERINTWOWEEKSSTOPPURCHASESHARES
GAILWOZLVKIFWZRHOQLPJMUKRIDXCMSSKQGGZPJKJFFQ

FURTHER TEXT? Y

ENTER TEXT: GAILWOZLVKIFWZRHOQLPJMUKRIDXCMSWKQGGZPJKJFFQ

<E>ncode or <D>ecode? D

GAILWOZLVKIFWZRHOQLPJMUKRIDXCMSWKQGGZPJKJFFQ
ANTICIPATEMERGERINTWOWEEKSSTOPPURCHASESHARES

FURTHER TEXT? N

Ok
```

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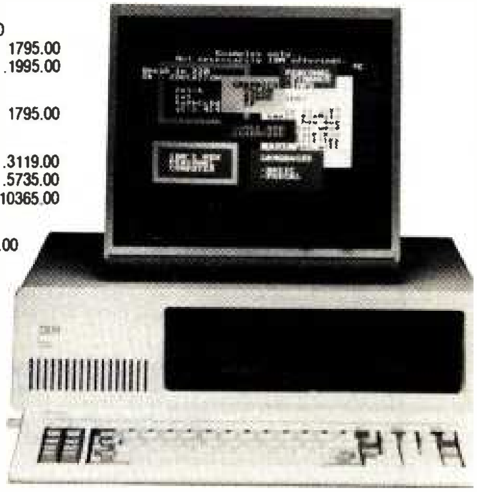

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Novel Methods of Integer Multiplication and Division

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You may be familiar with the method of multiplication, variously alleged to be of Kenyan, Russian, or even Himalayan origin, in which you repeatedly halve the multiplicand and double the multiplier until the multiplicand becomes 1. Then the sum of those multipliers that have a multiplicand counterpart of odd value becomes the product. This sounds complicated, but it's really not; table 1 shows an example.

Procedure: Repeatedly halve the multiplicand (discarding remainders) and double the multiplier until the former is 1. For every odd multiplicand, add the respective multiplier.

Example: 44 × 51

Multiplicand (a)	Multiplier (b)	Partial Sum (c)	Column (c) Expressed in Terms of Original Multiplier (d)	Remainder of Division of Column (a) by 2 (e)
44	51	—	—	0
22	102	—	—	0
11	204	204	4×51	1
5	408	408	8×51	1
2	816	—	—	0
1	1632	1632	32×51	1
	Total	2244	44×51	
	44 × 51 =	2244		

101100 is binary for 44

Table 1: *An example of the Kenyan double-and-halve algorithm for integer multiplication.*

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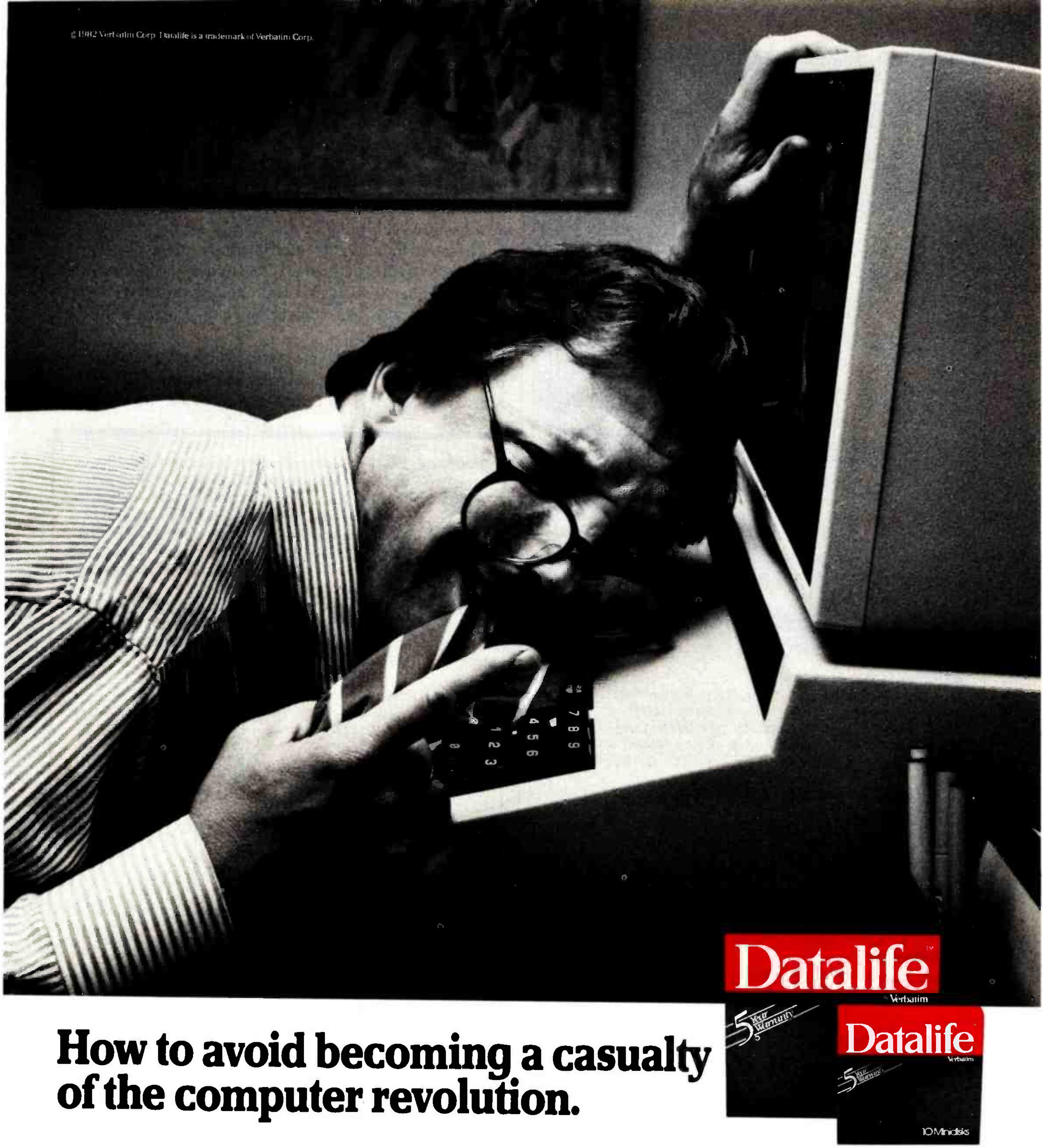

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This algorithm readily lends itself to coding, as exemplified by the sequence in 8080 code shown in listing 1. Halving is done by shifting to the right, and the odd/even test is performed by checking the carry. Doubling is done by adding to itself using the DAD instruction, which is also used for summing up the output terms.

Repeated halving of a number and then noting the odd/even results is a nice way of finding the binary form of the number (the last bit found being the most significant one). It also tells something of the binary nature of the Kenyan method.

Some time ago I became intrigued by the possibility of finding a procedure for division that was similar to the Kenyan method of multiplication. I came up with the

Procedure: Double the divisor until it is just less than the dividend. Then try to subtract the doubled divisors, starting with the largest, from the dividend. Note a 1 if the subtraction is possible; otherwise, note a zero and do not perform the subtraction.

The 1s and 0s constitute the binary form of the quotient. To obtain the decimal form, multiply the latter digits with the corresponding terms in a power of 2 series, arranged in reverse order. The quotient is the sum of the resultant terms.

To obtain decimal accuracy, multiply the dividend initially by an Nth power of 10. Then, after the division is complete, divide the quotient by the same power of 10 (moving the decimal point N places).

Example: 2246/51

				Counter
Double:	51			0
	102			1
	204			2
	408			3
	816			4
	1632			5
Subtract:	2246			
	− 1632			
	614	1	× 32 = 32	5
	− 816			
		0	× 16 = 0	4
	614			
	− 408			
	206	1	× 8 = 8	3
	− 204			
	2	1	× 4 = 4	2
	− 102			
		0	× 2 = 0	1
	2			
	− 51			
		0	× 1 = 0	0

Remainder: 2
Quotient: = 44
101100 = 44
(binary) (decimal)

Table 2: *An example of a new method of integer division suitable for implementation on microprocessors without a divide instruction.*

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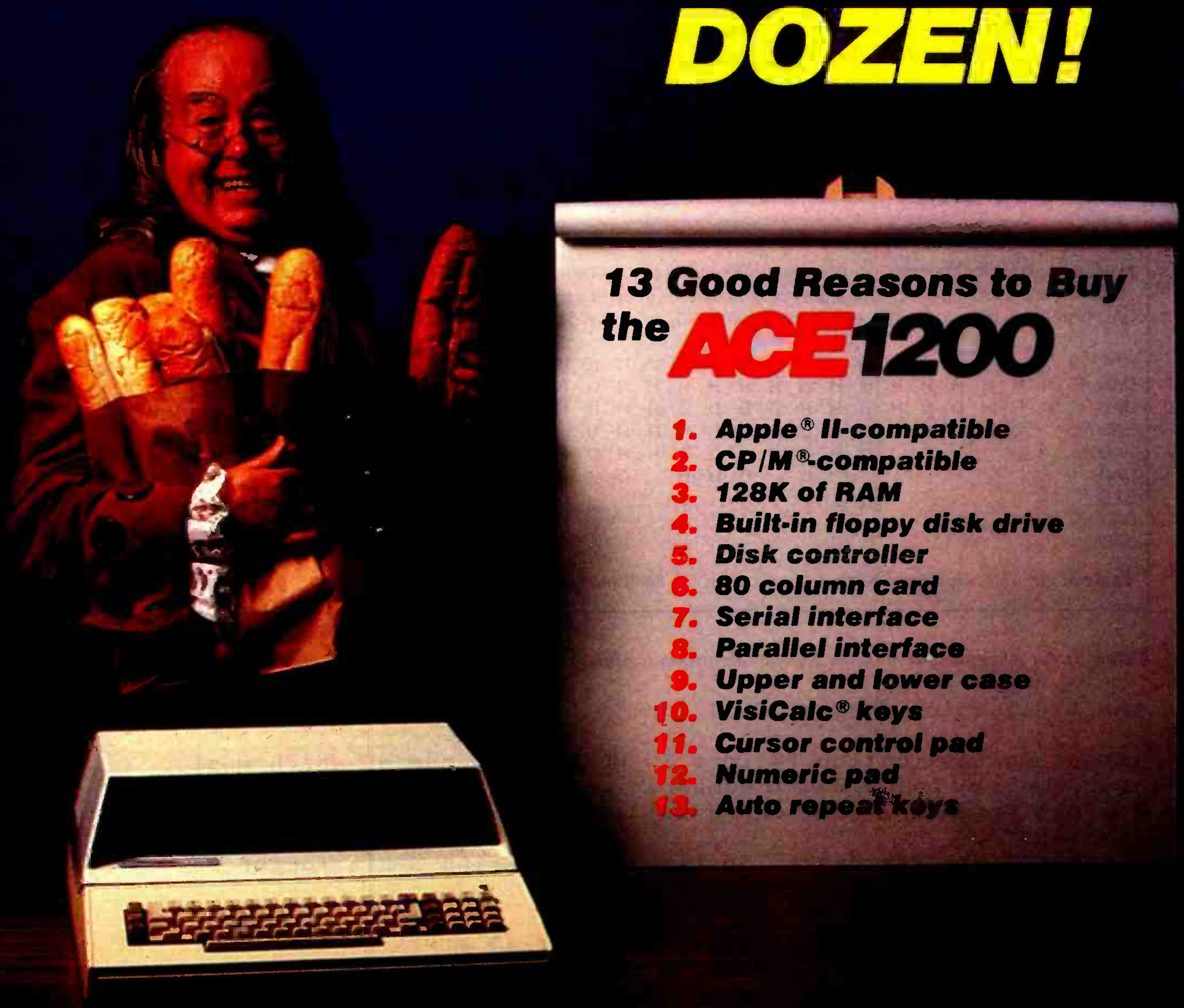

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2138 Route 38, Cherry Hill, NJ 08002 609-482-5900 Telex: 837-385 following scheme: The divisor is repeatedly doubled until just less than the dividend, then successively subtracted from the dividend. Every time the subtraction operation gives a positive result, a 1 is noted; otherwise a 0 is recorded. Remarkably enough, the resultant sequence of 0s and 1s constitutes the quotient directly in binary form, as shown in table 2.

Notice that the procedure is quite mechanical, with none of the trial-and-error search for the next correct quotient digit that is characteristic of the conventional method. Furthermore, it lends itself beautifully to coding (see listing 2). There need be no 8-bit restrictions on any of the numbers; the dividend, divisor, quotient, and remainder can all be entered as 16-bit numbers.

Procedure: Input multiplicand in both HL and DE register pairs. Constant K is the multiplier. Then perform a series of DAD D and DAD H instructions in the order given by the sequence of Ds and Hs under the given value of K. The final product will be in the HL register pair. If every DAD instruction is followed by a test of carry (JC or RC), carry will be set in case of overflow.

K =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
DAD	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
DAD		D	H	H	D	D	H	H	H	H	D	D	D	D	H	H	H	H	H	H	H	D	D	D	D	D	D	D	D	H	H
DAD				D	H	H	H	H	D	D	H	H	H	H	H	H	H	H	D	D	D	D	H	H	H	H	H	H	H	H	H
DAD						D		D	H	H	H	H	D	D	H	H	D	D	H	H	H	H	H	H	H	H	D	D	D	D	H
DAD										D		D	H	H		D	H	H	H	H	D	D	H	H	D	D	H	H	H	H	H
DAD														D				D		D	H	H		D	H	H	H	H	D	D	
DAD																						D				D		D	H	H	
DAD																														D	

Table 3: *An algorithm for integer multiplication for 8080 microprocessors.*

Listing 1: *An implementation of the Kenyan algorithm for integer multiplication for the 8080 microprocessor.*

```
;multiplication program MULT

;input multiplication factors in HL and DE, one of which must
;necessarily be an 8-bit number;  if not, carry is set
;output product in DE, carry set if overflow.

;**********************  Initial test to find 8-bit factor
MULT:   xra     a       ;clear A
        ora     d       ;is D zero?
        jz      found   ;yes, DE number is 8-bit factor
        xra     a       ;no, DE number was not 8-bit factor
        ora     h       ;is H zero then?
        stc
        rnz             ;no, return with carry set
        xchg            ;yes, place 8-bit factor in DE
found:  mov     a,e     ;transfer multiplicand to A

;**********************  Multiplication starts in earnest
        lxi     d,0     ;clear DE to receive output terms
        ana     a       ;8-bit factor now in A; clear carry.
next:   rar             ;halve the multiplicand; result odd?
        jnc     even    ;no, don't add multiplier term
        xchg            ;yes, therefore,
        dad     d       ;add multiplier (now in DE) to output.
        rc              ;overflow, carry set on return
        xchg            ;put multiplier back in HL
even:   ana     a       ;already reached 1 by halving?
        rz              ;yes, return with result, carry cleared
        dad     h       ;no, double the multiplier and
        jnc     next    ;continue the process.
        ret             ;overflow, carry set on return
```

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To handle 16-bit numbers, the add-to-itself DAD H instruction is used for doubling the divisor, and the necessary comparison with the dividend is accomplished by reverse-polarity addition, using the negative value of the dividend (in the DE register pair) and testing on the carry. Care is taken to restore the divisor before the next doubling by adding back the positive value (in the BC register pair). The doubled divisors are put in temporary storage by pushing them to the stack.

For the necessary subtraction of the doubled divisors from the dividend, reverse-polarity addition is used again. Luckily, the dividend is already present in negative form (in the DE register pair), and the divisors can be used in their existing positive form as they are popped from the stack for subtraction. The carry is then indicative of a positive or negative result, and for every subtraction, it is shifted into a register pair to form the final quotient. A counter sees to it that there are no more subtractions than there were doubling operations. The contents of the DE register pair constitute the remainder (in complemented form).

As we have seen, odd ways of multiplying and dividing can lead to useful code algorithms. But the reverse can also be true. Machine-code algorithms can lead to odd but perhaps not so useful manual methods.

First, consider a table used for multiplying by a fixed

Procedure: Repeatedly halve the multiplier (discarding remainders) until you reach 1. Ignore the 1 and arrange the resultant halved multipliers vertically in reverse order. For each halved multiplier, double the multiplicand. Add also the initial multiplicand if the halved multiplier is an odd number.

Example: 44 × 51

Repeatedly halve the multiplier: 51 25 12 6 3 1

Resultant		44	Double the multiplicand
odd/even halved		44	by adding to itself
multipliers:	3	+ 44	Add initial multiplicand
		132	
		132	
	6	+ 0	Don't add initial multiplicand
		264	
		264	
	12	+ 0	
		528	
		528	
	25	+ 44	
		1100	
		1100	
	51	+ 44	
Final product:		2244	

Table 4: *An example of manual implementation of the algorithm of table 3.*

Listing 2: *An implementation of the author's integer-division algorithm for the 8080 microprocessor.*

```
;division program DIVIDE

;input dividend in BC and input divisor in HL.
;output quotient in HL and output remainder in DE.
;carry set if division by zero

;**********************  Test for division by zero and prepare
DIVIDE: mov     a,h     ;for reverse polarity subtraction
        ora     l
        stc
        rz              ;division by zero; abort operation; carry set
        mov     a,b     ;put 2's complement of BC +1 into DE for
        cma             ;purposes of subtraction. (BC will be
        mov     d,a     ;incremented to enable subtraction when minuend
        mov     a,c     ;and subtrahend are having equal values).
        cma
        mov     e,a     ;dividend in negative form now in DE
        inx     b       ;BC +1; dividend incremented
        xra     a       ;reset counter A and
        sta     quot    ;clear the quotient buffer
        sta     quot+1  ;(high-order part of quotient buffer)
        jmp     double  ;start the division in earnest

;*********************** First phase: Doubling the divisor
restore:dad     b       ;add back
double: inr     a       ;increment counter
        push    h       ;save divisor
        dad     h       ;double it, but go to second phase if
        jc      change  ;HL now is larger than dividend in BC
```

Listing 2 continued on page 372

Listing 2 continued:

```
        dad     d       ;comparison with dividend by subtraction
        jnc     restore ;keep doubling unless HL now is larger than BC

;*********************** Second phase: Subtracting from the dividend
                                      and accumulating quotient bits.
change: mov     b,a     ;transfer count to new counter
subtrct:pop     h       ;fetch halved divisor as positive subtrahend
        dad     d       ;subtract by using negative dividend as minuend
        jc      shiftc  ;the carry bit becomes the quotient bit
        xchg            ;equivalent of adding back if subtraction fails
shiftc: cmc             ;invert quotient bit from reverse polarity
        lda     quot    ;shift quotient bits
        ral
        sta     quot    ;and place into temporary storage
        lda     quot+1
        ral
        sta     quot+1
        dcr     b       ;count-down finished?
        jnz     subtrct ;no, continue process
        lhld    quot    ;yes, place output quotient in HL.
        mov     a,e     ;change remainder in DE into proper polarity
        cma
        mov     e,a
        mov     a,d
        cma
        mov     d,a
        ret             ;division operation completed

quot:   ds      2       ;buffer for evolving quotient
```

Listing 3: *An implementation in 8080 assembly language of the integer-multiplication algorithm given in tables 3 and 4.*

```
;multiplication program DADDY

;input multiplicand in DE and input multiplier in A
;output product in HL, carry set if overflow

;**********************  Test for zero and leading zeroes, (8-bit
;                        factor already determined and placed in A)
DADDY:  lxi     h,0     ;clear output product register
        mvi     b,8+1   ;set bit counter
        ana     a       ;is multiplier in A zero? (carry cleared)
        rz              ;yes, skip multiplication operation; 0 in HL
skip:   dcr     b       ;check multiplier bit
        ral             ;leading zero?
        jnc     skip    ;yes, ignore it and check next bit
        dad     d       ;no, load HL with multiplicand in DE; carry
                                                            ; cleared
;**********************  Multiplication starts in earnest
next:   dcr     b       ;more multiplier bits?
        rz              ;no, return with result in HL
        dad     h       ;yes, do a DAD H, doubling the multiplicand
        rc              ;overflow, carry set on return
        ral             ;is the multiplier bit a 1?
        jnc     next    ;no, check the next bit
        dad     d       ;yes, do a DAD D too, adding the initial
        jnc     next    ;check the next bit                multiplicand
        ret             ;overflow, carry set on return
```

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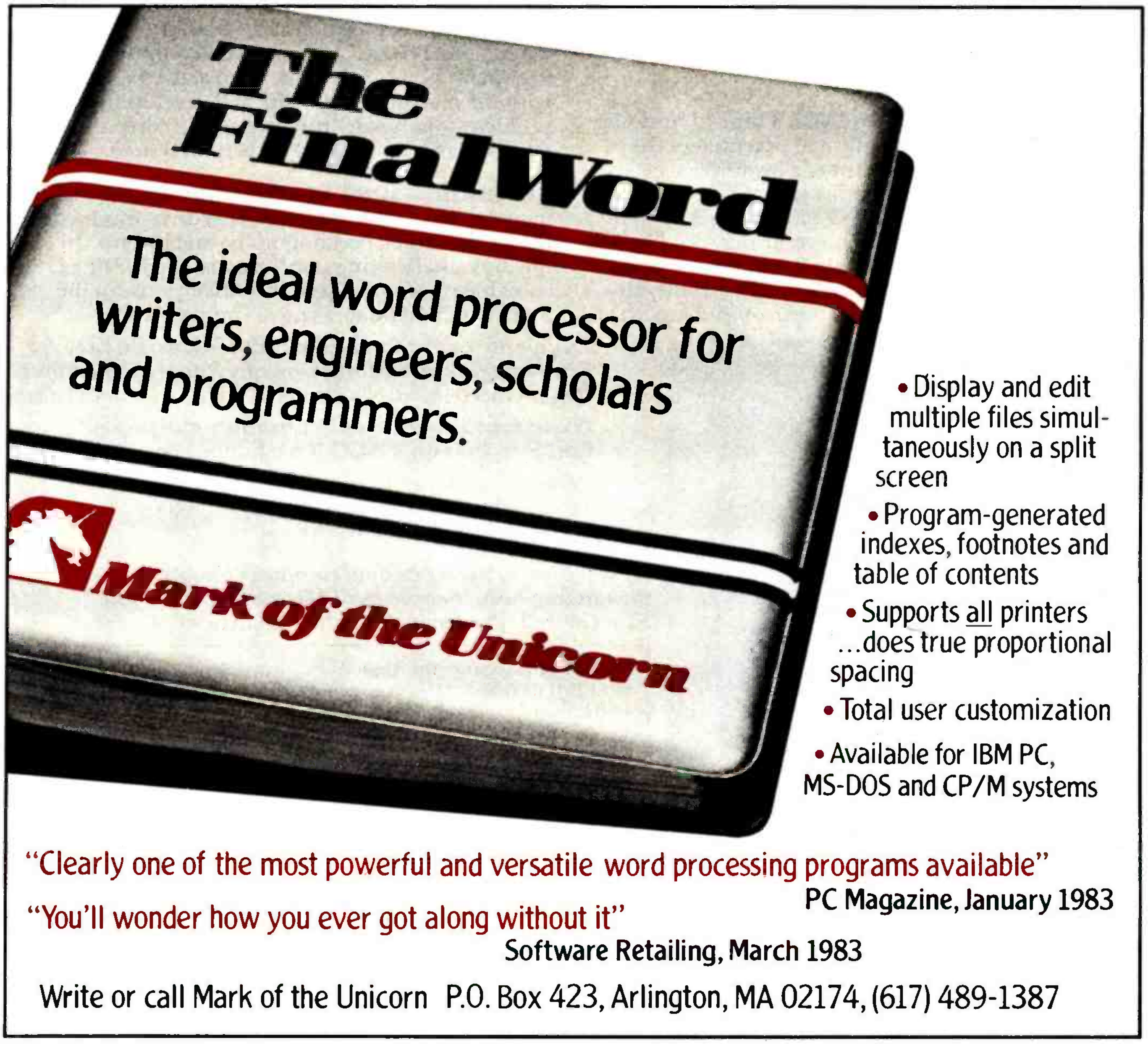
number K, based on using the 8080 DAD instruction (see table 3). The multiplicand is loaded into two register pairs (HL and DE), and the product is obtained by executing a sequence of DAD H and DAD D commands in the order given beneath each value of K (operand sequences for K=2 to K=32 have been included). DAD H doubles the accumulated multiplicand in the HL pair, and DAD D adds the original multiplicand to the HL pair.

It seems natural to look for a general algorithm based on DAD Hs and DAD Ds. If you look hard at table 3, you'll see a familiar pattern emerge: the Hs and Ds actually represent K in binary form. The 0s are represented by H, whereas the 1s are represented by H and D as a group. True, the most significant bit is missing, but that will always be a 1 anyway. As an example, consider K=19. The sequence is H H (H D) (H D), which translates into (1) 0 0 1 1.

Thus, we can multiply by shifting the multiplier and examining the carry. When carry is cleared, we perform a DAD H operation, and when it is set, we do both a DAD H and a DAD D. This gives us the code in listing 3.

Now for the manual method that can be derived from this: Repeatedly halve the multipler until it becomes 1 (in order to find the binary form). Reverse the sequence of halved multipliers and ignore the 1. Repeatedly double the multiplicand. Whenever the corresponding halved multiplier is odd, add also the original multiplicand to the accumulated doubled multiplicands; table 4 gives us an example of this method. Oh well, not everything is progress. But then, progress isn't everything. ■



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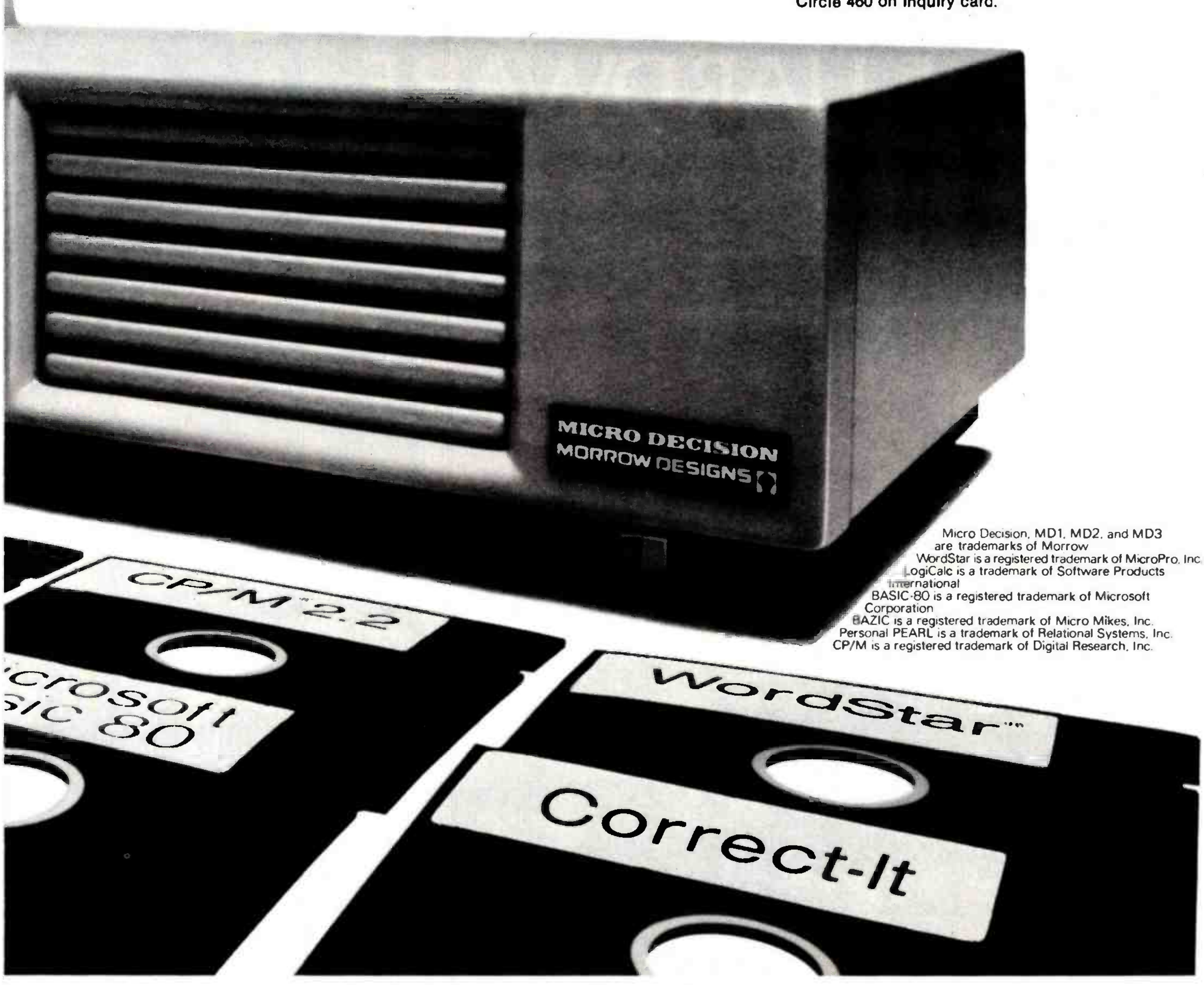

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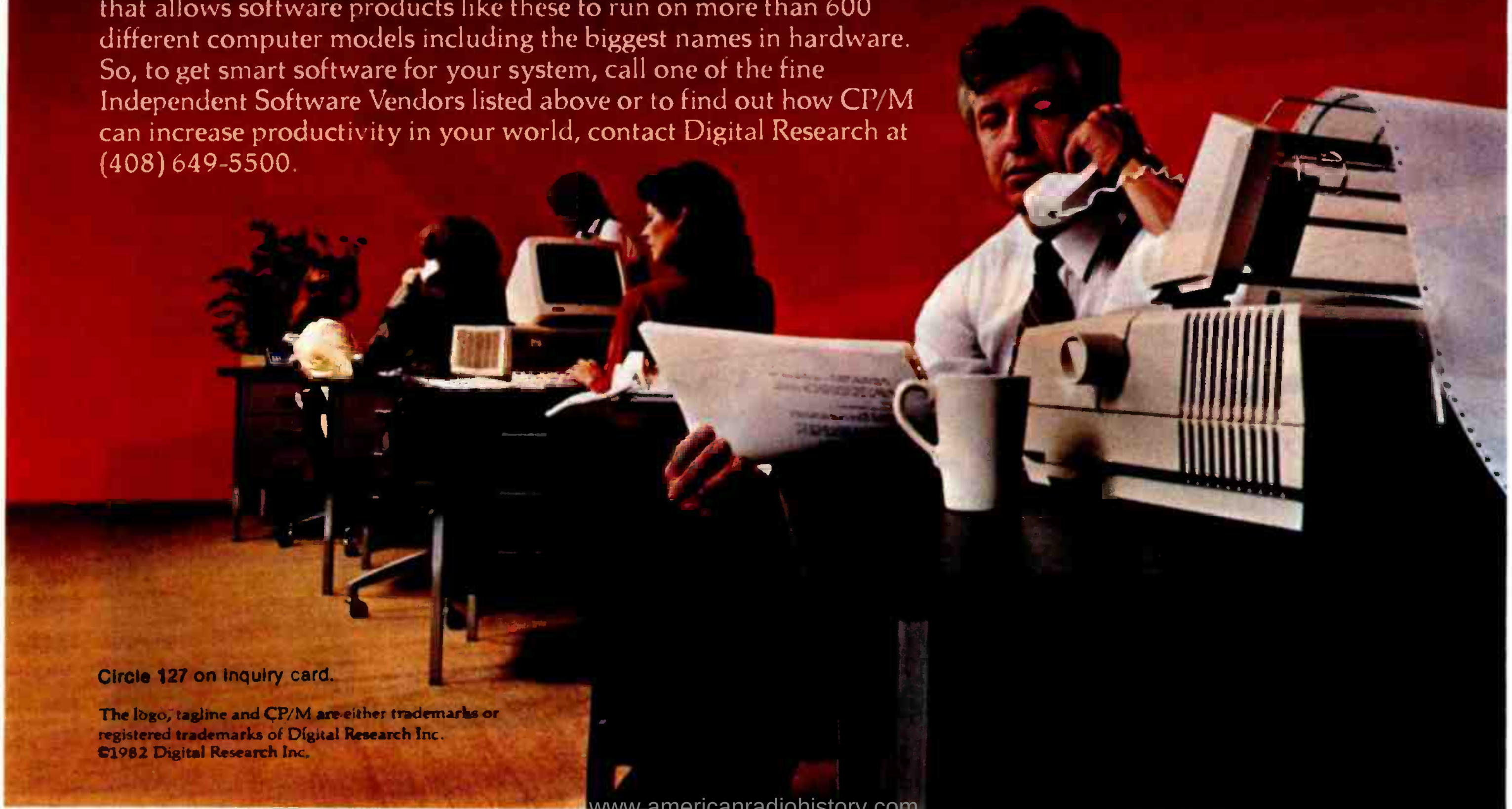

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Random Numbers from an All-Digital Generator

You don't need a complex and expensive analog generator to produce fast random numbers.

Gary Finley
Department of Psychology
Biological Sciences Building
University of Alberta
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A hardware source of random numbers, as discussed by Terry Mayhugh in the May 1981 BYTE Technical Forum column (page 452), is a useful addition to any computing system performing tasks that require a truly random selection of the values of some quantity. In some applications, the compelling attraction of hardware random-number generators over software routines is speed; when you simply cannot wait for the output of a software routine, a fast hardware source of random numbers becomes essential.

Such a requirement for high-speed random-number generation occurs in visual-perception experiments carried out at the University of Alberta. In this work, a minicomputer presents visual stimuli that consist of arrays of dots plotted rapidly on an oscilloscope screen. In some versions of these experiments the dot coordinates are chosen at random, and for maximum plotting speed, a new random coordinate must be available about every 3 microseconds (µs). No software technique can provide this demanding performance, so an analog-based random-number generator, very much like the one described by Mr. Mayhugh, has been used in these experiments for a number of years.

Recently, however, we have replaced this analog generator with a much simpler all-digital device, and the lower cost and reduced assembly time inherent in this design make it useful to microcomputer users who need fast random-number generation. As a result of the success of our first version, installed in a PDP-11/34 computer for laboratory experiments, we have since built several similar generators having clock speeds and word lengths suited to microcomputer applications. Two of these devices have been installed in portable video-display point plotters based on the Rockwell AIM-65 computer. We use these plotters in vision research studies conducted away from the laboratory.

Compared with traditional analog versions, the digital generator offers decreased sensitivity to external noise (which can induce periodic components into the output of analog designs) and decreased production of noise that may interfere with the host computer. An additional benefit of the digital generator is complete freedom from the logical asymmetry often found in analog generator outputs. Without very careful adjustments made with the help of calibration programs, analog-based random-number generators tend to produce unequal totals of logic 1s and 0s—in a large sample of random binary outputs these totals should be exactly equal. Although careful calibration allows you to obtain equal 1 and 0 totals with analog-based generators, the 1s-to-0s ratio tends to wander with time, requiring the periodic recalibration typical of any sensitive open-loop analog device.

Shift-Register-Based Circuit

The digital random-number generator (see figure 1, page 382) is a shift-register-based circuit more properly called a pseudorandom sequencer. This device, discussed by Don Lancaster in his excellent hobbyist reference *TTL Cookbook* (Howard W. Sams & Co., 1974), is essentially just a long shift register combined with additional logic circuitry. The outputs from two or more stages near the end of the register serve as the inputs to the logic circuit, which produces a bit that in turn feeds back to the register's first stage. This modified-ring shift register cycles through a number of states, each con-

sisting of a unique combination of binary bits present on the register outputs. The device assumes a new state each time a clock circuit causes the register to shift. When all possible states have appeared at the outputs, the first state reappears, and the cycle begins again.

As the device runs through its cycle of states, the outputs of eight arbitrarily chosen register stages can be used as the bits of a data byte. New bytes can be produced as rapidly as the register can be made to shift. For a register built from LSTTL (low-power Schottky transistor-transistor logic), this circuit can generate about 40 million random bytes per second, a rate far faster than that at which any microprocessor or minicomputer can operate on data.

This method of random-number generation is a close hardware equivalent of the multiplication and truncation technique used by many software random-number routines. Each register shift is equivalent to a multiplication by two, and the selection of 8 bits of the result as a data byte corresponds to the digit-truncation process.

The numerical values represented by the data bytes do not change at random; a precise logical function relates the value of each byte produced to the values preceding it. In the case of a single shift, the value of the new data is at most 1 bit different from one-half or twice the preceding value, depending on the direction of shift. The 1-bit variation arises from the way that the logical feedback circuit affects the bits of the current data. However, as successive shifts take place, the function relating the value of each new data byte to the starting value becomes extremely complex, and data bytes separated by a few shifts of the register have numerical values that appear to be completely unrelated, closely approximating the behavior of truly random values.

To avoid having any recognizable function relating one value of the data to the next, you need only to operate the circuit rapidly enough so that several shifts of the register take place between successive acquisitions of the output data by the computer.

In our microcomputer applications, we use 6502-based computers that have a 1-MHz clock frequency. These machines can acquire a latched byte of data from the pseudorandom sequencer and store it in memory (using indexed addressing) in about 15μs. The 500-kHz clock frequency of the circuit in figure 1 results in seven shifts of the register separating the computer-acquired data bytes, and the resulting stored data approximates random data extremely well.

For use with faster computers you can sample the pseudorandom data more frequently (with some loss of "randomness"), or you can speed up the device by decreasing the value of the capacitor that controls the frequency of its clock (C1 in figure 1).

The Number Series

At first glance, the finite size of the series of numbers produced by the pseudorandom sequencer may seem to be a serious drawback to this form of random-number generation, but a detailed look at the device shows why this is usually not so.

The length of the cycle of possible states in a shift register depends on the number of stages in the register and on the form of the logical feedback function used. For certain forms of this function, you can make the number of states as large as one less than the theoretical maximum of 2^n states, where n is the number of stages in the register. The complexity of the feedback function required to give maximum cycle length depends on the number of stages involved. A register with 31 stages runs through a maximum-length cycle when the feedback is a simple two-input exclusive NOR function that takes its inputs from the outputs of register stages 28 and 31. A 31-stage shift register can be made with only four 74LS164 eight-stage TTL packages. With the addition of another package (74LS86) containing exclusive OR gates and a final one (74LS04) to act as the system clock, we can build a sequencer with $2^{31} - 1$, or 2,147,483,647, discrete output states. The circuit shown in figure 1 uses only six logic packages and a handful of resistors and

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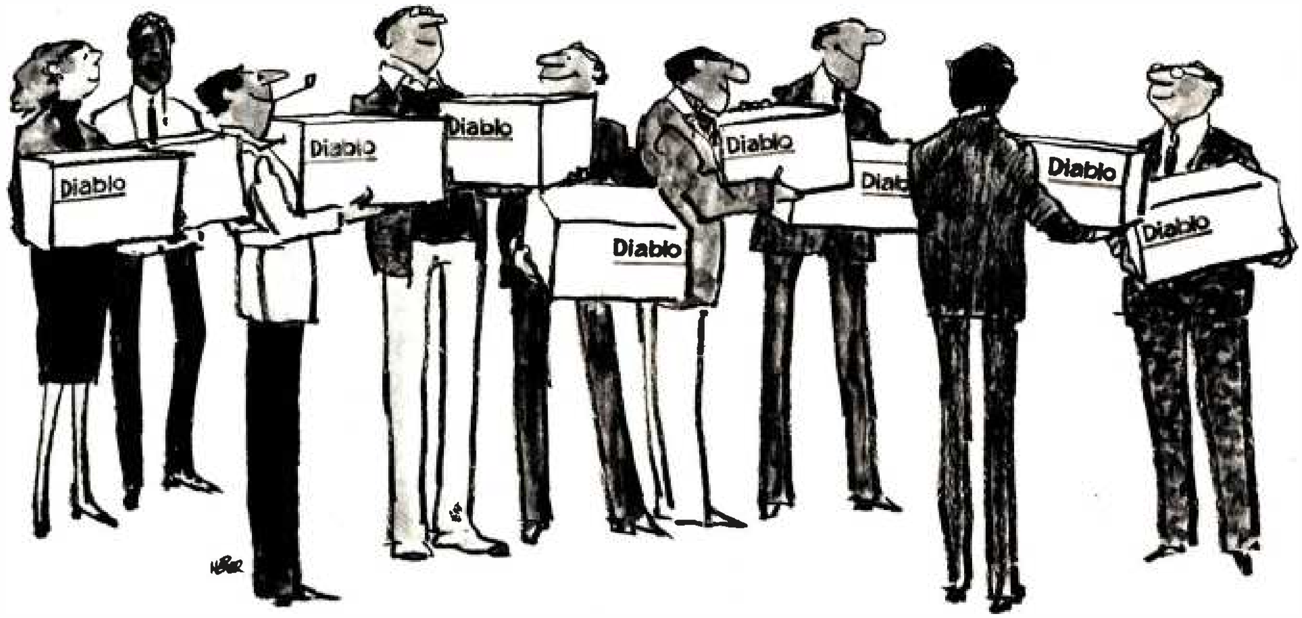

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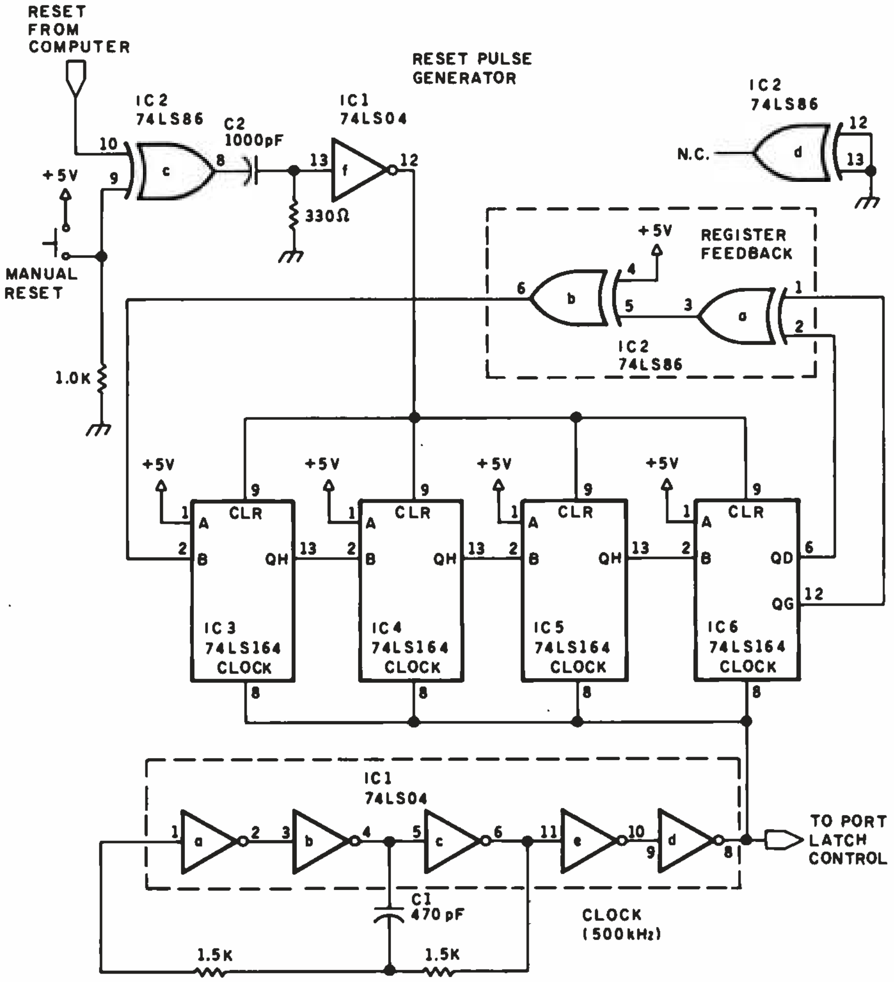


SEQUENCER OUTPUTS
(CHOOSE ANY 8 FOR DATA OUTPUT TO COMPUTER)

IC3, 4, 5 – PINS 3, 4, 5, 6, 10, 11, 12, 13
IC6 – PINS 3, 4, 5, 6, 10, 11, 12

N.C. = NO CONNECTION

Number	Type	+5V	GND
IC1	74LS04	14	7
IC2	74LS86	14	7
IC3	74LS164	14	7
IC4	74LS164	14	7
IC5	74LS164	14	7
IC6	74LS164	14	7

Figure 1: *Six TTL packages form a random-number generator capable of producing 2,147,483,647 discrete output states.*

capacitors, yet it produces a continuous stream of bytes of pseudorandom data at the rate of 500,000 bytes per second for more than an hour.

In applications not requiring such speeds, you could slow the clock enough to stretch the cycle time of the sequencer to several hours. However, in many applications the repetition of number sequences is extremely unlikely even if the generator cycles many times during a single computer-program execution. This characteristic is due to the sequencer being clocked by its own oscillator, which is not synchronized to the clock of the computer. In most applications, the computer selects a number or set of numbers from the rapid continuous stream of numbers (half a million per second in this case) produced by the sequencer. The program then performs some calculations or manipulations using these numbers before reading in a new set of numbers for the next series of operations. Frequently, these operations are separated by delays of several seconds during which the computer waits from some input, such as a keyboard entry.

If a small set of random numbers is read in once every few seconds on the average, then the chances of obtaining identical data during successive sequencer cycles is on the order of one in a million. Thus, in many cases, you will see no evidence of the cyclic nature of the device and can treat the pseudorandom sequencer as the source of a virtually infinite stream of random numbers.

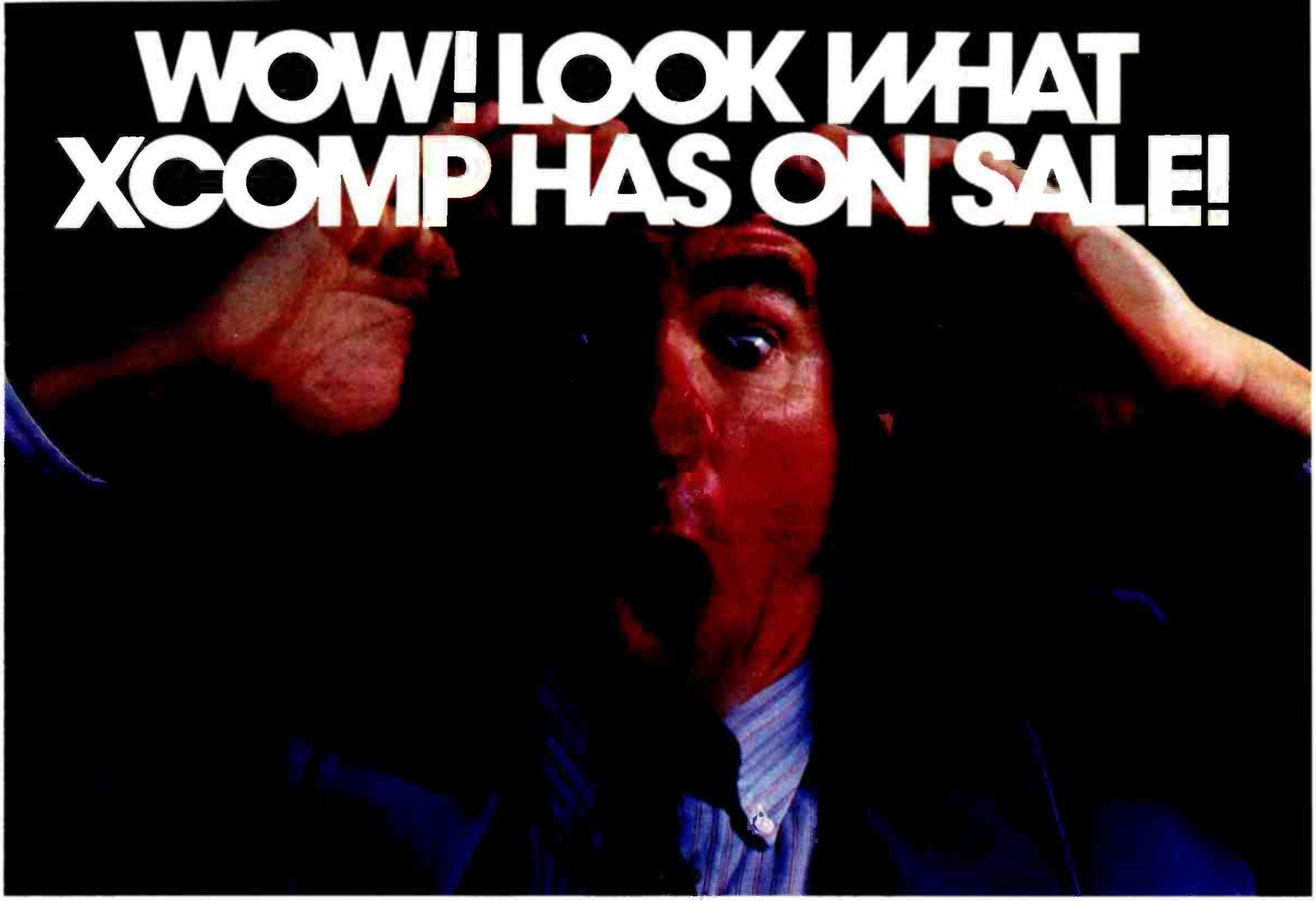
Demon State

I should clarify a few points concerning this design. First, sequencers of the form discussed here have one "demon state" that can trap them and halt operation. If all 31 stages of the register contain 1s, then no 0s can be produced by the feedback circuit, and the sequencer remains in this one state indefinitely. Fortunately, this state is not produced as a part of the cycle of usual sequencer outputs, but a remote danger exists that it may occur when the power is applied or through the chance action of some external event such as a glitch in the power-supply voltage. This frozen state can be escaped if you reset some or all of the stages of the shift register to 0 by applying a low pulse to the reset pins of one or more of the shift register packages.

In the figure 1 circuit, an unused inverter from IC1 is connected as a half-monostable circuit, which produces a suitable reset pulse in response to a positive transition at its input. A spare exclusive OR gate allows this reset transition to come from either a signal generated by the computer or the push of a button by the operator.

Interfacing

The random data produced by the digital device described here is useful only if it can be accessed through the data bus of the computer on demand. You can most easily accomplish this by using an 8-bit parallel-input port that is able to latch its inputs on the transition of an external signal.



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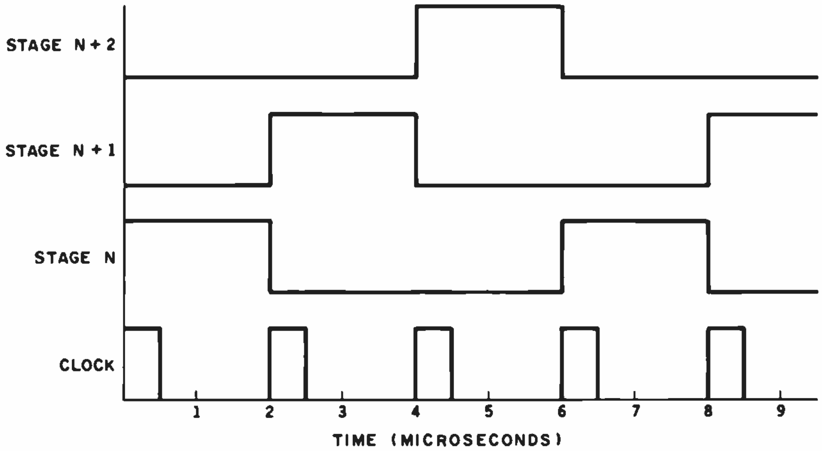

Figure 2: *As illustrated in this timing diagram showing the figure 1 circuit's clock signal and three register-stage outputs, sequencer data remains stable for about 1.5 µs following a negative-going clock transition.*

Figure 2 shows the relationship between the waveform produced by the sequencer clock and the contents of a few stages of the shift register. The register shifts on every positive transition of the clock waveform. The positive pulses produced by the clock in figure 1 occur every 2µs and have a duty cycle of about 25 percent. Thus, the data from the sequencer is stable for about 1.5µs following the clock pulse's negative transition. You use this transition as the signal that causes the latches in the input port to hold the current data. When the computer is finished with the byte of random data, the latches can be cleared in preparation for the latching of the next available random byte upon the clock waveform's next negative transition.

Conclusion

We have interfaced the output of the sequencer described here with a Rockwell AIM-65 microcomputer using one of the latchable ports in the 6522 VIA (versatile interface adapter) provided for user applications on the AIM-65 board. Frequency counts of the 256 possible outputs of the pseudorandom sequencer compiled with this computer showed a rectangular frequency distribution indicating that each of the possible numbers has equal probability of occurrence. No discernible patterns appeared in the frequency counts, even when the set of numbers tested reached 200 million samples. ■

About the Author

Gary Finley designs custom peripheral hardware and assembly-language software for computers used as laboratory controllers in the academic research conducted at the University of Alberta psychology department.

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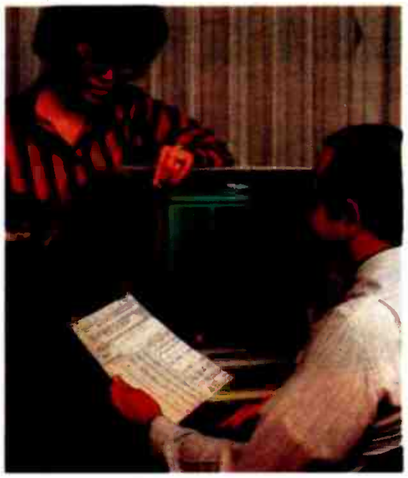
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AVL Trees

Introducing a Russian-developed scheme for searching and updating sorted data efficiently

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In most sciences, Russian contributions are well known and respected. Russians, for example, invented the tokamak fusion reactor. Advances in computer science sometimes seem almost exclusively Western, but even in this field the Russians have made significant contributions. One is the so-called AVL tree, a data structure that allows sorted data to be handled efficiently.

Sorting data in alphabetic or numeric order allows a unit of data to be found quickly via a binary or logarithmic search (see figure 1). The computer compares the key to element x, the desired item, with the key to element y, an item located halfway between the beginning and end of the table. If the x key is larger than the y key, x is in the second half of the table; otherwise, x is in the first half of the table. In either case, the search space has been cut in half. Ultimately, this procedure narrows the search space down to two items. The total number of comparisons required to search a table containing n items is $\log_2 (n) + 1$. Searching a table containing 1000 items, for example, requires at most 11 steps.

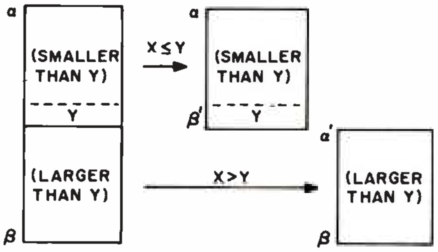


Figure 1: *A simple comparison reduces the problem of searching for x in a sorted array (left) to searching for x in a sorted array half the size of the original (right).*

The trouble with sorted tables comes when they have to be updated. On the average, inserting a new item in a table containing n elements requires shifting $n/2$ elements. (It might take more or fewer steps, depending on where the newly inserted element fits in the table.)

Many programs that have to search and update large tables quickly use a hash function to assign table locations to items based on their keys. This technique allows both efficient searching and insertion. But it has a drawback: data is scattered randomly around the table. This means that the data has to be sorted before it can be printed, a time-consuming process. Many applications require fast performance of three tasks: printing out data in sorted order, finding data, and adding new data. Neither a sorted array nor a hash table will suffice in such a case.

Enter the Russians—specifically, two Russians named G. M. Adelson-Velskii and Y. M. Landis. Writing in a mathematical journal called *Doklady Akademii Nauk* (Reports of the Academy of Sciences), they outlined a tree structure (figure 2) that permits these three operations to be carried out efficiently. The structure became known as an Adelson-Velskii-Landis tree, or an AVL tree for short.

A tree structure is a scheme for storing data in memory. It consists of interlinked nodes, each of which contains data plus one or more pointers to other nodes. A node that is not pointed to by any other node is called a root node; nodes that do not point to any other nodes are called leaf nodes. Each node occupies one or

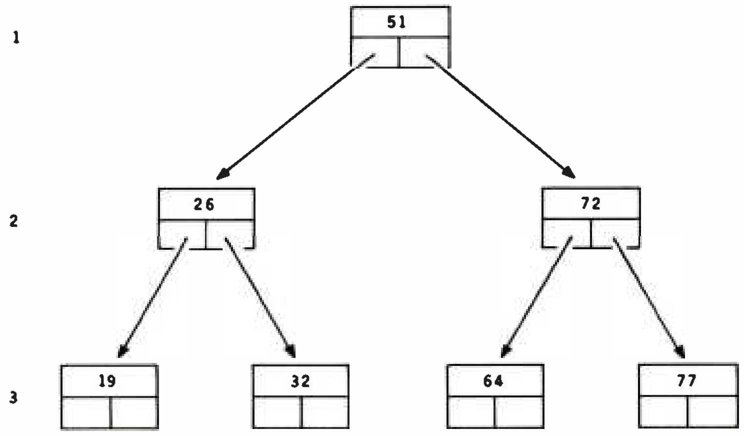


Figure 2: *An AVL tree represents sorted data as interlinked nodes.*

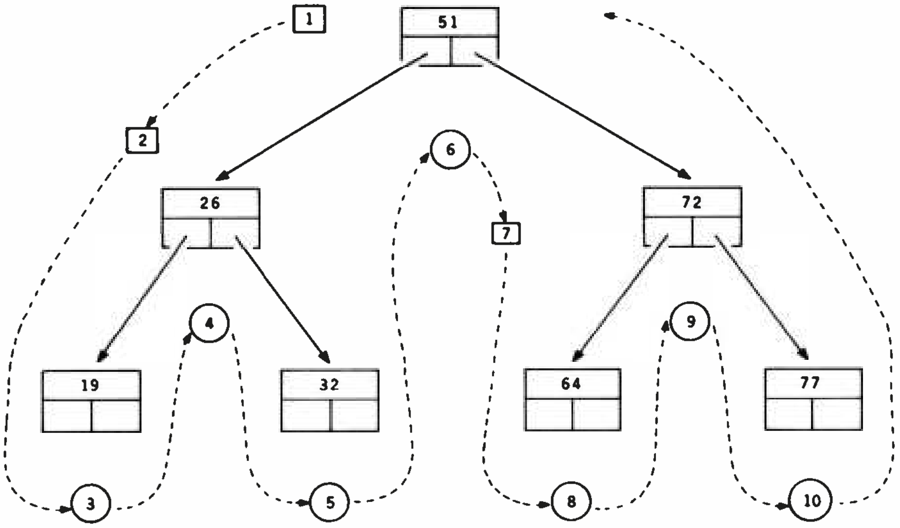


Figure 3: *To print an AVL tree in sorted order the computer traverses the tree along the path shown. The circled numbers indicate points at which elements are printed.*

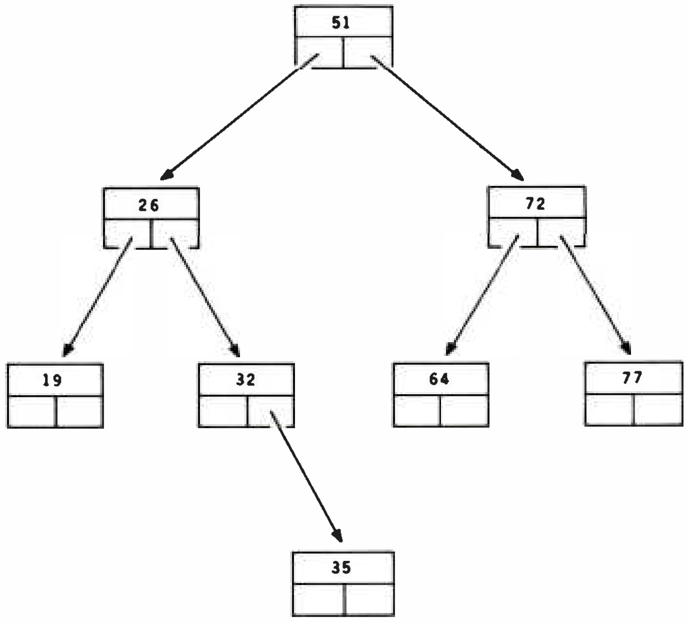


Figure 4: *Inserting a new entry into a tree creates a new level.*

more consecutive memory locations. A pointer is simply the memory address of a node.

An AVL tree represents the path taken by a computer through a sorted table during a binary search. The root node contains the middle item in the table and also contains two pointers, one to a subtree representing the lower half of the table and the other to a subtree representing the upper half. Each subtree similarly divides its half of the table into further subtree nodes. Searching the tree involves tracing through the branches from the root node to the leaves, comparing the key of the desired item to the contents of the nodes.

For example, to find item 19 in the AVL tree in figure 2, the computer would start with the root node. Because 19 is less than its contents, the computer would search the subtree pointed to by the left pointer. It would continue this process until it reached node 19, which happens to be a leaf node. The computer never searches the same level twice; therefore, the number of search steps is equal to the number of levels: $1 + \log_2 n$ where n is the number of items in the tree. Thus, searching an AVL tree is as efficient as searching a sorted table.

Printing out the tree elements in order may be accomplished by tracing through the tree in the pattern shown in figure 3. This scheme entails visiting some nodes twice before printing them out. Hence, printing an AVL tree in order requires more operations than printing out a sorted table. However, it is more efficient than printing out a hash table.

Adding new elements to an AVL tree presents the problem of keeping the tree in balance—that is, with about the same number of levels in the left as the right branch of the tree. A balanced tree has a minimum number of levels and hence is the most quickly searched. A simple procedure would be to tack a new node immediately beneath two adjacent leaf nodes that are smaller and greater than the new node, respectively (figure 4). But this procedure quickly leads to a badly unbalanced tree (figure 5).

Fortunately, trees do not need to be perfectly balanced, as in figure 2; restoring a tree to perfect balance can require a large amount of time. The basic contribution of Adelson-Velskii and Landis was to devise a relaxed definition of a balanced tree that allows efficient rebalancing whenever a new element is added.

They defined a balanced tree as one in which the two subtrees governed by any node never differ in height by more than one level. Specifically, the subtrees may either be equal in height, or the left subtree may be one level higher than the right, or vice versa. In an AVL tree, each node is marked as to which case holds (see figure 6):

L = left subtree higher
E = equal heights
R = right subtree higher

Only two bits are required at each node to hold this balance factor.

To insert a new piece of data into an AVL tree in such a way that it remains balanced, the computer first determines where to put the new datum. This is done by searching the tree for the two adjacent leaf nodes between which the new node fits in sorted order. The new node is then tacked onto the left leaf node, creating a new level, and the balance factors are adjusted appropriately (figure 7).

If the insertion violates the balance criterion, the computer must perform a balancing operation. There are six possible balancing operations, depending on the sequence of balance factors from the unbalanced node to the new node: LL, LRL, LRR, RLL, RLR, and RR (figure 8). For example, the insertion in figure 7 requires an RLR. In two cases, two node positions and three pointers are changed; in the other cases, three node positions and five pointers are changed. When a node position is changed, its balance factor is also changed. Once the balancing operation is completed, the insertion algorithm is finished.

How much time does this insertion algorithm take? It requires 1 + $\log_2 n$ steps to find the place to insert the

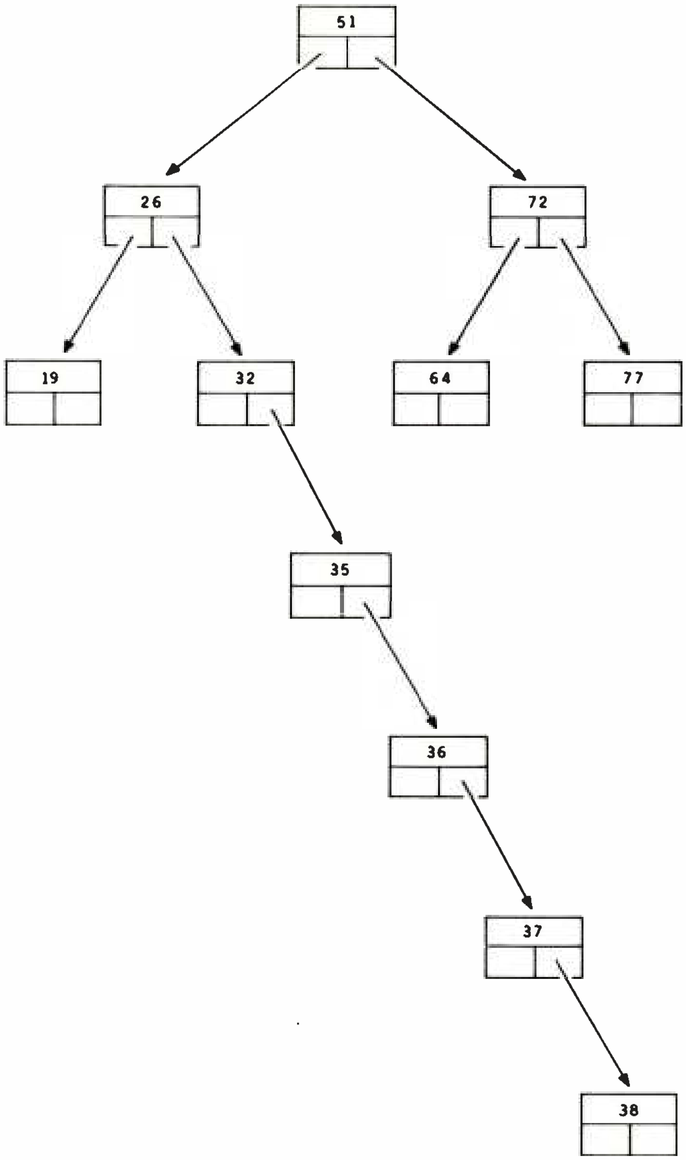


Figure 5: *Insertion of new items can lead to an unbalanced tree, increasing the length of a search path.*

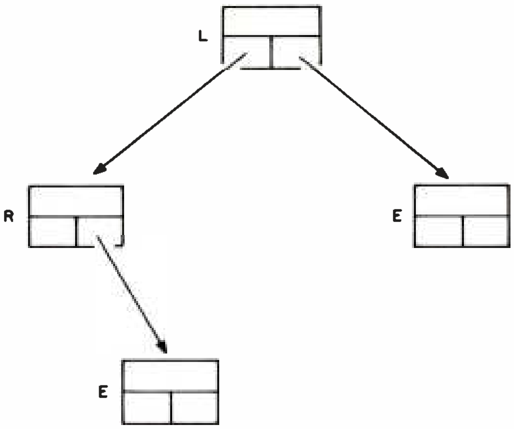
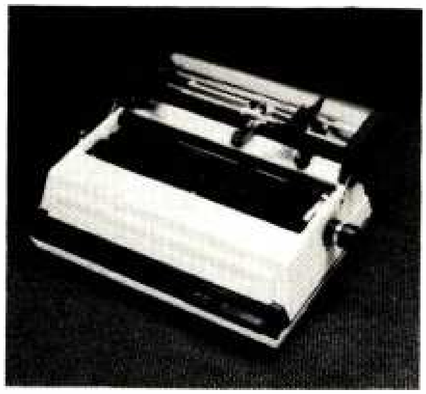


Figure 6: *An AVL tree includes factors that enable re-balancing the tree when a new element is added.*



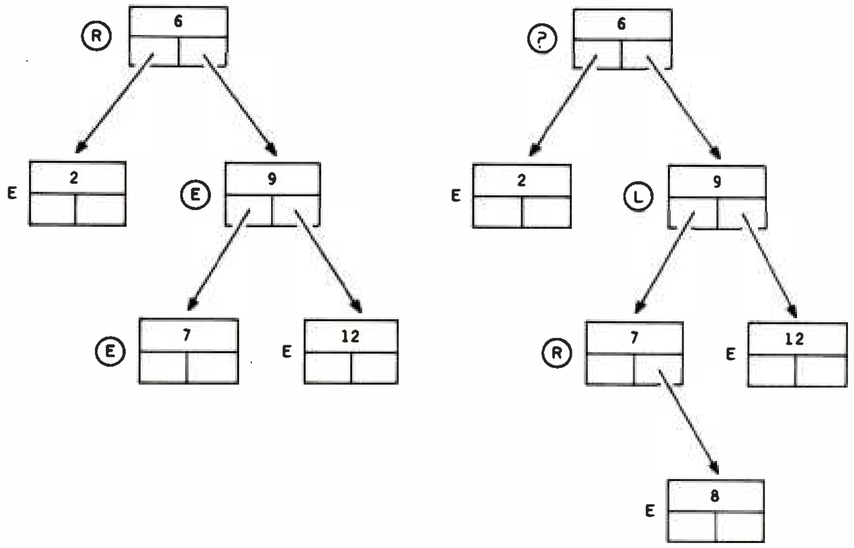


Figure 7: *Inserting a new element in a tree (left) requires changing the balance factors.*

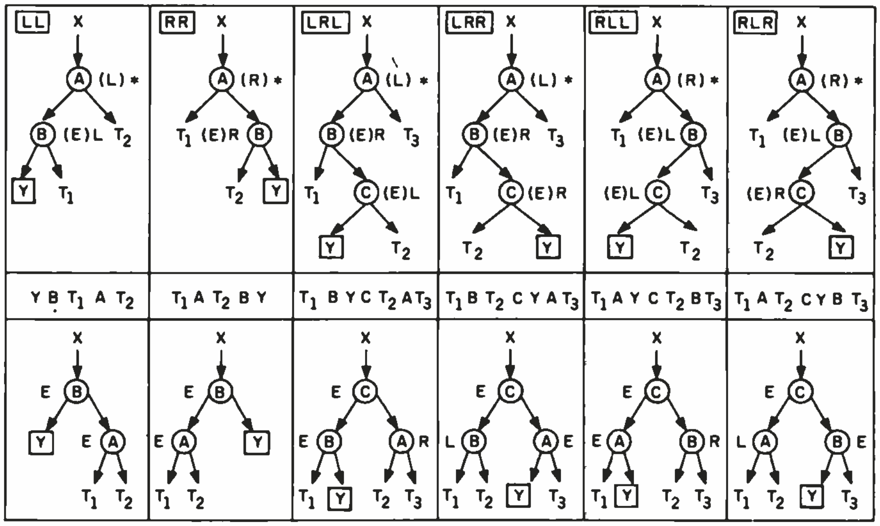


Figure 8: *Six possible balancing operations exist, depending on the sequence of balance factors from the unbalanced node to the new node: LL, LRL, LRR, RLL, RLR, and RR.*

new item plus a constant amount of time for the balancing operation, if necessary.

This is by no means the end of the study of balanced binary trees. The complete insertion algorithm for AVL trees is given in a high-level language in *Fundamentals of Data Structures* by Ellis Horowitz and Sartaj Sahni (Computer Science Press, 1976). There is a deletion algorithm for AVL trees, which allows one to take data out of an AVL tree in an amount of time that is also proportional to $\log_2 n$. Then there are bounded-balanced trees, B-trees, 2-3-trees, neighbor trees, *k*-trees, and brother trees; a guide to all this forestry is given in the bibliography of "Right Brother Trees" by Th. Ottmann, H. W. Six, and D. Wood, in the September 1978 issue of the *Communications of the ACM.* ■

About the Author

W. D. Maurer is a professor of computer science. His latest book, Apple Assembly Language, *is soon to be published by Computer Science Press of Rockville, Maryland.*

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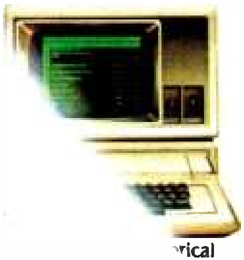
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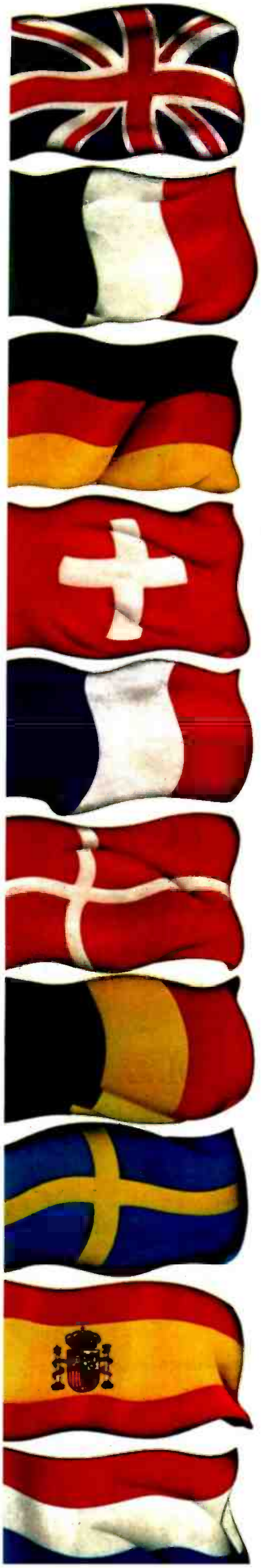

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Build a Simple Light Pen for the Apple II

Avoid complex hardware with the strategic use of software.

David J. Lilja
243 Acalanes Dr., #3
Sunnyvale, CA 94086

You can use an inexpensive light pen instead of keyboard entry or an expensive digitizing tablet to control the Apple II's extensive graphics capabilities. In this article, you'll find a light pen design that relies on software to do most of the work, keeping the hardware simple.

The light pen in this design consists of a photodetector that senses light emitted from the video display screen. The hardware provides a logic-level input to the computer—an input at one level when no light is detected and another level when it is. To determine the location on the screen to which the light pen is pointed, the computer plots a bright block at a known location on an otherwise black screen. It then checks the light-pen input to see whether the pen detected the light. If it did, the computer then knows the pen's location (the location of the block). If the pen did not detect the block of light, the computer moves the block on to another location and checks again. It continues in this fashion until it finds the pen or has searched the entire screen.

Uses of the Light Pen

The light pen serves two main purposes. The first is simple menu selection. When the display presents a list of possible alternatives, the user can merely point at one with the light pen rather than type in a choice. This capability eases selection for the inexperienced computer user and provides fewer opportunities for error than do other methods.

The second, and perhaps more important, task for the light pen is to input graphic information to the computer. The user can merely draw a figure on the screen to be stored in the computer's memory. This method is much easier than trying to define a complex figure by specifying coordinates via the keyboard.

Operation of the Apple II

You must understand the way the Apple II displays graphics to successfully use the light pen. The system has two graphics modes: high resolution (high-res) and low resolution (low-res). Both are bit-mapped, generating video information from data in specific locations in memory. The low-res display shares 1K bytes of memory (from hexadecimal 400 to 7FF) with the standard text display. This configuration provides a 40 by 40 array of blocks with four lines of text at the bottom. The high-res display occupies an 8K-byte block of memory (from 2000 to 3FFF), which provides a display of 44,800 dots in a 280 by 160 dot array. A program can move between these two modes by referencing a certain memory location. When the light pen is used, the main display is the high-res screen, but the search for the light pen is done on the low-res screen.

The computer must search the entire screen each time it looks for the light pen. This method allows you to place the pen at any point on the screen at any time as well as move the pen away from the screen without causing the computer to lose track of where the pen is pointed.

A program I wrote in Applesoft BASIC that can accomplish this entire screen search proved extremely slow, taking 10 to 15 seconds to locate the pen in the worst case—much too slow to be useful.

To speed up the search, I tried rewriting the program in 6502 assembly language. At first, the resulting program ran too fast. It would write data for a block to a memory location in the low-res buffer area, check the pen input, determine that it had not detected the block's light, and then erase the block and move on to the next location. The video display's update rate, nominally 1/60 of a second (16.7 milliseconds), proved to be the problem. The computer, running very fast, would write the block data, check the pen, and erase the block before it could be incorporated into the video stream and be actually displayed on the screen. The solution was to insert a delay between plotting the block and checking the pen to allow time for the block to be displayed. Unfortunately, the shortest delay time that seemed to work was about 4 ms, and therefore scanning the entire display took about 6 seconds.

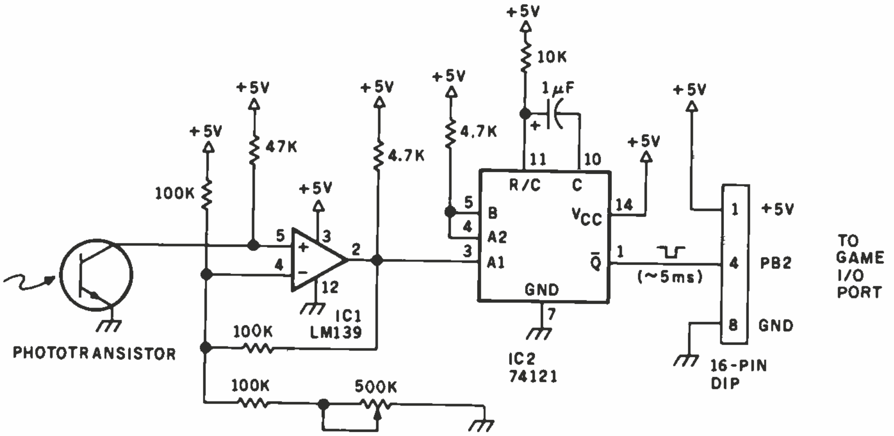

Figure 1: *The circuit in the light pen's design uses a phototransistor, which serves as the device's sensing element.*

Listing 1: *The PEN subroutine.*

```
PRESS ANY KEY TO CONTINUE

SOURCE FILE: PEN2
0000:              1 ;SUBROUTINE TO FIND LIGHTPEN IN
0000:              2 ;   SMALL SQUARE
----- NEXT OBJECT FILE NAME IS PEN2.OBJ0
0300:              3          ORG   $300
0300:4C 09 03      4 FINDPEN JMP   START
0303:              5 ******************************
0303:              6 *  DEFINE STORAGE
0303:              7 ******************************
0303:00            8 VERT     DFB   0            ;HORIZ POSITION
0304:00            9 HORIZ    DFB   0            ;VERT POSITION
0305:00           10 SAVEA    DFB   0            ;TEMP STORAGE FOR ACC
0306:00           11 HEND     DFB   0            ;HORIZ END OF BLOCK
0307:00           12 VEND     DFB   0            ;VERT END OF BLOCK
0308:00           13 HSTART   DFB   0            ;HORIZ START OF BLOCK
0309:             14 ;
0309:             15 ;DEFINE EQUATES
0309:             16 ;
0002:             17 OFFSET   EQU  2             ;"SIZE" OF SEARCH
000F:             18 WHITE    EQU  15            ;COLOR WHITE
0000:             19 BLACK    EQU  0             ;COLOR BLACK
F800:             20 PLOT     EQU  $F800         ;PLOT SUBROUTINE
F864:             21 SETCOL   EQU  $F864         ;SET COLOR SUB.
FCA8:             22 WAIT     EQU  $FCA8         ;DELAY SUBROUTINE
0028:             23 DELAY    EQU  40            ;LENGTH OF DELAY
C063:             24 PEN      EQU  $C063         ;ADDRESS OF PEN
C056:             25 LORES    EQU  $C056         ;SOFT SWITCHES
C057:             26 HIRES    EQU  $C057
C054:             27 PAGE1    EQU  $C054
C050:             28 GRAPHIC  EQU  $C050
F836:             29 CLRSCR   EQU  $F836         ;CLEAR SCREEN
0309:             30 ;
0309:             31 ********************************
0309:             32 *  MAIN PROGRAM
0309:             33 ********************************
0309:             34 ;
0309:20 36 F8     35 START     JSR  CLRSCR       ;CLEAR THE SCREEN
030C:AD 54 C0     36           LDA  PAGE1        ;SET LO-RES, P. 1
030F:             37 ;
030F:             38 ;INIT VARIABLES WITH LIMIT CHECKS
030F:             39 ;
030F:18           40           CLC                ;HEND=HORIZ + OFFSET
0310:AD 04 03     41           LDA  HORIZ
0313:69 02        42           ADC  #OFFSET
0315:C9 28        43           CMP  #40          ;A<40?
0317:90 02        44           BCC  HOK          ;YES
0319:A9 27        45           LDA  #39          ;NO, LIMIT TO 39
031B:8D 06 03     46 HOK       STA  HEND
031E:18           47           CLC                ;VEND=VERT + OFFSET
031F:AD 03 03     48           LDA  VERT
0322:69 02        49           ADC  #OFFSET
0324:C9 28        50           CMP  #40          ;A<40?
0326:90 02        51           BCC  VOK          ;YES
0328:A9 27        52           LDA  #39          ;NO, LIMIT TO 39
032A:8D 07 03     53 VOK       STA  VEND
```

Listing 1 continued on page 398

To overcome the problem caused by this slow search time, I changed the program so that the computer instead scanned only a small portion of the screen, an area of 25 blocks in a 5 by 5 array centered at the last-known position of the pen. Because the computer then must scan only 25 locations instead of 1600, search time decreases from about 6 seconds to less than 100 ms. This rate causes noticeable flicker on the display; however, it is not objectionable. This drastic reduction in search time requires a trade-off with ease of use, however. When the computer is searching only a 25-block area, you must slide the pen across the screen so that the computer does not lose track of it. If the pen is not detected in this small area, the computer assumes that the pen is not pointing at the screen and that nothing is changed. The increase in speed outweighs the minor inconvenience of having to slide the pen.

Hardware

The light pen communicates with the Apple using a TTL-level (transistor-transistor logic) signal to the Apple's game I/O (input/output) port, the port through which the game paddles are connected to the machine. To keep hardware requirements to a minimum, the pen's signal is linked through the push-button 2 input (PB2), which connects directly to a 74LS251 data selector. The signal is checked by examining the most significant bit of location hexadecimal C063.

A phototransistor serves as the light pen's basic sensing element. The emitter is grounded, the collector is pulled up to +5V (volts) with a resistor, and light input is used as the base drive. The phototransistor alone doesn't provide the necessary logic levels to drive the input, however; nor is the light from the screen sufficiently bright to completely saturate the transistor and create a solid logic 0.

The complete circuitry needed to make the pen work is shown in figure 1; it can be installed in any appropriate cylindrical housing. The phototransistor's collector is pulled up to +5 V through the 47 k-ohm

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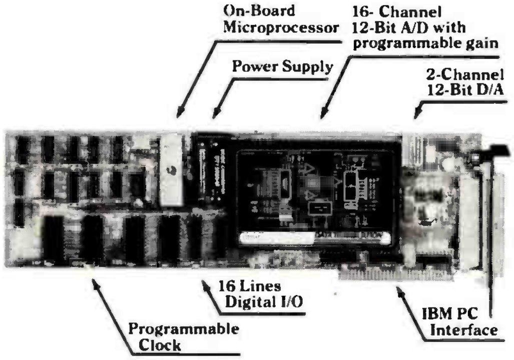

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Listing 1 continued:

```
032D:38                 SEC          ;Y=HORIZ - OFFSET
032E:AD 04 03           LDA  HORIZ
0331:E9 02              SBC  #OFFSET
0333:10 02              BPL  H2OK    ;A>=0?   YES
0335:A9 00              LDA  #0      ;NO, LIMIT TO 0
0337:8D 08 03   H2OK    STA  HSTART
033A:A8                 TAY
033B:38                 SEC           ;A = VERT - OFFSET
033C:AD 03 03           LDA  VERT
033F:E9 02              SBC  #OFFSET
0341:10 02              BPL  V2OK    ;A>=0?   YES
0343:A9 00              LDA  #0      ;NO, SET TO 0
0345:8D 05 03   V2OK    STA  SAVEA
0348:           ;
0348:           ;FIND LIGHTPEN
0348:           ;
0348:AD 56 C0   AGAIN   LDA  LORES   ;PLOT ON LO-RES SCREEN
034B:A9 0F              LDA  #WHITE  ;SET COLOR
034D:20 64 F8           JSR  SETCOL
0350:AD 05 03           LDA  SAVEA   ;PLOT POINT
0353:20 00 F8           JSR  PLOT
0356:A9 28              LDA  #DELAY  ;PAUSE
0358:20 A8 FC           JSR  WAIT
035B:AD 63 C0           LDA  PEN     ;READ PEN (BIT-7)
035E:10 29              BPL  FOUND   ;LOW => FOUND
0360:A9 00              LDA  #BLACK  ;SET COLOR
0362:20 64 F8           JSR  SETCOL
0365:AD 05 03           LDA  SAVEA   ;ERASE POINT
0368:20 00 F8           JSR  PLOT
036B:AD 57 C0           LDA  HIRES   ;SET TO HI-RES SCREEN
036E:C8                 INY           ;NEXT HORIZ
036F:CC 06 03           CPY  HEND    ;Y>HEND?
0372:90 D4              BCC  AGAIN   ;NO,
0374:F0 D2              BEQ  AGAIN   ;DO IT AGAIN
0376:AC 08 03           LDY  HSTART  ;YES, RESET Y
0379:EE 05 03           INC  SAVEA   ;NEXT VERT POSITION
037C:AD 05 03           LDA  SAVEA
037F:CD 07 03           CMP  VEND    ;A>VEND?
0382:90 C4              BCC  AGAIN   ;NO, DO IT
0384:F0 C2              BEQ  AGAIN   ;  AGAIN
0386:4C 9A 03           JMP  DONE    ;FINISHED, NOT FOUND
0389:A9 00      FOUND   LDA  #BLACK  ;SET COLOR
038B:20 64 F8           JSR  SETCOL
038E:AD 05 03           LDA  SAVEA   ;SAVE NEW HORIZ
0391:8D 03 03           STA  VERT
0394:8C 04 03           STY  HORIZ   ;SAVE NEW VERT
0397:20 00 F8           JSR  PLOT    ;ERASE POINT
039A:AD 57 C0   DONE    LDA  HIRES   ;RESET HI-RES
039D:60                 RTS           ;RETURN

*** SUCCESSFUL ASSEMBLY: NO ERRORS
```

VERT	—the pen's last-known vertical coordinate
HORIZ	—the pen's last-known horizontal coordinate
SAVEA	—temporary storage location for the accumulator
HEND	—the horizontal coordinate of the end of the search block
VEND	—the vertical coordinate of the end of the search block
HSTART	—the horizontal coordinate of the start of the search block
OFFSET	—the plus and minus offset that determines the search block's size

Table 1: *Variables for the PEN subroutine.*

resistor. This large resistor was used so that relatively small base currents would bring V_{CE} sufficiently low to trip the comparator. The comparator is linked (with hysteresis) to the 500 k-ohm potentiometer allowing adjustment of the overall sensitivity.

The comparator turns off too soon when the light pen is positioned on the edge of a block however, and the block drifts slightly on the screen, perhaps as a result of electromagnetic interference. When the block moves, the phototransistor is no longer saturated and thus turns off the comparator prematurely. To prevent the phototransistor from turning off too early, the comparator's output is connected to a monostable multivibrator that furnishes the actual signal output. The circuit provides a normally high signal on the PB2 input, but goes low for approximately 5 ms when the phototransistor detects light. The computer detects this negative-going pulse.

The PEN Subroutine

The PEN subroutine (listing 1) performs the search for the light pen on the screen. To ensure that the routine operates as quickly as possible, it is written in 6502 assembly language. The operating system resident in the Apple leaves page 3 of memory free from system use and available for user machine-language routines. For this reason, the subroutine was assembled at location hexadecimal 300 and is entered by a subroutine call to that location. As written, the routine is not relocatable object code. (Table 1 lists variables for the PEN subroutine.)

The routine does not require any parameters to be passed to it and returns with the horizontal and vertical coordinates stored in memory. Both of these coordinates are in the range 0 to 39; (0,0) is the upper-left corner of the screen and (39,39) is the lower-right corner. The vertical coordinate is returned in memory location hexadecimal 303; the horizontal, in location 304. If the light pen is not pointing to the screen when the subroutine is called, the subroutine will return with the pen's last-known position, thus leaving these two locations unchanged.

The PEN subroutine limits its search to a small area around the pen's last-known position, a 5 by 5 square that corresponds to an offset of ±2 blocks in both the horizontal and vertical directions. In figure 2, you see that the subroutine first calculates the limits using an offset of 2. The limits are within a 0-to-39 range so that the search for the pen does not extend off the screen. As the program progresses, the current horizontal position is in the Y register, and the vertical position is in the accumulator, A.

After this initialization, the subroutine switches the display to the low-res mode by referencing memory location C056. It then plots the first block of the search square using a subroutine in the Apple's monitor (PLOT). After a delay of about 4 ms, the subroutine checks the light-pen input. If the pen has sensed the block, the program erases it, updates the horizontal- and vertical-position parameters to the new position, and

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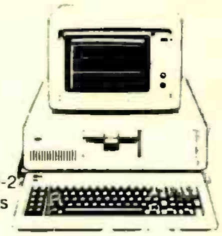

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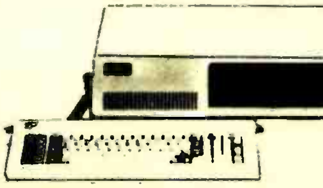

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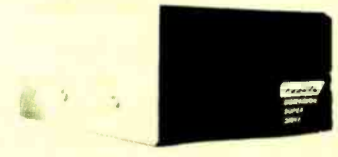

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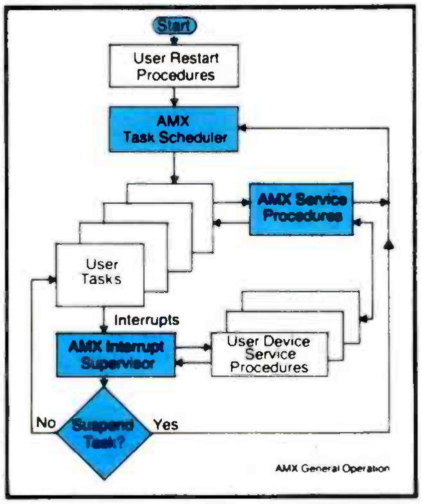

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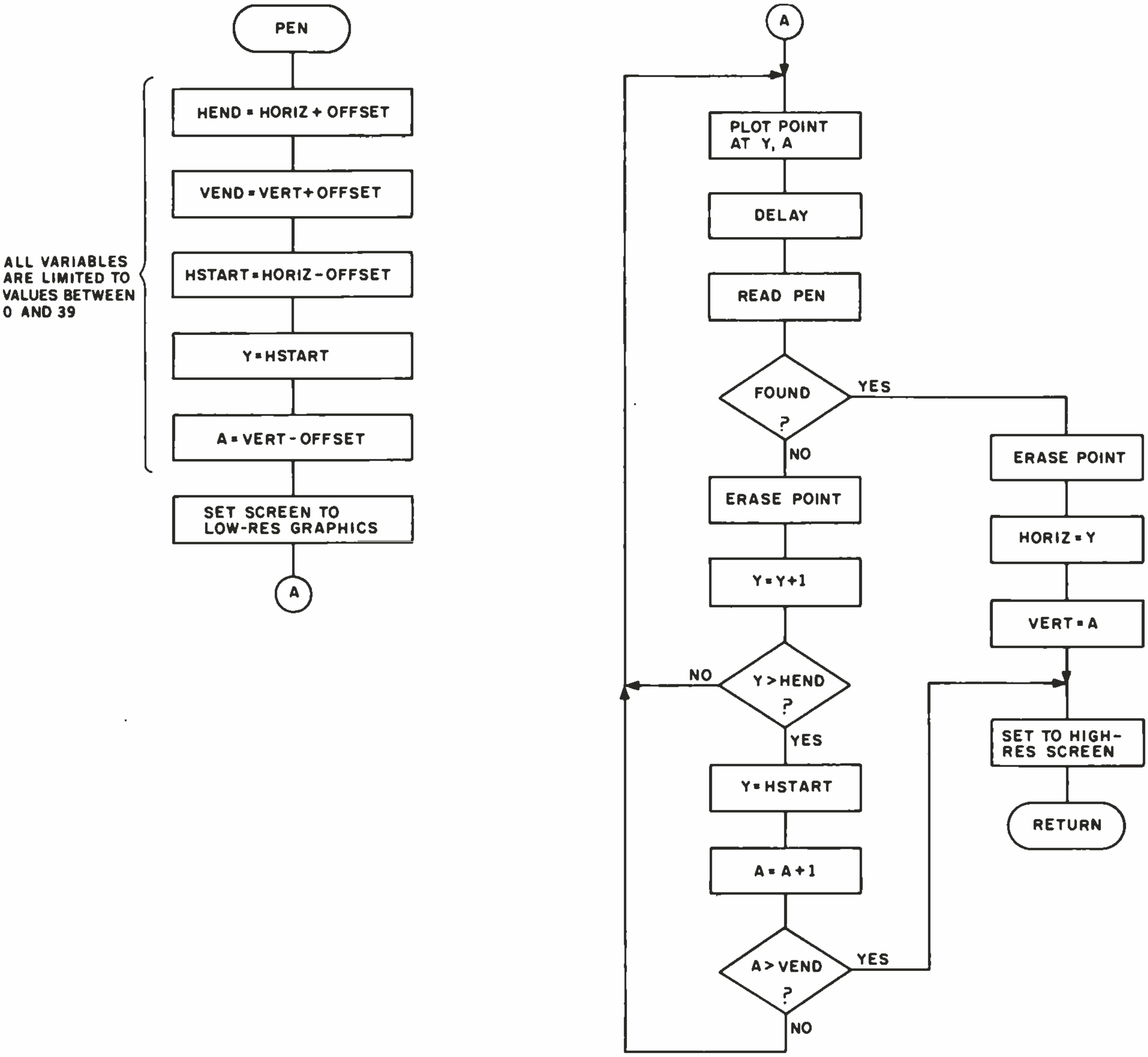

Figure 2: *This flowchart plots the course of the PEN subroutine, which uses the top portion of the low-res display.*

then returns to the calling program. If the pen does not sense the block, the program erases it and moves right to the next horizontal position, continuing until it reaches the end of the first line in the square. It then moves to the next line in the square and starts again. This process repeats until the pen is found or the entire square has been searched. The result of the process is a series of flashing blocks that seem to follow the pen around the screen. When the pen is not on the screen, the blocks remain stationary.

The PEN subroutine is very general and can be built into application programs to find the light pen's position on the screen. Note, however, that the subroutine uses the top portion of the low-res display, the same display used by the normal text mode. Thus, a program that must use more than the bottom four lines of text will require modifications to use this subroutine.

The LINES Program

The LINES program (listing 2), written in BASIC, enables you to draw shapes on the screen through the PEN subroutine. You move the flashing square, termed the *cursor*, anywhere on the top portion of the screen. Error messages appear in the bottom four lines of text. You can mark the current position of the cursor by pushing the space bar, which places a small cross on the screen and stores that point's location in an array. After marking a few points in this way, you can connect the points with lines by pushing another key and then move on to draw another figure. You can thus draw relatively complex figures simply by marking the vertices and using straight lines to connect them.

The first step the LINES program takes is to initialize all the variables (figure 3, page 405). This step includes loading a file from the disk that contains the PEN subroutine object code. The program then calls this subroutine to locate the light pen.

Listing 2: *The LINES program.*

```
]PR!#1
]LOAD LINES.REM
]LIOSTST

100  REM  *********************
110  REM
120  REM  PROGRAM TO DRAW
130  REM      WITH LIGHT-PEN
140  REM
150  REM  ********************
160  REM
170  PRINT  CHR$ (4);"BLOAD PEN2.
     OBJ0"
180 NMAX = 50
190  DIM PX(NMAX),PY(NMAX)
200  GOSUB 390: REM  INITIALIZE
210  GOSUB 610: REM  FIND PEN,  S
     ET X,Y
220 KEY =  PEEK (KB): REM  READ K
     EYBOARD
230  IF KEY < 128 GOTO 210
240  HOME
250 T =  PEEK (KS): REM  CLEAR ST
     ROBE
260  IF KEY = SPACE THEN  GOSUB 7
     10: GOTO 210
270 KEY = KEY - 192
280  IF KEY < 1 OR KEY > 17 THEN
      GOSUB 2060: GOTO 210
290  ON KEY GOSUB 2060,2060,1400,
     860,2060,2060,2060,1840,2060
     ,2060,2060,1240,2060,1600,20
     60,1090,1690
300 T =  PEEK (G): REM  GRAPHICS
     MODE
310  GOTO 210
320  REM
330  REM  *****************
340  REM
350  REM  INITIALIZE
360  REM
370  REM  ******************
380  REM
390 KB = 49152:KS = 49168
400 PEN = 768
410 HZ = PEN + 4:VERT = PEN + 3
420 CL = 3
430 SPACE = 160:G = 49232
440 N = 0
450  POKE HZ,20: POKE VERT,20
460  TEXT : HOME : NORMAL : SPEED=
     255
470  VTAB (12): PRINT  TAB( 7);"*
     **  WELCOME TO LINES  ***"
480  PRINT : PRINT  TAB( 10);"DO
     YOU WANT A MENU?";
490  GET Y$
500  IF Y$ = "Y" THEN  GOSUB 1840

510 T =  PEEK (KS)
520  HGR : HCOLOR= CL
530  RETURN
540  REM
550  REM  ******************
560  REM
570  REM   FIND PEN, SET X,Y
580  REM
590  REM  ******************
600  REM
610  CALL PEN
620 X = 7 *  PEEK (HZ):Y = 4 *  PEEK
     (VERT)
630  RETURN
640  REM
650  REM  ********************
660  REM
670  REM  "SPACE"--MARK POINT
680  REM
690  REM  ********************
700  REM
710  IF N < NMAX GOTO 750
720  GOSUB 2260
730  PRINT  TAB( 3);"TOO MANY POI
     NTS."
740  RETURN
750 N = N + 1
760 PX(N) = X:PY(N) = Y
770  GOSUB 2160: REM  DRAW CROSS
780  RETURN
790  REM
800  REM  ********************
810  REM
820  REM  "D"--DELETE POINT
830  REM
840  REM  ********************
850  REM
860 I = 1
870  IF PX(I) = X AND PY(I) = Y GOTO
     930
880 I = I + 1
890  IF I <  = N GOTO 870
900  GOSUB 2260
910  PRINT  TAB( 3);"NO POINT TO
     DELETE"
920  RETURN
930  IF I = N GOTO 970
940  FOR Z = I TO N - 1
950 PX(Z) = PX(Z + 1):PY(Z) = PY(
     Z + 1)
960  NEXT Z
970 N = N - 1
980  HCOLOR= 0
990  GOSUB 2160
1000  HCOLOR= CL
1010  RETURN
1020  REM
1030  REM  *********************
1040  REM
1050  REM  "P"--MAKE A POLYGON
1060  REM
1070  REM  *********************
1080  REM
1090  IF N >  = 3 GOTO 1130
1100  GOSUB 2260
1110  PRINT  TAB( 3);"NEED AT LEA
     ST 3 POINTS"
1120  RETURN
1130  HPLOT PX(N),PY(N) TO PX(1),
     PY(1)
1140  GOSUB 1240
1150 N = 0
1160  RETURN
1170  REM
1180  REM  ********************
1190  REM
1200  REM  "L"--DRAW LINES
1210  REM
1220  REM  ********************
1230  REM
1240  IF N >  = 2 GOTO 1280
1250  GOSUB 2260
1260  PRINT  TAB( 3);"NEED AT LEA
     ST 2 POINTS."
1270  RETURN
1280  FOR I = 1 TO N - 1
1290  HPLOT PX(I),PY(I) TO PX(I +
     1),PY(I + 1)
1300  NEXT I
1310 N = 0
1320  RETURN
1330  REM
1340  REM    ********************
1350  REM
1360  REM  "C"--CHANGE COLOR
1370  REM
1380  REM    ********************
1390  REM
1400  TEXT : HOME
1410  VTAB (3): PRINT "THE POSSIB
     LE COLORS ARE:"
1420  PRINT : PRINT "     0 = BLA
     CK"
1430  PRINT : PRINT "     1 = GRE
     EN"
1440  PRINT : PRINT "     2 = BLU
     E"
1450  PRINT : PRINT "     3 = WHI
     TE"
1460  PRINT : PRINT "     4 = BLA
     CK"
1470  PRINT : PRINT "     5 = YEL
     LOW"
1480  PRINT : PRINT "     6 = BLU
     E"
1490  PRINT : PRINT : INPUT "WHAT
     COLOR (0-6)? ";CL
1500  IF CL < 0 OR CL > 6 GOTO 14
     90
1510  HCOLOR= CL
1520  RETURN
1530  REM
1540  REM  ********************
1550  REM
1560  REM   "N"--NEW: CLEAR SCRN
1570  REM
1580  REM  ********************
1590  REM
1600 N = 0: HGR
1610  RETURN
1620  REM
1630  REM  ********************
1640  REM
1650  REM  "Q"--QUIT
1660  REM
1670  REM  ********************
1680  REM
1690  VTAB (23): PRINT "DO YOU WA
     NT TO SAVE THIS? "
1700  GET Y$
1710  IF Y$ <  > "Y" GOTO 1740
1720  INPUT "NAME OF FILE? ";Y$
1730  PRINT  CHR$ (4);"BSAVE ";Y$
     ;".PIC,A8192,L8192"
1740  TEXT : HOME : NORMAL
1750  POP
1760  END
1770  REM
1780  REM  ********************
1790  REM
1800  REM  "H"--HELP (MENU)
1810  REM
1820  REM  ********************
1830  REM
1840  TEXT : HOME : NORMAL
1850  PRINT : PRINT "HERE'S WHAT
     YOU CAN DO--"
1860  PRINT : PRINT : PRINT
1870  PRINT : PRINT  TAB( 2);"SPA
     CE--MARK CURRENT POINT"
1880  PRINT : PRINT  TAB( 6);"D--
     DELETE CURRENT POINT"
1890  PRINT : PRINT  TAB( 6);"P--
     CONNECT AS A POLYGON"
1900  PRINT : PRINT  TAB( 6);"L--
     CONNECT FIRST TO LAST POINTS
     "
1910  PRINT : PRINT  TAB( 6);"C--
     CHANGE COLOR"
1920  PRINT : PRINT  TAB( 6);"N--
     NEW:  CLEAR SCREEN"
1930  PRINT : PRINT  TAB( 6);"Q--
     QUIT"
1940  PRINT : PRINT  TAB( 6);"H--
     HELP!!!"
1950  PRINT : PRINT : PRINT  TAB(
     6);"PRESS ANY KEY TO CONTINU
     E..."
1960  GET Y$
1970 T =  PEEK (KS)
1980  RETURN
1990  REM
2000  REM  *********************
2010  REM
2020  REM  COMMAND ERROR
2030  REM
2040  REM  *********************
2050  REM
2060  GOSUB 2260
2070  PRINT  TAB( 3);"UNRECOGNIZE
     D COMMAND"
2080  RETURN
2090  REM
2100  REM   ********************
2110  REM
2120  REM  PLOT CROSS
2130  REM
2140  REM   ******************
2150  REM
2160  HPLOT X - 1,Y - 1 TO X + 1,
     Y + 1
2170  HPLOT X - 1,Y + 1 TO X + 1,
     Y - 1
2180  RETURN
2190  REM
2200  REM    ******************
2210  REM
2220  REM  ERROR MESSAGE
2230  REM
2240  REM  ********************
2250  REM
2260  VTAB (24): FLASH : PRINT "
     RROR!!!": NORMAL : RETURN
```

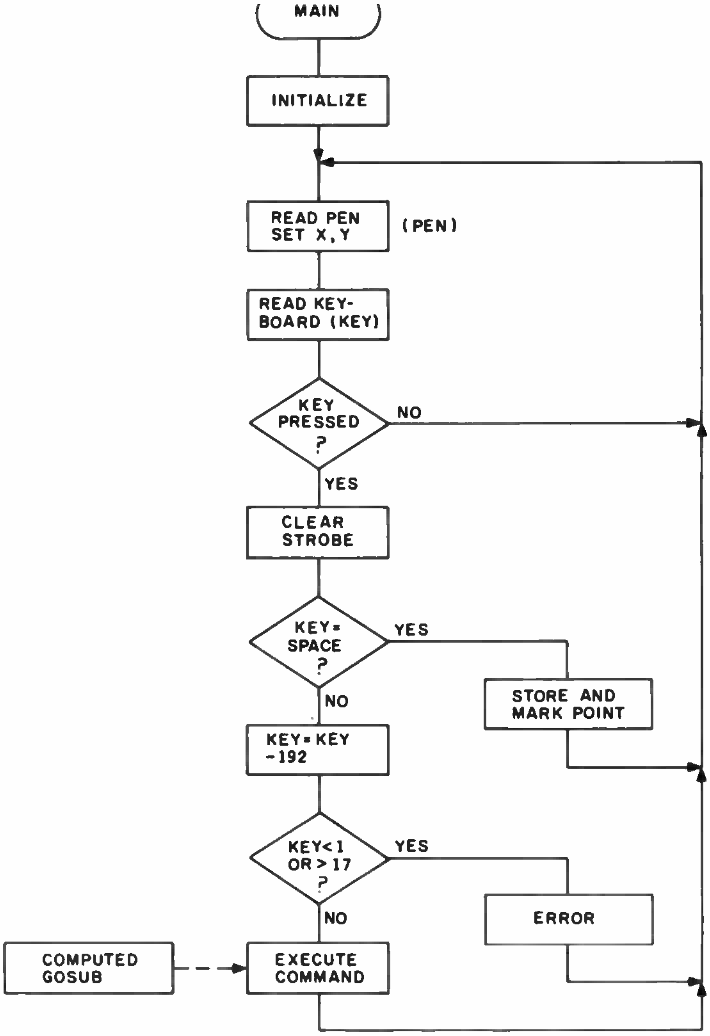

Figure 3: *Outlining the course of the LINES program, this flowchart lists the steps you take to use the light pen to draw figures on the screen.*

X,Y	—current position of the cursor
KEY	—value read from the keyboard
KB	—address of the keyboard
KS	—address of the keyboard strobe
T	—temporary ("dummy") use
PEN	—address of the PEN subroutine
N	—number of points marked thus far
NMAX	—maximum number of points possible
PX( ),PY( )	—arrays of X,Y coordinates marked thus far
I	—index counter used in loops
Z	—index counter used in loops.
Y$	—yes/no input variable
CL	—selected color
HZ	—address of horizontal coordinate parameter returned by PEN
VERT	—address of vertical coordinate parameter returned by PEN
SPACE	—value read from the keyboard if the space bar has been pressed (= 160)
G	—address of the soft switch to turn on the graphics mode

Table 2: *Variables for the LINES program.*

The LINES program plots in the high-res mode; the subroutine searches for the pen in the low-res mode. The value returned by PEN must, therefore, be scaled for the high-res screen. The horizontal position is thus multiplied by 7 and the vertical position by 4 in order to put these coordinates in the appropriate range to fit on the 280 by 160 dot high-res screen.

The program then reads the keyboard. If no key has been pressed, it goes to the top of the program to search again for the pen. If the space bar has been pushed, the program marks the point and saves the current pen position. If another key has been pressed, the program identifies it by first reducing the ASCII (American National Standard Code for Information Interchange) value to the 1-to-17 range. If it cannot recognize the function, an error message is printed and the program returns to the beginning.

Recognized functions are called through an ON. . .GOSUB statement. Then the appropriate command is executed via a subroutine. As a result, you can continuously move the cursor around the screen. Any command is immediately executed when you press the appropriate key. (See table 2 for an annotated variable list for the LINES program.)

The following list describes the valid commands and explains their operation.

- Space: mark and save the current point. Pushing the space bar marks the cursor's current position with a small cross and saves the coordinates of that point. The *x* and *y* coordinates are saved, in order, in separate arrays. You can subsequently scan these arrays to connect the points with lines. If you try to mark too many points, however, an error message is printed and the command is ignored. The maximum number, NMAX, is initialized in line 180.
- D: delete the current point. This command causes the cross at the cursor's current position to be erased and the point to be removed from the arrays. You can delete points from the screen in any order; the arrays will be adjusted accordingly. If you don't accurately position the cursor over a point, however, an error message is printed and the command is ignored.
- P: connect the currently marked points as a polygon. When this command is executed, the program connects the last point in the array to the first one. To connect the rest of the

points with lines, it then calls the subroutine for the L command. The array is then cleared (actually, the point counter, N, is set to zero), and you can begin defining a new figure. If you do not define at least three points, an error message is printed and the command is ignored.

- L: connect all of the points with lines. This command is the same as the P (Polygon) command except that the first point is not connected to the last one. It thus allows you to draw lines between points without making a closed figure. An error message is printed and the command is ignored, however, if you do not mark at least two points.
- C: change color. A menu of seven possible colors for subsequent lines is displayed with this command. It doesn't affect any of the old lines. The choice of colors is black, green, blue, white, black2, yellow, and blue2. These colors can appear different, depending on the adjustments made on your television set or monitor and the Apple's color-trim potentiometer.
- N: new, or clear the screen. Use this command to clear the screen to black and reset the number of elements in the arrays to zero. You can then start again without rerunning the program.
- Q: quit. An orderly exit from the program is implemented with this command. It also offers the option of saving the contents of the high-res display on the disk. The POP instruction in line 1750 of listing 2 is needed to clean up the stack because the return from the subroutine is otherwise never completed by the Q command.
- H: help, or print a menu. Press H to display a list of all the commands.

Conclusion

The light pen design presented in this article requires simple hardware and costs relatively little to implement because most of the processing is done in software rather than hardware. By limiting the search for the pen to a relatively small area, search time is kept short without much sacrifice in performance. The light pen provides a convenient, efficient method to input graphics information to the Apple II and thus complements the computer's excellent graphics display capabilities. ■

About the Author

David Lilja is a hardware design engineer for a computer manufacturer in Cupertino, CA.

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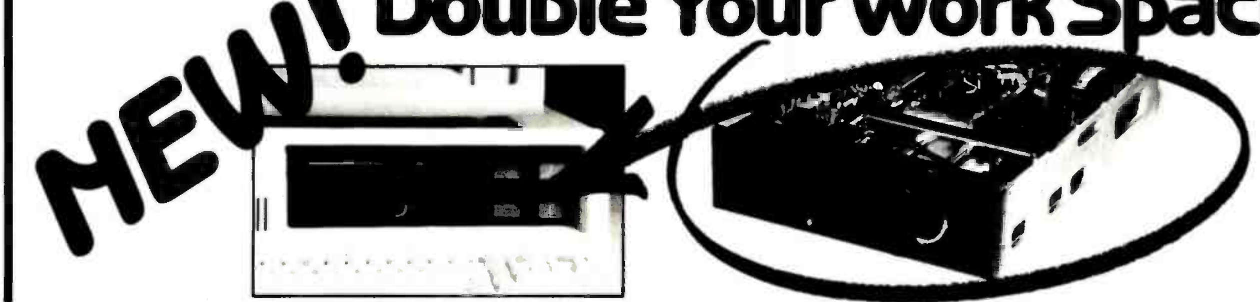

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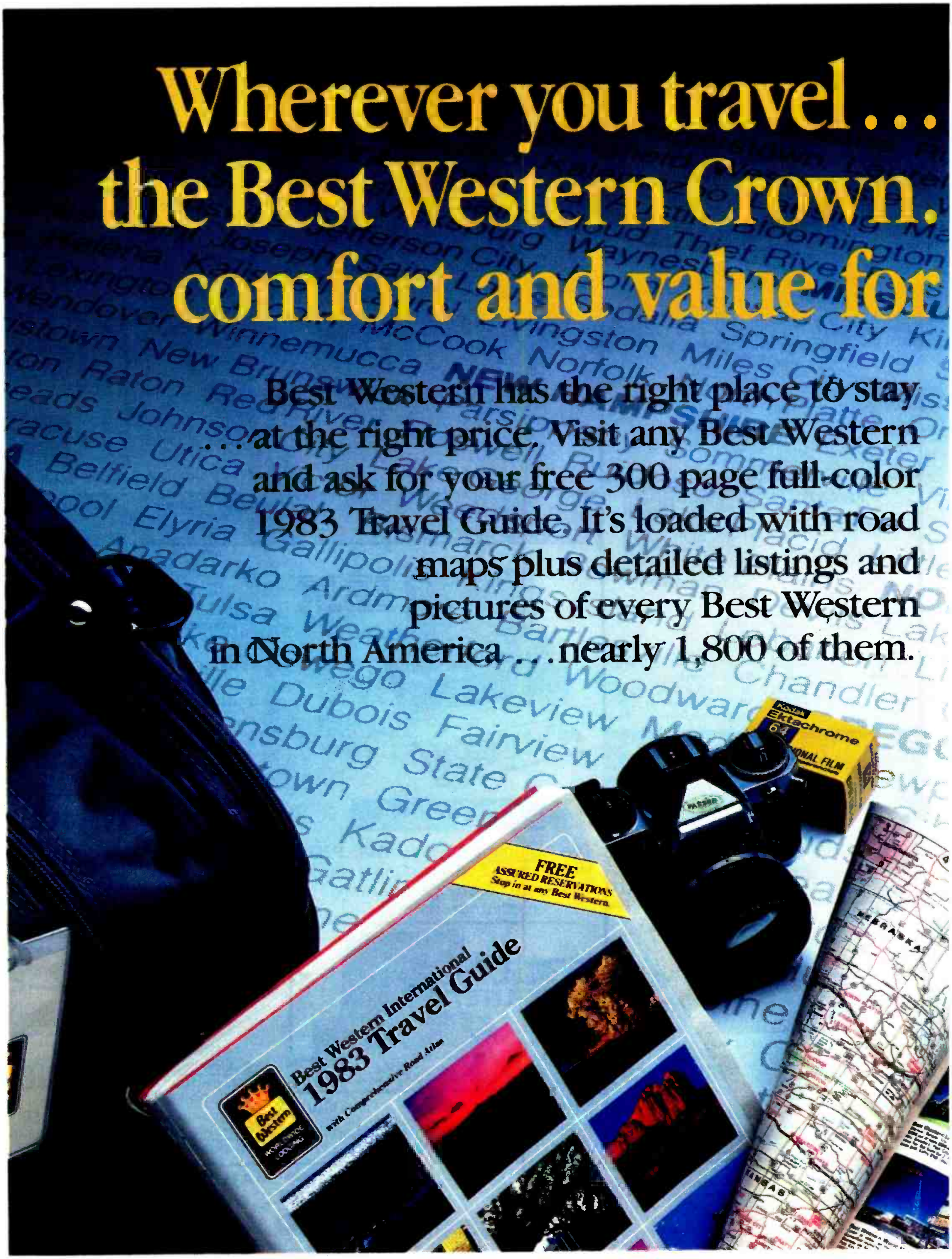

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Zenith Z-100, Epson QX-10, Software Licensing, and the Software Piracy Problem

Our intrepid columnist shoots from the hip and takes a little flak.

Jerry Pournelle
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The newest machine here at Chaos Manor is the Zenith Z-100. It's very colorful, so naturally it became known as Zorro.

The Z-100 has very nice features, and the best color graphics I've seen in a small machine. It's a dual-processor computer, with an 8-bit 8085 and a 16-bit 8088. In addition, there's a dedicated microprocessor chip that runs the elaborate keyboard. My system contains 128K bytes of memory, which is standard. There are sockets for more memory chips to bring it up to 192K bytes.

It's easy to add still more memory, because the Z-100 contains an IEEE-696 standard bus with five slots. This is better known as the S-100 bus. Thus you can add Zenith memory, or Compupro, or any other S-100 memory board you might have as long as it's bank selectable and can operate in a 5-MHz environment.

You can also add almost anything else you like. The Z-100 specification sheets specifically mention Compupro memory and I/O (input/output) boards, the Data Technology hard-disk controller, and the Tarbell disk controller as being compatible; they also say that just about any IEEE-696 board (except CPU [central processing unit] boards, of course) should work fine.

There's an awful lot of good stuff made for the S-100 bus, and it's nearly all available to the Z-100.

Because the Z-100 has both 8085 (8-bit) and 8088 (16-bit) CPUs, it's very flexible regarding software. The Z-100 uses ZDOS (the Zenith disk operating system), which is operationally identical to the IBM PC-DOS; most programs for the IBM Personal Computer will run just fine on the Z-100. For example, IBM's Pascal native-code compiler and 8086 assembler run just as they come from the box. The Z-100 will not run software that contains graphics written for the IBM PC or that makes use of the ROM (read-only memory) monitor in the IBM.

The other operating system for the Z-100 is CP/M-85, which is Zenith's name for standard CP/M-80 version 2.2. The result is that not only can the Z-100 run programs written for the IBM PC, but also most of the software written for 8-bit CP/M machines. Transfer of programs is no problem, either. The Z-100 comes with two built-in double-sided double-density 5¼-inch disk drives, but it also has a cable connector on the back for 8-inch disk drives. The nice part is that the Z-100 system expects the 8-inch disk drives to be jumpered as 0 and 1, meaning that I was able to plug my Compupro (Qume) disks from Zeke II (a Compupro Z80 computer) into the Z-100 and read disks as drives C and D immediately. I didn't have to change anything in either the Z-100 or in my Compupro disk drives. Just plug in the cable.

It won't read double-sided 8-inch disks unless I do something to the jumpers; but it reads single-sided double-density disks formatted by the Compupro Disk 1 controller just fine. That includes formats of 256, 512, and 1024 bytes/sector. I've just used PIP to copy XD.COM (an extended directory utility) from an 8-inch disk to Zorro's 5¼-inch disk, and it works. I was able to send over all kinds of stuff: a disk utility program called UNERASE, the program that checks for bad sectors (some outfits call it BADLIM), and SWEEP, which is a nifty utility that lets you go through a disk and copy, erase, rename, and otherwise muck about with the disk directory. All these programs, incidentally, are available from Workman and Associates for $32.50 a disk. Most are in the public domain.

The best news is that WRITE, my favorite text editor, works fine. I used the old version I had for the Z-19 terminal. Tony Pietsch had set things up to use the Z-19's special-function keys, and also to make the Z-19 numeric keypad into a block of cursor-control keys. That all works exactly as it should on the Z-100. I conclude that although the Z-100 makes use of memory-mapped video, it thinks it's talking to a Z-19 terminal when it's running under CP/M-80 2.2. If WRITE, with all its special calls and scrolling and cursor controls, will work without modification—and it does—then it's fair to conclude that anything configured for the Z-19 terminal will work. That's good news.

I've also been playing about with ZDOS, which is Zenith's work-alike for the IBM PC-DOS. It's a bit cumbersome; I think I'd prefer CP/M-86. That may just be a matter of getting used to MS-DOS, of course. (One might as well call it MS-DOS, meaning Microsoft disk operating system; PC-DOS and ZDOS are simply versions of MS-DOS set up for their particular machines.)

My Z-100 has some of the most spectacular color graphics I've ever seen. The screen consists of a field of 225 (vertical) by 640 (horizontal) individual pixels (dots), each of which can take on any one of eight colors. This high resolution compares favorably to the IBM PC's 640- by 200-dot high-resolution mode with white on black only. A character-set generator makes nicely formed letters that are very easy to read on the big monitor screen.

A demonstration disk comes with the Z-100. The disk has BASIC routines to make all kinds of pretty pictures. There are also programs to do scads of business graphics: pie charts, bar charts, wavy lines, etc., all in vivid color.

The only problem is that I have precious little applications software that runs under PC-DOS—and at the moment, the only language I have available (other than 8086 assembler, which I'm not ready to learn) is Zenith's version of Microsoft BASIC, ZBASIC. The color programs are all written in that. Microsoft has added a bunch of special commands, such as CIRCLE, LINE, and PAINT, to let you control the color.

I wanted to play with the color, and I didn't want to do any really serious work. Then I remembered that Epyx published the source code for Invasion Orion. This is a naval action game (well, it's supposed to take place in space, but it's rather two-dimensional, so that it's a lot like a wet navy battle). You have one fleet, and the computer has another, and the computer is a pretty good player. I liked that game on the Apple and the TRS-80; the only problem was that it was pretty slow. The Z-100 is a much faster machine, so that shouldn't be a problem. While I was at it, I modified the graphics to make use of the Z-100's color capabilities.

Alas, I never finished. I'd forgotten just how awful BASIC programs used to be. I've gotten used to CB-80, the CBASIC-II compiler, with its multiple line functions, and no line numbers, and local variables, and top-down structured code. After about three hours of trying to plow through a tangle of GOTO statements, and six or eight statements per line, and single-letter variables, I gave up.

I haven't given up completely, though; IBM Pascal works fine on the Z-100. Now all I have to do is figure out how to use the color graphics in something other than BASIC, and I can write my own space-war game. I have in mind The Moat Around Murcheson's Eye, in which the Moties are trying to escape. As the ships take more hits they change color, from red up the spectrum to violet (after which they explode).

Games, Games . . .

While I'm on the subject of games, I

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notice that whenever the boys play games on their Apple II, the games tend to be one or another by Epyx. They particularly like Rescue at Rigel, and they've nearly worn out the Dungeons of Aphsai. The Epyx games tend to be intellectual. Because I have terrible eye-hand coordination, I greatly prefer that kind to the arcade games (I always get killed in arcade games). I'm particularly partial to Crush, Crumble, and Chomp, in which I get to play my favorite movie monster rampaging through Washington and burning down the Pentagon.

We also play Zork, the super adventure developed by the Gang of Four Implementers at MIT. If you liked Adventure and wanted more after you solved the Colossal Cave, I guarantee you'll love Zork. The people who wrote it also bring you Deadline, a very popular and fun game of detective logic complete with documentary evidence; and Starcross. This latter is a Zork-like game of exploring a large alien starship. I'm not as fond of it as I am of Zork, but a number of science-fiction fans like it very much.

Meanwhile, Back to Zorro

I'm still testing the Z-100. There's a lot to like about it. For one thing, I really like the keyboard, which is a dead ringer for the IBM Selectric. It's completely sculpted, with the home keys formed in such a way that you can find them easily. The keyboard feels good, with just the right amount of tactual feedback. All the keys are there, including arrows, numeric keypad, and a row of 15 user-programmable special-function keys across the top. The only thing missing is that shifted comma and period make < and >, which is standard enough, but I'm spoiled by my Archive keyboard.

The keyboard is completely reprogrammable, though, and there are complete documents on what it does and how it does it. I can, if I like, change the period and comma so that they put out the same characters shifted as unshifted. If Zorro becomes the system master here, I'll probably do that.

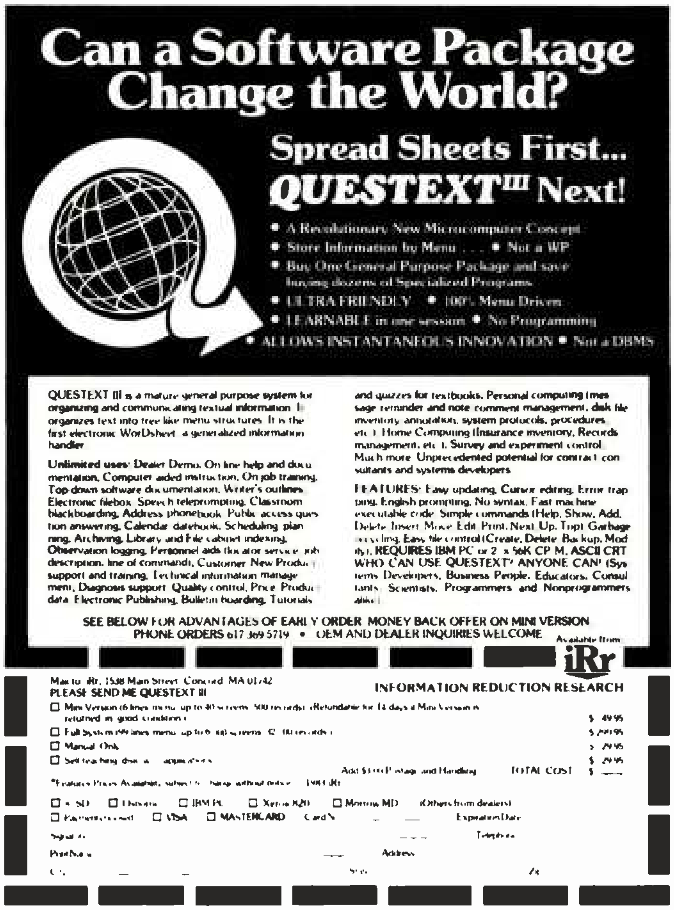
The Z-100 is professional-quality equipment. I once said the real problems with the IBM PC were its nonstandard bus and that awful keyboard. The Z-100 has fixed both those problems, and with its ability to run both CP/M-80 2.2 and MS-DOS, plus the spectacular color capability, it's going to be a strong contender for both business and development applications.

The machine has a couple of drawbacks. One, it's *big*. The keyboard, two disk drives, and the computer itself are all built into one box. (In some models, there's also a green screen built on top; that's *really* big.) In order to use the Z-100 properly, I'm going to have to build a special table that will get the keyboard low enough and have a place for the big 15-inch color monitor.

Most applications software available for the Z-100 is 8-bit stuff running under CP/M-80 2.2. That should change as more machines appear and people begin to take advantage of the 16-bit processor's capabilities. Meanwhile, there is an awful lot of CP/M-80 2.2 software. The Z-100 is a very good transition machine to go between 8-bit CP/M and 16-bit MS-DOS; and with the S-100 bus, it won't become obsolete for years.

A final problem is Zenith's documents. They range between good and excellent, but there are strange lacunae, and the indexes are just plain terrible. For example: the Z-100 has excellent tactile feel to the keyboard. There's no need for a keyclick, and certainly no need for the annoying squeak that Zenith has installed. Alas, the only index entry for "keyclick" refers you to the formal specifications for the machine, where it says, "Keyclick may be turned off." There's no hint as to *how* to turn it off.

I expect some of you are now wondering why I don't read through the entire set of documents, but if you could see them, you'd wonder no longer. The Zenith documents certainly *look* impressive: I have about five feet of them. They come in massive loose-leaf binders; two



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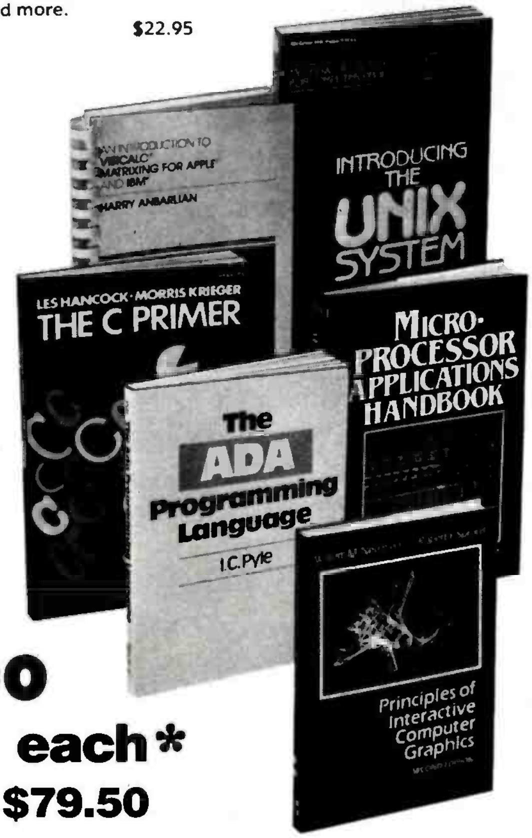

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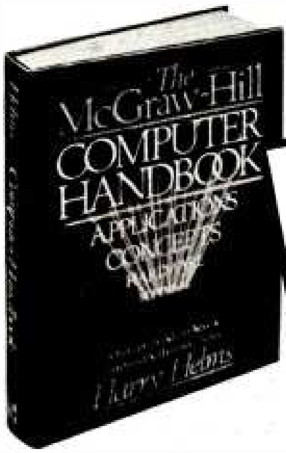

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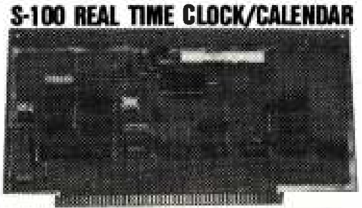

volumes for CP/M-85, two volumes for ZDOS, two for ZBASIC, and one user's manual for the machine. In addition, there are two enormous volumes of a service manual that Zenith was kind enough to send me (the technical manuals are not available now, although they will be by the time you read this).

The result is more than you can read; indeed, more than you can find room for. It just isn't practical to hunt through page after page of stuff, and the table of contents is informative only to those who know what they're looking for.

Example: when you load ZBASIC, the program automagically configures the 13 special-function keys. One becomes LOAD, another SAVE, another is GOSUB, etc. If you do PRINT CHR$(20) or type Control-T, a special twenty-fifth line on the screen lights up to show you what each function key does. However, once you've done that, it's not simple to turn *off* that twenty-fifth line, even if you want it for a program. You can write a program to put spaces on that line, but every time you clear the screen, there's that status line back again.

I searched through the ZBASIC index for some mention of the special-function keys. Nothing. Try user keys. Nothing. Now what? Eventually I stumbled across a command, KEY ON, and another, KEY OFF, that in fact turn on and off the status line; but unless you're reading alphabetically through every BASIC command, you're not likely to figure that one out.

There's other stuff like that. I strongly urge Zenith to get to work on its index and table of contents. The documentation is very clear, with lots of examples and good explanations; but the organization isn't optimum, and there's too much for anyone simply to read through. They need a better summary, and better indexes and tables of contents.

On the other hand, what Zenith has done, it has done well. Walt Bilofsky of the Software Toolworks told me he'd tried reading the IBM MS-DOS documents and eventually gave up. When he got the Zenith ZDOS documents, though, he read through the section on using macros and discovered he could use them after all.

Heath designs good machines (and offers the H-100, a Heathkit version of the Z-100 for $1000 less). It will be interesting to see whether Zenith knows how to market them.

Dots . . .

I never had a dot-matrix printer before. Now we have the Print-Mate 150 from Micro Peripherals Inc., which is a highly sophisticated printer that does graphics. It will even do a screen dump from the Z-100. It even substitutes gray shades for color. Otherwise, it prints exactly what you see.

The Print-Mate 150 has an impressive array of features, most of which I don't suppose I'll ever use. However, Mrs. Pournelle is getting interested, since someone told her there are programs that will cause the printer to produce musical scores. I don't have any such programs yet, but I'm looking, and tips would be appreciated. I don't write music myself, but I can see how this could make life a lot easier for a composer.

The Print-Mate 150 has a lot of other impressive features. It comes with a keypad to let you program it, and some pretty fair documents on setting it up. The print quality isn't bad, and it's very fast. For manuscripts I'll stick to my NEC Spinwriter, but the 150 is plenty good enough for listings and other stuff I want in a hurry, and it can do fancy graphics that letter-quality printers can't touch.

The Epson QX-10

I have a couple of good friends who believe in "synchronicity," which is a fancy way of saying that they don't believe there's such a thing as coincidence. If things happen together, there's a reason, and probably a lesson as well.

I don't have to believe that, but there are times when I wonder, as for instance a couple of weeks ago. Marvin Minsky, who cofounded the Massachusetts Institute of Technology's Artificial Intelligence Laboratory and

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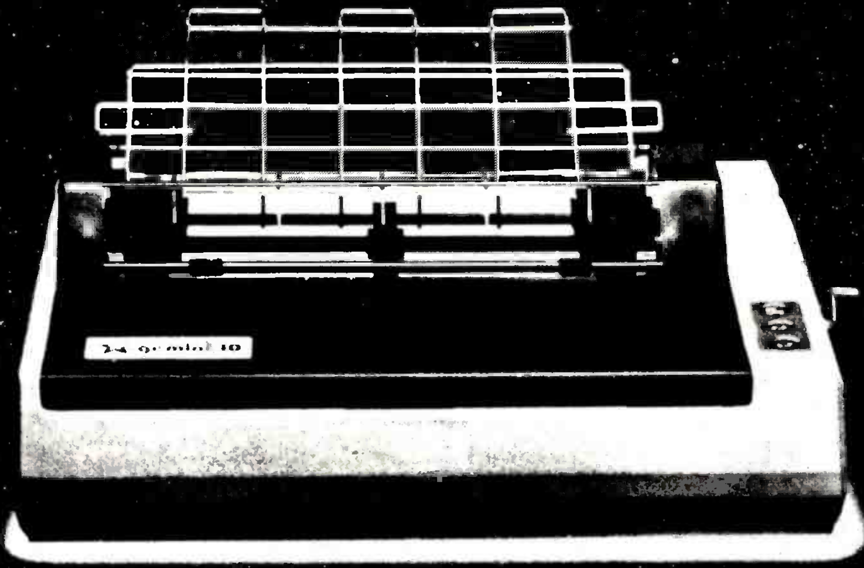

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invented the LISP machine, was in town, and we'd made a dinner appointment. Marvin finished his conference early and came directly here to Chaos Manor. There are always a lot of small computers here, and we discussed what he ought to get for a home computer.

"What do you think of this new Epson QX-10?" he asked. He then showed me the eight-page advertisement Epson had in the January BYTE. I hadn't seen it yet.

At that exact moment, the doorbell rang. It was Federal Express with three big boxes. Prominently on the outside was stenciled "Epson America."

Unfortunately for synchronicity, that's the best part of the story. What had arrived was a beta-test machine. We had no trouble getting it set up, but the software and manuals were sent from a different place, and I didn't get them until Marvin had gone back to Boston. The software and manuals that finally did arrive were incomplete—this is, after all, a system under development, and one reason they send these machines to people is to get their comments and reactions while there's still time to make changes.

The QX-10 is a very handsome and extremely well constructed single-board Z80 computer. Although the machine is single-board, there is a small (nonstandard; sigh) bus with five empty slots inside. I've no hint as to what Epson intends to put in there, but I'd bet a lot that by the time this is in print it will have a modem.

Physically this is an excellent machine. It comes with double-sided 5¼-inch thin drives, both parallel and serial ports, and a connector for a light pen. The computer itself is in one small box. There's a separate 9-inch (12-inch diagonal) green screen with a very pleasant character set, which, at the touch of a key, turns into italic and/or boldface right on the screen. That's impressive. There are also excellent monochrome graphics given the 640- by 400-dot resolution of the screen.

The detached keyboard is thin and sculpted, with a really nice key layout. That is, the layout is nice for those who intend to use the Epson for creating English text. Programmers might not care so much for it. It's missing a whack of a lot of keys—no tilde (~), no accent grave (`), no curly braces ({})—but it's said to be completely under software control, so that I presume it's possible to set it so that Control-Shift square bracket would be braces, and such like. To compensate for the missing keys, the Epson has one of my favorite features; the period and comma are doubled, so that you get them whether or not the key is shifted.

The QX-10 has a special pad of arrow keys placed conveniently between the Selectric-style letter keys and the number pad. There's also a row of special-function keys across the top. These latter have labels like Help, Index, Menu, Store, Retrieve, etc., all of which functions are tied into the Epson special software package, VALDOCS (short for valuable documents). Much of that works on

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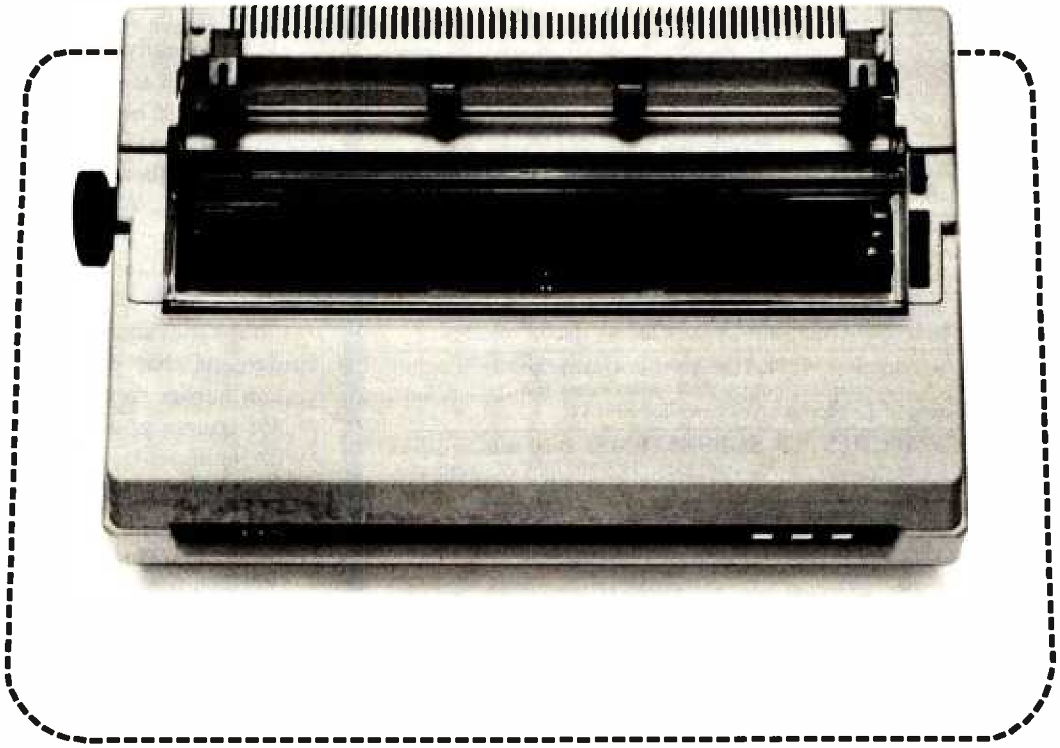

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this early version I have, but it wouldn't be fair to write any kind of evaluation until I have the production version.

There's no Escape key on the Epson. I suspect that one of the top row of special-function keys—probably Undo—makes the Escape character, but I don't know this, because I don't yet have the documents. The operating system that came with the Epson is TPM-II, which is a lot like CP/M, but not quite; unlike CP/M, TPM-II doesn't display control and other strange characters when in monitor mode. I could write a program that would do that, but this seems pointless because Epson promises complete technical documents for the machine.

I can't do a complete evaluation, but I am sufficiently impressed with the Epson to say this: before you buy an 8-bit small computer, be sure to look at the Epson QX-10. If its software ever gets done—it has been a while since it was announced—and it's anywhere near as good as the hardware, this machine could be a real contender.

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The Love Affair Continues

I've had a Modula-2 compiler for more than a month now, and I'm still in love. I'll make a flat prediction: this language is going to be one of the most important of this century. It compiles tight, efficient code, code as compact as the C programming language, and was designed to be used for operating systems; but it's as easy to read and understand as Pascal.

At the moment I still don't have Modula-2 running on anything but the Sage 68000-based computer with the UCSD p-System (Pascal) operating system. That's been no problem, since the Sage remains a joy to use. I received a software update package that removes several minor annoyances, and I'm finally getting used to the UCSD p-System. The Sage with Modula-2 is a formidable combination for a development system. Compilations are very fast.

What's really exciting is Modula-2 itself, which is everything we hoped Pascal would be. I can't say Modula-2 doesn't have faults. I would have done a number of things differently than Niklaus Wirth. For example, in Modula-2 *every* loop is terminated by an END statement. This means WHILE loops and FOR loops as well as loops that start with BEGIN. In my judgment that makes the programs much harder to read.

Of course you can always fix that with comments, and I do. That is, when I write a Modula-2 program, I tend to do

```
WHILE n < N DO
  FOR I :=1 TO 5 DO
    WriteString ("Foo")
  END (* NEXT I *);
  WriteString("fiddle");
  DEC(N);
END (* WEND *);
```

I think it is clearer if the FOR loop ends with NEXT, and the WHILE ends with WEND. Note the statement DEC(N), which decrements; there is a corresponding INC that will incre-

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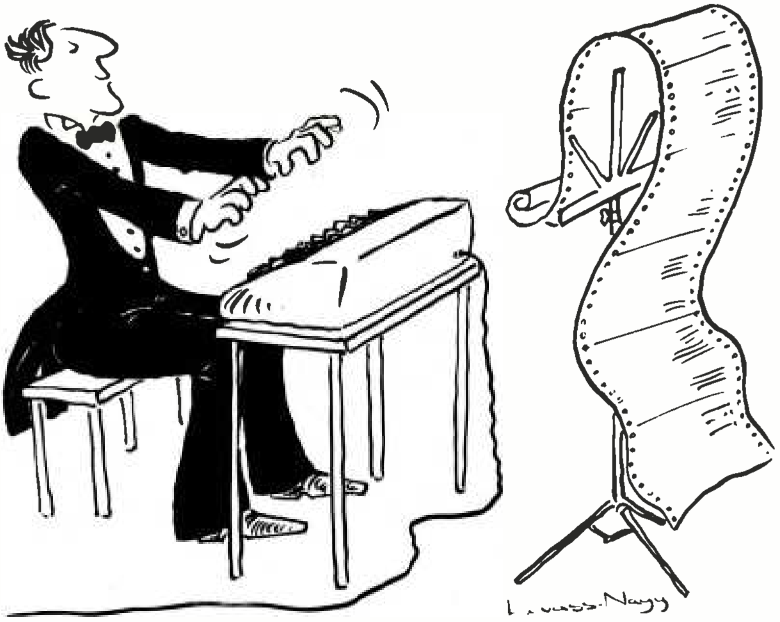

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ment a variable by 1. (You can also do INC(x,n), which will produce the result x := x + n.) These are *standard procedures* that come with Modula-2.

Despite my quibbles, though, I have not seen a language I was more instantly attracted to than Modula-2. The only thing stopping it is getting implementations on enough machines. I would dearly love to have Modula-2 for the Z-100, with those magnificent color graphics. I'd like it for CP/M-86 and my big Compupro. What will really be interesting, though, is if Modula-2 catches on and they begin to write operating systems in it for, say, the 16032 systems that ought to be running on the S-100 bus in the next year or so. That could really produce a revolution.

Again, the Piracy Problem

First a small apology. In the April column I reviewed a database-management program called Superfile from FYI Inc. There were a number of things to like about the program, as well as a few I thought needed improvement. As a courtesy, I sent a copy of my text to FYI.

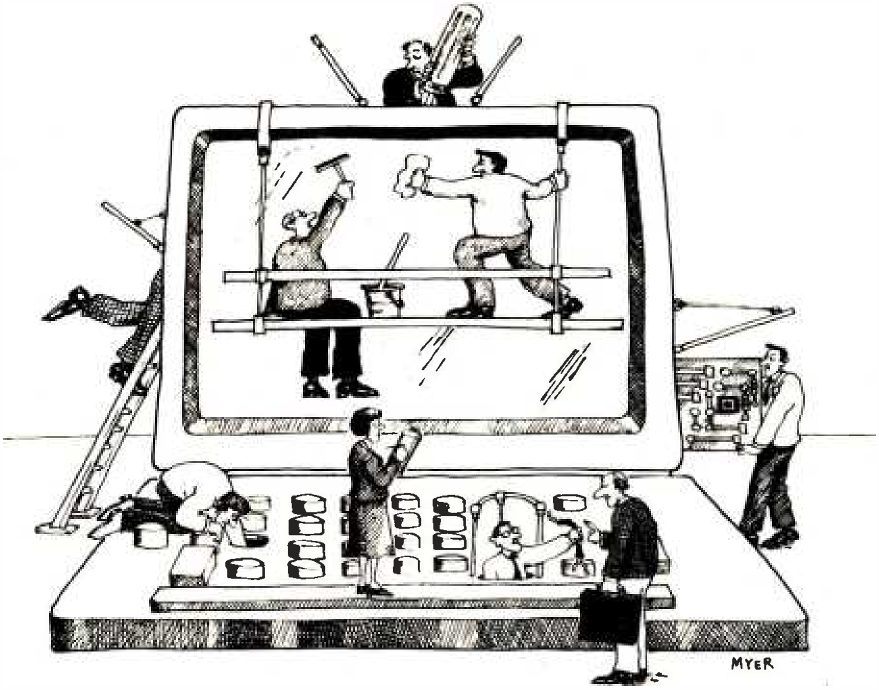
In addition to my comments on Superfile itself, I used the review as a jump-off point for a complaint about user-threatening licensing agreements. This wasn't unfair; FYI's agreement really is bad. On the other hand, it's no worse than a lot of others, including agreement forms used by some of the biggest software publishers around.

I wish software publishers would change their licensing agreements, because I hate 90 percent of the agreements I've seen.

Back came a letter from FYI. It didn't much care for the review, but since FYI didn't show where I was wrong, or tell me something I hadn't known (other than to quote some people who really liked the program, and heck, I'd said I like it myself), there seemed nothing to respond to, except one sentence: was it fair for me to condemn it for its licensing agreement, which was no worse than a lot of others?

I thought about that, and had just about concluded FYI was right, when the phone rang—a call from its lawyer. He, too, asked the same question, also in a reasonable manner. Okay, I thought. Maybe I should do something. Alas, he couldn't let well enough alone. There came a letter, on expensive legal stationery, from the lawyer, which began, "At the request of our clients we have been asked to review portions of your proposed column scheduled for publication — —"

I've been a journalist for some years, and I know a lot of other journalists, and we all seem to share one trait: if there's anything that will make a journalist see red, it's hinting at censorship. I may be a bit more irrational than some of my colleagues in what I see as a hint; but I do not at all care for lawyers informing me that



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they are reviewing what I have written. I particularly don't like it when they're doing it prior to publication. Thus my immediate reaction was an explosion heard throughout much of Hollywood.

My own lawyer friends tell me that the letter I received wasn't a threat or even a hint, and that lawyers talk that way to impress their clients. I wouldn't know, but I have calmed down, although it took me past last month's deadline.

So much for the explanation. Now for the apology.

Superfile is a decent program, as I said in the April review. It needs some improvements, but it is certainly a useful addition to our software library and will probably be used here. Although the documents led me to expect that it did things in a manner rather different from what it really does, it wasn't hard to learn to use it.

Moreover, FYI is to be commended: unlike most software publishers, FYI will let you use Superfile for 30 days, and if you don't like it, it will give you your money back. This isn't a unique policy, but it's both commendable and rare, and I should have made a point of saying so.

Finally, FYI has a particularly lousy licensing agreement. It's nearly impossible to read, it's full of legalese terms, and it's printed in blue ink in tiny letters. I really did have to use the magnifying glass from my transistorized *Oxford English Dictionary* in order to read it. For all that, it is not the worst licensing agreement I've ever seen, and the company's policy of giving your money back makes up for a lot.

I wish FYI would change its licensing agreement, but then I hate 90 percent of the agreements I've seen.

So What Should Agreements Look Like?

Mr. James Gallion, President of Engineering Technologies in North Carolina, asks a reasonable question: What kind of agreement is acceptable? He says, "Our licensing agreement is attached; unfortunately, it contains much of the Levitical documentation and fine print you would like to eliminate. I would like to eliminate it, too, but . . ."

He continues, "Bear in mind your license agreement covers an easily copied program selling for a hundred dollars or more, and your agreement must

> *Protect the supplier against outright piracy of the program for resale and profit.*
>
> *Protect the supplier against the "generous fellow" who runs copies for his mother, brother, and user's group.*
>
> *Protect against the unqualified user who misuses the program and loses thousands of dollars' worth of time and information.*
>
> *Apply equally for a one-person garage operation or a thousand-person corporation.*
>
> *Stand up in a court of law.*

Copyright law has some features, including "public interest" provisions, that may surprise you.

That's a reasonable statement of the publisher's wants. Unlike most publishers, Mr. Gallion goes on to look at the publisher's obligations:

> *The software supplier has an obligation to provide bug-free programs, and to provide updates and corrections automatically to all his program users. We adhere to this and it is a part of our licensing agreement. But we also recognize that* the user holds all the cards *when he has our program—he can easily make copies for money, or for his friends; or he can just as easily sue us when the program gives him bad information from his bad input. The license agreement is our only protection.*

That is an excellent statement of the problem; and I presume that most ethical software publishers would agree with it. What, then, shall we do?

First, I will never agree with the FYI approach, which is to fill a sheet of paper with legalese. I'm not very happy with the approach used by Digital Research Inc., which puts out documents with a copyright notice, then adds at the bottom of each page: "All Information Presented Herein Is Proprietary to Digital Research"; but at least DRI puts its agreement in legible print.

The DRI agreement in essence says that if you sell or give away this program you're in trouble, and you know that. It also tries to restrict the user to "a single computer"; if you're going to use its software on more than one machine, you're supposed to buy more than one copy.

Finally, DRI isn't obligated to do much. If it thinks you got a defective disk, it might replace it; and if it makes updates or fixes bugs, it will probably tell you how you can get your revisions. Otherwise, DRI is not liable for anything at all, and the company doesn't warrant that its product is useful, merchantable, or good for anything, unless state law forbids that kind of language, in which case DRI still doesn't claim its product is good for anything, and the most it will do is give you your money back.

You agree that you haven't bought "consumer goods," and that what you have isn't warranted.

It doesn't look like you get much for your money, does it? Here you're going to shell out a couple of hundred dollars, and in return you get the right to use a program on a single computer; if your computer dies, you should, strictly speaking, turn in your software, pay a transfer fee, and get a new license.

And that's silly. I doubt that has ever been done in the history of the microcomputer. No one does it, and no one expects it to be done.

Next, DRI seems a bit confused as to what's a trade secret, what's proprietary information, and what's protected by copyright. As a writer and officer of writers' associations, I've had to become reasonably familiar with copyright law. Writers' associations get involved in lobbying for copyright law changes. Sometimes we work with publishers. Sometimes we don't, because the interests of writers and publishers don't always coincide.

Copyright law has some interesting features. If you rely on copyright to protect your software, you can't possibly enforce the provision about

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not transferring a program from one computer to another. Not only is it legal for you to lend copyrighted material to your friends, but the law requires authors to support public institutions whose business is to lend out their books. I refer, of course, to public libraries.

There are also copyright law provisions dealing with "fair use," use by the blind and handicapped, and use by nonprofit educational institutions and public radio and television: in a word, there are "public interest" exceptions to the authors' and publishers' rights. Not all authors like all those exceptions; but they are part of the law.

Under copyright law, you cannot sell or give away *copies* of copyrighted material without permission of the copyright owner. Thus, if we stayed with *copyright* law, a fair interpretation might be that you couldn't run a program on more than one computer *at the same time*, and if you wanted to lend, sell, or give away a program, you'd have to fork over the original copy.

This seems pretty fair to me. After all, I don't expect the FBI to go close down used book stores and libraries, even though both theoretically cost me money. If you lend my book to your friends, that's legal; if you make a copy for your mother, that isn't. In practice I'm not likely to do much about that, but if you make 100 copies and start selling them, my publisher and I are likely to cry "Foul!" and run to the police.

If we can agree that's what we mean, somebody ought to be able to put that into legal language that would stand up. I shouldn't think it would take more than a few sentences, and there needn't be a "whereas" or "witnesseth" anywhere in them.

Now for the other side of the question: the obligations of the publisher.

First, I sure don't see why publishers shouldn't have to replace defective media. In order to cut down on returns, Barry Workman distributes all his software on Dysan disks. It costs more to begin with, but saves in the long run, or so he says. Even so, once in a while he'll get a disk returned as unreadable. He replaces it. Why shouldn't he? If I buy a defective tape recorder by mail, I'm entitled to a replacement or my money back, and the electronics places I deal with don't argue. They even pay to have UPS come pick up my defective equipment.

Why should software publishers escape from the consumer protection laws? Why are they so bloody special?

On the other hand, if I buy a telephone from JS&A and use it to make threatening and obscene phone calls, JS&A isn't responsible and shouldn't be. I'll go further: if I buy a phone, expecting it to work, and when it doesn't I find I've missed an important call to my broker so that I've lost a lot of money, I can't see why JS&A should be liable. It's my own silly fault for not being more prudent.

Thus I can agree with publishers stating in big letters that they're not liable for secondary, incidental, in-

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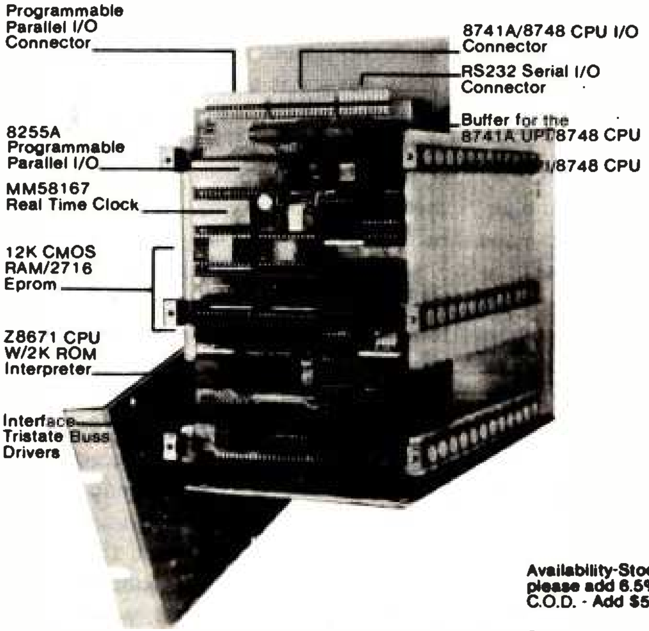

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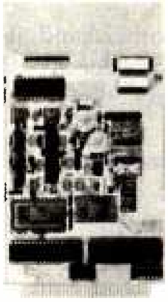

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direct, special, or consequential damages. You buy and use this at your own risk; if it doesn't do what you thought it would do, so that you lose all the time you've invested in keying in data, you've a right to tell the world that the software's no good, but I doubt you've much ethical standing to sue the publisher. Certainly you don't if you've been warned.

On the other hand, if the program's useless, or doesn't do what the manual says it will, why should the buyer be stuck for the price? Yet DRI's "agreement" says that it cannot be altered by advertising, meaning, presumably, that DRI could take out an ad promising that its software would find you gold and silver, and when it didn't, it wouldn't have to refund your money.

And yes, I know Digital Research wouldn't do that. Indeed, I'm using DRI as my example here precisely because they are good guys. I know for a fact that DRI spends a lot of time and money keeping its customers happy even when the customer makes quite unreasonable demands. Thus I wouldn't want anyone to think I dislike Digital Research or that I'm trying to lose it customers.

And yet, here's this agreement that says that if I buy a CB-80 compiler for Ezekial and later update to another computer, I'm in violation of the agreement and should destroy all copies of my software. Here's another, which says on the one hand that it's copyrighted software, and thus supposed to be published and made public (under the restrictions of the copyright law), while at the bottom of every page is the silly notation that everything in the book is proprietary. Yet I doubt anyone has brought suit against Rodnay Zaks or Thom Hogan for publishing books on how to use CP/M, even though their books are just *crammed* with that "proprietary" information.

When I carefully read my licensing agreement, I find that I'm supposed to put the serial number and copyright notice on all my work disks. I presume that's every darned one that has CP/M on it. Of course many work disks have a *lot* of copyrighted programs, from many different publishers, on them; after all, I can keep 1.2 megabytes on each floppy. There isn't *room* for all those copyright notices and serial numbers! And where, oh where, am I to put them on my *hard* disk?

Come on, fellows. No one expects those agreements to be kept, just as no one believes all that information is "proprietary," or that the customers will act as if it were.

I've seen no evidence to show that Levitical agreements—full of "Thou Shalt Nots"—have any effect on piracy.

In fact, that's my point. In *practice*, many companies tend to act about the way I think they should. They refund people's money, they provide support, they don't get unduly excited when Aunt Minnie snaffles up a copy on the sly, and they fix bugs. Why, then, do they insist on making their customers sign "agreements" that the customer has no intention of keeping, and which the company *knows* won't be kept? Is it to give work to lawyers, is it pure inertia, or are we in the computer business sailing under a curse?

Must we continue making hypocrites out of both publishers and customers?

They Don't All Do It, You Know

Although most publishers, including big ones like Microsoft and Digital Research, have legalistic licensing agreements, not all do. Walt Bilofsky's Software Toolworks places a copyright notice on its products, and reminds people in simple English that it tries to deal fairly with its customers, and "if you agree that we are dealing fairly with you, I hope you will be fair to us by respecting our copyrights on our material and not making copies for others."

I had much the same problem. When I began this column, I mentioned some programs I had written. There was an instant flood of mail requesting them. I'm not in the publishing business, nor can I afford the time or the money to give away hundreds of copies of programs.

Eventually I solved the problem by asking Barry Workman to handle it. My agreement with Barry is simple. "If you get rich off these, I want something." So far he hasn't. Meanwhile, we had to face the problem of licensing agreements. We solved it by not having any. Like Software Toolworks, Workman and Associates prints a disclaimer of liability. Then there's a copyright notice. Workman invites customers to make as many backup copies as might be needed, and reminds them that they're not supposed to use more than one copy at a time. Workman also points out that distribution of copies by loan, sale, or gift is a violation of federal law.

Bilofsky and Workman are still in business. Indeed, some of Workman's customers are so conscientious that they buy multiple copies of his *public-domain* utilities, even though they know they're ethically and legally entitled to give away copies. "I know that," one customer said in a letter. "But I want to encourage you to keep collecting the best utilities possible." Walt Bilofsky has had similar experiences.

On the other hand, we all *know* there's piracy and theft going on in microcomputerland. (As I use the terms, piracy is selling someone else's property on a large scale. Giving away copies of copyrighted programs is theft. Selling one or two is petty theft.) We *know* that it costs publishers money.

We don't know what the real effect is. How many stolen copies represent lost sales, and how many went to someone who wouldn't, or couldn't, have bought it anyway?

The question is complex. For example: suppose you have a program that you sell for $200. Suppose you know that for every program you sell, one is stolen. Suppose further that you are absolutely certain that if you dropped the price to $100, you would sell precisely *twice* as many programs and there'd be no theft at all.

Query: would you cut the price?

You probably wouldn't. You'd have twice as many legal customers.

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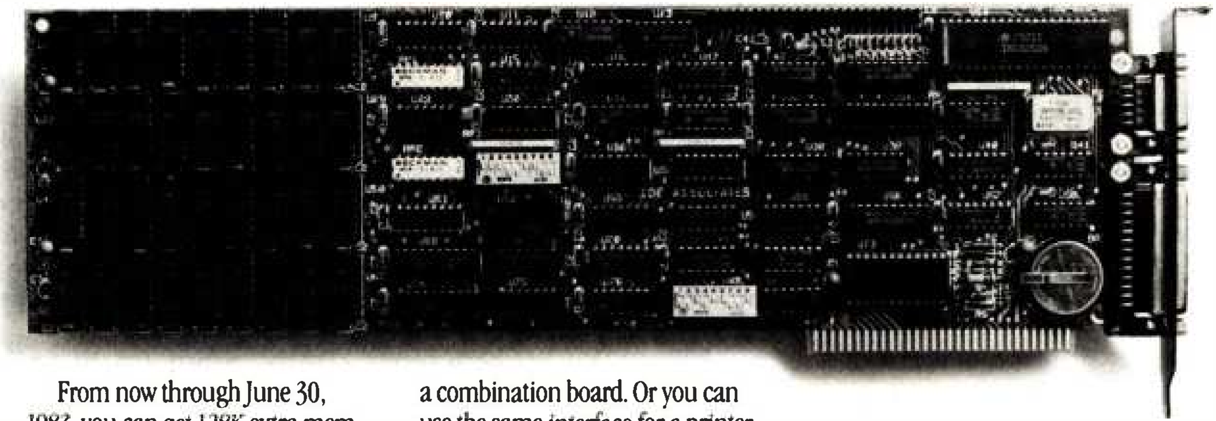

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I've seen no evidence to show that what my mad friend, Dan MacLean, used to call Levitical agreements—full of "Thou Shalt Nots"—have any effect on piracy. The evidence may exist, mind you; I just haven't seen any. It may be that people rip off Walt Bilofsky more than they do Digital Research, but I'd have to see it proved.

The bottom line, I think, is that we need to give a lot more thought to the whole problem. I can well understand software publishers' desire to keep software prices high. As a user, though, I've no desire to help them do it. I certainly won't concede their ethical right to discourage competition, nor will I cooperate in goofy schemes designed to protect publishers' rights to sell worthless junk and not refund the buyer's money.

There must be a fair way to "promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries"—which is the *only* Constitutional authority for granting monopolies through copyright or patent. The one thing I'm certain of, though, is that it does no good to encourage disrespect for the law by having people sign agreements no one believes they'll keep.

Snapshot

One thing that used to really enrage my mad friend was "uncopyable" software. He could concede that it made sense for games to be copy protected, but anything *useful* should be backed up. It's a sentiment I thoroughly agree with, and except for games I generally won't review software that has been copy protected.

However, for every ingenious copy protection scheme, there's an even more ingenious way to defeat it. It's probably impossible to make a disk thoroughly uncopyable, although some publishers have come pretty close.

CP/M doesn't lend itself to copy protection. In fact, you can't even lock up BASIC programs; most experienced programmers know how to unlock execute-only BASIC programs so that you can get at their sources. CP/M users thus haven't been too worried about copy protection.

Apple users, though, have always had the problem. So have those who used TRS-DOS, and I understand that MS-DOS has copy protection features. There are a number of copy protection schemes. All involve mislabeling a disk sector. All of them I know of have the side effect of making the program a bit more fragile.

For every copy protection scheme there's a hacker ready to defeat it. Most involve so-called "nybble" copiers, which try to analyze the original disk and then make a copy. This has driven the protectors to even greater lengths, causing them to put garbage in carefully chosen places on their original disk. The result is to make the program even more fragile,

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as well as to make it harder to analyze the protection scheme.

I'm not sure who's ahead just now, protectors or unlockers. It doesn't really matter, because there's another and better approach to making copies.

Snapshot doesn't bother analyzing the disk. Instead, Snapshot is a *hardware* addition to the Apple II; through Snapshot you can interrupt the program and write out an exact copy of memory to disk. If you later load that image back to memory, the program has no way of knowing that it was ever interrupted. Thus Snapshot is a kind of ultimate "unlock" system.

It can't copy everything, of course. Programs that have to access the disk for information can't be copied that way, since Snapshot can get only what's currently in memory. On the other hand, often the data files *can* be copied, so that Snapshot plus transferring data files will do the job.

Snapshot is easy to install and simple to document. We don't use it much, because nearly all our Apple programs are games, and I don't make backup copies of games. It does work, though, and there's a fallout benefit, since some games don't have a way for you to stop and save the game while you go have dinner. Snapshot makes that a cinch.

Snapshot requires an Apple II or II Plus with 48K bytes, one disk drive, and a 16K-byte memory card or language card. It is also said to work with the Franklin Ace computer. It's easy to install: a 16-year-old did ours from the Snapshot instructions.

Softlock

Another truly horrible scheme that has surfaced recently is Softlock. This is a system for rendering software more or less useless until you enter a secret password.

The idea is that you go to the software store and look over the programs. You select a program that costs, say $250, but you pay only $49.95. You take the program home and play with it. It runs, but some crucial aspect of the program won't work. If it's a database, it won't access more than five records. Something like that.

You send in your licensing agreement and the balance of the money, and when that's been received, you get the secret password that will "unlock" the program.

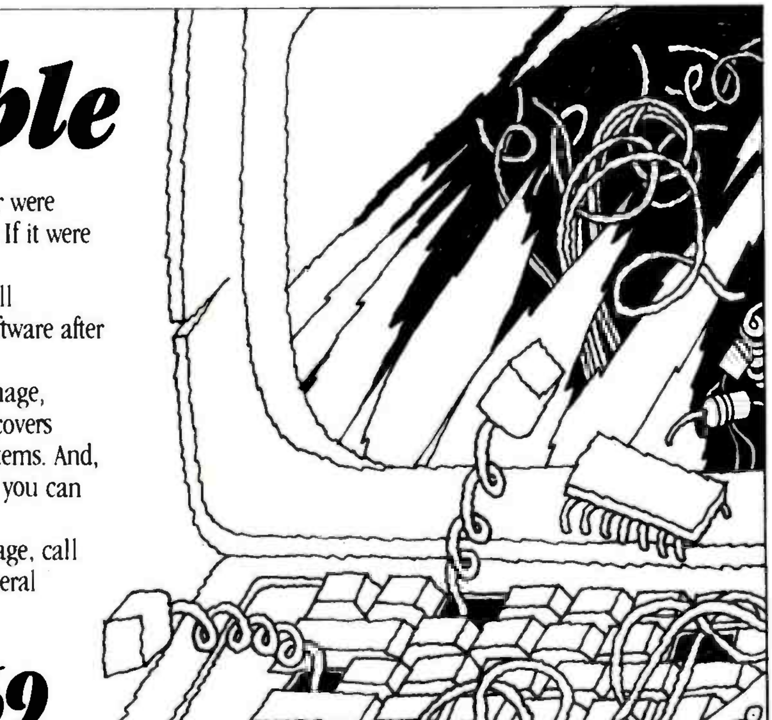
So far, so good; but what if you don't like the software? Suppose you've tried it and found it wanting?

Ah, well, you're out $49.95.

You're supposed to be grateful. After all, you could have been stuck for $250 before finding out that you don't like the program.

The big advantage of this scheme is that dealers like it. The Softlock people have set it up so that the dealer's inventory cost is based on the $49.95, rather than the full $250 nominal value of the program; but when the dealer makes the sale, he gets the full $250, less what Softlock takes for providing its service.

People who publish their software through outfits using Softlock tell me that dealers love this scheme, but "there's been considerable customer resistance." I'd hope to kiss a duck



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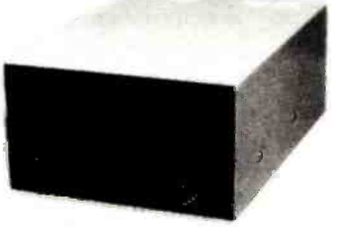

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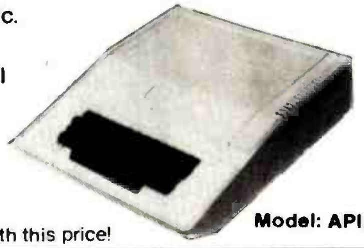

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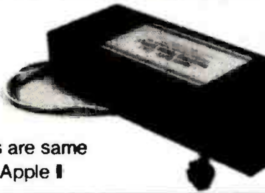

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there'd be resistance. I hope the resistance looks like a boycott. I guarantee I'll never buy a program protected that way. Anyone else want to take the pledge?

Nice Mice

One feature of Apple's new Lisa computer is a "mouse," a hand-held cursor controller. I'm pleased to say there is a mouse for the IBM Personal Computer. It is supposed to work with the IBM-compatible Zenith Z-100.

In fact, our mouse would work with just about any computer that has an RS-232C serial port; it's just that I don't have software for any machine other than the IBM PC.

The M-1 Optical Mouse from Mouse Systems Corporation is a pleasant-sized hand-fitting object with three buttons on it. Pressing a button from one to three times lets you use each button like three function keys. My friend Marvin Minsky tells me there's great controversy in the artificial intelligence community over how many buttons a mouse ought to have.

This mouse sits on a specially scribed metal board. The board is thin and will sit on any table. The mouse has to be on this board, because it sees the myriad of lines on the board. When you move the mouse about, it knows how many lines it has crossed, and at what angle, and therefore is able to tell this to the computer. Proper software will make the computer cursor do whatever you have done with the mouse and the buttons act like function keys.

At MIT I have seen programs that use a mouse to "paint" the screen, not only with colors, but with strange patterns. You move the cursor to a set of "brush sizes," put the cursor over the size you want, and hit a mouse button. The cursor is now that size. Take the "brush" and move it to a "pot of paint," i.e., a pattern at the edge of the screen, and push the button again. Now, move the mouse about the screen; push a button to leave "paint" on the screen, let go to "lift the brush." You can paint rather nice pictures that way.

I haven't seen any programs like that for microcomputers, but I'm sure it's only a question of time. If you like playing about with computers, you'll probably like having a mouse. I've noticed that almost all MIT hackers become addicted.

New Kaypro II Software

The Kaypro II continues to improve. It now has the Perfect line of software. I certainly would prefer Perfect Writer to Select, which used to come with the Kaypro. There's also the speller, filer, and calculator from the Perfect line, plus another spreadsheet that has always come with the Kaypro. If all that isn't enough, you also get my favorite spelling checker, Wayne Holder's The Word Plus.

There's even more. You also get Microsoft BASIC with the Kaypro as well as S-BASIC, and the S-BASIC manual has been rewritten.

That's just as well. If I had to give an award for the most unreadable computer document I've ever seen, the original S-BASIC manual would win hands down. The new one has been worked over by Kaypro and is a great deal more sensible.

S-BASIC itself is quite nice. It's a structured and compiled BASIC that rivals CB-80. I'm more familiar with CB-80 than S-BASIC, but all my experiences with S-BASIC have been relatively pleasant. I suspect that those who buy the Kaypro machine will begin by using Microsoft MBASIC, then start translating their programs into S-BASIC and learn more about structured programming.

Meanwhile, our Kaypro II has been out on loan to a collaborator, Dr. Alan Trimpi. He's been using it mostly as a word processor, and he loves it. All other reports I've heard from Kaypro users have been positive, too, except for that awful squeaky keyclick that is even worse than the Z-100's. Fortunately, it can be turned off.

The Kaypro II is a very good machine for those somewhat familiar with computers, and the company keeps upgrading the documents that

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come with it. If you don't need true portability – the Kaypro II can be carried on an airplane, for I've done it, but it's pretty big and painfully heavy – then you ought to look at the Kaypro line. That's a *very* impressive list of software that comes with the machine; the list prices add up to more than the $1795 charged for the Kaypro. Incidentally, by the time this is in print there will also be the Kaypro 10, which will have a 10-megabyte hard disk and sell for less than $3000. That sounds like an excellent package.

Magic Keyboard

Regular readers of this column know that I've no love for the IBM PC's crazy European keyboard with its extra key between the "Z" and the Shift key, and the nearly unreachable Return key. I sympathize with the Europeans, who must have keys to make letters we don't have in English. People saddled with *umlauts* deserve sympathy. Sympathy or no, I don't intend to learn to type all over again; let the Europeans learn, or, better yet, sell them one kind of keyboard and sell Americans another.

IBM, however, chose to try to ram its keyboard down U.S. throats, and indeed it appears to have been successful. A lot of people are buying the PC.

A lot of them are cursing their keyboards, too, if my mail is any sample.

Comes now Jim Baen with a solution. Jim Baen is arguably one of the best science-fiction editors in the world. Certainly Larry Niven and I regard him among the top two or three we've ever worked with.

I recall when I first got Ezekial, my poor late friend who happened to be a Cromemco Z-2. I began to tell Jim Baen about the joys of writing with a computer. He began to listen. One day he decided to do something about it. He went out to buy one.

What he got was an IBM PC. He hadn't noticed the keyboard until he got it home . . .

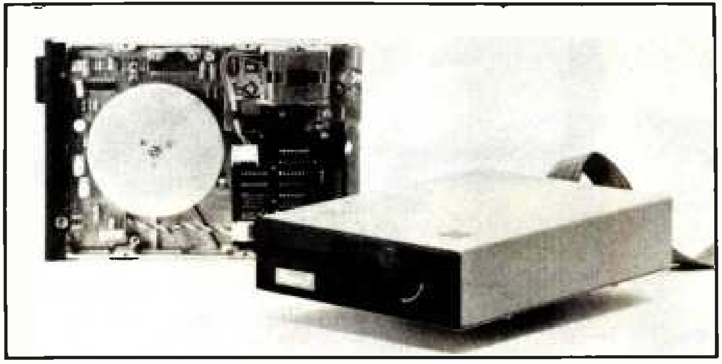
It nearly drove him crazy. Moreover, many of his authors refused to work with that keyboard, so he wasn't getting one of the main advantages of having a computer, namely having manuscripts in a format readable by his computer. Something had to be done.

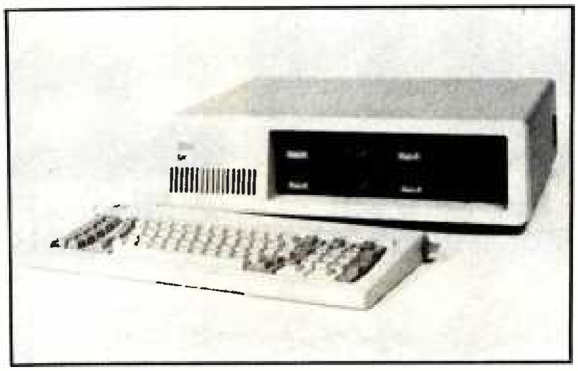
While others, including me, cursed, Jim did something. He got a programmer to write Magic Keyboard. Being an editor, Jim published it.

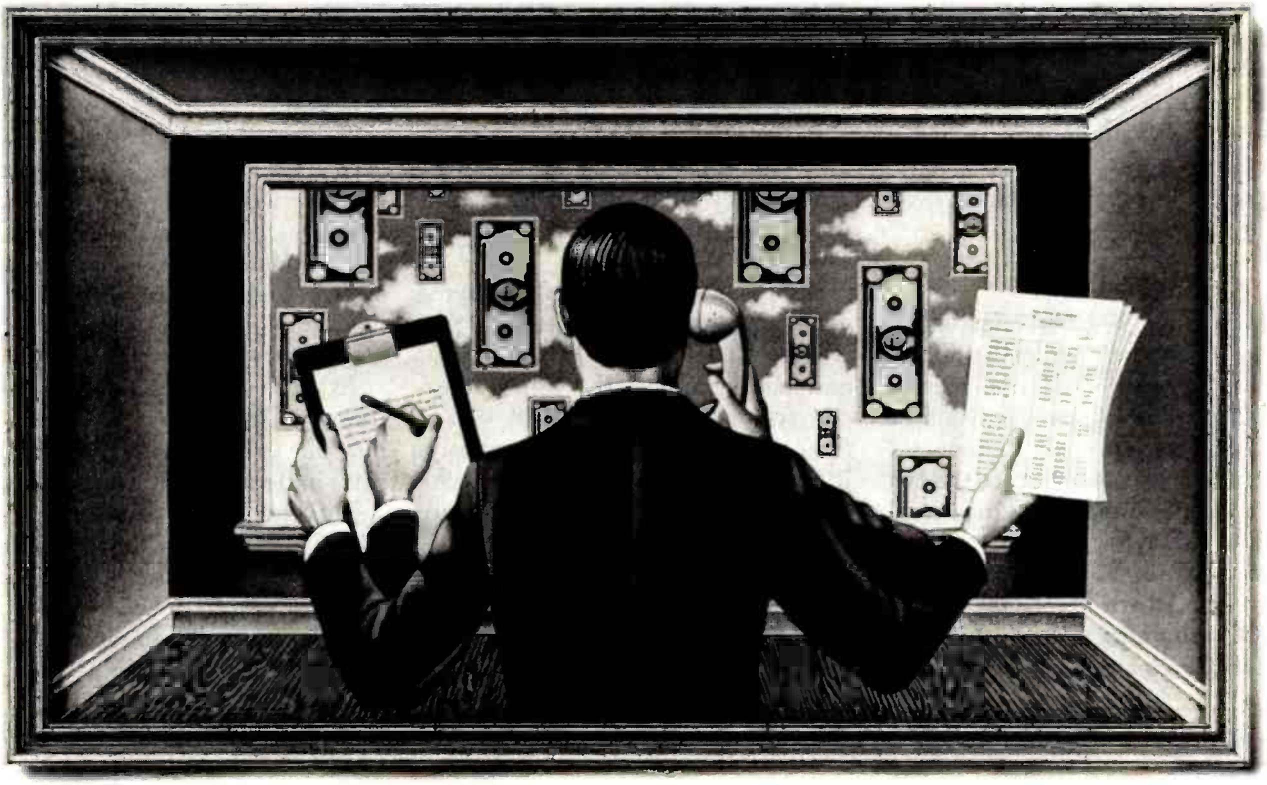
Magic Keyboard is a program that you run on your IBM PC. It immediately and invisibly reassigns the misplaced keys. The key between the "Z" and Shift becomes another Shift key. The key over there by Return *becomes* Return. And so forth. You can still get the characters those keys used to make: simply hit the Alt key and the changed key simultaneously.

Now that I have Magic Keyboard I wouldn't mind having an IBM PC, although now that we have Zorro I may not need one.

Incidentally, the Z-100 comes with what amounts to Magic Keyboard. That is, when you buy the machine and operating system, you get alter-







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nate French, German, Danish, Swedish, English, and graphics character sets, plus a couple more. Any of those can be made the "standard" character set and keyboard layout; or, if you like, you can create your own.

I don't know why IBM didn't do something like that. Fortunately, Jim Baen has corrected IBM's deficiency. I cannot imagine anyone with a PC not wanting to have Magic Keyboard. Neither could Barry Workman, who distributes it.

Hate Mail

Jeffrey Wade, of Liberty Mutual Insurance Company, writes to inform me that my "little diatribe against COBOL is pure poppycock," and he "thinks my readers ought to know it."

Mr. Wade calls as evidence the fact that "a recent estimate puts the inventory of COBOL programs in the world today at $200 *billion*. In my shop alone, there are 20,000 active COBOL programs. Do you honestly think they'll go away in five years? In your lifetime? In your son's?"

Moreover, COBOL is being updated. It will soon have, according to Wade, "structured programming constructs, Boolean operators, etc." He concludes, "If you're doing business applications which require lots of file processing, you'll be hard pressed to find a better language than my old friend, COBOL."

Perhaps Mr. Wade is right. It's almost certain that COBOL will be around for a while. The question is, is that a positive good or a regrettable evil?

If you want to write self-modifying code, COBOL has a statement that will do that for you. Whether you, and more importantly your successor, can understand what you've done is another matter entirely. Meanwhile, structured programming constructs and Boolean operators are coming Real Soon Now.

Perhaps, if what you need to do is process inputs from hundreds of terminals—say from a chain of department stores—or you must work with tens of thousands of insurance policies, COBOL is the language of choice. I wouldn't have thought so, but I'm willing to be persuaded.

The one thing you won't persuade me of is that you've much chance of handling the records of 100,000 policy holders on any kind of microcomputer I'm going to see in the next few years.

To put the record straight: BYTE calls itself "The Small Systems Journal." I write the *User's Column*. Within that context, I cannot and do not recommend COBOL. For larger systems and larger businesses I would have thought there were better languages, but perhaps I'm wrong.

As to the $200 billion value of all those COBOL programs, I'm reminded of the difference between price and value—or effort and work.

My other hate mail comes from Dr. Clyde Holsapple, whose brief introduction to database management I found incomprehensible.

Alas, I remain unrepentant. Dr. Holsapple informs me that I'm

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thoroughly ignorant of the basic principles of database management. He's demonstrably right, although I plead that I did try to learn from his document.

My sin, I find, is that I have confused hierarchical database schemes with the more formally structured CODASYL systems. These aren't the same at all, and according to Dr. Holsapple, "It is unlikely that even a database dilettante would make such a glaring error."

Moreover, according to him, MDBS "is neither CODASYL nor hierarchical, but embodies much more powerful and flexible data modeling of a posthierarchical variety. For readers who are interested in genuine database management, as opposed to mere file management, these fundamental distinctions are important."

I'm sure they are. Moreover, since Dr. Holsapple's primer, which I found difficult to read, is apparently ideal for teaching (he uses it in his courses), I can only conclude that his primer, and MDBS, are able to tell me more about database management than I really wanted to know.

To be fair: I did consult with people who used MDBS for military applications in Portugal. I think I was fair when I said that MDBS is a tool for professional programmers and unlikely to be useful to users.

Those of you who wish to know more about database management—as opposed to mere file management—are invited to read Dr. Holsapple's primer. Of your charity, you might then explain to me what it says. I cheerfully admit that I am not a database-management expert; and I am apparently unable to become one by study. It seems to be one of my many failings, and I'll just have to live with it.■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

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Del Mar, CA 92014
(619) 481-2286

Print-Mate 150 Printer — A1 $1125
Micro Peripherals Inc. — B1 $995
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Snapshot — $109.95
Dark Star Systems
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Superfile — $195
FYI Inc.
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Zenith Data Systems — low-profile with one drive, monochrome $3249
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Glenview, IL 60025 — RGB monitor $799
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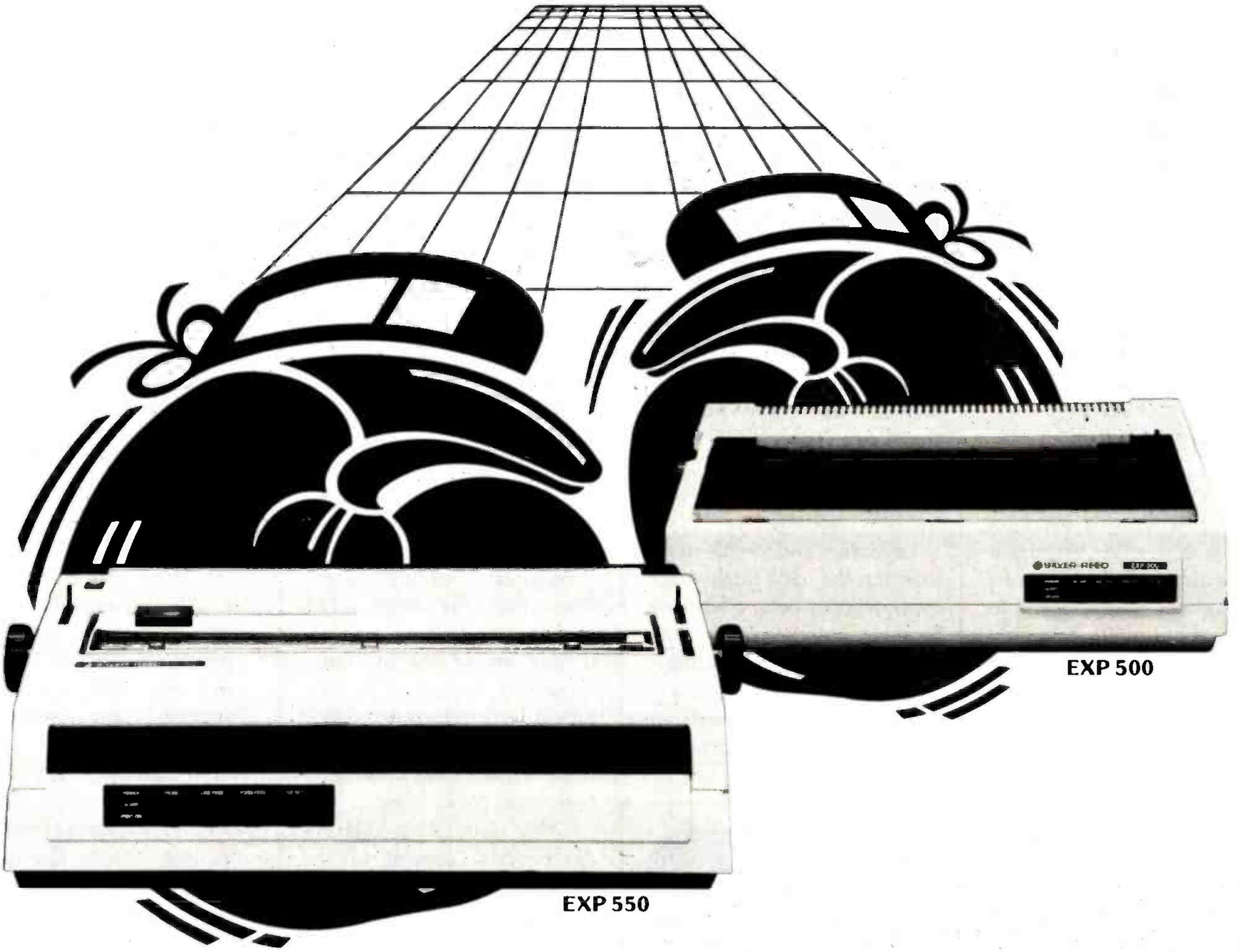

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Book Reviews

6502 Assembly Language Subroutines

Lance Leventhal
and Winthrop Saville
Osborne/McGraw-Hill
Berkeley, CA, 1982
550 pages
softcover, $15.95

Reviewed by
Paul E. Hoffman
2109 Shattuck Ave.
Berkeley, CA 94704

The title of this excellent book is misleading because it covers almost anything that a programmer would want to know about 6502 assembly language, not just subroutines. It does contain more than 50 well-documented subroutines that can be used in many applications, but the 150 pages of programming methods, hints, and common errors alone are worth the price of the book.

The authors have written a book that both experienced programmers and relative novices can use. The subroutines they present are clear, concise, and filled with excellent comments. Those who own a computer that runs the 6502 chip (such as the Atari, Apple II, or PET) and an assembler program should find the book particularly valuable.

Leventhal and Saville make learning the 6502 fairly easy, especially for people who are familiar with assembly language on other computers. After describing all of the addressing modes and registers of the 6502, the authors offer quick ways to implement common features that are found on many other chips. For instance, they present many three- and four-step examples of how to manipulate the registers in a manner similar to that used by many other machines. The discussion of I/O (input/output) handling is one of the best around, and it is relevant to many of the subroutines presented in the second part of the book.

The chapter on common programming errors in particular should be read by professional assembly-language programmers whether or not they use the 6502. The authors' comments on improper use of the bit flags, especially the carry bit, are particularly relevant to 6502 programmers because the 6502 handles flags differently than most processors.

Other interesting features of the first section of the book (we haven't even gotten to the subroutines!) are the discussion of stack handling and the clearest explanation of peripheral chips you're likely to find. The logical structure of the material and the profusion of hints make this section as relevant to experienced programmers as it is to novices.

The second section of the book presents subroutines that are useful whether you're writing a business system or a graphics-based game. Most of the common math functions, such as 16-bit multiplication and division, are covered, and all are supplemented by many multiple-precision routines. All of the standard bit manipulations and byte shifts are also shown.

The authors cover arrays in depth with some very easy-to-understand code. The subroutines they present, such as those for *n*-dimensional indexing and total-array summation, could save a programmer hours of coding and testing. Like most of the subroutines, the one for array handling is given in both 8-bit and 16-bit versions.

Assembly-language programming books that deal with string handling are hard to find. *6502 Assembly Language Subroutines* contains six examples of string handling, all of which are general enough to cover many applications. Through examples, the authors stress ways to handle strings consistently; they do not fall into the usual trap of treating strings as grouped numbers.

Because many of the 6502 computers currently available were designed years ago, their I/O processing and interrupt handlers are often confusing and sometimes unwieldy. Once you get past the operating system, the ability to handle your own I/O is important. Leventhal and Saville offer many good examples of how to program using your own I/O handling.

The authors cover each subroutine extensively. Even though the code is well documented, the book also provides enough information for most programmers to modify any of the routines to suit their particular programs.

Before discussing each subroutine at length, the authors explain its purpose and how it accomplishes its goal—in plain English. In addition, they offer suggestions about other areas in which the subroutine might be useful and the type of data for which it was intended.

A wealth of other information is given along with the subroutines. The technical considerations that an experienced programmer might have—such as which registers

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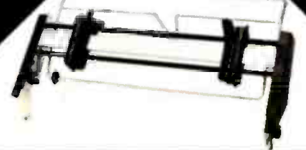

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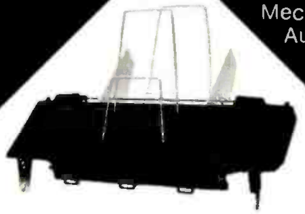

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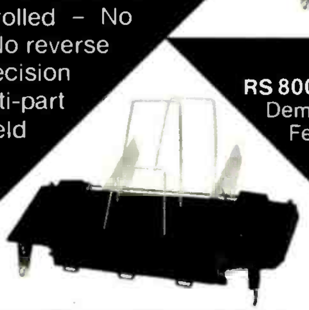

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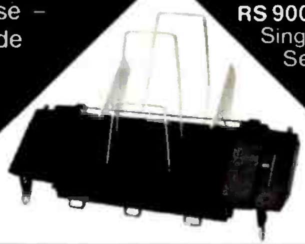

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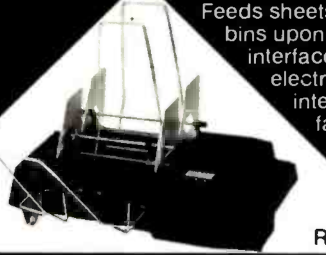

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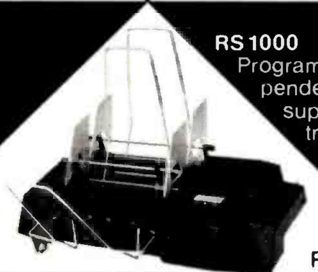

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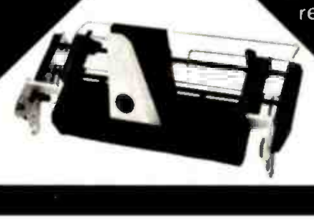

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are used—are covered concisely. These considerations include the size of the subroutine and the amount of data RAM needed.

The authors should be commended for their decision to include precise calculations for the execution times for each subroutine. Even though assembly-language programs on the 6502 are quite fast, programmers often forget that frequently called subroutines can slow a system down considerably. The authors give equations for determining the number of cycles for all of the given subroutines.

Most of the subroutines presented take all of their arguments from the stack, which makes the calling procedure much more general. An English description of the entry and exit conditions precedes the code. The authors also discuss special cases that you might encounter so that you can test for them before the subroutine is called.

In addition to offering thorough descriptions of everything in the code that they wrote, the authors documented the code completely. Variable names are surprisingly consistent throughout the book, and standard names for memory locations are used whenever possible.

The assembly pseudo-operations the authors use resemble those used on mainframe computers, so programmers shifting down to the microcomputer will feel at home. The authors define the variables on the first page of RAM memory at the beginning of the subroutine but wait until the end of the code to define the position-independent variables.

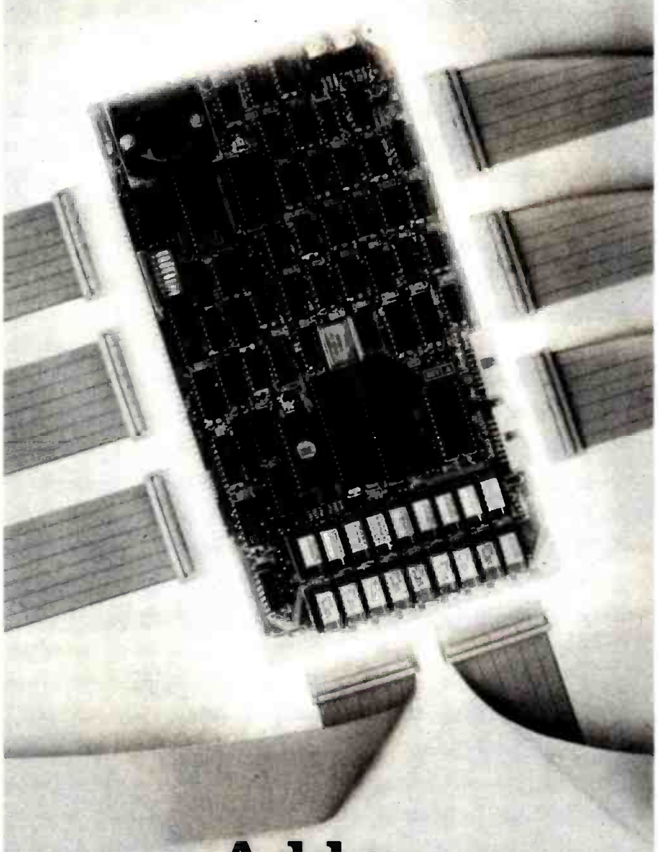
The authors stress good documentation for all of their code but also conserve space whenever possible. For example, the array-handling programs do not attempt to make row and column computations if others are more appropriate. The emphasis is on clean code that is easy to understand.

The heavy use of the stack, both for passing the parameters of the subroutine and for processing, makes many of the subroutines easier to understand. Although the 6502's stack is underused by many programmers, the authors' structured style emphasizes saving memory and machine cycles by pushing and popping short-lived variables on the stack.

When handling strings, the authors assume that the programmer knows the length of the string before the subroutine is called. This is often true when you're writing assembly-language programs that interface with BASIC, but it may not always be true otherwise. The lack of routines for handling floating-point numbers is also unfortunate because most BASIC languages deal almost exclusively with them. Still, the general nature of the subroutines that are given lets programmers preformat the data that is being passed.

6502 Assembly Language Subroutines is exceptionally complete in its presentation of subroutines and should be an indispensable reference for programmers. The explanations that go along with the subroutines are clearly written and contain almost all of the information that could be relevant to modifying the authors' code to fit a particular need.

The first part of the book is one of the best references about the 6502 on the market. It shows how to easily overcome most of the weaknesses in assembly language and how to prevent programming mistakes. Together, the two sections form a superior programming manual. ■



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The 8086—An Architecture for the Future

Part 1: Introduction and Glossary

The advanced 8086 microprocessor overcomes the limitations of previous designs.

Stephen A. Heywood
Intel Corporation
27 Industrial Ave.
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When the second-generation 8-bit microprocessors, such as the 8080, hit the market in the early 1970s, they were designed to meet the existing needs of the industry. Expensive memory made 64K bytes seem adequate.

In addition, the minicomputer architectures of the early 1970s favored assembly language with register-based data and linear-address programming. The second-generation microprocessors were also designed with this in mind.

As prices steadily dropped, however, microprocessors found their way into many applications they were not originally designed for. As a result, new performance demands revealed limitations that had to be sidestepped. For example:

- Overlays emerged as applications became increasingly memory-dependent and required more than 64K bytes of memory.
- Data types of greater than 8 bits proved difficult to manipulate and had to be divided into 8-bit parts, therefore increasing execution time.
- Programmers finding assembly language cumbersome for large projects shifted program development to high-level languages, which use data in memory instead of in registers. Compiled code was inefficient because the microprocessor's architecture did not contain the complex addressing structure needed.
- Linear-address programming gave way to modular programming because large projects were frequently allocated among several programmers. Second-generation microprocessors found this type of program development difficult.
- Software routines for multiplication and division evolved because multiply and divide instructions weren't provided in the microprocessor's hardware.
- System applications incorporated multiple processors to perform specified functions. But the second-generation microprocessors were not designed to cooperate with other processors.

The 8086 can address 1 megabyte of memory and can process both 16-bit and 8-bit data.

An advanced processor was needed to overcome these limitations. Therefore, Intel Corporation designed and produced the 8086, a 16-bit third-generation microprocessor.

This series of three articles takes a close look at how the 8086 meets the foregoing needs. Part 1 describes the architecture of the 8086, the programming model, the concept and use of segmentation, and the addressing modes. A glossary of terms associated with the 8086 is also included. Parts 2 and 3 will cover an introduction to the instruction set, advanced instructions, procedures, interrupt handling, modular programming, multiprocessing, coprocessing, and programming conventions.

Let's look first at how the 8086's physical architecture helps to satisfy users' requirements.

8086 Architecture

The 8086 register set consists of general registers, the instruction pointer, flags, and segment registers, as shown in figure 1. These registers are used to generate addresses, hold intermediate results, indicate the status of the machine, and fetch instructions.

Physically, the 8086 has 20 address lines that enable it to address 1,048,576 bytes (or 1 megabyte) of memory, or more than 16 times the memory capacity of an 8-bit microprocessor. Its internal and external data paths are 16 bits wide, giving the 8086 the ability to access and process both 16-bit (word) and 8-bit data. Support for multiprocessing (several processors using common resources over a common bus) and coprocessing (an extension that enhances the hardware capabilities of the processor) is also provided by the 8086 and its family of products.

To increase its speed of execution, the 8086 uses an instruction prefetch queue. While the 8086 executes an instruction, additional instructions are prefetched into the microprocessor and wait in line for execution. This method practically eliminates the fetch phase from the fetch, decode, and execute cycle of previous microprocessor designs.

To accommodate the wide range of available 8-bit devices, the 8086 has a close relative, the 8088 microprocessor. The 8088 possesses an 8-bit external data bus that interfaces with 8-bit devices. Internally, it's identical to the 8086 (same instructions, registers, etc.) but makes word (16-bit) transfers as two separate byte transfers instead of a one-word transfer as does the 8086.

General Registers

The general registers encompass the data group and the pointer and index group. These registers contain the source and/or the destination operands for most operations, and the BX (Base), SP (Stack Pointer), BP (Base Pointer), SI (Source Index), and DI (Destination Index) registers can address memory. However, a few operations require the use of specific registers, as shown in table 1.

Because most programmers usually give certain registers fixed duties in a program, they will not mind 8086 instructions that do the same thing. For example, a programmer can dedicate one register as a counter, another register as a pointer into the stack, and still another register as a pointer to a string. In this way, the programmer can keep track of the values in the registers. Dedicating certain registers also makes the instruction set more compact, which decreases program size. For example, instead of several multibyte string instructions with operands specified in the instructions, the programmer inserts a few 1-byte instructions with implied operands.

The data group contains four 16-bit word registers: AX (Accumulator), BX (Base), CX (Count), and DX (Data). Alternately, the high half (AH, BH, CH, or DH) or the low half (AL, BL, CL, or DL) of each of these registers can be individually addressed for byte operations. The data-group registers are also so named because of their dedicated use. These registers hold operands or intermediate results to reduce memory-access times.

The pointer and index group of 16-bit general registers normally accesses memory operands. These registers, as well as the registers in the data group, can also handle arithmetic and logical instructions.

The BP and SP registers normally point to the stack. SP is obviously employed for stack operations, such as saving the return address when calling a subroutine; it is similar to the stack pointer in 8-bit machines. BP is not designated for its named purpose, but is used instead as an additional pointer into the stack. This register allows a convenient method for accessing parameters passed to subroutines on the stack. Reentrant procedures, subroutines that can be invoked while already in execution or that can invoke themselves, can thus set aside space in the stack for their variables. These subroutines can receive information (parameters) on the stack at each invocation using the BP register to access them. (I'll provide more information on this process when I later introduce the subject of procedures.)

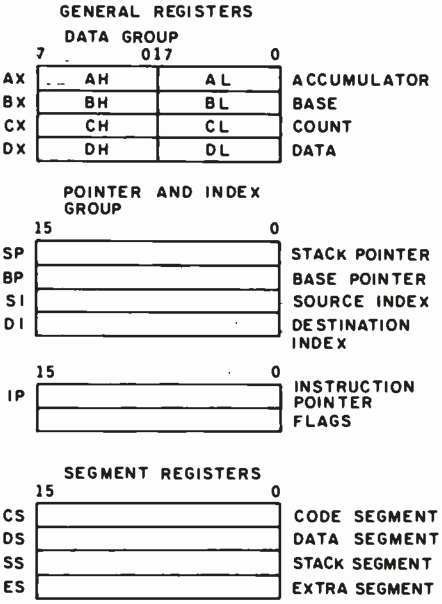

Figure 1: *The register set of the 8086 is used to generate addresses, hold intermediate results, indicate status, and fetch instructions.*

Register	Operations
AX	Word multiply, word divide, word I/O
AL	Byte multiply, byte divide, byte I/O, translate, decimal arithmetic
AH	Byte multiply, byte divide
BX	Translate
CX	String operations, loops
CL	Variable shift and rotate
DX	Word multiply, word divide, indirect I/O
SP	Stack operations
SI	String operations
DI	String operations

Table 1: *General registers with dedicated uses. Some instructions require that specific registers be used.*

The SI and DI registers access information in the normal data area of memory. Their names come from their explicit use in string instructions. But they can accomplish other tasks as well, such as accessing elements of an array. The full capabilities of these registers will become clear when I later present the subject of addressing modes.

To fetch instructions, the 8086 uses a 16-bit IP (Instruction Pointer) register, which is similar to the program counter installed in 8-bit

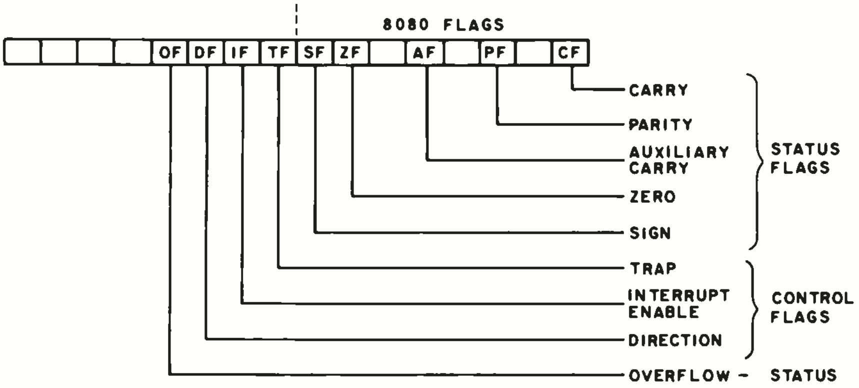

Figure 2: *The 8086 has six 1-bit status flags and three control flags in a 16-bit word register, with its low byte identical to the 8080 flag register.*

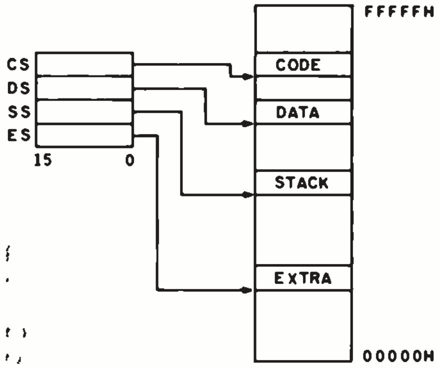

Figure 3: *The four segment registers contain the base address, or beginning location, of the current code, data, stack, and extra data segments.*

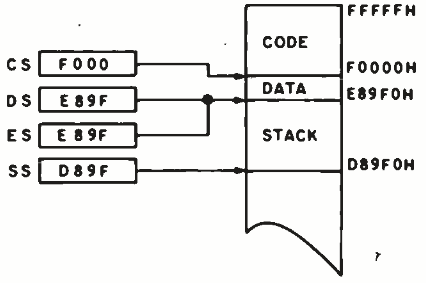

Figure 4: *The segment registers contain the most significant 16 bits of the 20-bit address, with the 4 least significant bits supplied by the 8086 equal to 0. Segments can be fully overlapped, partially overlapped, adjacent, or disjoint.*

machines. Basically, it points to the next instruction to be fetched in order to fill the prefetch queue. The IP register cannot be directly accessed by the programmer, but can be manipulated by program jumps.

Flags

The 8086 has six 1-bit status flags and three control flags configured in a 16-bit register, as shown in figure 2. The lower byte of the flag register is a bit-for-bit copy of the 8080 flag register to accommodate conversion of 8080 programs to the 8086.

Microprocessor decisions are based on the condition of certain flags that indicate the status of an arithmetic or logical operation's result. The 8080-type status flags are the carry flag, CF, which indicates a carry out of, or a borrow into, the high-order bit of the result; the parity flag, PF, which is set if an even number of 1s are in the result; the auxiliary carry flag, AF, which is used by the decimal-adjustment instructions; the zero flag, ZF, which is set if the result is 0; and the sign flag, SF, which is set if the result is negative. The status flag added to the 8086 is the overflow flag, OF, which indicates that an operation incorrectly changed the sign bit of the result. An example is adding two positive numbers with the result being negative, i.e., +127 (7F hexadecimal) + 2 (02 hexadecimal) = −127 (81 hexadecimal) and an overflow for a byte arithmetic operation.

The control flags direct 8086 operations. These flags are the direction flag, DF, which is used to control the direction of string operations; the interrupt-enable flag, IF, which, if set, enables an external maskable interrupt; and the trap flag, TF, which places the 8086 in the single-step mode for debugging purposes.

Later I will further explain the flags and their operations.

Segmentation

The last four registers are the segment registers, CS (Code Segment), DS (Data Segment), SS (Stack Segment), and ES (Extra Segment), which are the basic building blocks for forming addresses in the 8086.

Memory stores three types of information: the code, or instructions, to inform the microprocessor what to do; data, numbers, and characters to be operated on; and the stack for saving return addresses. These three types normally reside in their own area of memory to avoid confusion. Otherwise, they would result in problems, such as the stack overwriting the code, data being executed as instructions, etc.

The 8086 views its memory as being divided into a group of logical units called *segments*. Each physical segment can be up to 64K bytes long. The processor has direct access to four segments at a time through the *segment registers*. The four segment registers contain the base address, or the beginning location, of each segment, as shown in figure 3. The CS register contains the base address of the current code segment; DS, the current data segment; SS, the current stack segment; and ES, the current extra or global data segment.

Only one restriction confines segment locations. A segment must begin on a memory boundary that is divisible by 16 (called a paragraph). The least significant 4 bits of the 8086's 20-bit address must thus all be 0s to fall on this paragraph boundary. For example, the first paragraph starts at address 00000 hexadecimal; the second paragraph, at address 00010 hexadecimal; the next one, at address 00020 hexadecimal; etc.

The 16-bit segment registers store the most significant 16 bits of the 20-bit address. The all-zero least significant 4 bits are appended to the end of the segment register to derive the full 20-bit address base. For example, figure 4 shows the SS register pointing to the segment of memory beginning at address D89F0 hexadecimal, which contains the value D89F hexadecimal. This figure also indicates that segment registers can be fully overlapped (as pointed to by ES and DS), partially overlapped (as shown by the code and the data segments), and adjacent (as displayed by the stack and the data segments). The segments might also be disjoint, as shown in figure 3.

To access a particular byte or word in a segment, the 8086 employs an offset, which is the distance in bytes from the beginning of a segment. The actual 20-bit physical address results from adding a segment register, with the zeroed least significant 4 bits appended, and a 16-bit offset, as shown in figure 5. Note that the segment register contains E89F hexadecimal and that the offset is 0003. The segment register is therefore pointing at address E89F0 hexadecimal. To this value, we add 0003 to obtain the final physical address, E89F3 hexadecimal.

Earlier, I mentioned that some 8086 registers can address data in memory. However, because they are 16-bit registers, they actually contain the offset and thus require a segment register to access this data. The segment register and the source of the offset depend on the type of memory reference the 8086 has to make, as shown in table 2. Instructions are always fetched using the contents of CS as the segment register and the contents of IP as the offset. Similarly, a stack operation always uses SS as the segment register and SP as the offset to the top of the stack. Variable data is typically accessed by the DS register, with the addressing modes supplying the offset. Note from table 2 that this condition can be overridden to exercise another segment register for most instructions. Exceptions are the string instruction's destination, which always employs the ES register as the base and the DI register as the offset, and the string source, which must use the SI register for the offset.

Notice that BP defaults to SS as its segment register. As I mentioned earlier, having BP default to the SS register yields an extra pointer into the stack. We will see later how to use this to advantage.

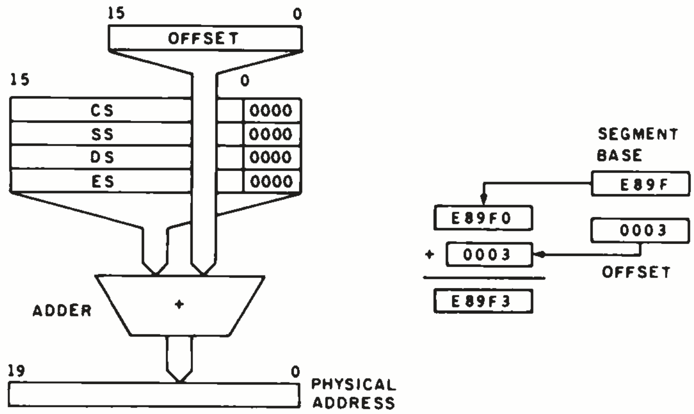

Figure 5: *The 20-bit physical address is the result of the sum of a segment register, with appended zeros, plus an offset.*

Type of Memory Reference	Default Segment Base	Alternate Segment Base	Offset
Instruction fetch	CS	None	IP
Stack operation	SS	None	SP
Variable (except the following)	DS	CS,ES,SS	Effective address
String source	DS	CS,ES,SS	SI
String destination	ES	None	DI
BP used as base register	SS	CS,ES,SS	Effective address

Table 2: *Explicit segment and offset use. For access of different types of data items, most variables can be accessed using any segment register.*

Allowing variable data to be accessed by any segment register permits the accessing of constants in the code area, the passing of parameters in the stack area, and the sharing of data between several programs in the extra data area. Figure 6 shows examples of segment and offset use.

Addressing Modes

High-level languages utilize variables in memory as opposed to registers. These variables can be simple or complex, such as arrays and records. The 8086 addressing modes can access these variables by supplying the offset portion of the physical address.

As recorded in table 3, several methods exist for accessing variable data. The immediate and register addressing modes are listed with their instructions. These two addressing modes do not access operands in the data area of memory.

The direct addressing mode supplies the offset in the instruction itself as a 16-bit quantity. It can access simple variables.

The remaining addressing modes that can generate the offset use a base or an index (or the sum of both) with an optional displacement added. The register indirect addressing mode employs a base or index register's contents (BX, BP, SI, or DI) as the offset. Because these registers can be manipulated by arithmetic and logic instructions, they can be used to access buffers and blocks of data.

The based or indexed addressing mode utilizes the contents of either a base register, BX or BP, or an index register, SI or DI, with a displacement to generate the offset. These modes can support the array and record data types found in high-level languages.

In figure 7, the displacement field of the instruction points to the beginning of the array. The contents of the index register are then added to access the element needed. Furthermore, the index register can be manipulated to do operations such as adding a specific value to each element of the array.

A record is made up of dissimilar

Mode	Location of Data
Immediate	Within instruction
Register	In register
Direct	At memory location pointed to by offset contained in instruction
Register indirect	At memory location pointed to by offset contained in register
Indexed or based	At memory location pointed to by sum of index or base register contents and displacement in instruction
Based and indexed with displacement	Memory address is sum of base register contents and index register contents and displacement

Table 3: *8086 addressing modes. To access variables for instructions, the 8086 uses its addressing modes to generate the offset for memory variables. The full address for memory variables consists of the contents of a segment register as modified by the addressing mode.*

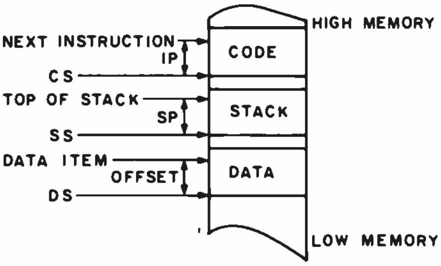

Figure 6: *The segment register used and the source of the offset depend on the type of memory reference.*

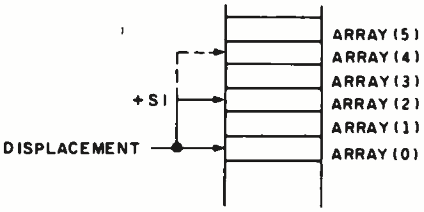

Figure 7: *To access an array, the displacement points to the beginning of the array with the index register pointing to the element needed.*

items, as opposed to an array, which is made up of similar items. In figure 8, the BX register points to the beginning of the record. The displacement can be added to this value to obtain the item from the record. What's more, the same item in a different record can be accessed by changing BX to point to the beginning of the new record and by using the same displacement to obtain the item as shown.

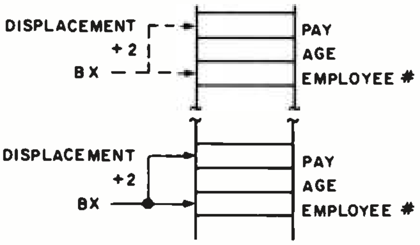

Figure 8: *A record of dissimilar items uses a base register to point to the beginning of the record, with the displacement pointing to the item needed. The base can be readjusted to point to the base of a new record with the same displacement to access an item in the same position.*

The based and indexed addressing mode is the sum of a base register, an index register, and a displacement. This powerful addressing mode can access an array in a record, as shown in figure 9. Note that the base register points to the beginning of the record, the displacement is added to point to the beginning of the array, and, lastly, the index is added to point to the element in the array.

The power of the addressing modes is revealed further when we introduce the instruction set.

Advantages of Segmentation

Accessing memory using a segmented architecture holds many advantages over the earlier linear-addressing method.

Linear addressing must supply the entire address in one entity, as opposed to the 8086 two-part structure of segment and offset. For a register to hold a linear address, it must be at least 20 bits wide. In addition, instructions would have to supply a 20-bit address for direct addressing of operands. Moreover, arithmetic functions must be extended to 20 bits for manipulating registers containing addresses. Any future expansion in linear addressing would involve enlarging these capabilities (including arithmetic functions to manipulate indexing) to generate addresses.

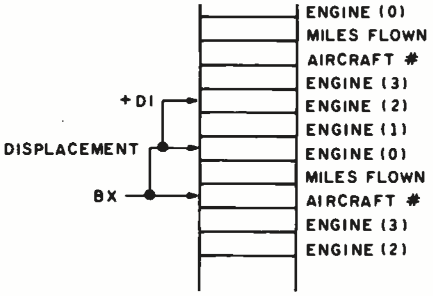

Figure 9: *The base register points to the beginning of the record containing the array, the displacement points to the beginning of the array, and the index points to the item needed.*

Because the 8086 is designed for word accesses and word arithmetic, linear addressing is not an advantage. A 16-bit offset allows word registers to hold addresses and word arithmetic to manipulate these registers. Instructions have only to provide the offset, thereby minimizing their length. To expand these capabilities in future microprocessor designs for increasing the memory, only the base or segment registers need to be lengthened. And because only the offsets are manipulated, this would not involve any drastic changes to the 16-bit design.

Because all 8086 instructions are accessed as an offset from the code segment register, dynamic-code relocation is possible. Code and data can be loaded into a free memory area, with the CS and DS registers adjusted to point to the new base. This setup allows programs to be constructed without prior knowledge of their memory location. Additionally, multiple programs (or tasks) can also take advantage of this setup. When a task is not needed, it can be saved on disk, and a new task can be loaded in its place. When the original task is needed again, it can be loaded into whatever memory area is available.

This setup also encourages modular program development. Programs can be developed in small manageable pieces (modules) instead of one large one. Individual modules can then be debugged or updated as needed. Program libraries can be employed containing often-used utilities such as terminal handling, disk accesses, and other such programs. Programs can be reconfigured for different hardware by changing to the modules for that particular machine.

Segmentation can easily be used for memory management and protection. For example, a program might be involved with handling employee records from several different departments. By changing the data segment register, the program can easily manage a different group of employees. It could also protect one department from looking at records from another department and changing those records. Future designs of microprocessors can take this segmentation one step further to include descriptor tables containing range checking and access rights without changing the architecture.

Being able to program in multitasking environments, using modular programming, and protecting and managing memory easily, segmentation takes away the heavy overhead previously needed with linear addressing. It also provides the base for future architectural growth in microprocessor development.

This article demonstrates how the 8086 handles the limitations that had arisen with earlier microprocessors. In sum, the 8086 addresses 1 megabyte of memory for increased memory capabilities and uses segmentation to generate addresses. The side benefits of segmentation fit in well with demands for modular programming, memory protection, memory management, multitasking, and future needs of programmers. The 8086 addressing modes support the high-level-language variable needs in memory. The 16-bit internal and external architectures and registers work well with the larger data types needed, but are still flexible enough to work with byte types.

Part 2 explores how the 8086's instruction set aids high-level compilers in their task. ■

About the Author

Stephen Heywood is an instructor with Intel Customer Training and is the course manager for the 8086 course.

Glossary

addressing mode: *the method used to access instruction operands, either from calculating the offset for variables in memory (using the 8086 segment and offset addressing), from the contents of a register, or from the instruction itself. The final memory address is called the effective address.*

assembler: *a program that takes a source file containing assembly-language instructions, which are symbolic representations of the machine language, and translates it to an object file consisting of machine code.*

compiler: *a program that converts high-level-language statements, such as those written in Pascal, to a sequence of machine instructions.*

coprocessor: *an extension of the processor that enhances the hardware capabilities. It does this by performing only the instructions pertaining to the coprocessor, while the processor ignores these same instructions. For example, the 8087, a coprocessor for the 8086, performs floating-point-math instructions.*

displacement: *the distance in bytes from a byte (or word) to another byte (or word) in memory.*

link: *a process that combines object files, consisting of machine code, from various sources, such as assemblers and compilers, into one final object file. Used in modular program development.*

modular programming: *a method of program development that allows a large programming task to be broken up into several small programs called modules. These modules can be assembled or compiled separately and then linked together. Updates and corrections are made only to the particular module instead of to the entire program.*

multiprocessing: *two or more coordinated processors in a system. Each processor performs its own program and shares system memory and I/O devices through a common bus with the other processors.*

offset: *the distance in bytes from the beginning of a segment. Used for calculating a memory address, which is the sum of a segment register with four 0s appended plus a 16-bit offset.*

overflow: *an indication that an arithmetic result using signed numbers is out of range. It most often occurs when adding two positive numbers with a negative result or adding two negative numbers with a positive result.*

paragraph: *a byte address that is divisible by 16 (least significant 4 bits equal to 0).*

parameters: *data items passed to a procedure to be operated on. For example, a character being passed to a procedure that outputs it to a video display is a parameter.*

procedure: *another name for a subroutine.*

reentrant: *an attribute of a procedure that can be called upon while already in execution from a previous invocation. This action can occur if the procedure calls itself, the procedure invokes another procedure, which in turn invokes the original procedure, or the procedure is interrupted and the interrupted procedure invokes the original procedure.*

relocatable: *machine code that can be placed anywhere in memory and executed from that point.*

segment: *method for partitioning memory. In the 8086, each segment can be up to 64K bytes long, but must start on a paragraph boundary. A segment register contains the base address, and an offset accesses the information in the segment.*

stack frame: *an area of the stack containing the parameters and the return address given to a procedure. The procedure can then access its parameters from the stack frame, but it has to discard the entire stack frame when the procedure exits.*

string: *a set of sequential bytes or words in memory. An example is text data in ASCII (American National Standard Code for Information Interchange).*

word: *a 16-bit data type (2 consecutive bytes) used in the 8086.*

word aligned: *an alignment in memory. To be word aligned, a word must begin in an even memory location. The 8086 can thus access them in one memory transfer. It would need two memory transfers if the words were not aligned (i.e., started on an odd address).*

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Circle 181 on inquiry card.

Clubs and Newsletters

News from South Africa

The TRS-80 User Group in Johannesburg, South Africa, has a NEWDOS/80 version 2.0 CBBS (computerized bulletin-board service) up and running. Access is via a post-office-supplied modem; tone pairs comply with the European CCITT standard. The club holds open meetings regularly. For a free user code and further details, send a self-addressed envelope to the TRS-80 User Group, POB 35461, Northcliff 2115, Republic of South Africa.

Computers in Construction

The *Construction Computer Applications Newsletter (CCAN)* is aimed toward contractors who use computers. It contains information on seminars, new products, and current issues such as software contracts and electronic mail. Annual subscriptions are $60; $80 overseas. For more information, write to Construction Industry Press, 1105-F Spring St., Silver Spring, MD 20910, or call (301) 589-4884.

APL/AUG News from Johns Hopkins

The Applied Physics Laboratory/Apple User's Group (APL/AUG) is supported by Johns Hopkins University and the Applied Physics Laboratory. A monthly newsletter contains news, updates, and articles. Further information is available from Dr. E. A. Davis, APL/AUG, Johns Hopkins University/-Applied Physics Laboratory, Johns Hopkins Rd., Laurel, MD 20707, or call (301) 953-7100, ext. 3704.

Meet On the Air

The Atari Microcomputer Network is a nonprofit amateur radio operator and users group that meets on the air every week via six regional networks. Membership dues are not required, but a $10 annual donation is requested to cover expenses of the network's bimonthly journal *Ad Astra*. For more information, write to Jack McKirgan II, WD8BNG, The Atari Microcomputer Net Users Group, 4749 S.R. 207 NE, Washington C.H., OH 43160, or call (614) 869-3597.

Attention: Political Scientists

The *Political Science Micro Review* focuses on programs, tutorials, and other items of interest to political scientists using microcomputers. This nonprofit newsletter is produced by the North Carolina State University Department of Political Science and Public Administration. Annual subscriptions are $10. A disk-based version with hard-copy backup costs $25. For details, write to *Micro Review*, PSPA Link 215, NCSU, Raleigh, NC 27511, or call David Garson at (919) 737-2481.

First Year Free

Stoneware Age, a newsletter designed for users of Stoneware products, has updates on the DB Master Database File Management series, the Graphics Processing System, and information on other Stoneware-compatible products. The first year of subscription is free to registered owners of Stoneware products; $6 per year thereafter. For further details, contact Stoneware Inc., 50 Belvedere St., San Rafael, CA 94901, or call (415) 454-6500.

Here's the Scoop

H-Scoop, the monthly newsletter of the H-8/H-89 User Exchange, has reports on new products, hardware, and software, and answers questions about Heath/Zenith computers. Annual subscriptions are $20 a year in the U.S. and Canada; overseas airmail costs $27. For information, write to *H-Scoop*, 2918 South 7th St., Sheboygan, WI 53081, or call (414) 452-4172 weekdays.

For Vector Graphic Owners

Every two months the *Vector Letter* provides Vector Graphic owners with solutions to common problems, product reviews, articles of interest, and reference materials. A one-year subscription is $29; in Canada and Mexico, $35; elsewhere, $40. Contact *Vector Letter*, POB 2403, Del Mar, CA 92014.

For Engineers in All Fields

The *Engineering Software Exchange* contains technical tips for chemical, civil, mechanical, industrial, and electrical engineers. It serves as a forum to exchange, buy, or sell personal software. Manuscripts are welcome. An introductory issue is $1; a yearly subscription (six issues) is $6. For details, write to Lidia Lopinto, Engineering Software Exchange, 41 Travers Ave., Yonkers, NY 10705.

Computer Language Newsletter

NCUG News, a monthly newsletter of the Nevada COBOL Users Group, disseminates information about the Nevada COBOL language. For further information, write to Nevada COBOL Users Group, 5536 Colbert Trail, Norcross, GA 30092, or call Bob Blum at (404) 449-8948.

Keep Up with Technology

Advanced Technology is a technical bulletin that keeps its readers informed about new products, processors, and applications from Advanced Micro Devices. For further information, write to Advanced Micro Devices, 901 Thompson Place, POB 453, Sunnyvale, CA 94086, (800) 538-8450; in Massachusetts, call (617) 273-3970.

Unofficially Yours

A bimonthly newsletter for owners of Texas Instruments' TI-99/4 and TI-99/4A computers, *Unofficial 99/4A* features programs, news, and a question-and-answer forum. Subscriptions are $10 a year. For a free introductory issue, send a self-addressed, stamped envelope to *Unofficial 99/4A*, POB 651, Clute, TX 77351.

Update Your Records

The new address of the Atari Computer Association of Orange County (ACAOC) is POB 9419, Fountain Valley, CA 92708, or call (714) 770-0372. (For a description of the club's activities, see the

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June 1982 BYTE, page 479.)

The new address of the Woodfield Area Computerist Organization (WACO) is POB 94781, Schaumburg, IL 60194 (July 1982 BYTE, page 417).

Supernews, a quarterly newsletter produced by Sorcim Corp., has moved to 2310 Lundy Ave., San Jose, CA 95131 (December 1982 BYTE, page 505).

The new name and address of the VIC-20 Users Group of Wichita is the Commodore Users Group of Wichita, Route 1, Box 115, Viola, KS 67149 (December 1982 BYTE, page 505).

Little Rock Club Formed

The Arkansas Computer Club meets on the second Saturday of each month in Little Rock. Inquiries are welcome. Write to Clarence Karr, The Arkansas Computer Club, 5 McGovern Dr., Little Rock, AR 72205.

Newsletter Seeks Manuscripts

The Micro Users Support Network, the monthly newsletter of the Connecticut/Westchester Computer Society, contains meeting notes, reports on product demonstrations, and a calendar of events. Articles are welcome. For details, write to the Connecticut/Westchester Computer Society, POB 1717, Darien, CT 06820.

NEC Group in Redondo Beach

An independent newsletter for NEC PC-8001A owners can be obtained by sending a self-addressed, stamped envelope to the *NEC 8000 Newsletter*, POB 7000-309, Redondo Beach, CA 90277.

For IBM PC Users

The Personal Computer Update, an independent newsletter produced each month by Texasoft of Dallas, Texas, for users of the IBM Personal Computer, contains information about Versatext and other Texasoft products. Address further inquiries to Texasoft, 3415 Westminster, Dallas, TX 75225.

Scanning Telecommunications

Telescan, the digest of the Center for Learning and Telecommunications, reports on how telecommunications systems are used in adult education, training, and professional development. The Center is affiliated with the American Association for Higher Education (AAHE). For AAHE members, an annual subscription (six issues) costs $40; for nonmembers, $45. For details, write to the Center for Learning and Telecommunications, American Association for Higher Education, Suite 600, One Dupont Circle, Washington, DC 20036.■

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Ask BYTE

Conducted by Steve Ciarcia

Comm-80 Adapted to ZX80

Dear Steve,

I read with interest your article on the Comm-80 Expansion interface for the TRS-80. (See "I/O Expansion for the Radio Shack TRS-80," Part 1, May 1980 BYTE, page 22; Part 2, June 1980 BYTE, page 42.) You mentioned that the Comm-80 could be adapted for other Z80-based computers. I would like to try it on my Sinclair ZX80 computer. Can you tell me what modifications I should make or refer me to other sources of information that I should have before I attempt this?

V. P. Subramanian
Temple, TX

The Comm-80 Expansion Interface for the TRS-80 can be easily adapted for use with the Sinclair ZX80. The only signals that are not compatible are the $\overline{MEMWR}$, $\overline{MEMRD}$, $\overline{IORD}$ and $\overline{IOWR}$ required by the Comm-80. Their definitions are as follows:

$\overline{MREQ}$ *Memory Request. Whenever a transaction occurs between the central processor and memory, the $\overline{MREQ}$ line goes to a logic 0.*
$\overline{IORQ}$ *Input/Output Request. Whenever a transaction occurs between the central processor and either an input port or an output port, the $\overline{IORQ}$ line goes to a logic 0.*
$\overline{RD}$ *Read Request. Whenever the central processor reads input data from either memory or an input port, the $\overline{RD}$ line goes to a logic 0.*
$\overline{WR}$ *Write Request. Whenever the central processor is writing data to either memory or to an output port, the $\overline{WR}$ line goes to a logic 0.*

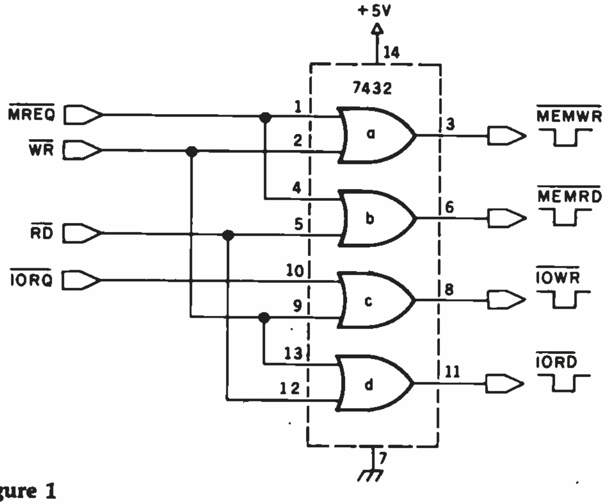


Figure 1

To differentiate between input and output ports during I/O instructions, $\overline{IORQ}$, $\overline{RD}$, and $\overline{WR}$ are gated together as shown in figure 1. In a similar manner, $\overline{MREQ}$, $\overline{RD}$, and $\overline{WR}$ are gated during memory transfers.

The resulting decoded strobes define the operations of Input Port Read ($\overline{IORD}$), Output Port Write ($\overline{IOWR}$), Memory Read ($\overline{MEMRD}$), and Memory Write ($\overline{MEMWR}$).

So you see, all that it takes is one chip to interface the Comm-80 to the ZX80.
. . . **Steve**

Monitor Buffer Has Simple Solution

Dear Steve,

I have a Sinclair ZX81 with a Sanyo video monitor attached. The *Syntax Newsletter* suggested that the Sanyo could be hooked to the ZX81, but the monitor's 75-ohm input impedance doesn't match the ZX81's output. I'm told that I need to add a buffer. Can you tell me what circuits to use and how to build them? Any help would be appreciated.

Bruce Schalamon
Manchester, CT

The buffer you need requires source follower or emitter follower circuits, which are transistor circuits that are used to transform a high impedance to a low impedance. The source follower is used with field-effect transistors, while the emitter follower circuit is used with bipolar transistors.

Figure 2 is a simple circuit for an emitter follower that uses readily available parts and will match your ZX81 to your Sanyo monitor. The circuit can be constructed on a small piece of perforated board and the required 5 volts and ground can be obtained from the expansion connector on the Sinclair.
. . . **Steve**

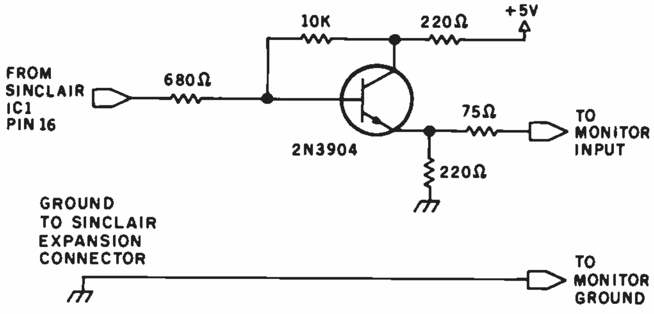


Figure 2

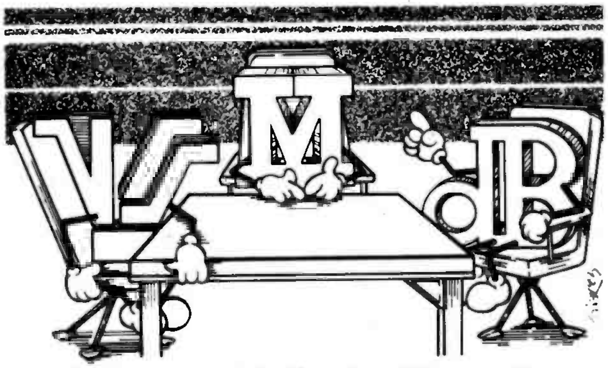
Multiple Screens for Classrooms

Dear Steve,

We have several North Star systems with Zenith Z-19 terminals that we use in our microcomputer lab. Our problem is simple: we need some way for up to 50 students to see what is happening on the terminal screen. Using a computer to support teaching is rather useless if only a few students in the front row can see the screen; and even then, the instructor must have his or her back to the class.

We want to equip at least one classroom with display facilities, although a portable projection system would be better. We are not aware of any commercial equipment to

Circle 138 on inquiry card.



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Please send ________ Word Challenge Disk(s) for which I've enclosed $39.95 each (plus $2.00 shipping and handling). Florida residents please add 5% sales tax.

Check appropriate box.

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☐ IBM Personal Computer (min 64k) w/disk
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Circle 319 on inquiry card.

do this, and no one has yet to suggest an acceptable setup. Ideally, the solution would require little, if any, hardware or software modification. Any ideas?

J. Burdeane Orris
Butler University
Indianapolis, IN

Yours is a classic problem. At various computer show demonstrations, I've seen multiple monitors placed around the room to provide visibility. This seems relatively effective and reminds me of the technique used to display camera shots to a live television audience.

I have used a Pioneer projection TV for displaying color graphics because it has a built-in video input jack. This works very well and would provide greater visibility because it has a 50-inch screen. Properly positioned, two of these units would be adequate for a 50-student class.

It should only be necessary to parallel the video inputs to provide the proper signal for the projection TVs. If the distances are excessive, or the drive signal is weak, an inline video amplifier can be used to boost the signal. This method offers three advantages: it's a relatively inexpensive way to provide the necessary visibility, no modifications to the computer are required, and it will allow the viewing of video tapes or TV programs as well.

At a recent convention, I saw an Electrohome Projection CRT that may do what you want. Contact Electrohome Ltd., 809 Wellington St. N, Kitchener, Ontario N2G 4J6, Canada, (519) 744-7111. . . . **Steve**

Guide's Contents Outlined

Dear Steve,

Can you supply a list of the periodicals covered in the *Periodical Guide for Computerists*? What's its expected frequency of publication?

Thank you.

David Ingham
Edina, MN

The Guide *is published annually by Applegate Computer Enterprises, POB 288, Applegate, OR 97530. Here is a list of the periodicals it covers:*

"68" Micro Journal
80 Microcomputing
80 U. S. Journal
BYTE
Call-A. P. P. L. E.
Compute
Creative Computing
Dr. Dobb's Journal
Digital Design
Infoworld
Interface Age
Kilobaud Microcomputing
Lifelines
Mechanix Illustrated
Mini-Micro Systems
onComputing
Personal Computing
Popular Computing
Popular Electronics
Popular Mechanics
Popular Science
Radio Electronics
Recreational Computing
S-100 Microsystems
Softalk

Another guide that appears to be more comprehensive and includes abstracts of all articles it references is the Micro Computer Index. *It's a quarterly publication available from Microcomputer Information Services, Suite 247, 2464 El Camino Real, Santa Clara, CA 95051.* . . . **Steve**

Bell Rings for ASCII-to-Video Board Converter

Dear Steve,

Having read your Ask BYTE column, your books, and your Circuit Cellar articles, I respect your ability to come up with answers. I hope that you can come up with one for me.

I have been asked to provide remote displays (approximately 20) of the screen from a Motorola 6800-based, multiplexed computer system that uses a serial port and Hazeltine 1500 as a console. Because this system is U. L. (Underwriters' Laboratories) listed, I do not want to enter it in any way that would void that status.

What I am looking for is an ASCII-to-video converter that would operate from the existing RS-232C port. The output of this converter would then be amplified and distributed to the required number of video monitors using commercially available video equipment. The key to the whole concept is the ASCII-to-video converter. I would appreciate any information you could furnish about a source.

Jerald Miskovsky
Farmingdale, NY

The ASCII-to-video converter that you are seeking is typical of the many computer video boards that are commercially available. In the early days of personal computing these devices were known as TV Typewriters, because they could display the output of an ASCII-encoded keyboard on the screen of a television. They usually were uppercase only and capable of only 32 or 64 characters per line.

With today's LSI (large-scale integration) integrated circuits, an entire TV Typewriter (now called a video-display controller) can be produced on one chip. This has led to very sophisticated video boards that are no longer stand-alone devices. They are designed to plug directly into the microcomputer bus.

One unit that will answer your requirements is a video terminal board from John Bell Engineering, catalog number 82-018. It is available for $199.95 assembled and tested, or for $89.95 as a bare board (this may allow you to custom package it for your systems). The address is John Bell Engineering Inc., 1014 Center St., San Carlos, CA 94070, (415) 592-8411. . . . **Steve**

On 68000s and Operating Systems

Dear Steve,

I am currently putting together a 68000 system based on the IEEE-696 (S-100) bus. The 68000 uses memory-mapped I/O (which personally I detest but will tolerate for the sake of all the other 68000 features). Is there any standard location for the I/O ports in the address space? Would I be better off including a Z80 (or some other) coprocessor to handle I/O?

Also, what DOS should I use? Unix is very inviting, but much too expensive. Could I rewrite CP/M in 68000 code, or maybe use a Z80 to handle unmodified CP/M? I haven't seen much 68000 software around, but I want to choose a disk format and operating system that will give me access to software still to be written. Any suggestions would be greatly appreciated.

Greg Trice
Scarborough, Ontario,
Canada

The Motorola 68000 microprocessor is relatively new in the microcomputer field, and memory-mapping standards have not been suggested. Upon a reset, the microprocessor jumps to location 00000 and vectors to the initialization program called at this location. Hence, there should be some ROM (read-only memory) in low memory to accomplish this.

The I/O ports do not have a standard location; they are a function of how the memory is configured. A 1K-byte block could be set aside to handle I/O, so it's not necessary to use a coprocessor for the task (I detect by your comments that you are a seasoned Z80 user). Memory-mapping I/O is convenient, fast, and easy to use.

The reason you haven't seen much 68000 software around is that the chip is just beginning to get popular. However, a listing of small-business computers in the June 1982 issue of Mini-Micro Systems, *"Small-Business Systems Solve Big Problems," by David Simpson (page 201), indicated a preference for Unix or Unix-like operating systems (such as Microsoft's Xenix).*

The thought of writing your own operating system is ambitious, and compatibility with other software is important. You might want to consider Digital Research's version of CP/M for the 68000. Most of this software is for the business and industrial markets and is quite expensive. . . . **Steve**

Quick Printer Interface

Dear Steve,

I would like to interface a Radio Shack Quick Printer II to an Atari 400. I would appreciate any help that you could give me.

Thank you.

Gary Greaser
Silverdale, WA

The Radio Shack Quick Printer II requires serial data input at 600 bps (bits per second). It has a built-in microprocessor to convert the incoming data to a 7-bit ASCII code. Only three lines are needed: Data, Ground, and a Clear-to-Send signal for handshaking.

The interface to the Atari 400 is a little more difficult. While the Atari 400 does produce serial data, it is at a high rate (i.e., in excess of 19,000 bps), and it's not RS-232C-compatible. It is conceivable that you could build an adapter specifically for this project, but it is far more reasonable to buy Atari's Model 850 expansion box. This unit adds one parallel port and four serial ports to an Atari 400/800. It costs about $150. . . . **Steve**

Printer Drops Characters

Dear Steve,

I have an Explorer 85 computer and the Heath H14 printer. When I Run or List a program, the printer loses characters after several lines. Do you have a circuit of a printing buffer that would hold several K bytes' worth of characters and let the printer catch up with the flow of data?

I purchased a surplus memory board with sixty-four 2102-type static memories; could it be used in the circuit?

Leroy W. Marshall
Schaumburg, IL

If your printer loses data after printing several lines, it is an indication that handshaking between the printer and the computer is not occurring. Handshaking is the means of telling the computer to send data only when the printer is ready to accept it. Adding a buffer will only postpone the problem, since data loss will occur after the buffer is full.

The solution is to check the handshaking signals between the computer and the printer. For a serial port, the signals are Request-to-Send (RTS) and Clear-to-Send (CTS). For a parallel port, the signals are Acknowledge (ACK), Data Accepted, or something similar. When these are properly connected, the flow of data from the computer will stop until the printer can catch up. This method is also much simpler than adding a buffer to the printer. For an idea of how RS-232C interfaces work, you may want to refer to Ian H. Witten's "Welcome to the Standards Jungle" (February 1983 BYTE, page 146). . . . **Steve**

Parts Located

Dear Steve,

I want to build my own personal computer (perhaps several) from the ground up so that I can learn about computers. I have a book by Charles Adams that gives plans for a computer, but I cannot find two parts that he specifies: 7093-type integrated circuits and an 8½-by 16-inch Vector board. Do you know where I can find them?

R. C. Coakley
Flandreau, SD

The 7093 chips referred to in Charles Adams's book, How to Build Your Own Working Computer *(Blue Ridge Summit, PA: Tab Books, 1979), are known as Tri-State (three-state) Quad Buffers and are made by National Semiconductor. They are equivalent to the DM8093 or the more common 74LS125. The latter is a pin-compatible replacement and is available from any of the mail-order houses that advertise in BYTE, such as Advanced Computer Products, Jade Computer Products, and Jameco Electronics.*

The Vector board is made by Vector Electronic Company (12460 Gladstone Ave., Sylmar, CA 91342) and is available in a variety of styles and materials (I prefer the epoxy glass). It consists of holes spaced at intervals of ⅒ inch on center in both directions. The model number for the 8½- by 17-inch board is 169P84. Vector boards can usually be obtained from the above mail-order sources. . . . **Steve**

Information on NASA's Videodiscs

Dear Steve,

I am most interested in your article "Build an Interactive-Videodisc Controller" (June 1982 BYTE, page 60). The text box accompanying it mentioned that NASA was producing videodiscs for distribution sometime in the near future. Do you have any further information?

Thank you.

R. Teakes
Toronto, Ontario, Canada

For further information, write to the Jet Propulsion Laboratory, Planetary Image Facility, 4800 Oak Grove Dr., Pasadena, CA 91103, Attn: Mr. Michael Martin, Planetary Data Management Team. . . . **Steve** ■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

Ask BYTE
c/o Steve Ciarcia
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, chat with Steve (TEC317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

Software Received

Apple

Concentrated Chemical Concepts. This introductory chemistry course for high school students is available as a whole or in parts: general, organic, and biological chemistry. For the Apple II; floppy disk, $550. Wiley Educational Software, John Wiley & Sons, 605 Third Ave., New York, NY 10158.

Correlated Samples, an educational program designed to teach difficult concepts in elementary statistics to high school and undergraduate students. For the Apple II; floppy disk, $75. HMS Software, POB 49186, Austin, TX 78765.

Dow Jones News and Quotes Reporter, a database information service. You can access the Dow Jones online database to receive current information on stocks and securities from *The Wall Street Journal, Barron's,* and the Dow Jones News/Retrieval Service. For the Apple II Plus; floppy disk, $135. Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014.

Econalysys. This economic-forecaster program helps you determine the best of several possible investments by comparing the costs of any energy- or maintenance-intensive purchase in six ways. For the Apple IIe; floppy disk, $100. Energy Software, 1403 South 7th Ave., Kelso, WA 98626.

Family Roots 1.2, a set of programs that assist you in your search for family historical information. You can edit, search, file, chart, print, and further organize family data. For the Apple IIe; floppy disk, $185. Quinsept Inc., POB 216, Lexington, MA 02173.

Health-Aide, a nutritional, diet, and personal data system designed to provide a comprehensive analysis of your health. For the Apple II; floppy disk, $79.95. Knossos Inc., 422 Redwood Ave., Corte Madera, CA 94925.

Laser Bounce, an arcade-type game. You must destroy enemy energy modules by bouncing laser beams off moving satellites and defend your own modules from the same attack. For the Apple II; floppy disk, $34.95. Hayden Software Co., 600 Suffolk St., Lowell, MA 01853.

Old Ironsides, a naval-battle game. As animated ships fire at each other, two players can either shoot out each other's ammunition or hide in the fog and contend with the wind. For the Apple II; floppy disk, $39.95. Xerox Education Publications, Computer Software Division, 245 Long Hill Rd., Middletown, CT 06457.

Pick That Tune, a musical-identification game. See if you can identify a song after hearing only a few notes. One to ten players can move through sixteen levels of difficulty. For the Apple II; floppy disk, $29.95. Swearingen Software, Suite 197, 6312 West Little York, Houston, TX 77088.

Pinball Construction Set, a video-construction set. You can design and build your own high-resolution pinball games using video tools and parts to make borders and obstacles. For the Apple II; floppy disk, $39.95. Budge Co. Inc., 428 Pala Ave., Piedmont, CA 94611.

Stickybear ABC, an educational program. Colorful animations help children between the ages of 3 and 6 to learn each letter of the alphabet. For the Apple II; floppy disk, $39.95. Xerox Education Publications (see address above).

Stickybear Bop, a game for the whole family. In this animated shooting gallery see if you can knock ducks, planets, balloons, and Stickybears off the screen. For the Apple II; floppy disk, $39.95. Xerox Education Publications (see address above).

Stickybear Numbers, an educational program. Colorful objects that move across the screen help children learn numbers and counting skills. For the Apple II; floppy disk, $39.95. Xerox Education Publications (see address above).

Zipscript, a word-processing system. This line-oriented text editor provides more than 65 editing and formatting commands. It is suitable for building data files and editing BASIC programs. For the Apple II Plus; floppy disk, $49.95. Carter-mation, 3245 Pursell Dr., Pensacola, FL 32506.

Atari

Jumbo Jet Pilot, a flight-simulation game. Put yourself in the pilot's seat, maneuver your way through the clouds to a safe landing, and receive a performance rating. Ten game variations; requires a joystick. For the Atari 400/800; cartridge, $49.95. Thorn EMI, 1370 Avenue of the Americas, New York, NY 10019.

The Magic Melody Box. This educational program lets you learn to create music simply by drawing a line. See and hear the computer harmonize your rhythm and melody in a song. Requires a joystick. For the Atari 400/800; floppy disk, $15.95. Atari Program Exchange, 3281 Scott Blvd., POB 3705, Santa Clara, CA 95055.

Soccer, a soccer-animation game. Try to score a goal as you dribble the ball down the field. Features include goals, lines, a time clock, and 200 variations. Requires one to four joysticks. For the Atari 400/800; cartridge, $49.95. Thorn EMI (see address above).

Submarine Commander, a submarine-patrol game. Your submarine must attack and destroy the enemy merchant-shipping boats in the Mediterranean. Requires one joystick. For the Atari 400/800; cartridge, $49.95. Thorn EMI (see address above).

CP/M

TCS Simple. This information-filing system allows you to store, query, and generate reports from database files. It can also create record types for logical organization of data. This utility package is designed to be used in conjunction with the TCS Total Accounting System. For CP/M 2.2-based systems, floppy disk. Price not available. TSC Software, 3209 Fondren Rd., Houston, TX 77063.

Z80 DIS. This disassembler package for Z80-based CP/M systems takes binary information from a disk file and converts it to either a source file or a listing file. For CP/M-based systems; floppy disk, $69.95. SLR Systems, 200 Homewood Dr., Butler, PA 16001.

Commodore

Arcadia, an arcade-type game. Defend your planet from multicolored aliens as they peel out of formation and attack your base. Eight skill levels; requires one joystick. For the Commodore VIC-20; cassette, $24.95. Startech Inc., Suite 204, 13900 Northwest Passage, Marina del Rey, CA 90291.

Bunny, an arcade-type game. Guide the bunny across a crowded highway, dodging speeding cars and trucks, and finally cross a river to safety. Requires a joystick. For the Commodore VIC-20; cassette, $24.95. Startech Inc. (see address above).

Mailfile, a mailing-list program. You can save up to 200 names and addresses per file. For the Commodore 64 and VIC-20; cassette, $14.95. Step Industries, POB 52605, Houston, TX 77052.

Ski-Run, an arcade-type game. Three skiing-simulation games in one: slalom, downhill, and giant slalom. Each game has nine skill levels. For the Commodore VIC-20; cassette, $24.95. Startech Inc. (see address above).

Super 64 Music Maker, a musical program that plays, saves, loads, and modifies music digitally with the Commodore Datasette. For the Commodore 64; cassette, $19.95. Seyau-Kaun Loke, 1021-H West Bishop, Santa Ana, CA 92703.

IBM Personal Computer

APL*Plus/PC, a utility package that is an implementation of the APL computer programming language. For the IBM Personal Computer; floppy disk, $495. STSC Inc., 2115 East Jefferson St., Rockville, MD 20852.

The Apartment House Manager, a user-friendly accounting program that keeps track of accounts related to managing an apartment house: tenants, leases, deposits, payments, and expenses. For the IBM Personal Computer; floppy disk, $395. User-Friendly Software Inc., POB 1192, Melville, NY 11747.

Basic Programming Tools. These five utility tools make programming in BASIC easy and efficient. For the IBM Personal Computer; floppy disk, $120. Synergistic Software, Suite 201, 830 North Riverside Dr., Renton, WA 98055.

The Chrome Ranger, an arcade-type game. Score points by collecting gold nuggets, grabbing energy tablets, and capturing the bandits in the maze. For the IBM Personal Computer; floppy disk, $29.95. Omniware, 8972 East Hampden Ave., POB 32, Denver, CO 80231.

Disk Magic. An easy-to-use utility program that allows you to access data on a disk at the sector level. Handy for locating control characters or repairing a damaged disk. For the IBM Personal Computer; floppy disk, $49.95. Norell Data Systems Corp., 3400 Wilshire Blvd., POB 70127, Los Angeles, CA 90010.

EZ*Maillabel, a mailing-list and label program. Records can be sorted by any field or fields with up to 64 total characters. For the IBM Personal Computer; floppy disk, $85. Data Consulting Group, 877 Bounty Dr. #EE203, Foster City, CA 94404.

EZ*Retail Plus. This sales and inventory-control program is a comprehensive method to control low-to-medium-volume retail or discount sales. For the IBM Personal Computer; floppy disk, $245. Data Consulting Group (see address above).

EZ*Screenaid. This screen-design generator works quickly and codes for data input efficiently. For the IBM Personal Computer; floppy disk, $35. Data Consulting Group (see address above).

E-Z—Tax. This user-friendly program makes tax-preparation easy to do on a home computer with prompts. It automatically computes your lowest tax. For the IBM Personal Computer; floppy disk, $69.95. E-Z—Tax, 2444 Moorpark Ave., San Jose, CA 95128.

EZ*Utilities, basic programmer aids. You can improve your productivity in data processing by eliminating time-consuming tasks. For the IBM Personal Computer; floppy disk, $65. Data Consulting Group (see address above).

Easycalc. This easy-to-use spreadsheet-calculator program computes budgets, projects investment returns, and figures taxes. For the IBM Personal Computer; floppy disk, $99.95. Norell Data Systems Corp. (see address above).

Easytext. This utility program formats documents that are well-spaced, clearly typed, and indexed according to your specifications. For the IBM Personal Computer; floppy disk, $79.95. Norell Data Systems Corp. (see address above).

Eliza, an educational game. Carry on a typed, two-way conversation with your computer using this recreation of the artificial intelligence program developed at MIT. For the IBM Personal Computer; floppy disk, $24.95. Norell Data Systems Corp. (see address above).

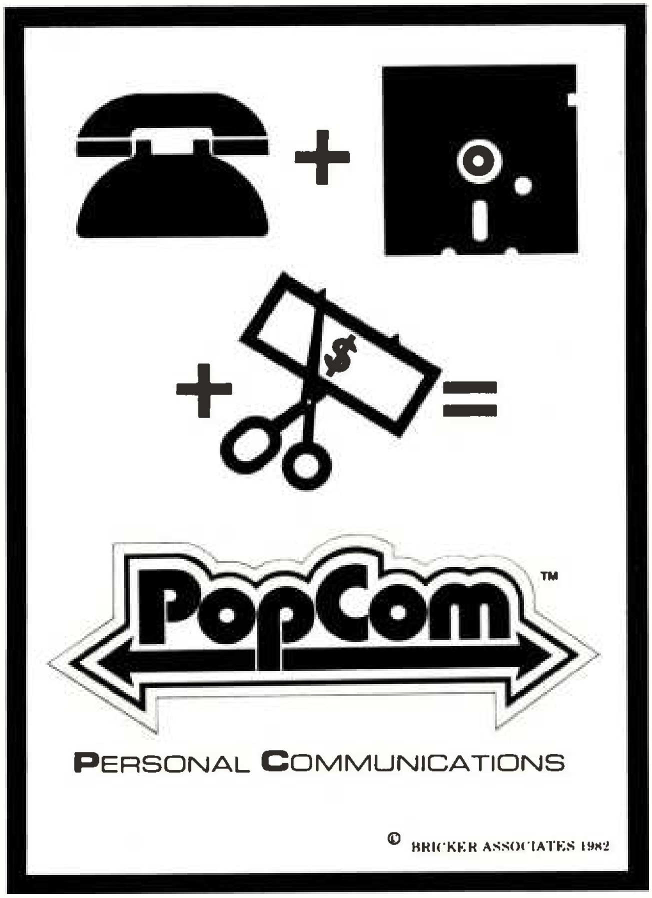
Flip-ello, a video game similar to the board game Othello that flips the pieces, keeps score, and offers advice and remarks. For one or two players. For the IBM Personal Computer; floppy disk, $12.50. Resuba Digital Systems, POB 440, Department 7, Blackwood, NJ 08012.

Fluidpak, an engineering program that contains subroutines to compute data on fluids-handling equipment such as turbines, compressors, fans, and cyclones. For the IBM Personal Computer; floppy disk, $225. Physical Sciences Inc., Research Park, Andover, MA 01810.

Graph 'n' Calc. A utility program that lets you quickly prepare a variety of stacked and side-by-side bar, line, and pie charts in high-resolution color graphics. For the IBM Personal Computer; floppy disk, $199. Desktop Computer Software Inc., 303 Potrero St., 29/303, Santa Cruz, CA 95060.

HXpak, an engineering program that provides analytical information on heat-exchangers: their general organization and the use of three modules used to model them. For the IBM Personal Computer; floppy disk, $275. Physical Sciences Inc. (see address above).

Hoser, an interactive color game. Try to prevent a thirsty hose, seeking a faucet in a yard filled with obstacles, from turning against you. For the IBM Personal Computer; floppy disk, $29.95. PC Connection, Mill St., Marlow, NH 03456.



Software Received

Kaleida. This interactive kaleidoscope generator is designed purely to provide a relaxing visual experience. For the IBM Personal Computer; floppy disk, $12. Once Begun Computations, Searsport, ME 04974.

Mathpak, a set of subroutines for solving engineering equations, algorithms, matrices, and more. For the IBM Personal Computer; floppy disk, $75. Physical Sciences Inc. (see address above).

Mechanical Engineering TK!Solver Pack, a mechanical-engineering program designed to run in conjunction with TK!Solver. For the IBM Personal Computer; floppy disk, $100. Software Arts Inc., 27 Mica Lane, Wellesley, MA 02181.

Munchkin, an arcade-type game. As you move your Munchkin through the maze eating dots, you must avoid getting eaten yourself. For the IBM Personal Computer; floppy disk, $24.95. Norell Data Systems Corp. (see address above).

1-2-3, a program that integrates information management, spreadsheet, and graphing functions. For the IBM Personal Computer (Compaq Portable Computer-compatible), floppy disk, $495. Lotus Development Corp., 55 Wheeler St., Cambridge, MA 02138.

The Original Adventure, an adventure-type game. In your exploration of Colossal Cave you can find a fortune in treasure and gold, solve puzzles, and become a wizard. For the IBM Personal Computer; floppy disk, $24.95. Norell Data Systems Corp. (see address above).

The Phantom's Revenge, an adventure-type game. In this classic adventure game you explore above and below ground for the treasure while avoiding danger. For the IBM Personal Computer; floppy disk, $24.95, Norell Data Systems (see address above).

S3Epak, an engineering program for steady-state systems that includes a tutorial on power-plant and chemical-system analyses as well as information on a fuel-cell power plant. For the IBM Personal Computer; floppy disk, $50. Physical Sciences Inc. (see address above).

TE100-FT, a utility package. This easy-to-use extension program allows your computer to function as a Digital Equipment Corporation VT100 series terminal emulator with ASCII file transfer. For the IBM Personal Computer; floppy disk, $150. Persoft Inc., 2186 U.S. Highway 51, Stoughton, WI 53589.

TK!Solver, a program that allows you to solve simple or complicated equations without knowing how to program. Just enter the equations you need, supply the known values, and press a key. For the IBM Personal Computer; floppy disk, $299. Software Arts Inc. (see address above).

A TRS-80 to IBM Tape Loader/Converter. This utility program will convert a TRS-80 BASIC program to run on an IBM Personal Computer. For the IBM Personal Computer; floppy disk, $25. T. R. Coxon, 33 Parkland Dr., Elton, Chester, England.

Thermopak, an engineering program to calculate enthalpy, temperature, vapor pressure, thermal conductivity, and equilibrium constants for pure and mixed chemical turbines. For the IBM Personal Computer; floppy disk, $100. Physical Sciences Inc. (see address above).

Thermo3pak, a high-precision version of Thermopak for dealing with water or ammonia in the evaluation of steam turbines. For the IBM Personal Computer; floppy disk, $200. Physical Sciences Inc. (see address above).

TRS-80

Autogrammer, a utility package. This automatic program-generation tool is for people who need to write customized microcomputer-based programs, but do not know programming languages. For the TRS-80 Model II; floppy disk, $299.95. Roklan Corp., 3335 North Arlington Heights Rd., Arlington Heights, IL 60004.

Copyart II, a utility package. A word-graphics processor that allows you to edit, format, print, fix crashed disks, write mailing lists, and more. For the TRS-80 Model I and III; floppy disk, $150. Simutek Computer Products Inc., 4897 East Speedway Blvd., Tucson, AZ 85712.

Maxi Mail, a utility package. This database-management system allows you to manage an extensive mailing list, generate labels and reports quickly, and merge text with most word processors. For the TRS-80 Model III; floppy disk, $99.95. The Business Division, POB 3435, Longwood, FL 32750.

Power Driver, a utility program for use with SuperScripsit that allows you to use the special features of the Epson MX80/100 printers such as superscripts, subscripts, underlining, and proportional modes. For the TRS-80 Models I and III; floppy disk, $29.95. Powersoft, Suite 125, 11500 Stemmons Expressway, Dallas, TX 75229.

Profile III Plus, a database-management program that allows you to organize files and manipulate data through storage and retrieval. It also performs math functions. For the TRS-80 Model III, floppy disk, $199. Radio Shack, One Tandy Center, Fort Worth, TX 76102.

64K Disk Utility Package, three utility programs: Romcrack, Software Print Spooler, and a 40K relocator. For the TRS-80 Color Computer; floppy disk, $23.95. Spectrum Projects, 93-15 86th Dr., Woodhaven, NY 11421.

Speak Up! a voice-synthesizer program that lets you type in words and sentences to be spoken or add speech statements to BASIC programs. For the TRS-80 Color Computer; cassette, $29.95. Classical Computing Inc., POB 12247, Lexington, KY 40582.

SuperScripsit, a program that simplifies word processing by eliminating the need for retyping. It allows you to type, proofread, revise, and print letters formatted to your specifications. For the TRS-80 Model III; floppy disk, $199. Radio Shack (see address above).

Other Computers

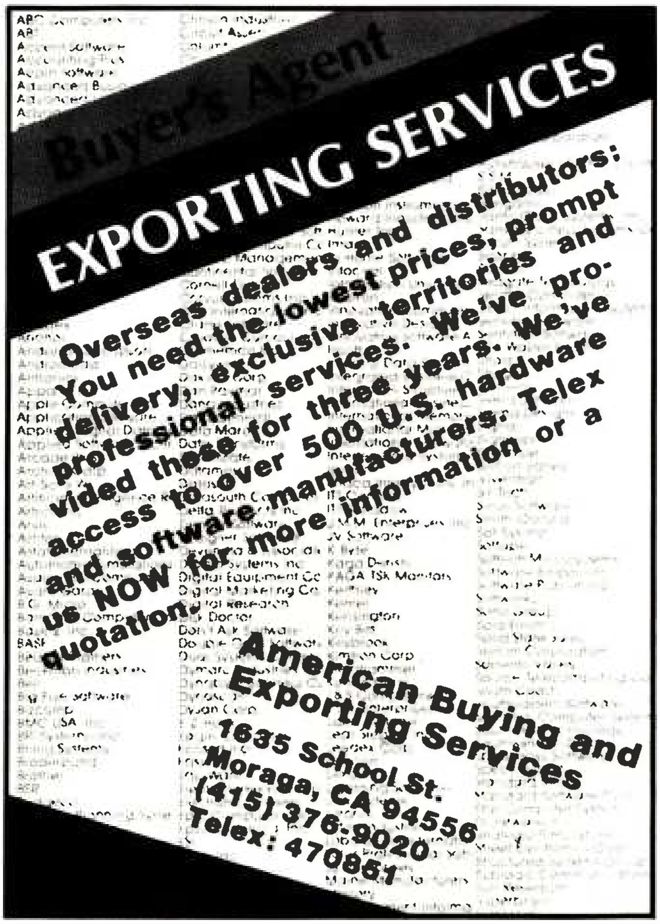
Datatree, a utility package. A database-management system designed for use with mailing lists, student/teacher records, bibliographies, business accounts, and a variety of other applications. For the Sage II; floppy disk, $150. Arizona Computer Systems Group Inc., POB 40878, Tucson, AZ 85717.

Pedigree Manager. This pedigree-documentation program is for breeders of pedigreed animals to keep records on the lineage of animals up to three or four generations. For the Heath/Zenith H-/Z-89 or Z-90, floppy disk, $25. RCK Associates, 640 Trephanny Lane, Wayne, PA 19087.

Xtal BASIC 3.1, a utility package. This updated version of the Xtal BASIC 2.2 enables you to write subroutines and insert owner-defined words in an auxiliary word table. For the Osborne 1; floppy disk. Price not available. Crystal Research Ltd., 40 Magdalene Rd., Torquay, Devon, England.■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.



Event Queue

June 1983

June

Continuing Engineering Education Courses, George Washington University, Washington, DC. Among the courses available are "Computer Communications Systems and Networks," "A Phased Approach to Software Conversion," and "Microcomputer Applications Workshop." Course fees range from $625 to $855. For information, contact Douglas Green, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-8512.

June

Courses from Ken Orr and Associates, various sites throughout the U.S. Among the courses being offered are "Structured Requirements Definition" and "Structured Systems Design/Structured Program Design." Further details are available from Gayle Giesecke, Ken Orr and Associates Inc., 1725 Gage Blvd., Topeka, KS 66604, (800) 255-2459; in Kansas, (913) 273-0653.

June

Courses from Q.E.D. Information Sciences, various sites throughout the U.S. Some of the courses listed are "Systems Analysis Workshop," "Project Management and Control," and "Data Analysis." Address inquiries to Priscilla Goudreault, Q.E.D. Information Sciences Inc., Q.E.D. Plaza, POB 181, Wellesley, MA 02181, (800) 343-4848; in Massachusetts, (617) 237-5656.

June

Data Processing Courses, Hartford Graduate Center, Hartford, CT. Among the courses being offered are "ANS COBOL Programming Workshop 1" and "CICS/VS Macro Level Coding Workshop." These data-processing courses are available for on-site presentation. For details, contact Don Florek, The Hartford Graduate Center, 275 Windsor St., Hartford, CT 06120, (203) 549-3600, ext. 252, 253, or 254.

June

Intel Microcomputer Workshops, various sites throughout the U.S. Among the workshops to be held are "Introduction to Microprocessors" and "iAPX 86, 88, 186 Microprocessors." Intel Customer Training courses are available for on-site presentation. For details, contact Intel Corp., Mail Stop SV3-1, 3065 Bowers Ave., Santa Clara, CA 95051.

June

Intensive Seminars of Interest to Data Processing Professionals, Boston metropolitan area. Among the two- to five-day seminars offered are "Project Management" and "Creative Problem Solving." Registration fees range from $495 to $975. For a seminar bulletin, contact Ms. Ginny Bazarian, Office of Continuing Education, Higgins House, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517.

June

Management Development Programs, Providence, RI, Boston, MA, and Hartford, CT. The Center for Management Development offers seminars on a variety of topics, including communications, industrial relations, and electronic data processing. Many of the Center's programs can be conducted on location for your organization. For details, contact The Center for Management Development, Bryant College, Smithfield, RI 02917, (401) 231-1200, ext. 314.

June

Microprocessor Seminars, Rochester Institute of Technology, Rochester, NY. Five one-week seminars are offered: "Basic 8085," "Advanced 8085," "Basic 6800," "Advanced 6800," and "Advanced Digital Electronics." Hands-on experience is provided. The fee is $480. Contact Jeanne Berry or Stacy Jordan, Rochester Institute of Technology, Rochester, NY 14627, (716) 475-2915.

June

Office Automation: Tee to Green, various sites throughout the U.S. This three-day seminar for administrative and information-systems professionals addresses productivity issues and opportunities presented by automating the office workplace. Seminar objectives include establishing long-range office systems plans and developing integrated communications systems. The fee is $385 for members of the Data Processing Management Association Education Foundation (DPMA/EF) or $410 for nonmembers. For registration information, contact DPMA/EF Conferences, D. L. Hiller & Associates, 14536 Island Dr., Sterling Heights, MI 48078, (313) 247-8444.

June

Professional Development Seminars, various sites throughout the U.S. Data communications, database management, software and systems, and computer-aided design/manufacturing are some of the areas investigated in seminars offered by the Institute for Advanced Technology. For a catalog, contact the Registrar, Institute for Advanced Technology, Control Data Corp., 6003 Executive Blvd., Rockville, MD 20852, (800) 638-6590; in Maryland, (301) 468-8576.

June

Seminars in Simulation, Management, Statistics, and Computer Science, various sites throughout the U.S. "Simulation Modeling for Decision Making," "Database Design," and "Systems Analysis and Design" are some of the topics to be presented. For information, contact The Institute for Professional Education, POB 756, Arlington, VA 22216, (703) 527-8700.

June-July

Courses from Integrated Computer Systems, various sites throughout the U.S. Course titles include "Computer Graphics," "Hands-On Pascal Workshop," "Defining Software Requirements, Specifications, and Tests," and "Computerized Robots." Fees range from $695 to $845. For information, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, or call (213) 450-2060.

June-July

Productivity '83, various sites throughout the U.S. and Canada. Hewlett-Packard's hands-on showcase of more than 32 computer products and 17 seminars is designed for both professionals and novices and aims to provide solutions to problems confronting the data processing industry. For details, call (800) 453-9500.

June-July

Software Workshops in MMSFORTH, Boston metropolitan area. These workshops are public versions of the professional training Miller Microcomputer Services (MMS) offers client companies in support of its MMSFORTH product line. A variety of topics and skill levels are covered. Full details are available from Miller Microcomputer Services, 61 Lake Shore Rd., Natick, MA 01760, (617) 653-6136.

June-July
Technical Courses from Zilog, Campbell, CA. A wide variety of such courses as "Advanced Peripherals," "C Programming," and "ZEUS/System 8000 User Course" are offered. Fees range from $175 to $875. For a complete schedule, contact Zilog Inc., Training and Education Department, 1315 Dell Ave., Campbell, CA 95008, (408) 370-8092.

June-August
Courses in C Language and Unix, various sites throughout the U.S. Three 5-day courses are offered by Plum Hall Inc. The "C Programming Workshop" is a hands-on course that covers all aspects of the C language for individuals able to program in another language. The "Advanced C Topics Seminar" covers efficiency, portability, readability, debugging, packaging, and interfacing. The "Unix Workshop" is an introductory course that focuses on software development. For further details, contact Joan Hall, Plum Hall Inc., 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770.

June-August
Engineering Summer Conferences, Chrysler Center for Continuing Engineering Education, North Campus, University of Michigan, Ann Arbor. More than 25 courses are offered in aerospace, chemical, civil, environmental, electrical, fluid, computer, information, and control engineering. One-week course fees range from $500 to $775; two-week courses are $875. For course outlines and registration details, contact Engineering Summer Conferences, 200 Chrysler Center, North Campus, University of Michigan, Ann Arbor, MI 48109, (313) 764-8490.

June-October
Courses from the AMA, various sites throughout the U.S. The American Management Associations (AMA) offers an on-going series of seminars in such areas as human resources, information systems, and manufacturing and technology management. In-house development and training seminars can be arranged. For information on AMA membership or seminar particulars, contact the American Management Associations, 135 West 50th St., New York, NY 10020, (212) 586-8100.

June-December
IEEE Conferences and Meetings, various sites around the world. The Institute for Electrical and Electronics Engineers (IEEE) sponsors conferences, meetings, and workshops covering high-technology issues. For details, contact the IEEE Computer Society, Suite 300, 1109 Spring St., Silver Spring, MD 20910, (301) 589-8142.

June-December
Intensive Two-Day Seminars for Professional Development, Worcester Polytechnic Institute, Boston metropolitan area and Hartford and Stamford, CT. Among the seminars being offered are "The Engineer as Manager," "Inventory Control: Using Computers," and "Fundamentals of Data Processing." For in-house seminar infor-

mation, call Robert J. Hall at (617) 793-5574. For a seminar bulletin and registration details, contact Ms. Ginny Bazarian, Office of Continuing Education, Higgins House, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517.

June-December
Systems Development Documentation: Forms Method, various sites throughout the U.S. and Canada. This one-day seminar is designed for data-processing managers, project leaders, programmers, and technical writers. Topics to be covered include system design documentation, format and style guidelines, and options for end-document publication. The course fee is $155, which includes all materials. In-company presentations are available for groups of 10 or more. For details, contact Technical Communications Associates Inc., 1250 Oakmead Parkway #210, Sunnyvale, CA 94086, (800) 227-3800, ext. 977; in California, (800) 792-0990, ext. 977, or (408) 737-2665.

June 10-12
International Conference on Databases in the Humanities and Social Sciences-ICDBHSS/83, Douglass College, Rutgers University, New Brunswick, NJ. Speakers from 24 countries will present papers on the structure, accessibility, and uses of databases in fields that include archaeology, religion, music, and law. The conference language is English. Registration fees are $80. For information, contact Dr. Robert Allen, Bishop House, Room 306A, Rutgers University, New Brunswick, NJ 08903, (201) 932-7335 or (201) 932-7505.

June 11-12
NJ-NY-CT Microcomputer Show and Flea Market, Meadowlands Hilton Hotel, New Jersey Sports Complex, East Rutherford, NJ. More than 75 commercial exhibitors and 200 flea-market booths will feature hardware, software, magazines, and accessories for all popular computing systems ranging from Apple to Zenith. Registration is $5 for adults and $2 for children under 12. Contact Kengore Corp., POB 13, Franklin Park, NJ 08823, (201) 297-2526.

June 13-15
Analysis and Design-Oriented Techniques, Los Angeles, CA. For details on this power-electronics course, contact Teslaco, Suite 6, 490 South Rosemead Blvd., Pasadena, CA 91107, (213) 795-1699.

June 13-15
The Sixteenth Annual Association of Small Computer Users in Education Conference, Taylor University, Upland, IN. This conference will feature formal papers and demonstrations of both the academic and administrative uses of computers. Topics on the agenda include "Artificial Intelligence in the Small College" and "How to Manage the Microkids." A one-day seminar on data communications will be held. Further information is available from Dr. Wally Roth, Department of Information Science, Taylor University, Upland, IN 46989, (317) 998-2751, ext. 269.

June 13-15
Systematic Software Maintenance, Chicago, IL. Topics to be addressed include structured methodologies, solutions for effective testing, resource allocation, and status determination. Full details are available from Eduteach Inc., Suite 907, 162 North State St., Chicago, IL 60601, (312) 641-1370.

June 14-16
Introduction to Microprocessors, University of Texas, Austin. This course will stress basic concepts with hands-on experience. Participants will write and run simple programs on a Z80-based Micro-Professor training system. Contact the College of Engineering, University of Texas, Austin, TX 78712, (512) 471-3396.

June 14-16
Ohmcon/83, High Technology Electronics Exhibition and Convention, Cobo Hall, Detroit, MI. For details, contact Electronic Conventions Inc., 999 North Sepulveda Blvd., El Segundo, CA 90245, (800) 421-6816; in California, (213) 772-2965.

June 14-16
Technology Opportunity Conference, Washington, DC. This conference will focus on the convergence of optical-storage, videodisc, and computer technologies. For full details, contact Technology Opportunity Conference, POB 14817, San Francisco, CA 94114, (415) 626-1133.

June 14-18
Tectronica, Earls Court Exhibition Centre, London, England. This exhibition on laboratory technology aims to show the latest in instrumentation, equipment, and services for life and physical sciences. For details, contact Good Relations Ltd., 15 Adeline Place, London WC1B 3AJ, England; tel: (01) 636-6561; Telex: 265903.

June 15-17
Basics of Power Electronics, Los Angeles, CA. For information on this course, contact Teslaco, Suite 6, 490 South Rosemead Blvd., Pasadena, CA 91107, (213) 795-1699.

June 15-17
The Twenty-first Annual Meeting of the Association for Computational Linguistics, Massachusetts Institute of Technology, Cambridge, MA. Papers to be presented will address syntax, the representation of knowledge, machine and machine-aided translation, and other linguistically and computationally significant topics. Information is available from Don Walker, Artificial Intelligence Center, SRI International EJ278, Menlo Park, CA 94025, (415) 859-3071.

June 16-17
Clinical Laboratory Computers: Symposium 1983, Towsley Center for Continuing Medical Education, Ann Arbor, MI. Course credit will be offered. Contact the Office of Continuing Medical Education, Towsley Center Box 057, University of Michigan Medical School, Ann Arbor, MI 48109, (313) 763-1400.

June 16-18
Personal Computer Interfacing and Scientific Instrument Automation, Reston, VA. This workshop provides each participant with hands-on experience in wiring and testing interfaces. The fee is $395. Call or write Dr. Linda Leffel, C.E.C., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848.

June 17-19
PC '83/West, Brooks Hall/Civic Center Complex, San Francisco, CA. This show will bring together users, developers, distributors, and retailers of products that are compatible with the IBM Personal Computer. Seminars, workshops, demonstrations, and a conference program will aim to educate users on product features and capabilities. Further details are available from Northeast Expositions, 826 Boylston St.,

Chestnut Hill, MA 02167, (800) 841-7000; in Massachusetts, (617) 739-2000.

June 19-23
Conference on Computer Vision and Pattern Recognition–CVPR '83, Crystal City Hyatt, Arlington, VA. This program, at one time called the Pattern Recognition and Image Processing Conference, provides a forum for the presentation of papers on vision, pattern recognition, and image processing. For full details, write to CVPR '83, POB 639, Silver Spring, MD 20901.

June 19-24
Problem Solving Leadership, Washington, DC. This workshop, designed to help managers and technical leaders enhance their problem-solving effectiveness, is sponsored by the Data Processing Management Association Education Foundation. Further information is available from Judy Cook, Weinberg & Weinberg, R R #2, Lincoln, NE 68505, (402) 781-2542.

June 20-24
Physical Data Analysis, Columbia Inn, Columbia, MD. For details, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111; on the West Coast, (213) 824-9545.

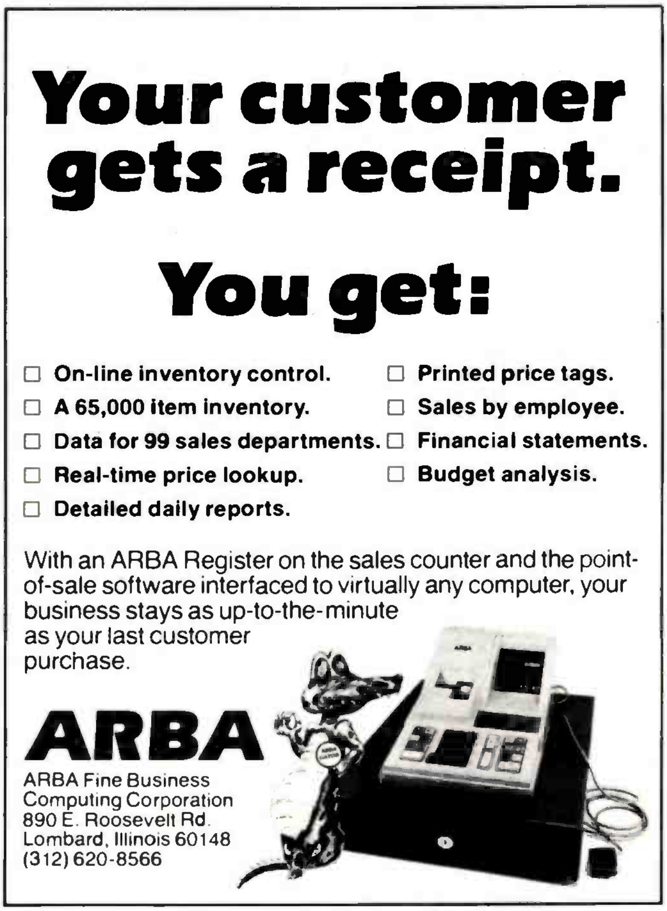
June 20-July 15
Computers in Education '83—CE '83, Rutgers University, New Brunswick, NJ. The theme of this conference is "Necessary Direction for Computer Education: Navigational Aids for the 80s." The focus will be on the impact of microcomputers on elementary, secondary, and college-level education. Conference highlights include presentations, special-interest sessions, a software exchange, film festival, and a variety of exhibits. The fee for the conference is $145.

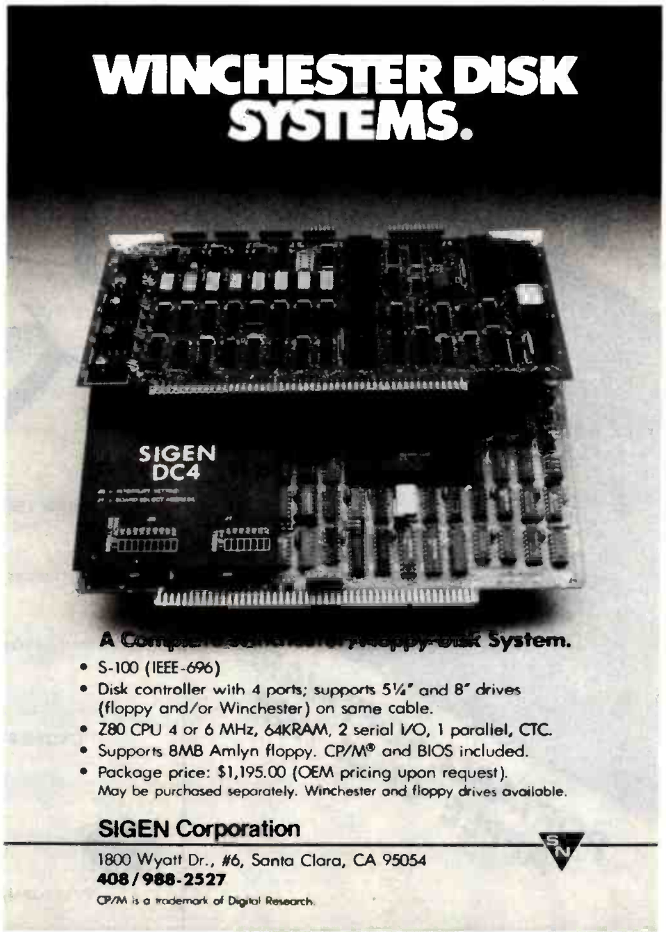
Running concurrently with CE '83, the Summer Institute for educators offers 40 short courses, ranging in length from one to twelve days. Topics include "The Turtle is the Teacher: An Introduction to Logo," "Using Computers in the Elementary School," and "Algorithm Design." These courses are $95 per day; preregistration is required. For additional information, contact Dr. Mitchell E. Batoff, Director CE '83, Institute for Professional Development, Suite D, 245 Nassau St., Princeton, NJ 08540, (609) 924-8333.

June 21-23
The Engineer as a Manager, Quail Lodge, Carmel, CA. For details, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111; on the West Coast, (213) 824-9545.

June 22-24
Machine Vision/Image Understanding, Los Angeles, CA. For details, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111; on the West Coast, (213) 824-9545.

June 23
The Twenty-second Annual Technical Symposium of the Washington DC Chapter of the Association for Computing Machinery, National Bureau of Standards, Gaithersburg, MD. The theme for this event is "Microcomputer Systems: Tools or Toys?" Topics





of interest include systems software, human factors, and office systems. For further details, contact Howard Weeks Associates, 15201 Shady Grove Rd., Rockville, MD 20850.

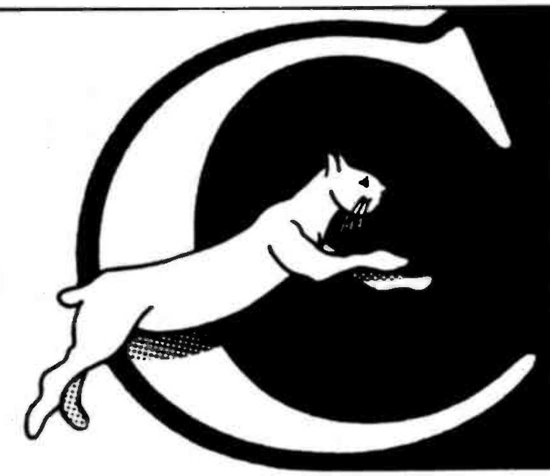
June 23-24
Computer Graphics in Design, Chicago, IL. This seminar begins with the historical development of computer images and an introduction to graphics programming. It ends with participants using a digital-art system to create charts, graphs, and free-form art. It's sponsored by the Dynamic Graphics Educational Foundation (DGEF). For a catalog and registration details, contact DGEF, Department R, 6000 North Forest Park Dr., POB 1901, Peoria, IL 61656, (309) 688-8866, ext. 505.

June 23-24
Shared Information Management Seminar, Hyatt Regency, Chicago, IL. This seminar is designed for department heads, information-center managers, senior applications personnel, and data-processing support coordinators. It strives to explain how to manage the development of new systems with reduced risk and how to introduce new flexibility into data processing. The fee is $455. Group discounts are available. For further information, contact Bob Mishler, Boeing Computer Services Co., Education and Training Division, POB 24346, Mail Stop 9A-90, Seattle, WA 98124, (800) 342-7700; in Washington, call collect, (206) 575-7700.

June 23-25
The Executive Microcomputer Conference & Exposition, Sheraton Centre, New York, NY. The main conference program will offer sessions ranging from how to buy a personal computer to new and future trends in personal computing. A special seminar for educators and administrators, "Microcomputers in Education," will highlight issues in educational computing. For details, contact CW Communications Inc., 375 Cochituate Rd., POB 880, Framingham, MA 01701, (800) 225-4698; in Massachusetts, (617) 879-0700.

June 27-28
Computer Literacy for Lawyers, San Francisco, CA. This seminar is intended to introduce attorneys to basic computer concepts and their application to the practice of law. Topics will include the specific uses, costs, and benefits of using computers in legal practice. The fee is $550, which includes reference materials. Group discounts are available. For further information, contact Kathryn Mann, Center for Legal Studies, 1926 Arch St., Philadelphia, PA 19103, (215) 732-6999.

June 27-30
The World of CAD/CAM, Marriott Resort, Newport Beach, CA. This seminar provides an overview of how manufacturing will change as the automated factory becomes a reality. It will consist of four one-day presentations in computer-aided engineering, design, manufacturing, and computer-integrated manufacturing. For a brochure, write or call the Center for Manufacturing Technology, 4170 Crossgate Dr., Cincinnati, OH 45236, (513) 791-8801.



June 27-July 1
Auditing Integrity Controls in the Contemporary Computer Environment, San Diego, CA. This program is designed to provide an overview of the computer environment, its controls, and its interrelationships. It combines theoretical and practical approaches for electronic data-processing auditing, with an emphasis on integrity controls and related operational concerns. Further details are available from Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187, (312) 682-1200.

June 27-July 1
Managing the Development and Introduction of New Products, University of Wisconsin, Madison. The fee for this course is $595. Contact William C. Dries, University of Wisconsin-Extension, Department of Engineering and Applied Science, 432 North Lake St., Madison, WI 53706, (608) 262-2061.

June 27-July 1
Physical Data Analysis, Miramar-Sheraton Hotel, Santa Monica, CA. For details, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111; on the West Coast, (213) 824-9545.

June 28-30
National Educational Computer Conference, New York Statler Hotel, New York, NY. The theme of this conference is "Higher Instructional Techniques in Education." Seminars, exhibits, hands-on demonstrations, and workshops will highlight this event. Additional information is available from the National Educational Computer Library, POB 293, New Milford, CT 06776, (203) 354-7760.

June 29-July 1
Microcomputers, Electronic Toys, and Genius Machines in Early Childhood Education, Teachers College, Columbia University, New York, NY. This conference will examine the growing use of new technology in the entertainment and education of children. Events will include panel discussions, workshops, a computer fair, and a film festival. Participants can attend on a noncredit basis for $125 or for graduate credit at $240 per point. For further information, contact the Program in Early Childhood Education, Box 9, Teachers College, Columbia University, New York, NY 10027, (212) 678-3971.

June 29-July 1
Tertiary Education for the Age of Communications, Royal Melbourne Institute of Technology, Melbourne, Australia. Formal presentations will focus on the educational implications of new technologies on the needs of industry and the requirements of curriculum development. Areas of interest include telecommunications, engineering, and computer and information sciences. For details, contact the International Conference on Communications, Royal Melbourne Institute of Technology, G.P.O. Box 2476V, Melbourne, Victoria 3001, Australia; tel: 3452822; Telex: AA36406.

July 1983

July
Continuing Engineering Education Courses, George Washington University, Washington, DC. Among the courses offered are "Hands-On Pascal Computer Programming," "Reliability of Computer Software and

Computing Networks," and "Computer Memory Systems." Fees range from $625 to $855. For details, contact Douglas Green, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-8512.

July-October
Repair of Microcomputer-based Equipment, various sites throughout the U.S. and Canada. This seminar describes general servicing practices that are applied to the subsystems of any microprocessor family. This lecture/laboratory sequence is intended for field-service personnel, engineers, and technical writers. For details, contact the Registrar, Testek Consultants Inc., 1000 North Patton St., Arlington Heights, IL 60004, (312) 577-2134.

July 5-7
Technology Opportunity Conference, London, England. For details, see June 14-16.

July 5-August 4
Laboratory Use of Microcomputers, Brandeis University, Waltham, MA. This is an introductory, hands-on course in data-acquisition by microcomputer. Topics of interest include the use of the IEEE-488 parallel interface bus, handshaking, analog-to-digital and digital-to-analog conversion, and vectored interrupts. Participants will be expected to produce executable programs for each method. Some knowledge of BASIC is required. Tuition is $495 and the course fee is $15. For details, contact the Summer School Office, Brandeis University, Waltham, MA 02254.

July 8-10
Computerfest '83: The Eighth Annual Midwest Affiliation of Computer Clubs Computerfest, Harbourfront, Toronto, Ontario, Canada. Seminars, exhibits, drawings, a computer flea market, and an auction will cover a broad range of topics, including computer languages and applications for the disabled. Carl Helmers, editor of *Robotics Age* magazine, is the featured speaker. Further information is available from the Toronto Region Association of Computer Enthusiasts, POB 6922, Toronto, Ontario M5W 1X6, Canada.

July 10-11
The Role of Microcomputers in Music Education, Triton College, River Grove, IL. Seminars, workshops, demonstrations, and manufacturer displays will highlight this event. Topics of interest include ear training, improvisation, computer basics for the teacher, choosing the right computer, and using computers in music for the disabled. The fee is $25 a day; $40 for both days. For details, contact Michael Ferrelli, Triton College, 2000 Fifth Ave., River Grove, IL 60171.

July 11-13
The 1983 Summer Computer Simulation Conference, Hyatt Regency, Vancouver, British Columbia, Canada. Full details are available from the Society for Computer Simulation, POB 2228, La Jolla, CA 92038, (714) 459-3888.

July 11-15
Technology Opportunity Conference, Los Angeles, CA. For details, see June 14-16.

July 12-14
Audio-Visual America, Hyatt Regency Hotel, Chicago, IL. The second annual Audio-Visual America will feature hardware and software exhibits, screenings of shows, and approximately 60 workshops on planning, production, and management. For more information, contact A-V America, IF Associates, 3150 Spring St., Fairfax, VA 22031, (703) 273-8272.

July 14-15
Computer Graphics in Design, Seattle, WA. For details, see June 23-24.

July 14-16
Personal Computer Interfacing and Scientific Instrument Automation, Charleston, SC. For details, see June 16-18.

July 18-28
Microcomputer-based Instrumentation for Schools, Middletown, OH. This workshop is designed for science and mathematics teachers in both secondary and undergraduate levels. Participants will learn how to construct and use simple, low-cost analog-to-digital and digital-to-analog converters for monitoring and controlling physical phenomena in classrooms and laboratories. Contact Bill Rouse, 301E McGuffey Hall, Miami University, Oxford, OH 45056, (513) 529-2141.

July 20-21
Token-based Local Networks, Washington, DC. This program is the second of four parts in the Architecture Technology Corporation's 1983 Forum Series. The series will bring together manufacturers and users of local network schemes to exchange information in an informal setting. The format includes presentations, panel discussions, and a technological summary. The fee is $395 per person. For details, contact the Architecture Technology Corp., POB 24344, Minneapolis, MN 55424, (612) 935-2035.

July 21-22
Shared Information Management Seminar, Hyatt Regency, Cambridge, MA. For details, see June 23-24.

July 25-28
The World of CAD/CAM, Dunfey's Resort, Hyannis, MA. For details, see June 27-30.

July 25-29
Robot Manipulators, Computer Vision, and Automated Assembly, Artificial Intelligence Laboratory, Massachusetts Institute of Technology, Cambridge, MA. The emphasis of this short course will be on developing strategies for the solution of problems that will arise in advanced automation: sensing, spatial reasoning, and manipulation. The use of current industrial robots and binary vision systems will be covered. For details, contact the Director of the Summer Session, Room E19-356, Massachusetts Institute of Technology, Cambridge, MA 02139.

July 25-29
SIGGRAPH '83, Detroit, MI. This is the tenth annual conference on computer graphics and interactive techniques sponsored by the Special-Interest Group on Computer Graphics of the Association for Computing Machinery (SIGGRAPH ACM). This show features tutorials, films and video tapes, exhibits of computing equipment, and a formal technical program. For full details, contact the SIGGRAPH '83 Conference Office, 111 East Wacker Dr., Chicago, IL 60601, (312) 644-6610.

August 1983

August 2-4
Microprocessor Background for Management Personnel, University of California, Berkeley. The fee for this course is $565. Full details are available from Continuing

Education in Engineering, Department 532N, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151.

August 8-10

The 1983 International Computer in Engineering Conference and Exhibit, Chicago Marriott Hotel, Chicago, IL. The exhibit portion of this event is tailored for the mechanical engineer involved in computer applications and technology. In the conference portion, more than 60 technical sessions covering computer-aided design, engineering software and hardware, and robotics and automation are planned. Contact the American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017, (212) 705-7100 for exhibit information and (212) 705-7795 for conference information.

August 8-12

The Eighth International Joint Conference on Artificial Intelligence-IJCAI, Karlsruhe, West Germany. This conference seeks to promote scientific interchange within and among all subfields of artificial intelligence research. Papers will address such topics as automatic programming, expert systems, knowledge representation, planning and search, and system support. Contact Saul Amarel, Computer Science Department, Hill Center, Busch Campus, Rutgers University, New Brunswick, NJ 08903, (201) 932-3546. In West Germany, contact Joerg Siekmann, Institut fuer Informatik, Universitaet Karlsruhe, Postfach 6380, D-7500 Karlsruhe 1, West Germany; tel: (49-721) 608-3977.

August 9-13

Individualized Language Teaching through Microcomputer-assisted Instruction, Boston, MA. This seminar will provide the theoretical background and hands-on experience necessary to enable participants to make practical use of microcomputer-assisted language instruction. Contact Ms. Anita Mires, American Language Academy, Suite 200, 11426 Rockville Pike, Rockville, MD 20852, (301) 984-3400.

August 10-12

Microcomputers and High Technology in Vocational Education Conference, Concourse Hotel, Madison, WI. Beginning and advanced classes on microcomputers, presentations on vocational education programs, and software exhibits will be featured. For details, contact Judy Rodenstein or Roger Lambert, Vocational Studies Center, 964 Educational Sciences Building, University of Wisconsin, 1025 West Johnson St., Madison, WI 53706, (608) 263-4367 or (608) 263-2704.

August 11-13

Personal Computer Interfacing and Scientific Instrument Automation, Williamsburg, VA. For details, see June 16-18.

August 16-19

Landsat: Sensor Design & Operation, University of California, Santa Barbara. This course is intended for users of remote-sensor data, including geographers, geologists, and engineers. It covers such topics as sensor requirements and user needs, sensor-design principles and tradeoffs, and applications and limitations. It's cosponsored by the Santa Barbara Research Center and the National Oceanic and Atmo-

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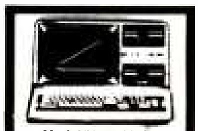

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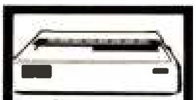

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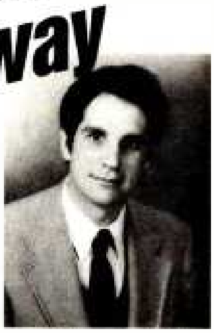


spheric Administration. The fee is $450. For a brochure, contact J. Weisman, University of California Extension, Santa Barbara, CA 93106, (805) 961-3697.

August 18-19
Computer Literacy for Lawyers, Denver, CO. For details, see June 27-28.

August 21-26
The Fourth World Congress on Medical Informatics–MEDINFO 83, RAI International Congress and Exhibition Centre, Amsterdam, The Netherlands. This event combines scientific, technical, and social programs. Approximately 300 scientific papers will be presented on health and hospital systems, clinical laboratory systems, imaging, nursing applications, and preventive and occupational care. Demonstrations, product exhibits, film and video sessions, tours, workshops, and special-interest meetings will be held. The language throughout the conference will be English. Further details are available from the MEDINFO 83 Congress Office, Enschedepad 41-43, NL-1324 GB Almere-Stad, The Netherlands.

August 22-26
The National Conference on Artificial Intelligence–AAAI-83, Washington Hilton Hotel, Washington, DC. This conference is sponsored by the American Association for Artificial Intelligence (AAAI). Displays of computer hardware and software, formal presentations, and the Fredkin Chess Prize Competition highlight this conference. Contact Claudia Mazzetti, AAAI, 445 Burgess Dr., Menlo Park, CA 94025, (415) 328-3123.

August 23-24
Indycon '83, Convention Center, Indianapolis, IN. This show features more than 35 technical sessions and 300 exhibition booths devoted to microcomputers and electronic components. Contact Indycon '83, POB 40312, Indianapolis, IN 46260, (317) 875-7711.

August 26-28
The First IBM PC Faire, Civic Auditorium and Brooks Hall, San Francisco, CA. The focus of this fair will be on hardware, software, and applications for the IBM Personal Computer. Technical conferences, formal papers, product expositions, and special-interest group meetings will be held. For details, contact IBM PC Faire, 345 Swett Rd., Woodside, CA 94062, (415) 851-7077.

August 26-September 3
The International Telecommunications, Scientific, and Technical Expoconference–Telexpo China 1983, Foreign Trade Center, Guangzhou (Canton), Jiangxi Province, People's Republic of China. The theme of this large show of communications equipment is "An Integrated Telecommunications System for China." Displays will include aerospace equipment, computers, and peripherals. Additional information is available from AVP Expositions Co. Ltd., Suite 13, 13/F, Block A, Wahkai Industrial Center, 221 Texaco Rd., NT Hong Kong; tel: 0-239003; Telex: 40725 AVPEX HX.

August 29-31
DBMS-M⁴ Systems, Washington, DC. For details, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111; on the West Coast, (213) 824-9545.■

Books Received

All About Chess and Computers, David Levy and Monroe Newborn. Rockville, MD: Computer Science Press, 1982; 150 pages, 14 by 22 cm, hardcover, ISBN 0-914894-75-7, $19.95.

Assembly Language Graphics for the TRS-80 Color Computer, Don Inman and Kurt Inman. Reston, VA: Reston Publishing Co., 1983; 280 pages, 37 by 51 cm, hardcover, ISBN 0-8359-0318-4, $19.95.

Celestial BASIC, Eric Burgess. Berkeley, CA: Sybex, 1982; 300 pages, 42 by 54 cm, softcover, ISBN 0-89588-087-3, $13.95.

The Computer-The Business-The Staff, Jack Bender. Princeton, NJ: Petrocelli Books, 1982; 123 pages, 16 by 24 cm, hardcover, ISBN 089433-196-5, $17.50.

Computer Peripherals That You Can Build, Gordon W. Wolfe. Blue Ridge Summit, PA: Tab Books, 1982; 272 pages, 46.6 by 51 cm, softcover, ISBN 0-8306-1449-4, $13.95.

Controlling Software Projects: Management, Measurement & Estimation, Tom DeMarco. New York: Yourdon Press, 1982; 296 pages, 42 by 58 cm, softcover, ISBN 0-917072-32-4, $28.50.

Crunchers: 21 Simple Games for the Timex/Sinclair 1000 2K, Yin Chiu and Henry Mullish. New York: McGraw-Hill, 1983; 137 pages, 33 by 49 cm, softcover, ISBN 0-07-010831-5, $8.95.

Digital Computer Structure and Design, 2nd ed., R. Townsend. Woburn, MA: Butterworths, 1982; 252 pages, 32 by 51 cm, softcover, ISBN 0-408-01155-6, $24.95.

Discrete Structures of Computer Science, Leon S. Levy. New York: John Wiley & Sons, 1980; 310 pages, 40 by 55 cm, hardcover, ISBN 0-471-03208-5, $25.95.

Electrical Power Systems: Design and Analysis, Mohamed E. El-Hawary. Reston, VA: Reston Publishing Co., 1983; 785 pages, 44 by 58 cm, hardcover, ISBN 0-8359-1627-8, $29.95.

iAPX 88 Book. Santa Clara, CA: Intel Corp., 1981; 80 pages, 42 by 54 cm, softcover, ISBN 0-8359-3016-5, $12.95.

Instructional Computing . . . Ten Case Studies, Carol Hargan and Beverly Hunter. Arlington, VA: ERIC Document Reproduction Service (POB 190), 1978; 225 pages, 18 by 23 cm, softcover, ISBN none, $17.90.

Interactive Computer Graphics Systems, William C. House, ed. Princeton, NJ: Petrocelli Books, 1982; 185 pages, 38 by 56 cm, hardcover, ISBN 089433-188-4, $25.

Interfacing to Microprocessors and Microcomputers, Owen Bishop. Woburn, MA: Butterworths, 1982; 147 pages, 33 by 51 cm, softcover, ISBN 0-408-01129-7, $12.50.

Introduction to Digital Logic Techniques and Systems, Matthew Mandl. Reston, VA: Reston Publishing Co., 1983; 201 pages, 37 by 51 cm, hardcover, ISBN 0-8359-3175-7, $23.95.

Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity, Richard J. Schonberger. New York: The Free Press/Macmillan Publishing Co., 1982; 244 pages, 15.8 by 24 cm, hardcover, ISBN 0-02-929100-3, $14.95.

Logic Circuits and Microcomputer Systems, Claude A. Wiatrowski and Charles H. House. New York: McGraw-Hill, 1980; 413 pages, 41 by 57 cm, hardcover, ISBN 0-07-070090-7, $33.95.

Machine Language Disk I/O & Other Mysteries, Michael J. Wagner. Upland, CA: IJG Inc., 1982; 272 pages, 21 by 27.5 cm, softcover, ISBN 0-936200-06-5, $29.95.

Making Money with your Microcomputer, Robert J. Traister and Rich Ingram. Blue Ridge Summit, PA: Tab Books, 1982; 160 pages, 31 by 50 cm, softcover, ISBN 0-8306-1506-7, $7.95.

Mathematical Problem-Solving with the Microcomputer, Stephen L. Snover and Mark A. Spikell. Englewood Cliffs, NJ: Prentice-Hall, 1982; 190 pages, 41 by 55 cm, softcover, ISBN 0-13-561811-8, $8.95.

Microprocessors and Logic Design, Ronald L. Krutz. New York: John Wiley & Sons, 1980; 467 pages, 40 by 56 cm, hardcover, ISBN 0-471-02083-4, $34.95.

Microprocessors for Industry, J.N.W. Baldwin. Woburn, MA: Butterworths, 1982; 149 pages, 33 by 52 cm, hardcover, ISBN 0-408-00517-3, $19.95.

Personal Graphics for Profit and Pleasure on the Apple II Plus Computer, Michael P. Barnett and Graham K. Barnett. Boston, MA: Little, Brown and Co., 1983; 192 pages, 21.5 by 27.8 cm, softcover, ISBN 0-316-08164-7, $14.50.

The Physician's Guide to Desktop Computers, Mark Harrison Spohr, M.D. Reston, VA: Reston Publishing Co., 1983; 222 pages, 37 by 51 cm, hardcover, ISBN 0-8359-5548-6, $21.95.

A Practical Guide to Computer Communications and Networking, Richard Deasington. New York: John Wiley & Sons, 1982; 132 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-470-27545-6, $39.95.

Professional Programming Techniques—Starting with the Basics, Richard Galbraith.

Blue Ridge Summit, PA: Tab Books, 1982; 308 pages, 31 by 50 cm, softcover, ISBN 0-8306-0128-7, $10.95.

Programming the PL/I Way, Dan Smedley. Blue Ridge Summit, PA: Tab Books, 1982; 300 pages, 31 by 50 cm, softcover, ISBN 0-8306-1414-1, $9.95.

Quick Pascal, David L. Matuszek. New York: John Wiley & Sons, 1982; 179 pages, 15 by 23 cm, softcover, ISBN 0-471-86644-X, $11.95.

Raising Venture Capital, Deloitte Haskins & Sells. New York: Entrepreneurs' Financial Advisory Group (1114 Avenue of the Americas), 1982; 104 pages, 14 by 23 cm, softcover, ISBN-none, $5.

A 60-Minute Guide to Microcomputers, Lew Hollerbach. Englewood Cliffs, NJ: Prentice-Hall, 1982, 137 pages, 33 by 48 cm, softcover, ISBN 0-13-811422-6, $6.95.

So You Think You Need Your Own Business Computer, William E. Perry. New York: John Wiley & Sons, 1982; 201 pages, 41 by 50 cm, softcover, ISBN 0-471-86196-0, $14.95.

Some Common BASIC Programs: IBM Personal Computer Edition, Lon Poole, Mary Borchers, and Peter M. Burke. Berkeley, CA: Osborne/McGraw-Hill, 1982; 195 pages, 50 by 65 cm, softcover, ISBN 0-9311988-83-7, $14.99.

Successful Software for Small Computers, Graham Beech. New York: John Wiley & Sons, 1982; 182 pages, 17 by 25.5 cm, softcover, ISBN 0-471-87458-2, $14.95.

TRS-80 Microcomputer Sourcebook for Educators. Fort Worth, TX: Radio Shack Education Division, 1980; 27 pages, 18.5 by 24.3 cm, softcover, ISBN-none, $1.

The Telidon Book, David Godfrey and Ernest Chang. Reston, VA: Reston Publishing Co., 1981; 309 pages, 38 by 55 cm, hardcover, ISBN 0-8359-7548-7, $39.95.

Understaning APL, Susan M. Bryson. Sherman Oaks, CA: Alfred Publishing Co. Inc. (POB 5964), 1982; 45 pages, 25.6 by 66 cm, softcover, ISBN 0-88284-220-X, $2.95.

Understanding Artificial Intelligence, Paul Y. Gloess. Sherman Oaks, CA: Alfred Publishing Co. Inc. (POB 5964), 1981; 47 pages, 25.6 by 66 cm, softcover, ISBN 0-88284-150-5, $2.95.

Understanding Atari Graphics, Michael Boom. Sherman Oaks, CA: Alfred Publishing Co. Inc. (POB 5964), 1982; 48 pages, 10.8 by 28 cm, softcover, ISBN 0-88284-224-2, $2.95.

Understanding LISP, Paul Y. Gloess. Sherman Oaks, CA: Alfred Publishing Co. Inc. (POB 5964), 1982; 64 pages, 25.6 by 66 cm, softcover, ISBN 0-88284-219-6, $2.95.

User's Handbook to the IBM Personal Computer, Jeffrey R. Weber. Cleveland, OH: Weber Systems Inc. (8437 Mayfield Rd.), 1982, 294 pages, 14 by 21.5 cm, softcover, ISBN 0-938862-13-8, $13.95.

Visicalc Book for the IBM Personal Computer, Donald H. Beil. Reston, VA: Reston Publishing Co., 1983; 335 pages, 18 by 24 cm, hardcover, ISBN 0-8359-8396-X, $20.

What's Where in the Apple, William F. Luebbert. Chelmsford, MA: Micro Ink (POB 6502), 1982; 256 pages, 22 by 28 cm, spiral bound, ISBN 0-938222-09-0, $24.95.

Word Processing Simulations for Text Editors, Information Processors and Personal Computers, Carol Ann Wheeler and Marie Dalton. New York: John Wiley & Sons, 1983; 224 pages, 21.5 by 28 cm, looseleaf, ISBN 0-471-08159-0, $12.95.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

BYTE's Bits

Call for Papers

Topic: A Journal of the Liberal Arts seeks papers concerning the use of computers in education or research in the liberal arts. Two formats will be considered for publication: 1000-word papers describing specific experiments in the use of computers in collegiate instruction or research and 2500-word papers on the educational value of computers and the philosophical issues involved in introducing the computer into the liberal arts environment. Preference will be given to those reports concerning fields not traditionally involved with computers. Contact Dr. Thomas W. Hart and Dr. Joseph Levenstein, Washington and Jefferson College, Washington, PA 15301.■

Personal Instruments Might Transform Labs

Today's sophisticated stand-alone laboratory equipment from industry giants such as Hewlett-Packard and Philips incorporates preprogrammed microprocessor systems. GPIB (general-purpose interface bus) controller boards or intelligent terminals make these devices user-programmable. Although this stringing together of stand-alone equipment works well enough, it is an expensive approach and oftens results in tasks being tailored to the tools at hand.

The two dozen employees of the Oregon-based Northwest Instrument Systems (NWIS) are out to change all that. Here's the idea: create a line of high-performance test instruments, make them peripherals for the Apple II/IIe rather than stand-alone units so that costly processors and displays can be omitted, and pass the savings on to your customers. It's a fetching idea, especially when company spokesmen point out that a complete waveform stimulus/acquisition system made up of an Apple IIe, video monitor, disk drive, a programmable oscilloscope, and a function or waveform generator can be purchased for less than $4000.

The Personal Instruments Approach

NWIS builds its products around a concept known as personal instruments. Personal instruments are easy-to-use, general-purpose computer peripherals that permit customized control over the instrument, analysis, and displayed results. Their architecture provides direct access to a computer, which enhances productivity because combinations of commands can be initiated with standard menu-driven software coupled with user-written programs. The overall system cost is said to be three to five times less than conventional units because of the elimination of redundant memories and other hardware that force prices skyward.

The Product Line

Introduced early in 1982, the Model 85 aScope turns any Apple II into a fully programmable digital-memory oscilloscope. It features signal averaging, 50-MHz dual-channel configuration, and hard-copy capabilities. The Model 85 comes with disk-based oscilloscope setups and offers menu-driven commands, keyboard-controlled functions, and the ability to perform as a waveform digital voltmeter.

This past April, NWIS unveiled its Model 65 aGen Programmable Function Generator and the Model 75 aSource Arbitrary Waveform Generator. Both devices operate as programmable waveform generators and can be combined with the aScope and an Apple for a complete programmable waveform, stimulus/acquisition system. Generated signals can be automatically changed as a function of the acquired waveform via analysis performed by a program resident in the Apple.

The aGen generates sine, square, triangle, ramp, and pulse waveforms at frequencies ranging from 0.5 Hz (hertz) to 5 MHz (megahertz) and at amplitudes to 20 V (volts) peak-to-peak into an open circuit or 10 V peak-to-peak into 50 ohms. It operates in continuous, triggered, gated, or N-burst modes and has AM/FM inputs and self-prompting menus.

The aSource features a waveform editor that lets you define complex waveforms with mathematical expressions or construct waveforms from previously stored waveform segments. The editor also provides for file management, insertion and deletion of segments, and interpretation of mathematical equations. Waveform resolution is 12 bits. An enhanced version, the Model 76 aSource, offers waveform record lengths of up to 4K bytes. Both units operate in continuous, triggered, or arm modes. Triggered signals can be initiated from the keyboard, software, or an external input.

The Model 2100 ISA (Interactive State Analyzer) offers 16 to 80 configurable channels of data input and memory depths of up to 4K bytes for each channel. It resides in the μAnalyst Personal Instrument Mainframe, which holds the probes and memory cards. ISA can operate in 15 independent trigger/strobe states, with an event counter and word recognizers available in each state. ISA can label each state, store qualifiers for local control over data, and provide real-time programmable outputs. Its symbol control lets you define all the word recognizers in the trigger/strobe menu. Hexadecimal, octal, binary, or ASCII values are assigned in a symbol-table menu.

Pricing

All NWIS's products are available factory-direct. The Model 85 aScope costs $995, including manual and software. The aGen is priced at $850. With the waveform editor, the Model 75 and Model 76 aSource generators are available for $895 and $995, respectively. The basic 1K-byte 16-channel Model 2100 with the μAnalyst mainframe costs $2495. With 4K-bytes of memory, it's $2695. Probes are available optionally, and additional 16-channel memory cards can be purchased for the ISA.

NWIS, a venture-capital-funded firm, organized in mid-1981 by former Tektronix employees Jon Brick and Rick Cordray, plans to go public with a stock offering some time in the future. In addition to the Apple II and IIe, it plans to support other computers as laboratory acceptance grows. For complete details on this company and its products, contact Northwest Instrument Systems at POB 1309, Beaverton, OR 97075, (800) 547-4445; in Oregon, (503) 297-1434.■

What's New?

16-BIT COMPUTERS

16-Bit CEC8000S Suitable for Multitasking

Compac's 16-bit Model CEC8000S microcomputer is suitable for multiuser/multitasking environments. It's based on Zilog's Z8001 chip, which provides a 4-MHz clock, a 16-bit data bus, and a 24-bit address bus. The CEC8000S comes with 512K bytes of RAM (random-access read/write memory), a 20-megabyte Winchester drive, a 20-megabyte cartridge-tape unit, a parallel port, six serial ports, an MMU (memory-management unit), and Unix. Each of the CEC8000S's I/O controllers has a dedicated microprocessor, reducing central-processor overhead. Language support for program development includes the native C compiler, FORTRAN-77, COBOL, and BASIC.

Expansion options include up to 7.5 megabytes of RAM, a floating-point processor that combines 8086 and 8087 processors with up to 128K bytes of memory, as much as 160 megabytes of Winchester disk storage, one or two 1-megabyte floppy-disk drives, a 9-track tape drive, and up to eight additional serial ports. In OEM (original equipment manufacturer) quantities, the standard CEC8000S costs less than $11,000. Contact Compac Microelectronics Inc., 3561 Ryder St., Santa Clara, CA 95051, (408) 773-0444.

Circle 550 on inquiry card.

IBM PC-Compatible 16-Bit Computers

Corona Data Systems markets a line of 16-bit microcomputers that are compatible with the IBM Personal Computer. Available in both portable and desktop units, the Corona PC comes with a 320K-byte half-height floppy-disk drive, high-resolution green-phosphor monitor, 128K bytes of RAM (random-access read/write memory), serial and parallel ports, and high-resolution graphics capabilities. System software includes Microsoft's MS-DOS operating system, a version of BASIC with added graphics commands, CP/M-86, and Digital Research's GSX graphics package for CP/M. Both machines are built on Intel's 8088 microprocessor and can be equipped for 8087 floating-point mathematics coprocessor operation. The keyboard is fully detached and comes with a 6-foot cable. The standard monitor is a high-resolution, high-contrast monochrome display offering a resolution of 640 by 325 pixels and built-in graphics. Graphics can be intermingled with text on the screen. Characters have a 16- by 13-dot resolution.

These computers can be expanded with any IBM PC-compatible card. User memory can be increased to 512K bytes without the use of an expansion slot. Both systems have full-size card expansion slots and can carry a second half-height floppy-disk drive, and a 10-megabyte hard disk. In the portable unit, the hard disk is a separate attachment.

The desktop Corona PC costs $2595, or $2995 with a second disk drive. A unit with an internal 10-megabyte hard-disk drive and a single floppy-disk drive is available for $4495. The base price for the portable PC is $2395. With dual disk drives, it's $2795. The 10-megabyte expansion unit for the portable computer costs $2695. Both machines come with additional applications software. For complete information, contact Corona Data Systems Inc., Suite 110, 31324 Via Colinas, Westlake Village, CA 91361, (800) 621-6746; in California, (213) 991-1144.

Circle 551 on inquiry card.

16-Bit Series 1000 Supports Large Software Library

Micro Five Corporation's 16-bit Series 1000 desktop computer supports a large library of applications software, including specialized programs for retail florists, beverage distributors, and insurance brokerages, and such operating systems as CP/M, MP/M, and MS-DOS, with the StarDOS operating system for multiuser applications provided as standard.

Series 1000 hardware features an 8-MHz 8088 microprocessor with no wait states and 16K bytes of onboard PROM (programmable read-only memory) containing self-test diagnostics for floppy- and hard-disk loaders, various utilities, and initialization bootstrap procedures. For local-area networking, the Series 1000 is equipped with multiprotocol serial chips for controlling asynchronous, byte-synchronous, or bit-synchronous communications. The Series 1000 can be configured with two to six I/O ports, which can be independently programmed for communications modes up to 19,200 bps (bits per second).

The Series 1000 is available in four standard configurations offering 128K bytes of RAM (random-access read/write memory), expandable to 512K bytes, up to 2 megabytes of floppy-disk storage, and two 5¼-inch Winchester hard-disk drives. Basic system prices range from $4995 to $8995. For complete details, contact Micro Five Corp., 17791 Sky Park Circle, Irvine, CA 92714, (714) 957-1517.

Circle 552 on inquiry card.

Rair Business Computer

The Rair Business Computer is a multiuser desktop system. The 8C, capable of supporting four workstations, has 19 megabytes of integral Winchester storage, up to 1 megabyte of RAM (random-access read/write memory), and 8- and 16-bit microprocessors. Its multitasking operating system is compatible with PC-DOS and 8- and 16-bit versions of CP/M and MP/M. An electronic spreadsheet, word processing, database management, and communications packages are supported, as are 16-bit implementations of BASIC, Pascal, and COBOL.

User workstations feature a high-resolution color monitor and an 83-key keyboard. The video display offers independent split-screen scrolling, foreground and background blink, and a display of 80 by 25 (each character can be displayed in one of eight colors). The keyboard connects to the monitor by means of a 6-foot coiled cable and has a 10-key numeric/editing keypad, shift and number locks, and 10 programmable function keys.

An entry-level, single-user system, configured with a 19-megabyte Winchester drive, 1-megabyte of floppy-disk storage, and 256K bytes of RAM (random-access read/write memory), costs $8500. Memory upgrades in 256K-byte increments are $1500. User workstations are priced at $1500. Additional 19-megabyte Winchester drives are $3500; workstation printers cost $950. For OEM (original equipment manufacturer) prices or more information, contact Rair Computer Corp., 4101 Burton Dr., Santa Clara, CA 95050, (408) 988-1790.

Circle 553 on inquiry card.

Low-Profile Sage

Sage Computer Technology has incorporated half-height floppy-disk drives into its Sage II 16-bit microcomputer, reducing its dimensions to 3.9 inches high by 12.5 inches wide by 16.7 inches deep. The low-profile Sage II uses the 8-MHz Motorola 68000 microprocessor, which operates without wait states and is capable of executing 2 million instructions per second. The basic Sage II comes with 128K bytes of RAM (random-access read/write memory), a half-height 640K-byte floppy-disk drive, two RS-232C serial ports, a Centronics-type parallel port, an IEEE-488 port, and the Pascal p-System. When running CP/M, the Sage II supports the C language. Other languages available include FORTRAN, FORTH, APL, and Modula-2.

One or two floppy-disk drives, one- or two-user capabilities with multitasking, and up to 512K bytes of RAM are among the hardware options for the Sage II. Suggested retail prices range from $3600 to $5150. For more information, contact Sage Computer Technology, Suite 4, 35 North Edison Way, Reno, NV 89502, (702) 322-6868.

Circle 554 on inquiry card.

FOREIGN

16-Bit Advance Compatible with IBM PC

For portability, the Advance 86's keyboard can tuck into the main computer unit. This 16-bit microcomputer, compatible with the IBM Personal Computer and running under MS-DOS, has 128K bytes of RAM (random-access read/write memory), 16K bytes of dedicated video memory, and 40K bytes of ROM (read-only memory) with diagnostics, BASIC, and a cassette operating system. The keyboard features 84 tactile keys and 10 programmable function keys. The Advanced 86 will support standard television, RGB (red/green/blue), composite color, or monochrome monitors while providing full-screen handling and resolutions of 40 or 80 by 25 (text) and 320 or 640 by 200 (graphics). Other video attributes include up to 16 colors, scroll, and reverse image. Built-in interfaces for a cassette deck, light pen, control stick, and Centronics-type parallel printers are standard. It uses the 8086 microprocessor operating at 4.77 MHz.

Shugart 320K-byte 5¼-inch floppy-disk drives and a 10-megabyte Winchester-disk drive are available as options. The Advance 86 Model A costs $599.95. With two floppy-disk drives and spreadsheet and word-processing software, the Model B costs $1799.95. For $3299.95, the Model B10W comes with the 10-megabyte Winchester hard-disk drive, one floppy-disk drive, and the software. Full details are available from Advance Products (U. K.) Ltd., 8a Hornsey St., London N7 8HR, England; tel: 01-609 0061; Telex 296701 JACK G.

Circle 555 on inquiry card.

After-Sales Service Center for Hire

Ferranti Computer Systems Ltd. is offering the services of its U. K. Electronic Support Centre to American companies seeking after-sales support for products sold in Europe. The Centre, located in Oldham, Lancashire, can provide a range of engineering resources for maintaining and servicing electronic equipment. Among the technologies supported are digital and analog circuitry, printed-circuit boards including multilayer, LSI- (large-scale integration) and microprocessor-based equipment, and germanium and silicon discrete component circuitry.

A descriptive brochure and information about available services can be obtained from Allan England or Stan Atkins, Electronics Support Centre, Ferranti Computer Systems Ltd., Waterhead, Oldham, Lancashire OL4 3JA, England; tel: 011 44 61 624 0281; Telex: 667645.

Circle 556 on inquiry card.

French Accounting Software Guide

The Practical Guide to Accounting Software Packages, written by Bernard Laur and Claude Salzman, contains up-to-date information on French computerized accounting systems and software. Designed for accountants and data-processing professionals, the data in this book, based on a survey conducted last year, covers 188 accounting packages used in 5558 installations on microcomputers, minicomputers, and mainframes. Statistical analyses of the packages' characteristics and a comparative chart spanning 125 categories from price to hardware specifications are provided. A complete index classifies packages by supplier and computer. Other features include an overview of accounting software based on the AFNOR (the French association for standardization) workshop specifications and a buying guide.

This 382-page book costs 450 francs, plus 50 francs postage. It's available from MLI-Editions D'Informatique, 54, rue de Bourgogne, 75007, Paris, France.

Circle 557 on inquiry card.

Uninterruptible Power Supplies

The KD1-6 line of standard-range uninterruptible power-supply units are designed to protect electronic equipment. Produced by Avel-Lindberg Ltd., these devices are suitable for most environments where continuous spike- and transient-free stabilized power sources are essential, such as in computer and communication networks. They can be supplied in single units of 1, 2, or 3 kVA and in double units of 5 and 6 kVA. Standard hardware includes a ferroresonant inverter, rectifier/battery charger, static or electromechanical transfer switches, and system-status monitoring alarm and control equipment.

With these power supplies, the degree of protection afforded to a power supply can be varied according to your level of priority by including a number of options. Battery alternatives include lead/acid tubular cells, nickel cadmium, and maintenance-free cells. Depending on rated capacity, the cells can be installed in one or two lockable steel cabinets. Contact Avel-Lindberg Ltd., South Ockendon, Essex RM15 5TD, England; tel: 070 885 3444; Telex: 897106.

Circle 558 on inquiry card.

SOFTWARE

Real Estate Package for Osborne

The Real Estate Investor Calcaid may be the first Supercalc spreadsheet enhancement for the Osborne computer. This package, configured by Simple Soft Inc., is marketed through authorized Osborne dealers. (Simple Soft's Real Estate Investor, parent program of Osborne Calcaid, runs on Xerox, IBM, and Apple computers.)

The Calcaid package for the Osborne provides in-depth financial analyses of both individual residences and income property purchases and sales. Designed for the novice, this program addresses complex real-estate problems such as variable-rate mortgages, expense schedules, cash flows, tax benefits, and internal rate of return. Hard-copy reports can be produced.

For sales-support, Simple Soft is offering a videotaped presentation for dealers carrying the product. It's available in Beta or VHS formats for $50. The Real Estate Investor Calcaid costs $129.95. For complete details, contact Simple Soft Inc., Suite 101, 480 Eagle Dr., Elk Grove Village, IL 60007, (312) 364-0752.

Circle 559 on inquiry card.

Free Classroom Programs

The Educational Computing Network has a number of free programs available for English and Social Studies teachers. For the English classroom, topics include vocabulary building and review, poetry, and the parts of speech. Social Studies teachers can pick from drill and review programs, simulations, and testing programs. All the programs are designed for the Apple II Plus. For more information, send a self-addressed, stamped envelope to Educational Computing Network, 12680 Hollyglen, Riverside, CA 92503.

Spreadsheet Has New Features

Zencalc 3.0, an enhanced version of the Zencalc spreadsheet program for Heath/Zenith computers, is available from The Software Toolworks for $49.95. Zencalc 3.0 features a new table look-up function, a numeric-keypad mode for rapid data entry, and a loan-amortization spreadsheet that automatically computes mortgage payments and schedules. Zencalc will run on Z-89 computers as well as Z-100 systems using the Z-89-compatible function keys.

Zencalc 3.0 comes on 5¼-inch hard and soft-sectored disks for Heath/Zenith CP/M- and HDOS-based systems and on an 8-inch CP/M disk for Z-19 terminals. Registered Zencalc owners may purchase it as an update for $10, plus $2 shipping. It's available at Heathkit Electronic Centers, Zenith Data Systems dealers, or factory-direct from The Software Toolworks, Suite 1118, 15233 Ventura Blvd., Sherman Oaks, CA 91403, (213) 986-4885.

Circle 560 on inquiry card.

Low-Cost Graph Printing Program

West Bay Co. has unveiled a multipurpose graph program for the Radio Shack Color Computer. Kwikgraf works with the Color Computer and the Epson MX-80 printer to produce camera-ready bar graphs in approximately three minutes. This program, modular in nature, provides screened instructions and permits rapid keyboard changes of data and design. The program listing can be modified for printers other than Epson, and a screen print program is not required.

Kwikgraf requires Extended BASIC and 4K bytes of memory. It costs $12.50, postage paid. For a sample graph produced with Kwikgraf, send a self-addressed, stamped envelope to West Bay, Route 1, Box 666, White Stone, VA 22578.

Circle 561 on inquiry card.

Peek 'n Poke Around Your IBM

Peeks 'n Pokes for the IBM Personal Computer, a collection of programming techniques and programs, is distributed by Data Base Decisions. Made up of a floppy disk and a 38-page manual, this package shows you how to use BASIC PEEK, POKE, INP, and OUT functions to access and modify system information. General-purpose assembler routines that perform DOS and BIOS function calls, read the file directory, and determine the space used and remaining are provided. For Pascal programmers, assembly-language routines that perform the same operations are included.

The Peeks 'n Poke disk contains more than 50 BASIC and Pascal programs that show you how to access the system's configuration, read and change the keyboard status, access the printer status, and generate sounds through the speaker. Also included are eight utility programs covering such functions as clearing the screen and swapping monitors.

Minimum system requirements are PC-DOS, 48K bytes of memory, a disk drive, and an 80-column monitor. It costs $30, plus $2.50 shipping, and is available from Data Base Decisions, 14 Bonnie Lane, Atlanta, GA 30328, (404) 256-3860.

Circle 562 on inquiry card.

Terminal Program Waits for You

The Intelligent Terminal System-80 lets you operate your Apple II/IIe computer in a smart-terminal mode or in a dumb-terminal mode. ITS-80 is a menu-driven program that provides such full-screen capabilities as left and right cursor movements, clear-to-end-of-line or screen, and character insert and delete. When a typing error is made while in its smart-terminal mode, you merely go back and correct the error because ITS-80 will not transmit blocks and lines of characters until the Return key is pressed. Other features include an 18K-byte character buffer, text file send and receive, simultaneous printing with user-defined formats, and predefined configurations for the system being called.

ITS-80 requires an 80-column card, the Apple Pascal language, and the D. C. Hayes Micromodem II. It costs $49.95. Contact Unisoft, 5520 12th Ave. S, Minneapolis, MN 55420, (612) 824-4131.

Circle 563 on inquiry card.

Bids Generated for Contractors

Scripps Data Systems' Estimating System for the IBM Personal Computer rapidly and accurately generates bids for building contractors. This system, written in BASIC and running under MS-DOS 1.1, features a user-maintained cost item database, with a retrieval time purported to be less than 1 second to any cost item. Major files are in ISAM (indexed sequential-access method) format, and all files are dynamically allocated. Estimates are structured by division, subdivision, subcontract bids, and cost items. Burden rates for materials, labor, and other costs can be maintained by division for each estimate. Any cost item change on an estimate immediately updates all division and estimate totals. Reports can be generated in detail or summarized by subdivision or division. Summary information can be automatically interfaced to other Scripps products for greater accuracy.

Minimum hardware requirements for the Estimating System are 64K bytes of memory, two single-sided disk drives, and a 132-column printer. The suggested retail price is $425. An Apple version is available. For full details, contact Scripps Data Systems Inc., Suite 202G, 9747 Businesspark Ave., San Diego, CA 92131, (619) 695-1540.

Circle 564 on inquiry card.

Graphics Interpreter for Matrix Printers

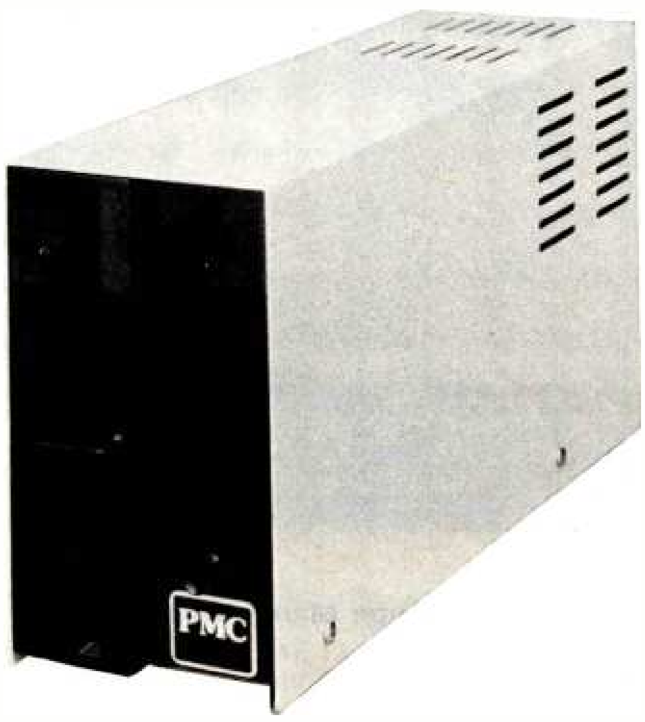
Printer Graphist is a high-resolution graphics interpreter for dot-addressable matrix printers. This program, an extension of your Radio Shack TRS-80's

BASIC interpreter, provides 14 simple high-resolution graphics commands. It lets you define the physical size and location of the plot area (up to 32 feet wide by 32 feet long, using multiple sheets of paper), and you can define which type of logical scaling (linear or logarithmic at any base) must be used for both axes and their logical ranges. Other commands connect two pairs of points together with up to six line styles and eight colors, initiate and halt chaining processes, grid and graduate the x- or y-axis, and label your plot in different character sets and colors.

Printer Graphist, available for the TRS-80 Models I and III, works with such printers as the IDS Prism 132, Epson MX-80 with Graftrax, Okidata with Okigraph, and Star Micronics. The price is approximately $250. Contact Printer Graphist Ltd., POB 603, Newport, VT 05855. When ordering, please enclose complete information on your system, including processor number, disk-drive specifications, DOS, and printer.

Circle 565 on inquiry card.

SYSTEMS



Convert Terminal to CP/M Computer

The Micromate converts any standard dumb or intelligent terminal into a CP/M-compatible computer. Produced by Personal Micro Computers, this portable computer, small enough to fit into a briefcase, has 390K bytes of disk storage and 128K bytes of RAM (random-access read/write memory) with bank-switching under CP/M Plus control. Built-in hardware is made up of two serial ports, an 8-bit parallel port suitable for Winchester-disk drives, a Centronics-compatible parallel printer port, and a connector for up to three external 5¼-inch floppy-disk drives for a total storage capacity of 1.5 megabytes.

System software comes in the form of a fully integrated package known as T/Maker III. This package provides spreadsheet, word processing, text editing, list processing, file management, and data transfer applications programs. It also has the ability to create bar charts from tabular data in the files.

A complete Micromate with a terminal, CP/M 3.0, and T/Maker costs $1495. Without the terminal, the price is $995. Dealer inquiries are invited. Contact Personal Micro Computers Inc., 475 Ellis St., Mountain View, CA 94043, (415) 962-0220.

Circle 566 on inquiry card.

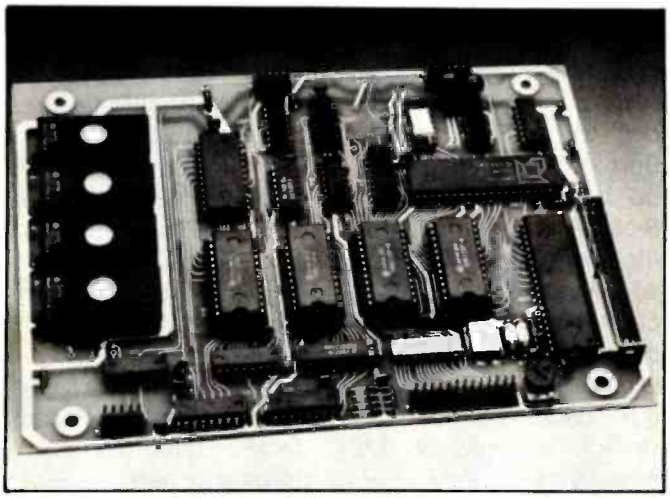
Cyzern 7000 Grows with Your Needs

The Cyzern System 7000 can grow with your computing needs. This modular 16K-byte microcomputer features a 53-key keyboard with cursor-control keys, VHF/RF modulator and composite-video connectors, and an uppercase/lowercase character generator with block and vector graphics capabilities. When used with an ordinary television set, it offers a 16-line by 32- or 64-character display format. The System 7000 uses the Zilog Z80 microprocessor and comes with an interactive BASIC interpreter, called IBI, which lets you load and run Radio Shack TRS-80 Model I and III programs. A standard cassette recorder is used for storage.

Options for this system include an internal expansion interface for a double-density floppy-disk controller, a parallel printer port, a real-time clock, and an RS-232C serial interface. A 5¼-inch floppy-disk drive, the CY-770, can store up to 160K bytes of data per disk; a total of four drives can be used with the 7000. Operating systems available include NEWDOS, NEWDOS 80 version 2.0, and TRSDOS. Languages such as BASIC, COBOL, FORTH, and Pascal are offered. Among the other options for the System 7000 are a music/speech synthesizer, a speech-recognition unit, 8- and 12-bit tracking A/D (analog-to-digital) converters, and a 16K-byte EPROM (erasable programmable read-only memory) firmware interface.

In kit form, the System 7000 costs $199.95. A completely assembled 64K-byte unit is $499. Options range in price from $8.95 to $599.95. For full details, contact Design Solution Inc., POB 1225, Fayetteville, AR 72701, (501) 521-0281.

Circle 567 on inquiry card.



Single-Board 6809 Computer

The Hart-09 single-board, stand-alone computer is built on Motorola's 6809 microprocessor. It's designed for dedicated OEM (original equipment manufacturer) applications in data processing, instrumentation, and industrial automation. The Hart-09 carries an RS-232C port, five 16-bit timer/counters, an 8-bit D/A (digital-to-analog) converter, 1K bits of nonvolatile RAM (random-access read/write memory), 64K bytes of EPROM (erasable programmable read-only memory) and CMOS (complementary metal-oxide semiconductor) static RAM memory, hexadecimal keypad interface, and a general-purpose parallel port. The OS-9 multitasking operating system is standard, as is the BASIC 09 language. The serial RS-232C I/O channel permits data communication at programmable rates ranging from 110 to 4800 bits per second.

Hart Scientific offers full applications support for the Hart-09, as well as power supplies and displays. Prices range from $800 to $1200. For complete details, contact Hart Scientific, 54 North 400 W, Provo, UT 84601.

Circle 568 on inquiry card.

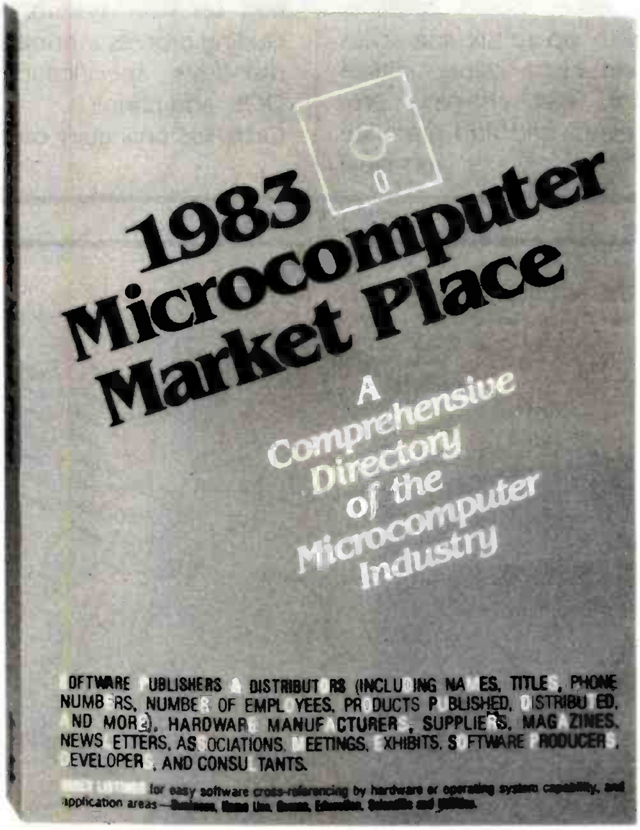
8- and 16-Bit S-100 Board

An IEEE S-100 standard central-processor board based on the Intel 80286/10 microprocessor and featuring code compatibility with 8- and 16-bit software, Compupro's CPU 286 has addressing capacity for multiuser/multitasking applications. Standard equipment includes sockets for an 80287 mathematics coprocessor and for up to 16K bytes of EPROM (erasable programmable read-only memory). The clock rate is 8 MHz, and a clock-switching circuit permits 8- or 16-bit slave processors to run on the same bus at various clock rates without timing conflicts. With a 24-bit address and 16-bit data bus, the CPU 286 can access as much as 16 megabytes of online system memory without segmentation. Its onboard logic can read or write 2 bytes serially to simulate 16-bit operation in the presence of 8-bit memory or I/O. A memory-management unit is incorporated into the CPU 286.

In single units, the CPU 286 costs $1595. A 10-MHz high-reliability version is also available. For more information, contact Compupro, Oakland Airport, Oakland, CA 94614, (415) 562-0636.

Circle 569 on inquiry card.

PUBLICATIONS



1983 Computer Market Directory

The 1983 Microcomputer Market Place was compiled from a questionnaire survey of the industry. It covers software publishers and distributors, hardware manufacturers, suppliers, magazines, newsletters, software developers, and associations. The information provided includes the company name and address, telephone numbers, number of employees, number of products produced or distributed, and the names of key executives in marketing, editorial, finance, and administration. Also provided are 13 indices with information on 11 microcomputer systems, 16 supply categories, 35 special-interest categories, games and applications for business, home, education, and utilities.

The 1983 **Microcomputer Market Place** is available for $75 from Dekotek Inc., POB 1863, Grand Central Station, New York, NY 10163, (212) 799-6602.

Circle 570 on inquiry card.

Telecommunications, Speech Synthesis Probed

Talking Computers and Telecommunications by John A. Kuecken examines this rapidly growing field. It deals with the use of talking-computer technology in telecommunications and provides a practical approach to the engineering problems encountered when computer speech is used in telephone systems. It discusses the concurrent social, economic, and technological forces that have produced the need for more advanced communications systems. The problems with such systems are explained and solutions are offered. Other features of this book include a rundown of the basic aspects of telephony and descriptions of pneumatic and mechanical vehicles for the production of sound. More than 100 illustrations are provided.

This 256-page hardcover book costs $26.50. It's available from Van Nostrand Reinhold Co. Inc., 135 West 50th St., New York, NY 10020, (212) 265-8700.

Circle 571 on inquiry card.

Visicalc Applications

T. G. Lewis's **32 Visicalc Worksheets**, a collection of ready-to-enter Visicalc programs, can be ordered from the Dilithium Press. The programs include games, business and household applications, and statistical analyses. Photographs of the programs as they appear on the computer screen are provided.

All the programs in this book are available on 5¼-inch floppy disks formatted for Apple or IBM Personal Computers. The book alone is $19.95. With the disk, it's $29.95. Contact the Dilithium Press, Suite E, 11000 Southwest 11th St., Beaverton, OR 97005, (503) 646-2713.

Circle 572 on inquiry card.

Modula-2 Manual Has Tutorials, Library Definitions

A 264-page **Modula-2 User's Manual** from Volition Systems is said to provide a complete description of the company's implementation of Modula-2. Written by Richard Gleaves, this manual is designed to be used with Niklaus Wirth's 48-page monograph that defines Modula-2; the monograph is provided. A tutorial for Pascal programmers and standard library definitions highlight this work. It's divided into six sections that range from a system document that describes the implementation of Modula-2 for UCSD Pascal to a machine-specific implementation guide that has information on library modules, interrupt handling, and machine-level data representation.

The **Modula-2 User's Manual** costs $35. It can be ordered directly from Volition Systems, POB 1236, Del Mar, CA 92014.

Circle 573 on inquiry card.

Ada Style Guide

A free six-page guide for Ada applications programmers is available from Intellimac. This guide illustrates proven techniques for efficient program structuring and provides examples of preferred methods for inhouse standardization of program syntax. Style rules that help to enhance program maintainability and decrease software life-cycle costs are presented. The methods outlined in this guide were derived from more than 100,000 lines of Ada code developed and delivered over a 22-month period. For a copy, contact Intellimac Inc., 6001 Montrose Rd., Rockville, MD 20852.

Circle 574 on inquiry card.

Journal Covers Pascal and Ada

The **Journal of Pascal and Ada** features programs, algorithms, and procedures for many different applications. Produced bimonthly, this magazine covers the role of Pascal and Ada through articles, book and software reviews, reports on new developments, and a question-and-answer column. All the software published in the Journal is available to subscribers over the telephone.

Annual subscriptions to the **Journal of Pascal and Ada** are $14. Foreign subscriptions are $21. Single issues cost $3 in the U.S. and $4 elsewhere. For more details, write to the **Journal of Pascal and Ada**, POB 383, Orem, UT 84057.

Circle 575 on inquiry card.

Access Your Computer

Access: The Journal of Microcomputer Applications is devoted to helping you make maximum use of your personal computer. It contains information on how to use your computer to solve traditional engineering and scientific problems and write reports, as well as giving you tips on how to keep track of technical papers and manage your time. Other topics of interest include mathematical modeling, process design, and economic and numerical analysis.

A year's subscription to **Access** costs $16 (six issues). Foreign rates are $21 in Canada and Mexico; $34 elsewhere. Contact Access, Leds Publishing Co. Inc., POB 12847, Research Triangle Park, NC 27709.

Circle 576 on inquiry card.

PERIPHERALS

VT-100 Emulator

The Ergo 301 from Micro-Term fully emulates the VT-100, including its advanced video, 132-column display, and printer port features. The Ergo 301 has a detached keyboard with a coiled cable and seven LEDs (light-emitting diodes) to show terminal status. The monitor tilts 10 degrees and has a green nonglare display and a front panel on/off switch; it is equipped to accept up to four boards for expansion purposes. Standard features include two pages of memory, English-language setups, programmable function keys, transparency mode, and Xoff indication.

Options for the Ergo 301 include an amber screen and Plot 10/Regis-compatible graphics. The Ergo 301 costs $895. With the Plot 10 graphics option installed, it lists for $1790. An add-on graphics capability costs $1095. Nationwide service is available through more than 450 Western Union locations. For full details, contact Micro-Term Inc., 1314 Hanley Industrial Court, St. Louis, MO 63144, (314) 968-8151.

Circle 577 on inquiry card.

Videodisc Interface

Matrox Electronic Systems' VDI-1 videodisc graphics and data interface is a three-board, Multibus-compatible set designed for applications using NTSC (National Television Standard Code) laser videodiscs, including computer-aided instruction, mapping, simulation, and electronic publishing. The VDI-1 provides four operating modes that let you display a high-resolution image by combining a number of standard-resolution NTSC frames, retrieve large amounts of digital information, play an audio sound track while displaying a single television frame, and overlay computer graphics and alphanumerics on top of a video picture. This product allows four NTSC frames to be simultaneously stored in picture memory. For alphanumerics and graphics overlays, the system's central processor can read or write to any pixel or any bit of a pixel in the picture-memory space.

The VDI-1 costs $7900 per set, which includes demonstration software. Contact Matrox Electronics Systems Ltd., 5800 Andover Ave., Town of Mount Royal, Quebec H4T 1H4, Canada, (514) 735-1182.

Circle 578 on inquiry card.

Switchable Memory for VIC Has Dual Connectors

RAMAX, a 28K-byte switchable memory and dual connector expander for the Commodore VIC-20, is available factory-direct from Apropos Technology. RAMAX has two extension connectors that are identical to the VIC's memory-expansion connector, except that the game cartridge signal, BLK 5, can be enabled or disabled. The memory is switchable in or out of use in one 3K- and three 8K-byte sections. Standard features include a Reset switch, a safety fuse, self-test program, and a display case.

RAMAX costs $169, which includes an operating manual and shipping fees. A 19K-byte version, RAMAX Jr., costs $139. Dealer inquiries are invited. Contact Apropos Technology, Suite 821, 350 Lantana Ave., Camarillo, CA 93010, (805) 482-3228.

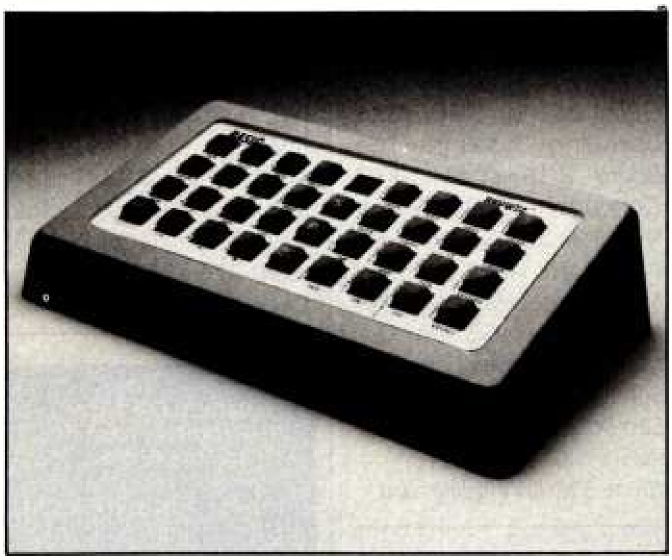
Circle 579 on inquiry card.

Sweet-P Plots Colorful Graphics

The Sweet-P Personal Plotter from Enter Computer draws hard-copy graphics such as colorful bar charts and illustrations. Sweet-P lets you create, edit, and store color graphics that can be recalled and instantly plotted in any scale. Graphics and engineering symbols may be programmed in memory and recalled with a single keystroke. Standard features include 19 programming commands, a plotting area of 7½ by 118 inches, a step size of 0.004 inch (i.e., 250 line segments per inch), and a programmable plotting speed of up to 6 inches per second. Alphanumeric character sizes can be as small as ⅛ inch or as large as 20 inches. Sweet-P draws on overhead transparency film or 8½-inch-wide paper up to 120 inches long using specially made or commercial pens.

Optional accessories include an acetate-compatible pen set, advanced analytical and business graphics, and interface cables for Apple, Radio Shack TRS-80, IBM Personal Computer, and other popular microcomputers. Sweet-P costs $795, which includes basic analytical engineering and business graphics software, a pen adapter, a pen set made up of red, green, blue, and black fiber-tip pens, plotting paper, and an operation manual with maintenance tips and programming instructions. It's available from Enter Computer Inc., 6867 Nancy Ridge Dr., San Diego, CA 92121, (619) 450-0601.

Circle 580 on inquiry card.

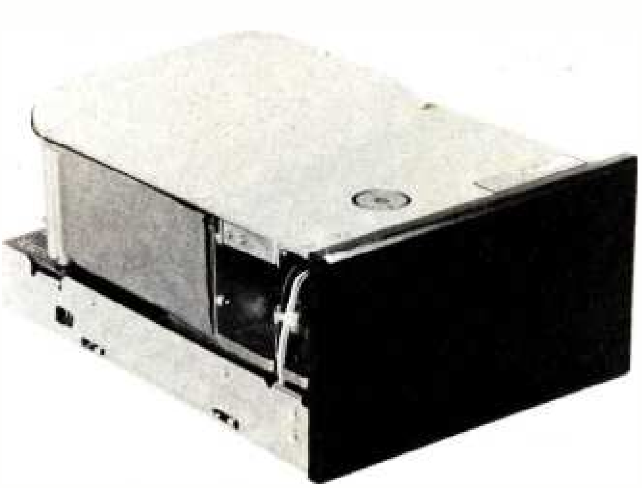


248 Preprogrammed Keys Possible with Keywiz

An auxiliary keyboard with 31 user-programmable function keys, the Keywiz VIP is manufactured by Creative Computer Peripherals. Each programmable key can be set for as many as eight characters and reprogrammed once again using the shift key for a total of 62 user-defined keys. The Keywiz comes with four easy-to-access keyboard layouts in memory, which makes 248 preprogrammed keys available at any time. A 7-segment LED (light-emitting diode) displays which keyboard mode you're using. Individual keys can be programmed any number of times, even while you're running a program.

The Keywiz VIP is software-independent and can be ordered for Apple II Plus, Apple IIe, Franklin Ace, and Radio Shack TRS-80 Model III systems. Contact Creative Computer Peripherals Inc., Aztec Environmental Center, 1044 Lacey Rd., Forked River, NJ 08731, (609) 693-0002.

Circle 581 on inquiry card.



XT Memory Expansion

Microdisk has unveiled a memory-system upgrade kit for the new IBM Personal Computer XT. With this kit, IBM dealers can expand the XT's integral Winchester hard-disk storage from 12 megabytes to 20, 27, or 54 megabytes (unformatted). The kit includes a new DOS with print spooling and a higher-capacity Winchester disk. Also available is the 1DOS operating system, which allows your XT to run CP/M-80 and CP/M-86 applications software under native PC-DOS. For the name of your nearest IBM dealer, contact Microdisk Inc., 1422 Industrial Way, POB 1377, Gardnerville, NV 89410, (702) 782-8105.

Circle 582 on inquiry card.

Add an Apple to IBM

Quadlink, a mulifunction board designed to allow Apple software to be used with IBM PC and XT computers, is produced and marketed by Quadram Corporation. Quadlink is a simulated Apple computer on a single board that provides a means for translating DOS 3.3 software for use on an IBM. It works with most programs designed for the Apple II, II Plus, and IIe and permits the use of such IBM enhancements as printers and buffers while running Apple software. Entering and exiting the Apple mode is accomplished with a single command. Disks do not require reformatting or converting. Quadlink connects to one IBM expansion slot.

Quadlink comes with 64K bytes of memory and game, parallel, and serial ports. The suggested retail price is $680. Full information is available from Quadram Corp., 4357 Park Dr., Norcross, GA 30093, (404) 923-6666.

Circle 583 on inquiry card.

MISCELLANEOUS

Software Modules Tailor Keyboard for Tasks

Executive Peripheral Systems markets a detachable keyboard upgrade for Apple II/II Plus computers that features plug-in PROM (programmable read-only memory) modules to configure it for popular software packages. When used with EPS PROMware modules, the board's 12 special function keys provide up to 48 commands tailored for the software package. Each module comes with a label strip identifying the commands programmed into the function keys. Current modules include Wordstar, Screenwriter II, Visicalc, and Apple Writer II.

The EPS keyboard connects directly to the Apple's keyboard socket. It has a complete word-processing layout with full-travel key switches, multifunction edit keys, shift and shift-lock keys, and cursor-control keys. Most keys are equipped with automatic repeat capabilities. A built-in 21-key numeric keypad, full ASCII characters, parallel output, and a 6-foot cord are standard.

The suggested retail price is $399.95, which includes BASIC and DOS modules and an interface card. Additional PROMware modules cost $32.95. This keyboard can be ordered from Executive Peripheral Systems Inc., 800 San Antonio Rd., Palo Alto, CA 94303, (415) 856-2822.

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16-Bit Upgrade Upholds 8-Bit Software

Octagon Computer Systems' Board 8/16 lets you upgrade to a 16-bit system without making your 8-bit software obsolete. This board features IEEE-696 (S-100) compatibility, an 8-MHz, 16-bit 8088 processor, and an NSC-800 chip that operates at 4 MHz and executes the full Z80 instruction set. A built-in Intel 8272 floppy-disk controller provides 24-bit DMA (direct memory access), can handle four 5¼- or 8-inch floppy-disk drives, and allows file transfers between drives. The Board 8/16 has an 8K-byte PROM (programmable read-only memory) monitor that boots the operating system and comes with such debugging features as memory test, dump, and search. Also standard are two serial ports with software-selectable data rates of up to 19,200 bits per second, an interrupt controller with eight vectored interrupts, and a fixed-frequency real-time clock interrupt for multiuser dispatching.

Options include an 8087 mathematics coprocessor and Concurrent CP/M-86 or MP/M-86 operating systems. The Board 8/16 costs $895. Concurrent CP/M-86 and MP/M-86, sold only with the board, are $195 and $495, respectively. Full details are available from Octagon Computer Systems, Suite 5, 151 Bernal Ave., San Jose, CA 95119, (408) 225-2700.

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Nonvolatile Memory Module

The NVRD64, a 64K-byte nonvolatile memory module, can be used as all the memory in a conventional 8-bit system. Produced by the British firm Greenwich Instruments Ltd., this 4- by 2- by 1-inch plug-in unit can be paged into memory and used as data RAM (random-access read/write memory), emulating a high-speed disk. It features internal buffering, 150-nanosecond access time, 10-year data retention, an unlimited number of read/write cycles without wait states or additional hardware, and 5-volt operation. Up to eight NVRD64s will fit on an S-100 card; four on a Eurocard. As a replacement for a ROM (read-only memory), this device permits immediate reconfiguration at any time while retaining the convenience of a ROM-based system.

The NVRD64 uses an industry-standard connector that's compatible with vertical- or horizontal-mount printed-circuit boards, backplanes, and IDC connectors. The NVRD64 costs $875. It's distributed by LMS Electronics, 3401 Monroe Rd., Charlotte, NC 28205, (704) 376-7805.

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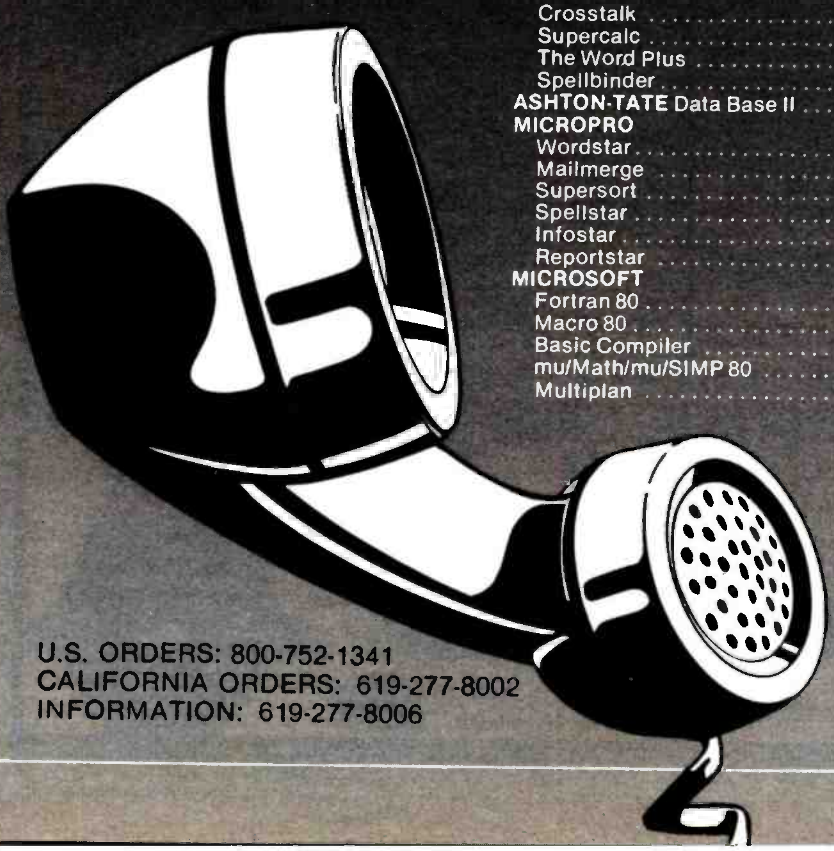

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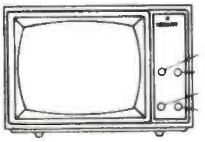

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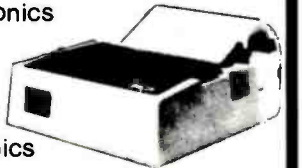

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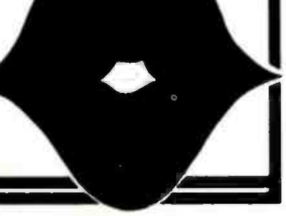

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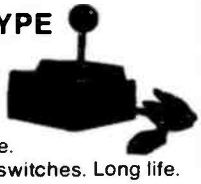

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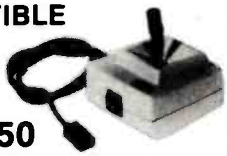

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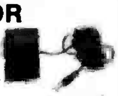

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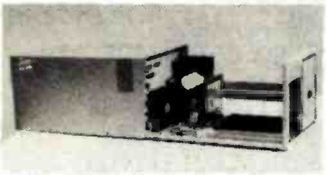
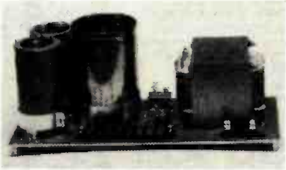

No. 806 & No. 516 Mainframes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S_3, S_4 for S-100 & 2 Drives

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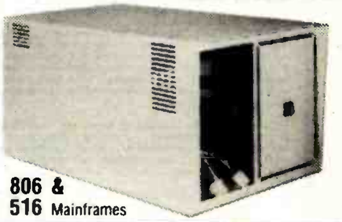
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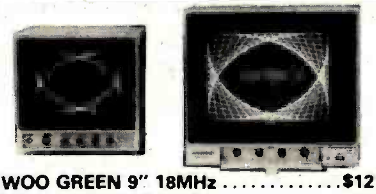

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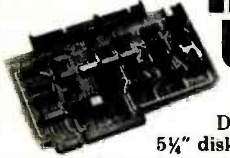

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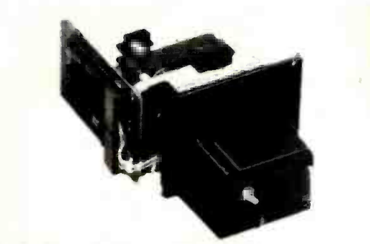

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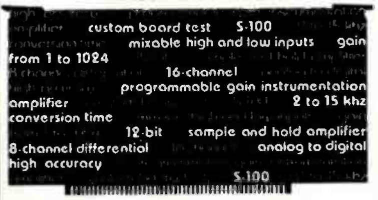

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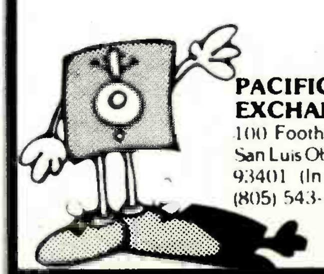

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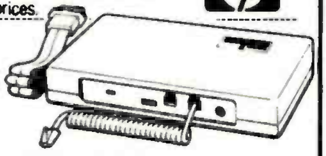

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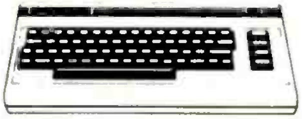

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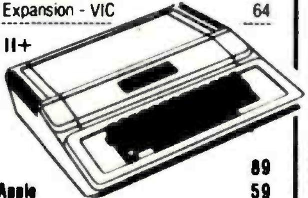

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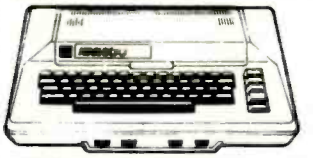

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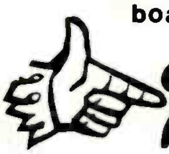

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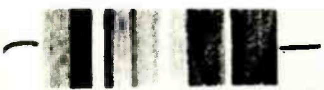

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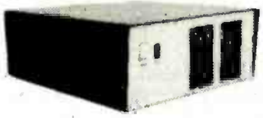

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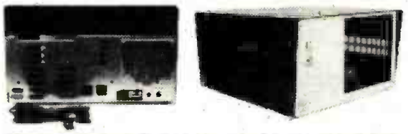

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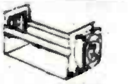

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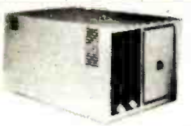

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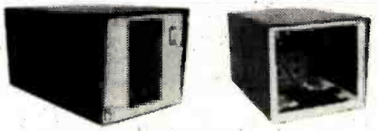

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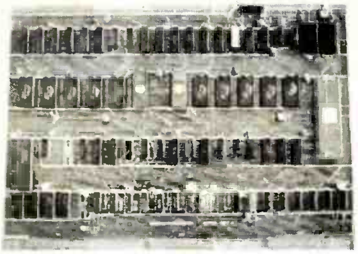

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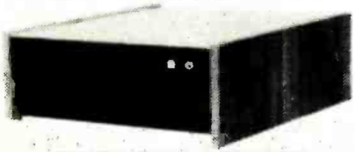

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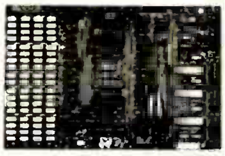

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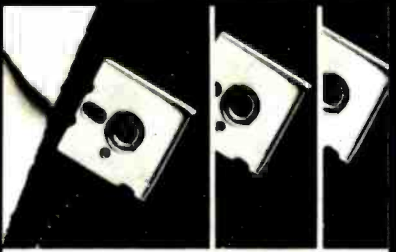

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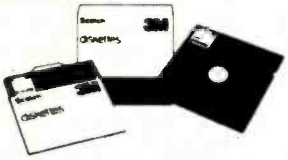

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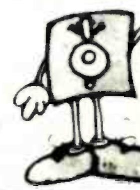

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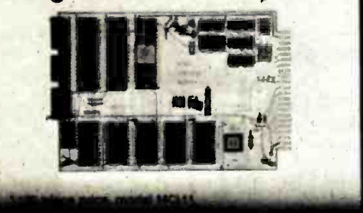

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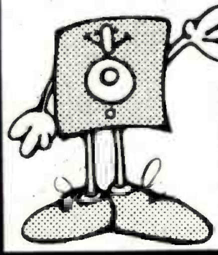

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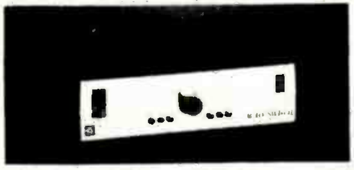

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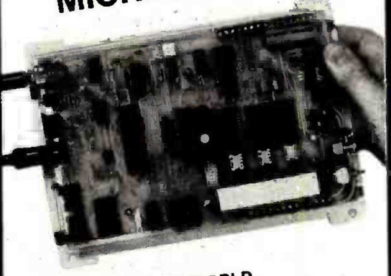

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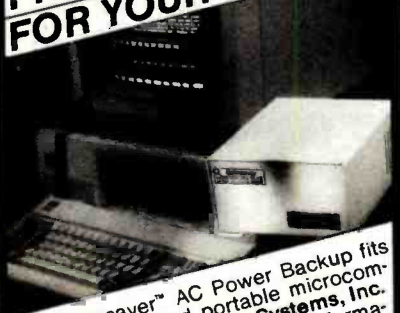

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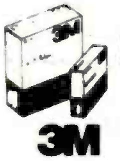

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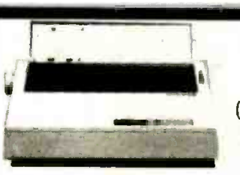

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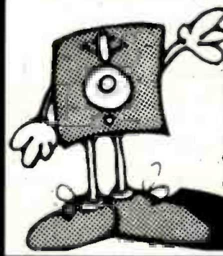

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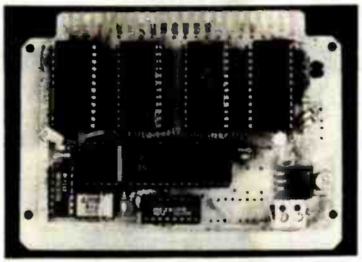

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J-Cat	$119

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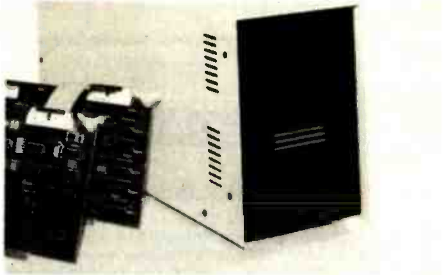

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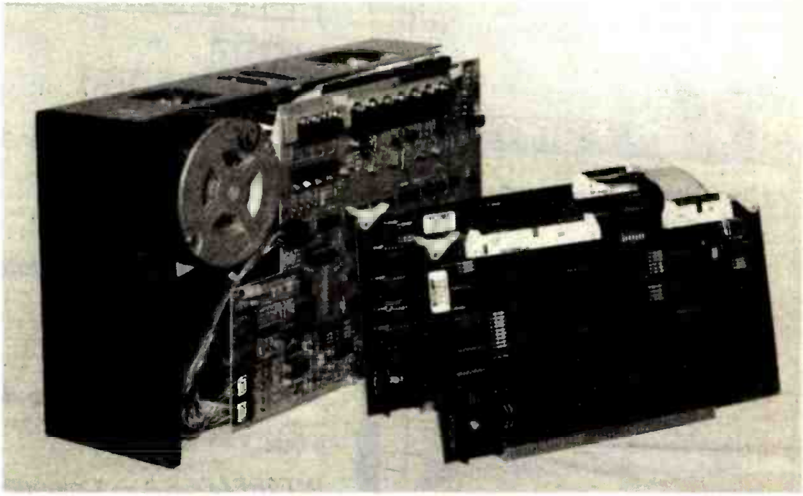

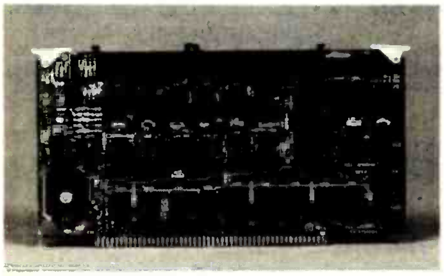

VERSAFLOPPY II

SD Systems' Versafloppy II is a reliable field-proven S-100 double-density floppy disk controller. For full software compatibility it can also read and write standard IBM 3740 single density format. The Versafloppy II controls single or double sided drives in single or double density format. 5¼" 8" in any combination and up to 4 drives simultaneously. The Versafloppy II is faster, more stable and more tolerant of bit shift and "jitter" than most other controllers. All control and diagnostic firmware included

IOO-1160A	*Versafloppy II*	**$359.95**

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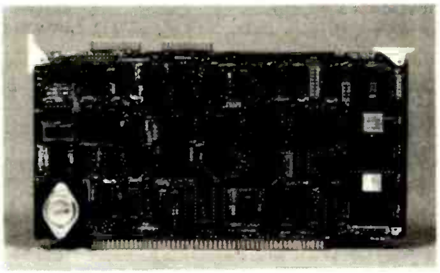

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SO System's SBC-200 is an S-100 bus compatible single board computer based on the 4 MHz Z80A CPU. It contains a sychronous/asynchronous serial port with software programmable baud rates, a parallel I/O port, a four channel counter timer and 1K on-board RAM. Up to 8K of firmware may be added to the board's 4 EPROM sockets. The SBC 200 is the ideal heart of a system composed of the other boards in the SD product line, or can stand alone in process control applications.

CPC-30200A	*SBC-200*	**$399.95**

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MEM-66256A	*RAM DISC*	**$799.95**

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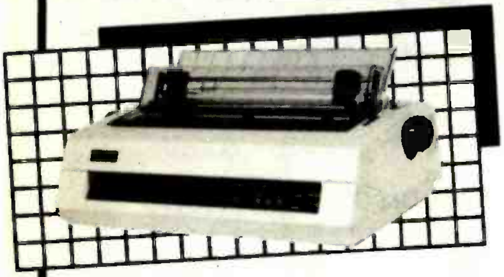

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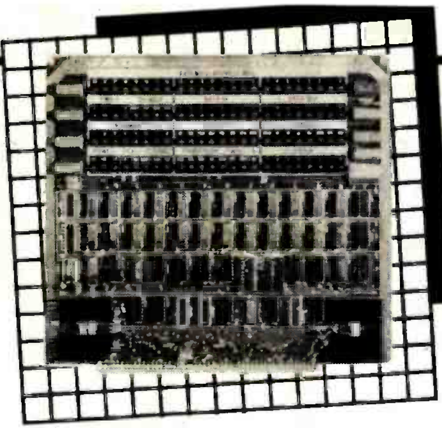

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Inexpensive S-100 Diagnostic Analyzer

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END-000436	*Kit w/2 Shugart SA-851Rs*	**$1274.95**
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MBS-061A	*A & T*	**$69.95**

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MBS-121K	*Kit*	**$69.95**
MBS-121A	*A & T*	**$109.95**

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MBS-181A	*A & T*	**$149.95**

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Both 8 & 16 bit CPUs, standard 8 bit S-100 bus, up to 8 MHz, accesses 16 Megabytes of memory

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Dual 8" Slimline Sub-Systems

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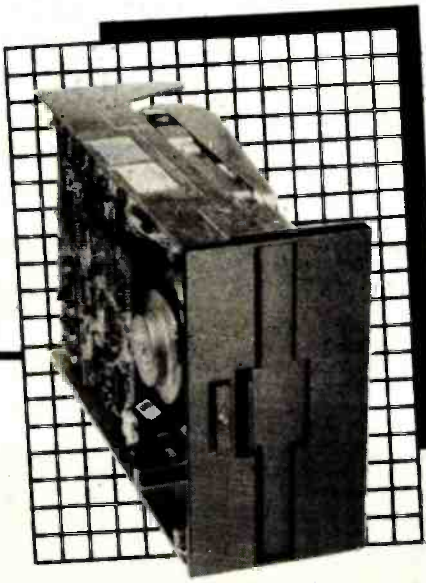

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74LS08	.23	74LS137	.89	74LS273	1.48
74LS10	.23	74LS138	.49	74LS275	3.20
74LS11	.25	74LS139	.49	74LS279	.48
74LS12	.25	74LS145	1.19	74LS280	1.79
74LS13	.39	74LS147	2.39	74LS283	.68
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74LS15	.29	74LS151	.39	74LS293	.78
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74LS37	.29	74LS163	.64	74LS367	.44
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74LS76	.34	74LS192	.64	74LS447	.37
74LS78	.45	74LS193	.64	74LS490	1.94
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74LS109	.35	74LS245	1.48		
74LS112	.35	74LS247	.74	81LS95	1.48
74LS113	.35	74LS248	.89	81LS96	1.48
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2.4576	2.69	14.31818	2.69
3.2768	2.69	15.0	2.69
3.579545	2.69	16.0	2.69
4.0	2.69	17.430	2.69
5.0	2.69	18.0	2.69
5.0688	2.69	18.432	2.69
5.185	2.69	20.0	2.69
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7824T	.85		
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7805K	1.29	7912K	1.39
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RS232	Male	3.00
RS232	Female	3.50
RS232	Female Right Angle	4.95
RS232	Hood	1.20
30 pin Edge		2.49
44 pin Edge		2.49
50 pin Edge		2.69
86 pin Edge		3.90
100 pin ST		3.90
100 pin W/W		4.90

DoKay Computer Products, Inc.
3250 Keller Street, #9
Santa Clara, CA 95050
(800) 538-8800
Calif. Residents
(800) 848 8008
Local Phone
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STORE HOURS:
MON-FRI 8:30 A.M.-5:30 P.M.
SAT 10:00 A.M.-3:00 P.M.

BANKAMERICARD VISA

master charge

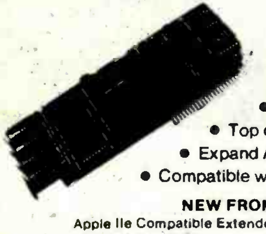
TERMS: For shipping include $2.00 for UPS Ground. $3.00 for UPS Blue Label Air. $10.00 minimum order. Bay Area residents add 6½% Sales Tax. California residents add 6% Sales Tax. We reserve the right to limit quantities and substitute manufacturer. Prices subject to change without notice. Send SASE for complete list.

Circle 129 on Inquiry card.

ADVANCED COMPUTER PRODUCTS

SEND $2.00 for 1983 CATALOG

16K Apple™ Ramcard



LIST 195
ACP
$59.95

- Full 1 year warranty
- Top quality — gold fingers
- Expand Apple II 48K to 64K
- Compatible with Z-80 Softcard™

NEW FROM COEX
Apple IIe Compatible Extended 80 Column TEXT Card
List $199.00 ACP $149.00

32K STATIC RAM

2 or 4 MHz
Expandable
Uses
2114L's

16K 4 MHz Kit		$159.95
16K 4 MHz A&T		217.95
32K 4 MHz Kit	$129.95	~~269.95~~
● 32K 4 MHz A&T		● 339.00
BARE BOARD		39.95
Bare Bd w/all parts less mem.		99.95

REPEAT OF SELL-OUT 58 Key Unencoded Keyboard

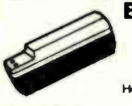
$19.95 ea.

This is a new 58 key terminal Keyboard manufactured by a major manufacturer. It is uncoded with SPST keys unattached to any PC board. Solid molded plastic 11" x 4" base.

Unencoded Key Pad

15 key Keypad with 1-10 keys and tab, return, (−), (;) and (.).
only $9.95 ea.

UV "EPROM" ERASER



Model DE-4
$89.95
Holds 4 EPROM's at a time.
Model S-52T $325.00

16K Memory Expansion Kits for Apple/TRS-80

8 pcs 4116 16K
200/250nS
Specify computer $12.95
CALL FOR VOLUME PRICING

CORCOM FILTER

Popular CORCOM Filter
6 amps $4.95
Compatible Line Cord Add ... $3.50

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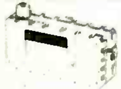
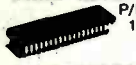


for COLOR & B/W
P/N 1082 Channel 3 or 4 $6.95

AMD MODEM IC

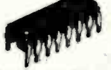


P/N AM7910
1200Baud
5 Volts
Special ACP Price $99.00

64K CMOS RAMCARD

IEEE Compatible
Uses Low Power 6116 IC's
5Volt
Single Supply
Assm and Tested
$299.00

INTEL 4K STATIC RAMS



Super Fast!
Super Low Power!
Part No. 2147 ...... $1.95 ea.

STEPPER MOTOR

Operates by applying 12VDC in one direction and then reversing polarity (or square wave). Uses 12VDC, Clock Wise Rotation, Rated 3 RPM at 4 P.P.S. with a 5 degree stepping angle.

ACP PRICE $3.95 ea. 10 for $34.95

RS232 SIGNAL TESTER

COEX RS232 Line Tester
(7) LED Indicators
only $24.95
Other Styles Also Available

INTEL CODEC IC

P/N 2910A
For Digital Voice
$9.95 ea.
For Filter P/N 2912A ... $4.95 ea.

SURGE SUPPRESSOR

"Surgeonics" Power Sentry
15 Amps 250 Volts transient suppression
ACP Low Price $39.95

CONNECTORS

DB25P (RS232)	$3.25
DB25S Female	3.75
Hood	1.25
Set with Hood, Sale	7.50
22/44 S/T, KIM	2.95
43/86 S/T, MOT	6.50
50/100 S-100 Connector W/W	4.95
50/100 S-100 Connector S/T	3.95

PARALLEL ALPHA NUMERIC PRINTER

19 Column Printer prints 16 numerical columns plus 3 columns which have math, alpha and other notations. Each wheel has 12 positions with position 12 blank. Position 11 on numerical columns have decimal point or #. Utilizes 2.75" wide adding machine tape and a dual color ink ribbon. Input data parallel with four bit BCD comparator circuit (schematic provided). Print rate, 3 lines per second. Operating voltage 22-28VDC with typical cycle time of 340mS. Size 6½"W x 3⅛"H x 5⅝"Dp. New. $9.95 ea. 3/$27

MICROPROCESSORS

Z8001	$99.00	8008-1	$14.95	6802P	14.95
Z8002	69.00	2901	9.90	8035	14.95
Z80	9.95	2901A	14.95	8039	12.95
Z80A	11.95	9900JL	49.95	8073N	34.95
F-8 (3850)	16.95	6502	9.95	8755	49.95
2650	16.95	6502A	16.95	8748	49.95
1802	9.75	IM6100	29.95	6809	30.00
8080A	4.75	6800	11.75	8086	49.95
8085	14.95	68008	19.95	68000	129.95

RAMS

CALL FOR QTY PRICING

6116/2016	$7.95	2147	$5.99	5290	$1.99
8264-64K	5.95	411	5.99	5298	1.49
4116-2	1.99	414	4.69	6508	4.50
4116-2	8/12.95	1101	.99	6518	6.79
2101	3.99	1103	.99	6561	3.79
2102	.79	4027	4.69	6604	3.99
21L02-2	1.49	4044	3.99	6605	7.99
21L02-4	1.29	4050	4.69	9130	8.99
2111	3.49	4060	4.69	9140	8.99
2112	3.49	4096	3.99	93415	6.99
2114	1.99	4115	1.49	93425	6.99
2114L-2	3.25	4200	7.95		
2114L-4	2.29	4402	1.99		
2125	6.99	5260	4.60		

64K only [illegible]

SUPPORT

8155	$9.95	8259	$8.95	68047	$22.95
8156	9.95	8275	19.95	68488	19.95
8202	29.95	8279	9.50	46505	22.95
8205	2.69	6810	4.75	6520	6.95
8212	2.75	6820	8.50	6522	9.95
8214	4.95	6821	6.50	6530-X	24.95
8216	2.75	6828	10.50	6532	17.95
8224	2.95	6834	16.95	6551	19.95
8226	2.95	6845	22.95	Z80-PIO	6.50
8228	3.95	6847	27.95	Z80A-PIO	9.50
8243	9.50	6850	5.25	Z80-CTC	6.50
8250	14.95	6852	5.25	Z80A-CTC	9.50
8251	8.50	6860	10.95	Z80-DMA	19.95
8253	11.95	6862	10.95	Z80A-DMA	27.95
8255	4.50	6875	5.95	Z80-SIO	24.95
8257	9.50	6880	2.49	Z80A-SIO	29.95

MOS PROMS

2764 (8Kx8) TS	$69.95	2708 (450nS)	$5.75
2732 (4Kx8) TS	12.95	2708 (650nS)	5.25
2716/2516, 5V (2Kx8) TS	7.95	1702A	5.75
TMS2716, 5V, 12V	17.95	MM5203AQ	14.50
2758, 5V, (450nS)	3.50	MM5204Q	9.95

HI-TECH

2513-001 (5V) Upper	$9.50	DAC08	$9.95
2513-005 (5V) Lower	10.95	DAC100	9.95
2513-ADM3 (5V) Lower	14.95	8038 Function Generator	4.50
MCM66710 ASCII Shifted	12.95	MC4024 VCO	2.95
MCM66740 Math Symbol	13.95	LM566 VCO	1.95
MCM66750 Alpha Control	13.45	XR2206 Function Generator	5.25
1771-01 8" & Minifloppy	24.95	TR1602B (5V, 12V)	3.95
1781 Dual Floppy	29.95	AY51013 (5V, 12V)	4.95
1791-01 Dual Floppy	36.95	AY51014A/1612 (5-14V)	6.95
1791-02 Dual Floppy	44.95	AY51015A/1863 (5V)	6.95
1793 DD, DS Floppy	44.95	IM6402	7.95
1797 DD, DS Floppy	54.95	IM6403	8.95
1691 Data Separator	18.95	2350 USRT	9.95
2143 Clock Generator	18.95	1671B Astros	24.95
8700 8 bit Binary	13.50	MC14411	11.95
8701 10 bit Binary	22.00	4702	14.95
8703 8 bit TS	13.50	WD1941	9.95
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8750 3½ Digit BCD	13.95	INS8250	15.95
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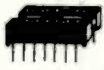
1408L8 8 bit	5.95	AY5-3600	13.75
DAC01 D to A	5.95	MM5740AAC	8.95

SOCKETS



LOW PROFILE SOCKETS (TIN)

	1-24	25-49	50-100
8 pin LP	.16	.15	.14
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

3L WIREWRAP SOCKETS (GOLD)

	1-24	25-49	50-100
8 pin WW	.55	.54	.49
10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
16 pin WW	.80	.77	.70
18 pin WW	.95	.90	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
28 pin WW	1.60	1.53	1.38
40 pin WW	2.20	2.09	1.89

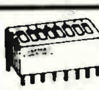
LINEAR

78H05K	$5.95	LM1414N	$1.90
78M06	1.49	LM1458CN/N	.49
78M G	1.49	MC1488N	.99
LM108AH	2.95	MC1489N	.99
LM300H	.99	LM1496N	.89
LM301CN	.35	LM1556N	1.50
LM304H	1.98	LM1820N	.95
LM305H	1.89	LM1850N	.95
LM306H	3.25	LM1889N	3.10
LM307CN	.29	LM2111N	1.75
LM308CN	.98	LM2900N	.99
LM309K	1.49	LM2901N	2.50
LM310CN	1.25	LM2917N	2.95
LM311D/CN	.89	CA3013T	2.19
LM312H	1.75	CA3018T	1.99
LM317T	1.70	CA3021T	3.49
LM318CN	1.49	CA3023T	2.99
LM319N/H	1.25	CA3035T	2.75
LM320K-XX*	1.35	CA3039T	1.29
LM320T-XX*	1.39	CA3046N	1.29
LM320H-XX*	1.25	LM3053N	1.49
LM323K	4.95	CA3059N	3.19
LM324N	.95	CA3060N	3.19
LM337K	5.95	CA3062N	4.95
LM338K	6.95	LM3065N	1.49
LM339N	.95	CA3080T	1.29
LM340K-XX*	1.75	CA3081N	1.69
LM340T-XX*	1.25	CA3082N	1.69
LM340H-XX*	1.25	CA3083N	1.55
LM344H	1.95	CA3086N	.80
LM348N	1.20	CA3089N	2.99
LM350K	5.60	CA3096N	3.49
LM358CN	.98	CA3097N	1.99
LM360N	1.49	CA3130T	1.30
LM372N	1.95	CA3140T	1.19
LM376N	3.75	CA3146N	2.49
LM377N	2.75	CA3160T	1.19
LM380CN/N	1.25	CA3190N	1.95
LM381N	1.79	CA3410N	.59
LM383T	1.95	MC3423N	1.49
LM386N	1.25	MC3480N	3.95
LM387N	1.40	SG3524N	3.95
LM390N	1.95	CA3600N	3.39
NE531V/T	3.75	LM3900N	.59
NE555V	.39	LM3905N	1.19
NE556N	.98	LM3909N	.98
NE561T	19.95	LM3914N	3.75
NE565N/H	1.25	LM3915N	3.95
NE566H/V	1.75	LM3916N	3.75
NE567V/H	1.50	RC4131N	2.95
NE592N	2.75	RC4136N	1.10
LM702H	1.99	RC4151N	3.70
LM709N/H	.29	RC4194TK	4.95
LM710N/H	.75	RC4195TK	5.40
LM711N/H	.39	ULN2001	1.25
LM715N	1.95	ULN2003	1.50
LM723N/H	.65	SN75450N	.59
LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
LM748N/H	.39	SN75492N	.89
LM760CN	2.95	SN75493N	.89
LM1310N	1.90	SN75494N	.89
MC1330	1.95	TL494CN	4.20
MC1350	1.95	TL496CP	1.65
MC1358	1.75		

74S00

74S00	$ .39	74S124	3.69	74S244	$2.99
74S02	.43	74S133	.54	74S251	1.35
74S03	.45	74S134	.66	74S253	1.35
74S04	.52	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.69	74S258	1.29
74S08	.49	74S138	1.29	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
74S30	.42	74S160	2.79	74S471	7.95
74S32	.49	74S174	1.49	74S472	7.95
74S38	1.19	74S175	1.49	74S473	7.95
74S40	.49	74S188	2.69	74S474	9.95
74S51	.42	74S194	1.89	74S475	9.95
74S64	.46	74S195	1.69	74S570	5.75
74S65	.46	74S196	1.69	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
74S86	.72	74S241	2.75	74S573	8.95
74S112	.72	74S242	2.99	74S940	2.90
74S113	.72	74S243	2.99	74S941	2.90
74S114	.72				

DIP SWITCHES



2 Position	$ .99	7 Position	$1.39
4 Position	1.19	8 Position	1.49
5 Position	1.29	9 Position	1.65
6 Position	1.35	10 Position	1.69

MUFFIN® FAN

The dependable, low cost, largest selling fan for commercial cooling applications.

- 105cfm free air delivery
- 4.68" sq. x 1.50" deep Weight - 17 oz.

SPECIAL PURCHASE
NEW! $9.50 ea.

7400

7400	$ .19	7475	$ .38	74161	$ .88
7401	.22	7476	.34	74162	.89
7402	.22	7479	4.60	74163	.87
7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7485	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	.45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.85
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.69	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
7445	.79	74147	1.95	74276	1.69
7446	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.67	74284	3.90
7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	.68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.65	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.88	74393	1.90
7474	.34			74490	1.90

74LS00

74LS00	$ .26	74LS113	$ .43	74LS245	$2.20
74LS01	.28	74LS114	.43	74LS247	1.10
74LS02	.28	74LS122	.55	74LS248	1.10
74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	.35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.85
74LS09	.35	74LS132	.79	74LS258	.98
74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.85	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
74LS14	.95	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.79	74LS275	4.40
74LS20	.26	74LS153	.79	74LS279	.59
74LS21	.33	74LS154	1.70	74LS283	.99
74LS22	.33	74LS155	1.19	74LS290	.99
74LS26	.33	74LS156	.99	74LS293	.99
74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.89	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS365	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.89	74LS373	1.89
74LS55	.29	74LS174	.89	74LS374	1.89
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS86	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.89	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
74LS95	.88	74LS240	1.69	81LS95	1.69
74LS96	.98	74LS242	1.69	81LS96	1.69
74LS107	.45	74LS243	1.69	81LS97	1.69
74LS109	.45	74LS244	1.49	81LS98	1.69
74LS112	.43				

VOLUME PRICING CALL TOLL FREE

CMOS

4000	$ .35	4037	$1.95	4089	$2.95
4001	.35	4040	1.29	4093	.99
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4012	.25	4049	.45	14415	8.95
4013	.45	4050	.69	14419	4.95
4014	1.39	4051	1.10	4501	.39
4015	1.15	4052	1.10	4502	1.65
4016	.59	4053	1.10	4503	.69
4017	1.19	4055	3.95	4505	8.95
4018	.89	4056	2.95	4506	.75
4019	.45	4059	9.25	4507	.95
4020	1.10	4060	1.39	4508	3.75
4021	1.19	4066	.75	4510	1.19
4022	1.15	4069	.35	4511	1.19
4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	.85	4075	.35	4520	1.25
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4031	3.25	4078	.35	4566	2.25
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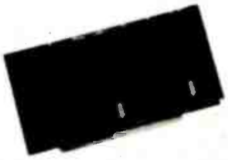

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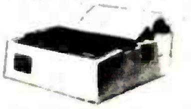

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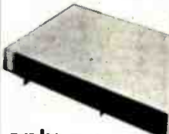

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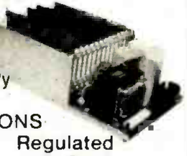

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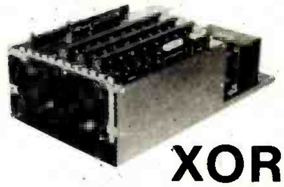

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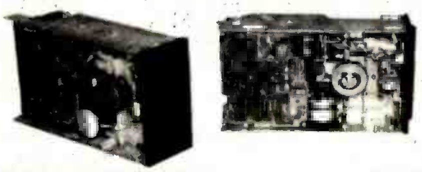

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INTERFACE TO ANY S-100 SYSTEM!!!

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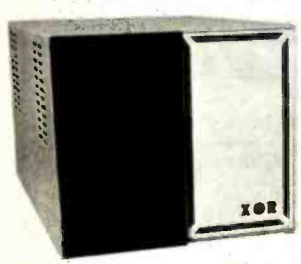
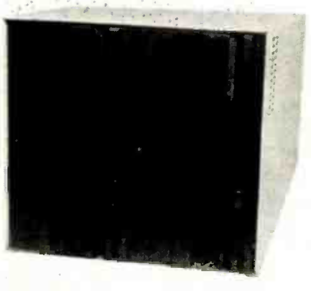


NOW **U.S. Micro Sales** offering mass storage subsystem add-ons for your **XOR** S-100-4, S-100-12, or any S-100 computer systems. Choose from five to 15 megabytes of hard disk storage or invest in a 10 or 20 megabyte removeable cartridge subsystem and never worry about storage problems again! The 20 megabyte cartridge add-on includes two cartridge drives which means 10 meg to 10 meg back-up and storage in under 3 minutes! All subsystems include chassis, cabinet, power supply, all necessary cables, and all required software. All non-**XOR** S-100 systems will require an S-100 Interface board for the 5, 10 and 15 megabyte hard disk units at an additional **$199⁰⁰**. The Iomega™ cartridge subsystems include this interface at no extra cost.



ONLY 6" x 6" x 11"! Save $150 on our 5 megabyte hard disk add-on. Reg. $1295

5 megabyte	#S-1000-52	**$1145⁰⁰**
10 megabyte	#S-1000-53	**$1495⁰⁰**
15 megabyte	#S-1000-54	**$1695⁰⁰**

XOR Data Sciences S-100 interface board is included with the above cartridge subsystems to interface the hard disk controller to the S-100 bus.

10 megabytes of removeable cartridge add-on. #S-100-55	**$1995⁰⁰**
20 megabytes 2 drive add-on backup cartridge to cartridge a full 10 meg. in less than 3 minutes. #S-1000-56	**$2950⁰⁰**
Extra cartridges. #M-2000-51	**$50⁰⁰**

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TERMS: We accept VISA/MC, prepay, check or money order. Please allow personal check two weeks to clear before shipment. $5.00 handling charge on all orders under $50.00. 15% Restocking Fee. All orders shipped via U.P.S. unless otherwise specified. All UPS C.O.D. orders over $100.00 require a Cashiers Check. ★ Our products carry a full 6 months parts and labor warranty excluding drives, printers and terminals which carry the full O.E.M. factory warranty. PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

U.S. MICRO SALES

★ *MADE IN U.S.A. BY AMERICANS* ★

★ *EAST* ★ *11 Edison Drive, New Lenox, Illinois 60451*
★ *WEST* ★ *15392 Assembly Lane, Huntington Beach, CA 92649*

TERMINALS

Adds Viewpoint 3A+: A low cost high performance terminal w/green screen and detachable keyboard. Features include ★ Reverse video ★ ½ intensity ★ Visual highlighting ★ Full auxiliary port use ★ 150 — 19.2K baud rate.

#T-1000-04	**$519.00**

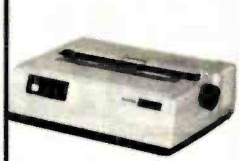
Televideo 910+: Save your eyes on a great green screen w/features like ★ Built-in self test ★ Full editing ★ Tab options ★ cursor control ★ 16 visual attributes like, reverse video, monitor mode and ½ intensity.

#T-1000-05	**$569.00**

Televideo 925: From the hobbyist to the basic professional this popular terminal will fit your needs. ★ Detachable keyboard ★ Numeric keypad ★ Green screen ★ Self test ★ Time of day display ★ Programmable function keys ★ 912/920 emulation hardware/software programmable configurations.

#T-1000-08	**$739.00**
Televideo 950 #T-1000-09	**$939.00**

PRINTERS



C-Itoh Starwriter F-10: The best you can get in a daisy-wheel letter quality printer with removeable print head and speed to 45 C.P.S. Order serial or parallel models — same price. No extra charge for the quiet-low profile design.

F-10 Starwriter Parallel #M-2000-47	**$1475.00**
F-10 Starwriter Serial #M-2000-31	**$1475.00**

Okidata Microline: New versatility, correspondence quality printing and speed make the ML92 and ML93 the best printer values in their categories. Both printers provide multi-speed print modes; bi-directional high speed mode with short line seeking logic at 160cps, emphasized and enhanced mode printing at 80cps, and high resolution correspondence quality printing at 40cps. Dot-addressable graphics is standard. Both serial and parallel interfaces are standard and **BOTH prices include** full tractor assembly at no extra charge.

ML92 #M-2000-10	**$ 629.00**
ML93 #M-2000-11	**$ 965.00**

Epson FX-80: This is the latest entry from the manufacturer that has taken the printer market by storm by offering the highest quality at very reasonable prices.

One quick glance at the features below should convince you that Epson has created a real winner with the new FX80:

• Burst print speed of 160 cps; continuous speed of 110cps • 11x9 character matrix; 18x18 in emphasized and doublesize modes • User definable characters • Internal RAM can function as either 2K print buffer or user-definable character set storage area • Standard Centronics parallel interface • Programmable left margin; 32 horizontal tab stops and 8 sets of 16 vertical tabs.

Introductory offer #M-2000-70	**$599.00**
Above w/Serial/Int #M-2000-71	**$699.00**

The 4 slot S-100 systems below are equipped with the **XOR** Z-80 4MHZ three board set. Each can run 8″ or 5″ disk simultaneously. In addition to the high speed **XOR** mini format, they can read KPRO, IBM and Morrow 5″ disk formats. Each has a modular dual power supply sub chassis. They are fan cooled. Standard IO is 2 serial ports and one centronics parallel. Expansion IO is available.

TWIN 5¼″ MINI

★ System less boards and drives	**$ 425.00**
★ Mini 48TPI SS/DD	**$1395.00**
★ Mini 48TPI DS/DD	**$1495.00**
★ Mini 96TPI DS/DD	**$1650.00**

5¼″ HARD DISK ★ NEW PRODUCT SPECIAL ★

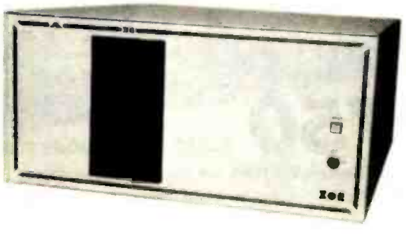
★ w/1 48TPI + 5 Meg	**$2395.00**
★ w/1 96TPI + 5 Meg	**$2495.00**
★ w/2 96TPI + 5 Meg	**$2750.00**
★ w/2 96TPI + 10 Meg	**$2995.00**
★ w/2 96TPI + 20 Meg	**$3445.00**

8″ MITSUBISHI/TANDON

★ System less boards + drives	**$ 395.00**
★ w/2 Mitsubishi DS/DD	**$1895.00**
★ w/2 Tandon SS/DD	**$1725.00**

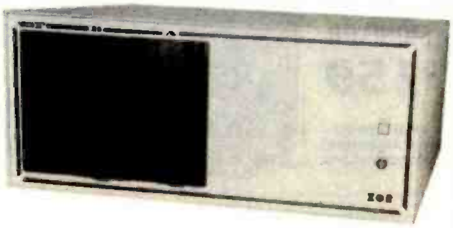
The 12 slot commercial grade S-100 systems below have all of the features listed above plus a massive 30 amp power supply capable of the expansion we expect you will do. All units are cooled by four inch fans. Each system must pass 2 days of constant read and write disk testing without a single error before shipment. ***One year complete system warranty is included.***

BASIC PROFESSIONAL



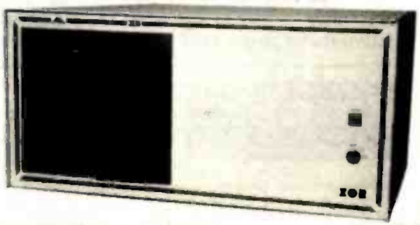
★ w/no drives (full board set)	**$1350.00**
★ w/2 Mitsubishi	**$2295.00**
★ w/2 Shugart 801R	**$2125.00**
★ w/2 Shugart 851R	**$2425.00**
★ w/2 Qume	**$2450.00**
★ w/2 Mitsubish/wide	**$2295.00**

IOMEGA S-100-12+



★ w/1 Iomega + 1 Floppy	**$3395.00**
★ w/1 Iomega + 2 Floppies	**$3715.00**
★ w/2 Iomega + 1 Floppy	**$3995.00**

PROFESSIONAL 8″ HARD DISK TO MP/M



★ w/20 Meg + 1 Floppy	**$4395.00**
★ w/40 Meg + 1 Floppy	**$4950.00**
★ w/85 Meg + 1 Floppy	**$5395.00**
★ Add Tape Backup	**$1495.00**
★ Add MP/M	**$ 695.00**
★ Add per User	**$ 250.00**

Circle 395 on inquiry card.

California Digital

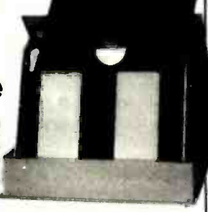
Post Office Box 3097 B • Torrance, California 90503

★ FREE ★

Plastic library case supplied with all diskettes purchased from California Digital

$19.95

New Low Price



Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life all diskette are manufactured with a reinforced hub.
Each box of diskettes is supplied with a free plastic library case.
Soft sector CAL-501, Ten sector CAL-510

5¼" DISKETTES WITH LIBRARY CASE

$26.50

Your Choice
**SCOTCH
MEMOREX
VERBATIM**

Single Side Double Density

	Soft Sector	10 Sector	16 Sector	
SCOTCH	744D-0	744D-10	744D-16	26.50
MEMOREX	3481	3483	3485	26.50
VERBATIM	525-01	525-10	NA	26.50
MAXELL	M01	MH1-10	MH1-16	29.85
DYSAN	104/1D	107/1D	NA	45.00

Double Side Double Density

SCOTCH	745-0	745-10	745-16	42.50
VERBATIM	550-01	550-10	NA	42.50
MAXELL	MD2-D	MH2-10D	MH2-16D	45.00
DYSAN	104/2D	107/2D	NA	49.50
DYSAN 96	204/2D	NA	NA	59.50

EIGHT INCH DISKETTES

Single Side Single Density

SCOTCH	740-0	29.50
MEMOREX	3060	29.50
DYSAN	3740/1	39.50

Single Side Double Density

SCOTCH	741-0	39.00
MEMOREX	3090	35.00
DYSAN	3740/D	57.50

Thirty Two Sector

SCOTCH	740-32	29.50

Double side Double Density

SCOTCH	743-0	47.50
MEMOREX	3114	39.50
DYSAN	3740/2D	65.00

Scotch Head Cleaning Kits 5¼ & 8"	$24.95
Plastic Library Cases 5¼ & 8"	2.95
Diskette Flip Tubs fifty diskettes 5¼"	
Diskette Flip Tubs fifty diskettes 8"	

Microswitch ASCII KEYBOARD $79

Each keyboard contains 81 high reliability Hall Effect keys. Outputs seven bit parallel ASCII MIC-81SD5 3 Lbs.

HITEK KEYBOARD $24.95

This Hitek keyboard is the same unit used by Lear Siegler in their middle line CRT terminals. The keyboard features 58 unencoded metal on metal contacts (HIK-58). Matching numeric cluster with 15 keys is available for $9.95 (HIK-15). Buy both of these units for only $29.90 and save $5.00 (HIK-5815).

MEMORY

16K DYNAMIC	2732 EPROM
1.95	**4.95**
4116 150ns.	450ns.
64K DYNAMIC	**16K STATIC**
6.95	**4.95**
4164 150ns.	6116 200ns.

2764 EPROM SALE $6.95

DYNAMIC MEMORY

		1-31	32+	100+
4027 4K dynamic 250ns	ICM-4027250	1.99	1.85	1.75
4116 150ns 16K	ICM-4116150	1.95	1.85	1.75
4116 200ns 16K	ICM-4116200	1.75	1.65	1.50
4164 150ns 64K 128 refresh	ICM-4164150	6.95	6.50	5.90
41256 150ns 256K	ICM-41256150			

STATIC MEMORY

21L02 200ns 1K static	ICM-21L02200	1.49	1.29	1.15
21L02 450ns 1K static	ICM-21L02450	1.29	1.15	.99
2112 450ns 2K static	ICM-2112450	2.99	2.85	2.75
2114 300ns 1K x 4	ICM-2114300	1.95	1.85	1.75
4044TMS 450ns 4K x 1	ICM-4044450	3.49	3.25	2.99
5257 300ns 4K x 1	ICM-5257300	2.50	2.25	1.99
6116 P4 200ns 2K x 8	ICM-6116200	4.95	4.80	4.65
6116 P3 150ns 2K x 8	ICM-6116150	5.95	5.75	5.60
6167/2167 100ns 16K x 1 (20 pin)	ICM-6167100	8.95	8.50	7.90

EPROMS

2708 450ns 1K x 8	ICE-2708	4.95	4.75	4.55
2716 450ns 2K x 8	ICE-2716	4.95	4.75	4.55
2716TMS 450ns Tri-voltage	ICE-2716TMS	7.95	7.65	7.25
2732 450ns 4K x 8	ICE-2732	4.95	4.75	4.55
2732 350ns 4K x 8	ICE-2732350	8.50	8.00	7.60
2532 450ns. 4K x 8	ICE-2532	10.50	9.90	9.50
2764 350ns 8K x 8	ICE-2764	6.95	6.65	6.47
27128 350ns 16K x 8	ICE-17128	29.95	26.95	

CONNECTORS

S-100 Gold
$2.95

DB25P
$2.50

GOLD EDGE CONNECTORS

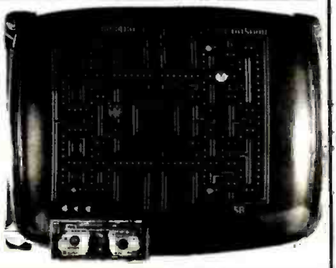
S-100 .125" centers	each	10+
Imsai solder .250" row	$2.95	$2.50
Imsai wire wrap (TI)	3.95	3.50
Sullins Hi-Rel. .250"	4.50	4.00
Sullins Hi-Rel. W/W	5.35	4.90
Sullins / Altair .140"	4.95	4.50
.156" Centers (standard)		
22/44 Kim Eyelet	2.50	2.15
36/72 Digital Group S/T	5.93	5.50
36/72 Digital Group W/W	6.60	6.15
43/86 Motorola 6800 S/T	6.60	6.15
43/86 Moto. 6800 W/W	7.00	6.85

INTEGRATED CIRCUIT SOCKETS

	Low Profile		Wire Wrap	
	each	100+	each	100+
8 pin	$.10	$.09	$.46	$.41
14 pin	.10	.09	.45	.41
16 pin	.12	.11	.50	.45
18 pin	.15	.13	.68	.61
24 pin	.26	.24	.94	.87
40 pin	.42	.40	1.60	1.47

"D" Type	each	10-24	25+
DE9P male	$1.60	$1.40	$1.30
DE9S female	2.25	2.00	1.90
DE hood	1.50	1.35	1.20
DA15P male	2.35	2.15	2.00
DA15S female	3.25	3.10	2.90
DA hood 2/P	1.60	1.35	1.30
DB25P male	2.50	2.35	2.25
DB25S female	3.35	3.15	3.05
DB hood 2/P	1.35	1.15	1.05
DC37P male	4.20	4.00	3.70
DC37S female	6.00	5.75	5.50
DC hood 2/P	2.25	2.00	1.75
DD50P male	5.50	5.10	4.75
DD50S female	9.40	8.60	8.00
DD50 hood 2/P	2.60	2.40	2.10
CENTRONICS			
57-30360	7.95	6.75	5.75
RIBBON CABLE CONNECTORS			
17/34 5" disk	4.85	4.15	3.95
20/40 TRS-80	5.65	5.05	4.70
25/50 8" disk	5.90	5.15	4.90

23" COMPOSITE MONITOR $159



Ideal monitor for classroom demonstrations.

Ever try gathering a classroom of students around a 12" monitor? Here is your opportunity to purchase a 23" high resolution monitor at a reasonable price.
These units accept standard composit video signals generated by most personal computers including the Apple and IBM. Attach it your computer and in second you are shooting down Klingons in wide screen video.
MOT-BW23 35 Lbs. Monitors are open frame and for safety should be enclosed. Wood grained enclosure for above $35.00 additional CAL-ENC23 15 Lbs.

BLOWOUT SALE

$189

California Digital has recently participated in the purchase of several thousand Siemens FDD 100-8 floppy disk drives. These units are electronically and physically similiar to that of the Shugart 801R. Most applications that will accept the Shugart will work with the Siemens FDD 100-8. All units are new and shipped in factory sealed boxes. SEA-F1008 17lbs. Manual and power connectors supplied free upon request. Your choice 115 volt 60 Hz. or 230 volt 50 Hz. Also available: Two drive subsystem supplied in metal enclosure with power supply and exhaust fan. CAL-2F1008

NOTE! European customers, we have a large quantity of 230 volt 50 Hz. units warehoused in Frankfort Germany. Arrangements can be made to will call these drives in quantities of 50 or more in Frankfort reducing import duty and freight charges.

	One	Two	Ten
Eight Inch Single Sided			
SHUGART SA801R	$395	385	375
SIEMENS FDD100-8			
TANDON 848-1 SLIMLINE	379	369	359
Eight Inch Double Sided			
SHUGART SA851R	525	495	475
QUME DATA TRACK 8	525	495	475
MITSUBISHI M2894-63	485	475	469
OLIVETTI 802/851	369	359	349
TANDON 848-2 SLIMLINE	495	485	475
SHUGART 860 THINLINE	569	549	539
Five Inch Single Sided			
SHUGART SA400	215	209	199
TANDON TM 100-1	209	199	195
Five Inch Double Sided			
SHUGART SA450	349	329	315
TANDON TM 100-2	295	269	259
TANDON 96TPI TM100-4	369	355	350
OLIVETTI 502 ⅔ height	239	225	215
Three Inch Rigid Floppy			
HITACHI-AMDEK	call for pricing		
Five Inch Winchesters			
SEAGATE 506 6 Megabyte	759	725	695
SEAGATE 512 12 Megabyte	995	960	960
TANDON 603SE 14 Megabyte	995	960	895
WESTERN DYNAX removable	995	960	950

Upon request, all drives are supplied with power connectors and manual

$750 *Eight Inch Subsystem*

Two Siemens FDD100-8 disk drives with power supply, 4" exhaust fan complete with all necessary power cables.

Same as aoove but with:

Shugart 801R	MSD2801	$1195
Shugart 851R	MSD2851	1450
Olivetti 802	CAL2802	$1250
Qume DT8	MSD80T	1450

Shipping: First five pounds $3.00. Each additional $.50.
Foreign orders: 10% shipping. Excess will be refunded.
California residents add 6½% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "strong" Dun & Bradstreet.
Warehouse: 15608 Inglewood Blvd.

**TOLL FREE ORDER LINE
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TECHNICAL & CALIFORNIA
(213) 679-9001**

California Digital

Post Office Box 3097 B • Torrance, California 90503

LIBERTY FREEDOM 50 $475

The Liberty Freedom 50 terminal features detachable keyboard with 93 keys including 10 function keys, 15 graphic symbols, and DIP switch selectable character set for 7 foreign languages. The 12 inch etched non-glare green phosphor screen displays 24 rows by 80 characters in 7x9 matrix with true descenders. Self test and 25th data display row also included. Switch selectable baud rates from 110-19,200 baud. Screen attributes do not use display memory, allowing operator to display a full 1920 characters. Emulates 5 popular CRT terminals for easy software configuration. Switch selectable between 115 and 230 volt. We have never seen a terminal with all these features for the incredibly low price of only $475. UB-F50 40 lbs.

DIABLO

Word Processing Printer

$995

Now from the originator of the daisy wheel printer, the Diablo 620. Print speeds to 24 char/sec., user selectable bi-directional printing, superscripts, subscripts, graphics and more. Plus standard RS-232 interfacing. Communication speeds to 1200 baud with a 1500 character print buffer. Software programable absolute horizontal tabs makes report formatting easy. Over 20 different print wheels are currently available. The 620 automatically selects the print spacing for 10, 12, 15 char/inch print wheels. On site service available worldwide. DBL-620 50 lbs.

ECLIPSE 100

$695

The Eclipse 100 is an industrially rated IEE-696 S-100 18 slot mainframe. Equipped with a 500 watt toroid modular power supply to assure operation in the most severe enviorments. Provisions for internally mounting a 5¼ Winchester disk drive. All card positions receive proper cooling from a filtered 85 cfm fan. Constructed from 304 brushed stainless steel is suitable for medical and process control applications. Use of the highest grade materials and state of the art construction techniques has made Eclipse Data Products the industry standard for quality and versatility in computer mainframes. EDP-100 50 lbs.

MORROW DESIGNS

Micro Decision MD1

Include $1800 worth of FREE software

$995

The Morrow Micro Decision offers one of the best values in small business computers. Standard features include 64K of RAM, 4MHz Z 80 CPU, two RS232 serial ports, dual density floppy disk controller capable of supporting four disk drives, and a 200 Kilobyte 5¼" disk drive. The Micro Decision is delivered complete with CP/M 2.2 as well as Basic 80, Wordstar and other software packages. MDS-MD1 18 lbs.

Also available, pictured above, the Micro Decision MD2 with two 5¼" disk drives at only $1195.00 MDS-MD2 22 lbs.

Houston Instruments PLOTTERS

AS LOW AS $995

The DMP-29 is the latest in a long line of high reliability plotters from Houston Instruments. Software selectable 8 pens allows the operator to plot color illustrations, with dot resolution of .001". The DMP-29 can create graphs up to a maximum plot size of 10 by 15 inches. Easily interfaced to most computers through an RS-232 serial port. This unique plotter is also capable of functioning in a digitizing mode electronically inputing charts and graphs back into the computer. HOU DMP29 $1995.00 35 lbs. Also available, the single pen HOU DMP2 at $995.00

U.S. ROBOTICS 1200 BAUD MODEM

$419

The U.S. Robotics 212A/103 modem represents a major advance in 1200/300 baud modem technology. Proprietary 1200 baud LSI integrated circuits allows the U.S. Robotics 212A modem to maintain higher reliability over marginal phone lines.

The U.S. Robotics 212A features auto dial, auto answer, command repeat and auto intelligent baud selection. USR-212A $419.00 2 lbs.

Other excellent values in direct connect modems. Signalman Mark 1 at $74.95 and the Universal Data 1200 baud at only 369.00

PRINTERS

Star Gemini $319

MATRIX PRINTERS

Star Gemini-10 friction & tractor 100 char/sec. parallel	STR-G10	319.00
Star Gemini-15, 100 char./sec. 15" paper	STR-G15	559.00
Star Coex 80FT friction & tractor	VST-C80FT	259.00
Okidata 82A serial & parallel 9½" paper	OKI-82A	459.00
Okidata 92A serial & par'l 160 char/sec.	OKI-92A	679.00
Okidata 83A parallel 15" paper	OKI-83A	695.00
Okidata 84A parallel 15" paper	OKI-84A	1079.00
Okidata 2350 (new) 350 char/sec	OKI-2350	1995.00
Epson FX80,160 char./sec. with graphtrax, fric. & tractor	EPS-FX80	575.00
Epson MX100 with graphtrax, 15" paper	EPS-MX100	895.00
NEC8023A parallel 9½" paper, graphics	NEC-8023A	439.00
Anadex 9500A high speed 15" paper	ADX-9500A	1279.00
Anadex 9501A high speed with graphics	ADX-9501A	1279.00
Datasouth 180 high speed 180 cps 15"	DSI-180	1295.00
Quantex 7030 corespondence quality 180 char/sec	QTX-7030	1595.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	495.00
Prowriter 8510 serial 9½ paper	PRO-8510S	639.00
Prowriter II, parallel 15" paper, graphics	PRO-2P	750.00
Printronix P300 high speed printer 300 lines per minute.	PTX-P300	4500.00
Printronix P600 ultra high speed 600 lines per minute.	PTX-P600	6150.00
Mannesmann Tally 1805 200 char/sec serial	MAN-1805	1650.00

WORD PROCESSING PRINTERS

NEC7710 55 char/second, serial interface	NEC-7710	2379.00
NEC7730 same as above only parellel interface	NEC-7730	2379.00
NEC3510 15" serial interfacing 35 char/sec	NEC-3510	1775.00
Diablo 630 40 char/sec serial	DBL-630	2250.00
Diablo 620, proportional spacing, horz & vert. tab. 20 cps	DBL-620	995.00
Brother HR11 daisy wheel, parallelinterfacing	BTH-HR1P	855.00
Brother HR11 serial interface	BTH-HR1S	895.00
Starwriter F10 serial, 40 char/sec	PRO-F10S	1475.00
Starwriter F10 parallel, 40 char/sec	PRO-F10P	1475.00

EPSON MX80 RIBBONS $6.95

MONITORS

BMC 12A green phosphor 15 MHz. composit video.	BMC-12A	88.00
BMC 12" high resolution 20MHz	BMC-12EN	139.00
Zenith ZVM121 green phosphor 12" 40/80 column switch	ZTH-Z121	109.00
NEC JB1201 green phosphor 18 MHz composit video.	NEC-JB1201	169.00
NEC JB1260 commercial grade composit	NEC-JB1260	129.00
USI Amber screen 12" composit monitor.	USI-12A	169.00
Motorola 23" open frame blk/white composit video.	MOT-BW23	159.00
Motorola 12" open frame requires horz sync and power.	MOT-BW12	69.00
Conrac 9" open frame requires horz sync & 12v supply.	CON-BW9	59.00
COLOR		
BMC AU9191U Color composit video with sound	BMC-9191	279.00
BMC 9191M RGB designed for use with the IBM computer.	BMC-9191M	499.00
NEC JC1203DM RGB color monitor	NEC-1203	699.00
NEC JC1201 color composit.	NEC-JC1201	339.00
Zenith ZVM134 RGB color suitable for IBM PC	ZTH-Z134	595.00
Comrex color composit with sound	COM-6500	329.00
Amdek Color 1 composit video	AMK-100	329.00

MODEMS

DIRECT CONNECT $75.00

Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	575.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Hayes Micromodem 100, S-100 auto answer, auto dial	HYS-100	319.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
U.S. Robotics 212A 300/1200 baud, auto dial/answer.	USR-212A	419.00
Penril 300/1200 auto dial,autolog	PEN-12AD	695.00
Universal Data 103LP, line power, answer & originate	UDS-103LP	169.00
Universal Data 103LPJ, Auto answer	UDS-103LPJ	209.00
Universal Data 202, 1200 baud, half duplex only	UDS-202LP	209.00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	395.00
Universal Data 212A,300/1200 baud, auto answer	UDS-212A	595.00
Novation 'J' Cat, direct connect, auto answer	NOV-JCAT	119.00
Novation Cat, acoustic connect	NOV-CAT	159.00
Novation SmartCat 103, auto answer, auto dial	NOV-SC103	219.00
Novation SmartCat 103/212, 1200 baud auto dial	NOV-SC212	529.00
Signalman Mark 1, direct connect with terminal cable	SGL-MK1	75.00

TERMINALS

The Wyse WY-100 features die cast aluminum case, 102 key keyboard and non-glare 26 line green phosphor video display. Split screen both horizontal and vertical makes the WY-100 unusually user friendly. This unique terminal is perfect to enhance your next business system.

$795

Freedom 100, split screen, detatchable keyboard	LIB-F100	495.00
Visual 50, detatchable, keyboard selectable settings,	VSL-50	659.00
Visual 50 Green screen	VSL-50G	679.00
Visual 330, emulates DEC, DG, LSI green	VSL-330G	995.00
Ampex Dialogue 80 green screen, two page, func. keys	APX-D80G	695.00
Ampex Dialouge 80 amber screen, two page, func. keys	APX-D80A	695.00
Wyse 100, horz & vert. split screen, metal enclosure	WYS-100	795.00
Wyse 300, Eight color display, split screen	WYS-300	1159.00
Televideo 910 Plus, block mode	TVI-910P	595.00
Televideo 925, detatchable keyboard 22 function keys	TVI-925	795.00
Televideo 950, graphic char., split screen, 22 func	TVI-950	985.00
Televideo 970, 14" green screen, 132 column, European	TVI-970	1259.00
Zenith 29 terminal, VT52 compatible detatchable keyboard	ZTH-Z29	765.00
ADDS Viewpoint A1 detatchable keyboard	ADD-VP1	585.00
ADDS Viewpoint A2, xy cursor	ADD-VP2	595.00

APPLE

II-E Starter System Includes Disk Drive, Green Phosphor Monitor, and 80 Column Card.

$1595

APPLE BRAND PRODUCTS

APL-DSK1	Apple disk with controller card	560.00
APL-DSK2	Apple disk without controller card	495.00

XITEN

XTN-G10	Xiten 10 Megabyte Gallium hard disk	1 995.00
XTN-16K	16K RAM card for Apple II	69.00

RANA SYSTEMS

RAN-APL1	Apple add on disk drive with controller	525.00
RAN-APL2	Apple add on drive without controller	395.00

CALIFORNIA COMPUTER SYSTEMS

CCS-7710	Asynchronous Serial Interface	125.00
CCS-7728	Centronics Parallel Interface	95.00
CCS-7720	Apple Parallel Interface	95.00
CCS-7114	12K Rom/Prom Module	115.00
CCS-7424	Calendar/Clock Module	95.00
CCS-7440	Programmable Timer	95.00
CCS-7811B	Arithmetic Processor for Apple II plus	319.00

MOUNTAIN COMPUTERS, INC.

MTN-CPS	CPS Multifunction Card	169.00
MTN-TCLK	Clock/Calendar	
MTN-STLK	Supertalker SD200	149.00
MTN-ROMF	Rom Plus with Keyboard filter	169.00
MTN-ROMRTR	Rom Writer with Eprom socket	145.00
MTN-ADDA	A-D/D-A Converter	269.00
MTN-BSR	.X-10 Control Card for BSR system	149.00

MICRO SOFT

MSF-SFTCRD	Microsoft Z-80 CPU card	249.00
MSF-16KRAM	Microsoft 16K RAM card	125.00

VISTA

VSA-A800	Vista 8" controller card	489.00
VSA-VIS80	Vista Vision 80	289.00
MCI-CNTRL	Micro Sci disk drive controller	89.00

FOURTH DIMENSION

FON-SPRDRV	Super Drive-35 track Apple add on	329.00

SORRENTO VALLEY ASSOC

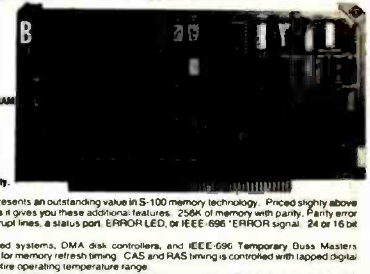
SVA-221	Single sided, single density controller	360.00
SVA-222	Double sided, single density controller	360.00
SVA-223	Single or double sided, double density	475.00

ADVANCED BUSINESS TECH

ABT-13KEYN	13-Key pad for new Apple	95.00

256K DYNAMIC MEMORY BOARD

$495



- **256 kilobytes of memory using 64K dynamic RAM**
- **Over one megabyte of memory using the new 256K dynamic RAM chips.**
- **Error detection-trap capability.**
- **Individual 16K block can be relocated to any boundry within a megabyte of RAM.**
- **24 bit addressing and phantom mode capability.**

The California Digital 256K RAM board represents an outstanding value in S-100 memory technology. Priced slighly above earlier generation 64K dynamic ram boards it gives you these additional features. 256K of memory with parity. Parity error feature can be jumpered to any of the interrupt lines, a status port ERROR LED, or IEEE-696 *ERROR signal. 24 or 16 bit addressing with memory management.

Proper operation with front panel equipped systems, DMA disk controllers, and IEEE-696 Temporary Buss Masters assured with an on the board M1 generator for memory refresh timing. CAS and RAS timing is controlled with tapped digital delay lines for proper operation over the entire operating temperature range.

The board is very recent in design using the National Semiconductor DP-8409 RAM Controller chip. Split termination networks are used on all address lines, CAS line, and RAS lines eliminating the last traces of ringing. The board uses two separate voltage regulators. One for the DRAMs and one for the interface logic increasing the noise immunity of the ram array. Typical power dissipation is 8 watts.

Documentation includes theory of operation, configuration guide, a schematic, and application notes on the use of the memory management options. CAL-256K 2 Lbs.

S-100 BOARDS

16 BIT MICROPROCESSORS

Godbout 8086-8087 microcomputer 16 bit	GBT-8687	495.00
Godbout dual processor 8085-8088, 8/16 bit	GBT-8588	359.00
Lomas Data Systems Lighting One, 8 MHz	LOM-8086	429.00

SINGLE BOARD COMPUTERS

Wavemate Bullet 128K with CPM	WAV-BLT1	495.00
Advanced Digital Floppy & 64K	AMD-Z80	750.00
Teletek System master NEC765 floppy, 64K	TEL-SM1	895.00
Teletek FDC-1 single board without memory	TEL-FDC1	675.00

8 BIT MICROPROCESSORS

Godbout Z80, 24 bit extended add	GBT-Z80	250.00
California Computer Z80 microprocessor	CCS-2810	275.00
Tarbell Z80 with two RS232 ports	TAR-Z80	339.00

FLOPPY DISK CONTROLLERS

Godbout Disk 1, double density, NEC765	GBT-DSK1	395.00
California Computer Systems 2422A with CPM	CCS-2422	339.00
Morrow Disk Jockey II with CPM 2.2	MDS-DJ2	350.00
Morrow Disk Jockey I with CPM, single density	MDS-DJ1	225.00
Tarbell Electronics double density controller	TAR-DDC	419.00
Tarbell Electronics single density controller	TAR-SDC	279.00
Fulcrum DMA OmniDisk, I/O to hard disk	FCM	389.00

CPM OPERATING SYSTEM

Digital Research CP/M 3.0, 8" single density	DRC-CpM30	249.00
Godbout CPM 2.2 for Disk 1	GBT-CpM22	159.00
Godbout CPM86 for 8088 and 8086	GBT-CpM86	265.00
Tarbell Electronics CPM 2.2	TAR-CpM22	159.00

HARD DISK CONTROLLERS

Godbout Disk 2, 8" & 14" hard disk	GBT-DSK2	569.00
Godbout Disk 3, for 5¼" Winchesters	GBT-DSK3	July
Morrow Designs controller for 5¼ Winchester	MDS-W506	495.00
Western Digital new WD-1001 (not S-100)	WD1-1001	495.00

EPROM BOARDS

Inner Access EPROM Bd. programs 27128's	IAC-P100	465.00
Digital Research read only PROM board 32K	DGR-P32	119.00

STATIC MEMORY BOARDS

Godbout Ram 16, 64K 16 bit data transfer	GBT-R16	459.00
Godbout Ram 17, 64K 8 bit 24 bit extend. add	GBT-R17	359.00
Godbout Ram 21 128K byte 8/16 transfer	GBT-R21	859.00
Fulcrum OmniRam 8/16 transfer bank select	FCM-R816	395.00
California Digital 2116 8 bit only 16K byte	CCS-2116	249.00

DYNAMIC MEMORY BOARDS

California Digital 256K byte, expand to 1 Meg	CAL-D256	495.00
California Computer 2066 64K bank select	CCS-2066	295.00

INTERFACE BOARDS

Godbout Interfacer I, 2 serial ports	GBT-133A	199.00
Godbout Interfacer II, 1 serial 3 parallel ports	GBT-150A	199.00
Godbout Interfacer III, with 5 serial ports	GBT-135A	495.00
Godbout Interfacer III, with 8 serial ports	GBT-138A	585.00
Godbut Interfacer VI, 3 serial, 2 parallel	GBT-187A	319.00
California Computer 2710, 4 serial ports	CCS-2710	279.00
California Computer 2719, 2 serial & 2 parallel	CCS-2719	295.00
California Computer 2720, 4 port parallel	CCS-2720	219.00
California Computer 2830, 6 port serial board	CCS-2830	429.00
Morrow Designs Switchboard, 2 serial & 2 par'l	MDS-SW1	239.00
Morrow Designs Multiboard, 3 serial 2 parallel	MDS-MTL1	319.00

SPECIAL FUNCTION BOARDS

Hayes S-100 Micromodem, 300 baud FCC reg	HYS-M100	325.00
QT Computer clock calendar, bat. back up	QTC-CC100	139.00
Godbout System support board, 4K EPROM	GBT-SYS1	350.00
Godbout System support board with 9511 math	GBT-S9511	539.00
Dual Systems 4 channel 12 bit D/A converter	DSC-AOM12	619.00
Dual System 12 bit resolution 32 channel A/D	DSC-AIM12	629.00
Mullins Opto-isolator, controls 8 channels	MUL-ICB10	179.00
Mullins extender board with logic & test probe	MUL-7B1	79.00
I/O Technology wire wrap prototype board	IOT-W100	49.00
Artec Electronics wire wrap prototype board	ART-WW100	25.00
Artec Electronics general purpose solder board	ART-GP100	25.00

MAINFRAMES & MOTHER BOARDS

Eclipse Data, industrial stainless steel 18 slot	EDP-100	695.00
Godbout Enclosure 2, 20 slot active termination	GBT-MF20	675.00
California Computer 2200, 12 slot with term	CCS 2200	479.00
California Digital 18 slot mother board	CAL-MB18	35.00
Godbout 12 slot mother board assembled	GBT-MB12	149.00

SYSTEMS

Apple II-E Syst'm	64K bytes, includes disk drive, Apple green monitor & 80 column card	1595.00
Franklyn 1000	48K bytes of memory, ten key pad, Apple II look-a-like	989.00
Syscom II	48K bytes of memory, Apple II look-a-like	789.00
Columbia	Two 5¼" floppys, IBM PC look-a-like. Keyboard & video card extra	2395.00
Compaq PC	Portable with green phosphor CRT, IBM look-a-like	PHONE
Kaypro II	Portable with two drives and 9" display, bundled with lots of software	1679.00
Altos 586-10	10 meg. hard disk & 5¼" floppy, up to five users, 16 bit 8086 CPU	6250.00
Eagle II	Two 5¼" disk drives, 12" green phosphor monitor with Perfect Software	1795.00
Morrow MD2	Two 5¼" disk drives, bundled with six software packages, CPM 2.2	1195.00
CCS Calstar	128K byte, two Quad density disk drives with CPM and Perfect Software	3150.00
CCS 2210 CPU	Complete Z-80 based S-100 system, 64K byte, floppy disk with CPM 2.2	1639.00
Northstar 15-MB	System includes 15 Megabyte Winchester, 5¼" floppy, 64K byte	4995.00
Northstar 2Q	Two quad density disk drives, 64K dynamic memory	2595.00

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SN7407N	14	.29
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SN7409N	14	.25
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SN7437N	14	.25
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SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.69
SN7482N	14	1.19
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.59
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.69
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	2.75
SN74100N	24	1.49
SN74104N	14	.89
SN74105N	14	.89
SN74107N	**14**	**.29**
SN74109N	**16**	**.39**
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.55
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.69
SN74142N	16	2.95
SN74143N	24	2.95
SN74144N	24	2.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59
SN74156N	16	.59
SN74157N	**16**	**.59**
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.79
SN74170N	16	1.29
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN74177N	14	.69
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	.89
SN74184N	16	1.95
SN74185N	16	1.95
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SN74193N	16	.69
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SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	1.95
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
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SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

74LS00	14	.25
74LS01	14	.25
74LS02	14	.25
74LS03	14	.25
74LS04	14	.29
74LS05	14	.29
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74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	**14**	**.29**
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.35
74LS33	16	.55
74LS37	14	.35
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74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
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74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
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74LS123	16	.79
74LS125	14	.49
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.59
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74LS153	16	.59
74LS154	24	.99
74LS155	16	.69
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74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
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74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.59
74LS175	16	.59
74LS181	24	2.49
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74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
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74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.09
74LS245	20	1.49
74LS247	16	1.09
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74LS258	16	.59
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74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.29
74LS374	20	1.29
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
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74S/PROMS*

74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S124	16	2.95
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	.99
74S175	16	.99
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49
74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
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CA3082N	16	1.49
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.19
CA3130E	8	1.49
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CA3160H		1.95
CA3401N	14	.59
CA3600N	14	3.95

CD—CMOS

CD4000	14	.29
CD4001	**14**	**.29**
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CD4007	14	.29
CD4009	**16**	**.39**
CD4010	16	.39
CD4011	14	.29
CD4012	**14**	**.15**
CD4013	14	.39
CD4014	16	.79
CD4015	**16**	**.39**
CD4016	14	.39
CD4017	16	.75
CD4018	16	.79
CD4019	16	.39
CD4020	16	.75
CD4021	16	.79
CD4022	16	.79
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.95
CD4035	16	.89
CD4040	16	.79
CD4041	14	.79
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.39
CD4049	**16**	**.39**
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CD4068	14	.39
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CD4072	14	.29
CD4073	14	.29
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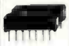
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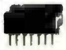
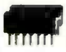

SG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74HC393	14	1.49
74HC533	20	3.95
74HC534	20	3.95
74HC595		3.75
74HC688		3.19
74HC4002	14	.79
74HC4020	16	2.19
74HC4024	14	1.59
74HC4040	16	2.19
74HC4060	16	2.19
74HC4075	14	.75
74HC4078	14	.69
74HC4511	16	3.29
74HC4514	24	4.79
74HC4538	16	2.95
74HC4543	16	4.95

74HCU04 is unbuffered. All others are buffered. **Send $.30 for Data Sheet.**

NEW Programmable Array Logic (PALS)

Part No.	**Pins	Function	Price
PAL10H8	20	Octal 10-Input AND-OR Gate Array (High Output)	$5.95
PAL12H6	20	Hex 12-Input AND-OR Gate Array (High Output)	5.95
PAL14H4	20	Quad 14-Input AND-OR Gate Array (High Output)	5.95
PAL10L8	20	Octal 10-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL16L8	20	Octal 16-Input AND-OR-Invert Gate Array (Low Output)	9.95
PAL16R8	20	Octal 16-Input Register AND-OR Gate Array	9.95
PAL16R6	20	Hex 16-Input Register AND-OR Gate Array	9.95
PAL16R4	20	Quad 16-Input Register AND-OR Gate Array	9.95

30012 1982 NATIONAL PAL Data Book (176p.) .. **$5.95**

74C—C/MOS

74C00	14	.35
74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19
74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	.79
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39
74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	16	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.39
80C97	16	.39

LINEAR

TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM323K		5.95
LM324N	14	.59
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LM348N	14	.99
LM350K		4.95
LF355N	8	1.10
LF356N	8	1.10
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
TL494CN	16	2.95
TL496CP	8	1.19
NE510A	14	4.95
NE529A	14	2.95
NE531V	8	2.95
NE536H		8.95
NE540H		4.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.89
NE570N	16	3.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.56
LM733N	14	1.00
LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	.69
LM1496N	14	1.95
LM1800N	16	1.49
LM1889N	18	1.95
LM1896N	14	2.95
LM2002T		1.49
LM3189N	16	1.59
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	3.49
LM3915N	18	3.49
LM3916N	18	3.49
RC4136N	**14**	**1.25**
RC4151NB	8	1.95
ICL8038B	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19

MORE AVAILABLE

30003 1982 Nat. Linear Data Book (1952 pgs.) . **$11.95**

Circle 206 on inquiry card.

Wall Transformers AC and DC Types

AC250 (Pictured)

Part No.	Input	Output	Price
AC 250 (above)	117V/60Hz	12VAC 250mA	$3.95
AC 500	117V/60Hz	12VAC 500mA	$4.95
AC1000	117V/60Hz	12VAC 1 amp	$5.95
AC9004	117V/60Hz	8.2VAC 2.5 amp	$3.95
DC 800	120V/60Hz	8VDC 400mA	$1.95
DC6912	120V/60Hz	6,9,12VDC 300mA	$8.95
DC5490	117V/60Hz	9.5VDC 275mA	$2.95
DC900	120V/60Hz	9VDC 500mA	$3.95
DC1200	120V/60Hz	9.5VDC 300mA	$2.95
DV9200	117V/60Hz	9VDC 200mA	$3.25

PCB-3 Makes Circuit Assembly A Breeze!

Lets you work with both hands. Sturdy aluminum construction.

Clamp *"3rd Hand"* on edge of bench table or workboard. Insert circuit board, position components. Notice convenient working angle. Flip circuit board to flat position for soldering and clipping. Reverse procedure for double-sided boards.

PCB-3 .... **$13.95**

Extension to hold PCB-3 2" from bench and 6" from front edge.

PCB-X **$6.95**

Mostek DC/DC Converter +5 VOLTS TO -9 VOLTS

Input: +5V. Output: -9V (regulated) @ 30mA. Printed circuit mounting. Specifications incl.

DC10 ...... **$2.95 ea. or 2/$4.95**

Jameco Digital Thermometer Kit

Dual sensors — switch controls for indoor/outdoor or dual monitoring — can be extended to 500 feet. Continuous LED .8" ht. display. Range: -40°F to 199°F, -40°C to 100°C. Accuracy ±1° nominal. Calibrate for Fahrenheit/Celsius. Simulated walnut case. AC wall adapter included. Size: 6⅝"L x 3¼"H x 1⅞"D.

JE300 ...... **$39.95**

RADIO CONTROL CIRCUITS

Ideal to use for:

- Toys, hobby crafts, robots, trains
- Burglar alarms • IR data link
- Remote slide projector control
- Consumer remote data links
- Energy-saving, remotely switched lighting systems

A complete 6-channel digital encoder and RF transmitter, low power, at frequency of 27MHz or 49MHz, a field strength of 10,000uV meter at 3 meters. 9V operation on chip RF oscillator/transmitter, on chip 4.6 regulator. Up to 80MHz carrier frequency operation.

LM1871N RC Encoder/Transmitter Chip ... **$1.95**

A complete RF receiver/decoder, used at either 27MHz, 49MHz or 72MHz. It provides 4 independent channels when used with LM1871 (2 analog, 2 dig.) operates from four 1.5V cells. Crystal controlled.

LM1872N	RC Receiver/Decoder Chip	$2.49
SRX1504	49.435MHz Crystal (LM1872N)	$3.95
SRX1505	49.890MHz Crystal (LM1871N)	$3.95

ATARI

ATARI PADDLES

JSP (2) .... **$4.95 pair**

ATARI DRIVER

JSD (1) .... **$2.95 ea.**

TV GAME SWITCH

Used on Atari. Cosmetically blemished. 100% functional.

TGS-1 ... **$2.95 ea.**

BOOKS

NATIONAL SEMICONDUCTOR — INTERSIL — INTEL

30002	National Interface Data Book (1980) (704 pages) DP, DS8000, DS3600, DS5700, etc.	$6.95
30003	National Linear Data Book (1982) (1376 pages) LM, LF, ADC, DAC, LH Series	$11.95
30005	National TTL Logic Data Book (1981) (624 pages) 7400,LS,L,H,S, and DM8000 Series	$8.95
30008	National Memory Data Book (1980) (464 pages) RAMs, ROMs, PROMs, EPROMs Series	$6.95
30009	Intersil Data Book (1983) (1356 pages) Complete line.	$9.95
30010	National Audio/Radio Handbook (1980) (240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps	$5.95
30011	National Linear Application Handbook (1980) (736 pages) Application Notes, Linear Briefs, etc.	$15.95
30012	National PAL Data Book (1982) (176 pages) Application Notes, Linear Briefs, etc.	$5.95
30013	Zilog Data Book (1983) (641 pages) Microprocessors and Support Chips	$7.95
210830	Intel Memory Components Handbook (1983) (798 pages) Contains all Application Notes, Article Reprints, Data Sheets, and other design information on Intel's RAMs, EPROMs, E²PROMs & Bubble Memories	$14.95
210844	Intel Microprocessor & Peripheral Handbook (1983) (1027 pages) Contains Data Sheets on all of Intel's Microprocessors and Peripherals.	$14.95

Universal Computer Keyboard Enclosures

"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. alodine type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency. Rigid construction provides unlimited applications. Assembly instructions included.

PANEL WIDTH

3.40 — 8.38

DTE-8	Panel Width 7.5"	$24.95
DTE-11	Panel Width 10.13"	$27.95
DTE-14	Panel Width 13.5"	$29.95
DTE-20	Panel Width 19.25"	$34.95

TIMEX sinclair 1000

• Powerful - fully programmable 2K memory • Portable - 6⅝" x 6⅝" x 1⅝" - 12 oz. • Expandable - Optional 16K RAM module • Single-key entry commands • Educational • Unique syntax-check report codes for error identity • Accurate to 9½ decimal places for full range math and scientific functions • Graph drawing and animated display • Advanced 4-chip design combining power, portability and affordable price.

TS1000 .... **$69.95**

ACCESSORIES FOR TIMEX sinclair 1000 and ZX81

TIMEX sinclair 1016 Expansion from 2K to 16K - Size: 3" x 3" x 1.5" - 5 oz TS1016 $49.95

Keyboard Mask for Your ZX81/1000* Computer

BRAND NEW!!

FEATURES

- Install in seconds. Remove adhesive backing from mask and place over keyboard.
- All characters and symbols reproduced on mask.
- Durable — formed with poly carbonite sheet satin finish

JE681 KEYBOARD MASK

The JE681 Keyboard Mask provides users of the ZX81/1000 series computer the individual feel of each keypad on the keyboard. The mask has a raised outline around each keypad allowing the user to feel and correctly position their fingers onto the keyboard.

JE681 KEYBOARD MASK ..... **$9.95 each**

Jameco ZX81/1000* Keyboard Conversion Kit

JE682-AK KEYBOARD KIT MOUNTED IN DTE-AK ENCLOSURE. LIGHT TAN PANELS WITH MOLDED DARK BROWN END PIECES. SIZE: 14½"W x 3½"D x 3½"H

The JE682 Kit provides users of the ZX81/1000 series computers a full-size industrial keyboard hook-up to their computer. The JE682 Kit allows the use of either the full-size keyboard or the Sinclair/Timex Keyboard. The Kit also permits the simple disconnection of the Sinclair/Timex Keyboard for portable use. The JE682 Kit consists of a full-size industrial grade keyboard with 62 keys, 2 p.c. boards, 24" ribbon cable, DIP socket and 4 rubber feet. The keyboard conversion kit can easily be mounted into the DTE-AK enclosure. This enclosure is large enough to contain the ZX81/1000 computer and the full-size keyboard together. A handy label representing the ZX81/1000 keyboard layout is placed on the enclosure.

JE682 Keyboard Conversion Kit .... **$59.95 ea.**
(WITHOUT DTE-AK CASE)

DTE-AK CASE ONLY .... $49.95 each

JE682-AK Keyboard Conversion Kit ..... **$99.95 ea.**
(WITH DTE-AK CASE - AS PICTURED)

*ZX81/1000 IS A TRADEMARK OF SINCLAIR-TIMEX

QUANTITY DISCOUNTS AVAILABLE!

80-Key Keyboard

CA150C **$69.95**

84-Key Keyboard

CA153A **$69.95**

95-Key Keyboard

CA154A **$79.95**

CONTROL DATA KEYBOARDS

- ★ Parallel ASCII
- ★ SPST Switching
- ★ FTZ Shielded Base
- ★ N-Key Rollover
- ★ 128 Character ASCII
- ★ Non-Slip, Non-Glare Keycaps
- ★ CDC752 Terminal Keyboards
- ★ Attractive Case

Limited Quantities!

These Control Data Keyboards consist of a base, cover, the keyboard assembly, and an interface cable. Color (case): Harvest gold and black. Color (keycaps): Black, blue, and red. Electrical requirements: +5V @ 600mA, -12V @ 50mA. Weight: 6 lbs. All units brand new in original boxes, specifications included.

Keytronics 90-Key Soft-Programmable Keyboard

WITH SECURITY KEYLOCK SWITCH

300 Available!

BRAND NEW!!

- RFI shielded
- Cursor controls
- Numeric keyboard
- 8-bit Parallel
- Capacitance keys
- 10 user-programmable keys
- Positive TTL Logic
- Size: 17"L x 8¼"W x 2¼"H

Made for Visual Technology, this keyboard features: a security keylock (includes two keys) to guard against unauthorized use, an 11-key numeric keypad, cursor controls, and 10 user-programmable keys. Electrical requirements: +5VDC. Color (case): White. Color (keycaps): Black. Complete with case, keyboard assembly, 40-inch interface cable, and schematics.

Part No. KB270 .... **$109.95 each**

MICRO SWITCH 85-KEY KEYBOARD

23"L x 5¼"W x 1-3/8"H

Word Processing Keyboard, 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.

Part No. 85SD18-1 .... $29.95 each

HI-TEK 14-KEY NUMERIC KEYPAD

3"L x 3"W x 1½"H

SPST switching. Charcoal grey keycaps. Mounted on printed circuit board.

Part No. K-14 .... $9.95 each

ALPS 29-KEY CALCULATOR KEYBOARD

9½"L x 4½"W x 1½"H

Features one 8-position decimal select switch, one 3-position switch, and two 2-position switches. mechanical SPST switching, 22-pin edge card connection. Pin-out included.

Part No. KB297D4D (Fits DTE-11 Enclosure) .... $4.95 each

POWER SUPPLY +5VDC @ 1 AMP REGULATED *Transaction Tech*

Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. 6½"W x 7"D x 2¼"H. Wt. 3 lbs. Data sheet incl.

Part No. PS51194S .... $14.95 each

POWER SUPPLY +5VDC @ 3 AMP REGULATED *Deltron*

Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp, 6VDC @ 2.5 amp. Adjustable current limit. Ripple & Noise: 1MV rms, 5MV p-p — 2 mounting surfaces. UL recognized. Size: 4"W x 4½"L x 2-7/16"H - wt. 2 lbs. Data sheet included.

Part No. QPS-1 .... $29.95 each

POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING

Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½"W x 13¾"D x 3¾"H. Wt. 6 lbs.

Part No. PS94V0S .... $39.95 each

POWER SUPPLY 4-Channel Switching - Apple Compatible

Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A; +12VDC @ 1A, -12VDC @ 1A. Line reg.: ±0.2%. Ripple: 30mV p-p. Load reg.: ±1%. Overcurrent protection. Adj. 5V main output ±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1½ lbs.

Part No. FCS-604A .... $69.95 each

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Shipping — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sales Flyer!

Spec Sheets — 30¢ each
Send $1.00 Postage for your
FREE 1983 JAMECO CATALOG
Prices Subject to Change

Call for Quantity Discounts

Mail Order Electronics • Worldwide
Jameco ELECTRONICS

NEW! Telex Number Telex 176043

1355 SHOREWAY ROAD, BELMONT, CA 94002
6/83 *PHONE ORDERS WELCOME — (415) 592-8097 Telex: 176043*

5¼" Mini-Floppy Disk Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I (Industry Standard)

Features single or double density. Recording mode: FM single, MFM double density. Power +12VDC (±0.6V) 1.6A max., +5VDC (±0.25V) 0.8A max. Unit as pic. at right (does not incl. case, power supply, cables). 30-pg. data book incl. Wt. 3½ lbs. Size: 5¾"W x 8"D x 3¼"H.

Part No. *Limited Quantity!* Price

FD200 .... **$179.95**
Single-sided, 40 tracks, 250K bytes capacity

FD250 .... **$199.95**
Double-sided, 35 tracks, 438K bytes capacity

Siemens 8" Floppy Disk Drive

- Shugart 801R compatible
- Single-Sided
- 77 Tracks
- 400/800K Bytes Capacity
- Industry Standard

The FDD100-8 8" Floppy Disk Drive (Industry Standard) features single or double density. Recording mode: FM single, MFM double density. Transfer rate: 250K bits/sec. single density; 500K bits/sec. double density. The FDD100-8 is designed to work with the single-sided soft sectored IBM Diskette I, or eq. disk cartridge. Power: 115VAC @ 50-60Hz, +24VDC @ 1.7 amps max., +5VDC @ 1.2 amps max. Unit as pictured above (does not include case, power supply, or cables). Size: 8.55"W x 14"L x 4.5"H. Weighs 12 lbs. Incl. 96-pg manual.

Part No.		Price
FDD100-8	Buy 1 for	$269.95 each
FDD100-8	Buy 2 for	$259.95 each
FDD100-8	*Buy 10 for*	*$249.95 each*

2708,2716,2732 & 2764 EPROM Programmer

JE664 EPROM PROGRAMMER

8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES

Self-Contained — Requires No Additional Systems for Operation

• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, <10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3½"H • Wt.: 5¾ lbs.

JE664-A EPROM Programmer **$995.00**
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80* Model I, Level II Computer. Baud rate: 9600. Word Lgth.: 8 bits - odd parity. Stop bits: 2. Option may be adapted to other computers.

JE664-ARS EPROM Prog. w/JE665 Option **$1195.00**
Assembled and Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM.

Part No.	EPROM	EPROM MANUFACTURER	PRICE
JM08A	2708	AMD, Motorola, National, Intel, TI	$14.95
JM16A	2716,TMS2516	Intel, Motorola, National, NEC, TI	$14.95
JM16B	TMS2716	Motorola, TI (+5,-12,+12)	$14.95
JM32A	TMS2532	Motorola, TI	$14.95
JM32B	2732	AMD, Fujitsu, NEC, Hitachi, Intel	$14.95
JM32C	2732A(21V)	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	Motorola	$14.95
JM64B	2764	Intel	$14.95
JM64C	TMS2564	TI	$14.95
JM64D	HN482764G-4	Hitachi (21V)	$14.95

UV-EPROM Eraser

8 Chips — 51 Minutes

1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

UVS-11EL Replacement Bulb **$16.95**

DE-4 UV-EPROM Eraser **$79.95**

EXPAND YOUR MEMORY

TRS-80 to 16K, 32K, or 48K

**Model 1 = From 4K to 16K Requires (1) One Kit
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K two Kits Required
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns	for Color & Model III	$12.95
TRS-16K4 *250ns	for Model I	$10.95

TRS-80 Color 32K or 64K Conversion Kit

Kit comes complete with 8 each 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D and E circuit boards, and all new color computers to 32K. Minor modifications of 32K memory will allow the use of all 64K of the dynamic RAM providing you have a FLEX DOS operating system.

TRS-64K2 .... **$54.95**

JOYSTICKS

JS-5K (Pictured)

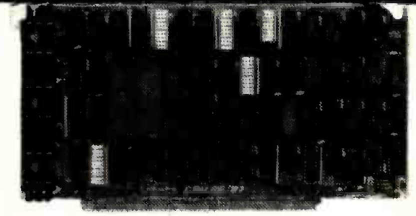
JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JS-150K	150K Linear Taper Pots	$4.75
JVC-40	40K (2) Video Controller in Case	$4.95
JS KNOB	Knob for JS5K,100K,150K	$.99 ea.
JVC KNOB	Knob for JVC-40	$.99 ea.

Circle 206 on Inquiry card.

PRIORITY ONE ELECTRONICS

THERE ARE NO BETTER BOARDS — THERE ARE NO BETTER PRICES!

CompuPro FROM PRIORITY ONE ELECTRONICS



CPU BOARDS

CO-PROCESSOR 8086/8087

16 bit 8 or 10 MHz 8086 CPU with sockets for 8087 and 80130

Part No.	Description	List Price	Our Price
BRGBT186A	A&T 8MHz 8086 only	$750.00	$669.00
BRGBT186C	CSC 10MHz 8086 only	$850.00	$764.69
BRGBT186A87	A&T with 8087 option	$1050.00	$939.00
BRGBT186C87	CSC with 8087 option*	$1150.00	$1065.00

**8087 Limits clock speed to 5MHz*

(816) DUAL PROCESSOR 8085-8088

6 or 8 MHz provides true 16 Bit Power with a standard 8 bit S-100 bus

BRGBT1612A	A&T 6MHz	$495.00	$439.00
BRGBT1612C	CSC 6/8 MHz	$595.00	$529.00

68K - 68000 16 BIT CPU

16 bit 8 or 10 MHz on-board sockets for 2716, 2732, or 2764 EPROMs for up to 8K x 16 of memory

BRGBT184A	A&T 8MHz	$695.00	$625.00
BRGBT184C	CSC 10MHz	$850.00	$765.00

FORTH OPERATING SYSTEM FOR 68K CPU

Requires a DISK 1, 64K of CompuPro memory, and an INTERFACER 3 or 4.

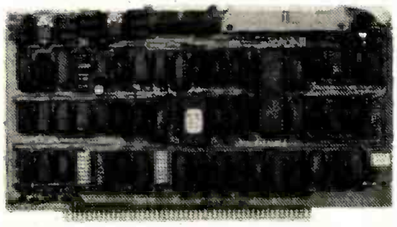
BQGBT68KOS	FORTH operating system	$200.00

CPUZ - Z80B CPU NOW 6MHz!

3/6 MHz Z80B CPU with 24 Bit Addressing.
FASTEST Z80 CPU AVAILABLE!

BRGBT160A	3/6 MHz A&T	$325.00	$289.00
BRGBT160C	3/6 MHz CSC	$425.00	$379.00

DMA DISC CONTROLLER CP/M 2.2 FOR FREE!!*



**When 2 or more 8" disk drives are purchased with Disk 1 Controller.*

DISK CONTROLLERS

DISK 1 FLOPPY CONTROLLER - OUR BEST!

Fast DMA, Soft Sector, Controls Up to Four 8" or 5¼" Single or Double Density Drives.

BRPDB171ACPM	A&T w/CPM 2.2 & BIOS	$670.00	$495.00
	*When purchased with two 8" disk drives only.		$450.00
BRPDB171CCPM	CSC w/CP/M 2.2 & BIOS	$770.00	$595.00
BRGBT171A	Disk 1 Controller A&T	$495.00	$440.00
BRGBT171C	Disk 1 Controller CSC	$595.00	$550.00
BRGBTCPM80	CP/M 2.2 for Z80/8085 w/manual & BIOS 8" S/D disk		$174.00
BRGBTCPM86	CP/M 2.2 for 8086 w/manuals & BIOS 8" S/D disk.		$200.00

DISK 2/SELECTOR CHANNEL HARD DISK CONTROLLER

Fast DMA 2 board set. controls 4 Shugart 4000 series or Fujitsu 2300 type drives. Includes CP/M 2.2'

BRGBT177A	Assembled & Tested	$795.00	$750.00
BRGBT177C	CSC	$895.00	$850.00

CMOS RAM SALE!

RAM 17 - 64K CMOS STATIC RAM

12 MHz, RAM 17, 2 Watt, DMA Compatible 24 Bit Addressing

Part No.	Description	List Price	Our Price
BRGBT175A64	64K A&T 12MHz	$499.00	$460.00
BRGBT175C64	64K CSC 12MHz	$599.00	$550.00

RAM 16 - 32K x 16 BIT CMOS STATIC RAM

8 and/or 16 Bit
(816) *12 MHz, RAM 16, 32K x 16 or 64K x 8*
IEEE/696 16 Bit 2 Watt, 24 Bit Addressing

BRGBT180A	64K A&T 12MHz	$550.00	$510.00
BRGBT160C	64K CSC 12MHz	$650.00	$616.00

(816)

NEW! RAM 21 - 128K STATIC RAM

816 RAM 21 12MHz, 128K x 8 or 64K x 16
IEEE/696 8 or 16 Bit, 1.2 Amps, 24 Bit Addressing

BRGBT190A	128K A&T	$1095.00	$ 995.00
BRGBT190C	128K CSC	$1245.00	$1125.00

M-DRIVE SOLID STATE DISK DRIVE, 3500% FASTER!!

Not really, but the next best thing for CompuPro 8085/88 Users. Call for Details on M-Drive.
M-Drive requires a 6MHz CPU 8085/88 dual processor, Disk 1 DMA disk controller and System Support 1 Multifunction Board.

BRGBTMD128KA	128K of A&T memory & M-Drive Software	$1100.00
BRGBTMD128KC	128K of CSC memory & M-Drive Software	$1300.00
BRGBTMD256KA	256K of A&T memory & M-Drive Software	$2300.00
BRGBTMD256KC	256K of CSC memory & M-Drive Software	$2700.00

M-DRIVE/H HARDWARE LOGICAL DISK SYSTEM

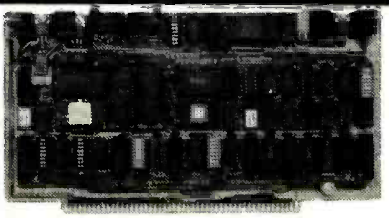
Interfaces through two I/O ports, and runs at 10MHz. IEEE 696 compatible. Requires any CompuPro CPU and a Disk 1. Each board contains 512K of fast, low power (900mA) RAM, with parity checking.

BRGBT197A	M-DRIVE/H w/software, A&T	$1895.00	$1295.00
BRGBT197C	M-DRIVE/H w/software, CSC	$2095.00	$1495.00

S-100 MAINFRAME

110V 60Hz CVT Mainframe uses famous 20 slot CompuPro Motherboard (55 lbs.)

BRGBTENC20RM	20 Slot Rackmount	$895.00	$825.00
BRGBTENC20DK	20 Slot Desk Top	$825.00	$760.00



I/O BOARDS

SYSTEM SUPPORT 1 MULTIFUNCTION BOARD

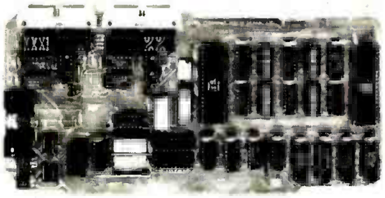
Serial port (software prog. baud), 4K RAM included, 15 levels of interrupt, real time clock, optional math processor

Part No.	Description	List Price	Our Price
BRGBT162A	Assembled & Tested	$450.00	$395.00
BRGBT162C	CSC	$550.00	$485.00
BRGBT8231	Math Chip		$165.00
BRGBT8232	Math Chip		$165.00
BRGBT162AM1	A&T w/8231 Math Chip		$570.00
BRGBT162CM1	CSC w/8231 Math Chip		$676.00
BRGBT162AM2	A&T w/8232 Math Chip		$570.00
BRGBT162CM2	CSC w/8232 Math Chip		$676.69

MPX CHANNEL BOARDS

I/O Multiplexer, using 8085A-2 CPU on board w/16K RAM

BRGBT166A16	Assembled & Tested	$649.00	$584.89
BRGBT166C16	CSC	$749.00	$674.89



INTERFACER 1

Two Serial I/O

BRGBT133A	Assembled & Tested	$295.00	$259.00
BRGBT133C	CSC	$370.00	$329.00

INTERFACER 2

Three parallel, one serial I/O board

BRGBT150A	Assembled & Tested	$325.00	$289.00
BRGBT150C	CSC	$399.00	$359.00

INTERFACER 3

Eight-channel multi-user serial I/O board

BRGBT1748A	Assembled & Tested	$699.00	$628.89
BRGBT1748C	CSC 200 hr. 8 port	$849.00	$748.89
BRGBT1745A	Assembled & Tested	$599.00	$558.89
BRGBT1745C	CSC 200 hr. 5 port	$699.00	$628.69

INTERFACER 4

Three Serial, 1 Parallel, 1 Centronics Parallel

BRGBT187A	Assembled & Tested	$450.00	$399.00
BRGBT187C	CSC	$540.00	$479.00

S-100 MOTHERBOARDS

Active termination, 6-12-20 Slot

BRGBT153A	A&T 6 slot, 2 lbs.	$140.00	$125.00
BRGBT153C	CSC 6 slot, 2 lbs.	$190.00	$155.00
BRGBT154A	A&T 12 slot, 3 lbs.	$175.00	$155.00
BRGBT154C	CSC 12 slot, 3 lbs.	$240.00	$220.00
BRGBT155A	A&T 20 slot, 4 lbs.	$265.00	$235.00
BRGBT155C	CSC 20 slot, 4 lbs.	$340.00	$310.00

RETAIL STORE PHONE NUMBERS: (Chatsworth:) (213) 709-5464 - (Irvine:) (714) 660-1411

Circle 309 on inquiry card.

PRIORITY ONE ELECTRONICS

S-100 STATIC RAM 128K RAM 21

● Meets or exceeds all IEEE 696/S-100 standards ● Uses less power than dynamics (1.2 amps typical) ● 24 bit extending addressing ● 8 bit (128K) or 16 bit (64K) operation ● Addressable as one block ● 16K window deselect. DIP switch selectable ● Switch selectable PHANTOM disable ● 16K x 1 static RAM ● Capable of DMA processing ● Assembled and Tested ● 1 year warranty

BRGBTRAM21 Catalog Price: $1225.00

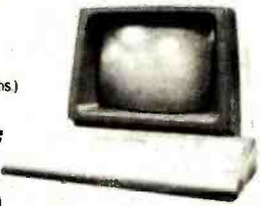
BUY IT NOW FOR ONLY:

$695

FREEDOM 50

LIBERTY ELECTRONICS

- 9 cursor control keys
- 7 editing function keys
- Programmable protection
- Multi-emulations
- Green screen 12"
- Tilt Base
- 5 function keys



BRLIBF50 (Sh. Wt. 34 lbs.)

List Price: $599.00

SALE PRICE:

$475

FREEDOM 100

Contains all of the above features of the FREEDOM 50 plus 5 additional function keys, 7 character sets, 15 special graphics symbols, and block mode transmission. **(Sh. Wt. 34 lbs.)**

BRLIBF100 List Price $649.00 **SALE PRICE: $525.00**

California Computer Systems

64K - 4MHz IEEE/S-100 DYNAMIC RAM

● Operates with either an 8080 or Z-80, providing processor transparent refreshes ● Bank-select system ● Any 16K block can be made bank-independent ● Phantom input ● Assembled & Tested

REGULAR LIST PRICE IS $375.00

$175.00 ea.

4/$640.00

BRCCS20653 (Sh. Wt. 2 lbs.)

RAM BOARD DISK DRIVE BONUS!

As an added bonus, PRIORITY ONE ELECTRONICS is giving away software developed by Micro Resources that will allow 4 CCS20653 boards to be used as an in-memory disk drive. This allows for an incredible speed increase in speed in your computer. This software is only available with the purchase of 4 CCS20653 memory boards. Use part number **BRMRSRDSK** (Sh. Wt. 1 lb.)

DUAL QUME 8" FLOPPY DRIVE, CABINET, DMA S-100 CONTROLLER, AND CP/M® FROM CompuPro

$1595.00

BRPDSGBTSYS206

YOU SAVE $1419.77!!

ABSOLUTELY THE MOST COST EFFECTIVE DISK SUBSYSTEM EVER OFFERED BY PRIORITY ONE ELECTRONICS!!

- 2 Double-sided 8" QUME DT8 disk drives
- DMA Floppy Controller (controls up to 4 drives)
- CP/M™ 2.2 w/bios written for the Disk 1 Controller
- Cabinet includes power supply & internal data cable
- External data cable included

(Shipped freight collect)

		List Price
1	GBT206SP	$2325.00
1	GBT171A	$495.00
1	GBTCPM80	$175.00
1	PGC50S60S	$ 19.77
		$3014.77

CABINET AND 2 QUME DT8 DOUBLE SIDED DRIVES PROVIDE 2.4 MBYTES OF MASS STORAGE!! $1295.00

(Sh. Wt. 50 lbs.) List $2325.00 SAVE $1030.00! BRGBT206SP

CompuPro™ UN-SYSTEM 816

FOR THOSE WHO DEMAND EXCELLENCE!

Each CompuPro system contains the same nucleus of common hardware and software. This insures compatibility between systems as well as allowing you to expand as your needs grow. The following is a list of the basic hardware components as well as software.

HARDWARE:

- Desk top Enclosure 20 slots
- Floppy disk enclosure with 2 Qume DT8 drives
- DMA Floppy Controller
- 8085/8088 CPU operates 8 or 16 software
- Memory in the form of RAM 17s
- System support 1 (Clock calendar, RAM/ROM/math processor options, RS-232 Serial port, dual interrupt controllers, triple interval timers, and more!)
- All internal cables

SOFTWARE:

- CP/M 2.2™ and CP/M 86™
- M Drive Software - allows the use of memory as another disk drive
- Sorcim's SUPERCALC 86™
- Ashton Tate's DBase II

DIG DEEP!! Now is the time to buy the CompuPro UN-SYSTEM 816!!

SAVE MONEY, and have an UN-SYSTEM 816 for your very own! All UN-SYSTEMS contain the very same components as the SYSTEM 816s listed in our Winter 1983 Engineering Selection Guide, but are not installed or configured. All it takes is your professional computer experience and knowledge to have the highest performing S-100 computer system on the market today. BEWARE! This is not for the novice and inexperienced user, as it requires a well-matured knowledge in system integration procedures.

So, WHY WAIT!? Don't Pass Up This Incredible Deal!!

Each component of the UN-SYSTEM 816 has been assembled and individually tested. Final installation and configuration are the sole responsibility of the purchaser.

UN-SYSTEM 816/A

ENTRY LEVEL - SINGLE USER

Disk storage: 2.4 Megabytes. Expandable to 4.8 Megabytes.
Main memory: 128K - expandable to 1 Megabyte
Serial Ports: 4 / Parallel Ports: 1
Centronics/Epson ports: 1
Software: CP/M 2.2™, CP/M-86™, M-Drive, SuperCalc-86, dBase
Component List Price: $6705.00 **BRGBTUNSYSA16**

OUR SALE PRICE: $4795.00 **SAVE $1910.00!!**

UN-SYSTEM 816/B

ENHANCED HIGH PERFORMANCE SINGLE USER SYSTEM

Disk Storage: 2.4 Megabytes. Expandable to 4.8 Megabytes.
Main memory: 256K - expandable to 1 Megabyte
Serial ports: 6
Software: CP/M 2.2™, CP/M-86™, M-Drive, SuperCalc-86™, dBase II™
Component List Price: $8497.00 **BRGBTUNSYSB16**

OUR SALE PRICE: $5795.00 **SAVE $2702.00!!**

UN-SYSTEM 816/C

HIGH PERFORMANCE MULTI-USER SYSTEM

Disk storage: 2.4 Megabytes. Expandable to 4.8 Megabytes.
Main memory: 384K - expandable to 1 Megabyte
Serial ports: 9
Software: CP/M 2.2™, CP/M-86™, MP/M 8-16™, M-Drive, SuperCalc-86™, dBase II™
Component List Price: $10,636.00 **BRGBTUNSYSC16**

OUR SALE PRICE: $7595.00 **SAVE $3041.00!!**

PRIORITY ONE ELECTRONICS

ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (213) 709-5111

Terms: U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through June, 1983. Credit Card orders will be charged appropriate freight. If you haven't received your Winter '83 Engineering Selection guide, send $1.00 for your copy today! Sale prices for prepaid orders only.

RETAIL STORE PHONE NUMBERS: (Chatsworth:) (213) 709-5464 - (Irvine:) (714) 660-1411

Circle 309 on inquiry card.

PRIORITY ONE ELECTRONICS

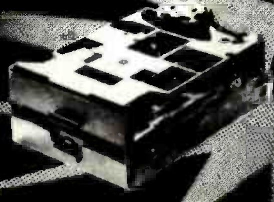
SIEMENS FDD100-8

8" FLOPPY DISK DRIVE

SINGLE SIDED, DOUBLE DENSITY

SHUGART 801R COMPATIBLE

90 DAY WARRANTY!



ONCE AGAIN YOU RECEIVE THE BENEFIT OF OUR UNEQUALLED PURCHASING POWER!

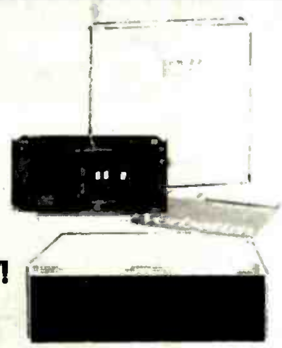
Ea.	$225.00
2-9	$199.00
10+	CALL

OEM INQUIRIES INVITED
(Include $7.00 per drive for shipping)
BRSIEFDD1008

ORDER NOW AND SAVE!

S-100 DUAL 8" SUBSYSTEM

BRCCS2422A	S-100 Disk Controller with CP/M 2.2	1	$399.00
BRSIEFDD1008	Siemens Double Density 8" drive	2	$398.00
BRIIIFDE002	Dual Horizontal Cabinet with Power Supply	1	$295.00
	and Data Cable	1	$ 35.00
			$1127.00



SAVE $132.00!!

$995.00

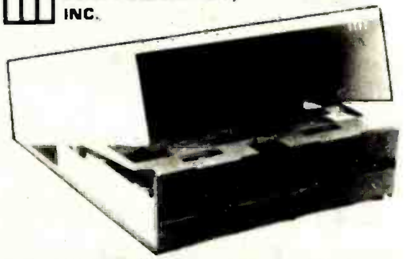
(Include $30.00 for shipping)

DON'T MISS OUT!

Order No.
BR PDBSIESUB1

BUY DRIVE AND CABINET TOGETHER AND $AVE!

INTERNATIONAL INSTRUMENTATION, INC.



- Positive Pressure Filter Cooling
- Power Supply 4A @ +5V,3A @ +24V 1A@-5V
- Each output is individually fused
- Hinged top for easy access
- Heavy non-flex .090 aluminum base
- Modular power connectors

DUAL 8" SIEMENS FDD1008,
DUAL 8" CABINET POWER SUPPLY
AND INTERNAL POWER CABLES

IF BOUGHT SEPARATELY: $890.00

PRICED AT: **$675.00**

BR PDBIIISIE

ENVIRONMENT MONITOR PANEL

Temperature and voltage monitor with visual and audible alarm for overtemp condition. Direct Digital Readout of internal temperature in C on standard DVM

BR IIIFDE002	CABINET ONLY (Sh. Wt. 38 lbs.)	$295.00
BR PDBIIISIEEM	2-Drives, Cabinet & disk environment monitor	$775.00
BR IIIFDE002EM	Cabinet only with disk environment monitor	$375.00
BRPDB50M1BE1BE	Dual Data Cable	$ 31.15
BRPGC50S60S	External Data Cable	$ 19.77

OUR FINEST 8" DUAL DISK DRIVE CABINET

International Instrumentation Incorporated

Compare these features listed and you'll see why this cabinet is our

FINEST DISK CABINET

FEATURES

- Positive pressure forced air cooling for reliable disk drive operation
- AC input via 3 wire 7 foot international cord/socket set
- AC input EMI filtered to six amps to help prevent disk crashes due to power spikes and line noise
- 14 gauge main chassis
- Integral power supply with 5V @ 6A/-5V @ 1A/24V @ 6A
- Double-sided custom PC power board and supply
- Each DC supply and AC separately fused

STANDARD UNIVERSAL DISK ENCLOSURE

	List Price	OUR Price
BRIIIUDE004	$495.00	$425.00
With augmented power suply to handle Tandon Slimline, or Winchester disk drives. Includes the disk environment monitor.		
BRIIIUDE004AUG	$733.00	$625.00
With Disk Environment Monitor for cool, reliable operation		
BRIIIUDE004EM	$584.95	$495.00

MPI

NEW LOW PRICES!

5¼" DISK DRIVES

BRMPI51*	Single-Sided Double-Density 48 TPI	$200.00
BRMPI52*	Double-Sided Double-Density 48 TPI	$270.00
BRMPI91*	Single-Sided Double-Density 96 TPI	$275.00
BRMPI92*	Double-Sided Double-Density 96 TPI	$400.00

**Replace "*" when ordering, with "M" for MPI style bezel, or "S" for Shugart style bezel. (Shipping Weight 5 lbs.)*

NEW! NEW! NEW! NEW! NEW!

5¼" HALF HEIGHT DRIVES!

BRMPI501	1 side, 48 tpi 6ms access	$260.00
BRMPI502	2 side, 48 tpi 6 ms access	$300.00
BRMPI901	1 side, 96 tpi 3ms access	$300.00
BRMPI902	2 side, 96 tpi 3ms access	$355.00

(Shipping Weight 4 lbs.)

2" HIGH 8" DISK DRIVES

The first 2" high 8" disk drive allows for mounting under the keyboard on CRT, etc.
NO AC Required +5V +24VDC only
FAST 3 msec track to track!

BRMPI41M	½ High 1 side double-density	$380.00
BRMPI42M	½ High 2 side double-density	$460.00
BRMPI41S	Full height 1 side single drive, dble.-density	$300.00
BRMPI42S	Full height 2 sided single drive, dble.-density	$460.00
BRMPI41D	Full height 1 side dual drive, dble.-density	$700.00
BRMPI42D	Full height 2 side dual drive, dble.-density	$820.00

(Shipping Weight: 11 lbs. per drive)

Tandon

8-INCH THIN LINE

Exactly one-half the height of any other model
Proprietary, high-resolution, read-write heads patented by Tandon
D.C. only operation - no A.C. required
Industry standard interface
Three millisecond track-to-track access time (9 lbs.)

TANDON 8" DRIVES

BR TNDTM8481	Single Sided $380.00	2 or more:	$370.00 ea.
BR TNDTM8482	Double Sided $495.00	2 or more:	$485.00 ea.

TANDON 5¼" DRIVES

BR TNDTM1001	Single Sided, 250KB (5 lbs.)	$220.00 ea.
	2 or More: $200.00 each	
BRTNDTM1002	Double Sided, 500KB	$295.00 ea.
	2 or More: $270.00 each	
BR TNDTM1003	Single Sided, 500KB	$295.00 ea.
	2 or More: $270.00 each	
BR TNDTM1004	Double Sided, 1000KB	$395.00 ea.
	2 or More: $375.00 each	

DUAL 8" HALF HEIGHT FLOPPY CABINET

- 24V @ 4A 5V @ 3A -5V@ 800ma
- Fan cooled
- Socketed power connections
- All supplies regulated

INTERNATIONAL INSTRUMENTATION, INC.

	List Price	SALE
BRIIIDTL002 Dual Thin Line Cabinet (12 lbs)	$225.00	$165.00

BUY THE CABINET & DRIVES AND $AVE!

With 2 Tandon Thinlines

BRPDBIIITND1 Cabinet w/2 TNDTM8481 -1 sided (30 lbs.)	$885.00
BRPDBIIITND2 Cabinet w/2 TNDTM8482 -2 sided (30 lbs.)	$1115.00

With 2 MPI Slimlines

BRPDBIIIMPI1 Cabinet w/2 MPI41M - 1 sided (30 lbs.)	$820.00
BRPDBIIIMPI2 Cabinet w/2 MPI42M - 2 sided (30 lbs.)	$1000.00

Options

BR IIIDTLMPIKIT MPI drive adaptor mounting kit (2 lbs.)	$24.95
BR IIIDCCSHU Shugart / AC/DC power connector kit (2 lbs.)	$14.95

(For full size single SA801 or compatible drives)

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Circle 309 on inquiry card.

PRIORITY ONE ELECTRONICS

APPLE II 5¼" DISK DRIVES

FULLY APPLE II COMPATIBLE

APPLE ADD-ON DISK DRIVE

BRVIS3101 (Sh Wt 6 lbs) List Price $299.95

SPECIAL SALE PRICE: ***$229.00***

DISK DRIVE WITH CONTROLLER

BRVIS3111 (Sh Wt. 7 lbs) List Price $379.00

SPECIAL SALE PRICE: ***$289.00***

BRVISAFDC Apple II Drive Controller **ON SALE NOW FOR ONLY** ***$79.00***

LOWEST COST PRINTERS AVAILABLE

$299.00 !!

COEX 80 F/T by star

- 80 cps • 10, 12 or 16.5 cpi • 3 selectable fine spacing • Vertical format control • Centronics parallel interface • Uses a standard Underwood spooled ribbon • Friction and tractor feed

(Shipping Weight 21 lbs)		**List Price**	**OUR Price**
BRCOX80FT	Parallel int	$399.00	**$299.00**
BRCOXAPLINTP	Apple parallel interface w/cable		**$49.95**

$229.00

AXIOM
AXIOM CORPORATION

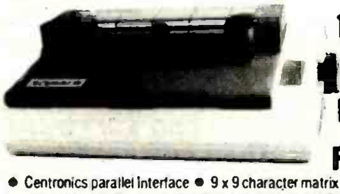
SAVE $160.00!!

(Sh. Wt. 11 lbs.)

- 5 x 7 Dot Matrix • Parallel Interface (Centronics) • Tractor Feed • Dot Addressable Graphics • Up to 3-Part Paper • Self Test • One Year Warranty • 30 CPS 80 Column Unidirectional • Uses Regular Paper

BQAXMGP100A	Dot Matrix Printer	$389.00	**$229.00**

star MICRONICS • INC gemini



100CPS DOT MATRIX PRINTER

- Centronics parallel interface • 9 x 9 character matrix • 6 x 6 block graphic matrix • Bit image (7 or 8) x 480 dot matrix (single density) (7 or 8) x 960 dot matrix • Bi-directional printing with logic seeking • 40, 48, 66, 80, 96, or 132 characters per line • 96 ASCII characters • 5, 6, 8.5, 10, 12, or 17 characters per inch • 1/6, 1/8, n/72, n/144 Line pitch • Sprocket or friction feed • Uses a standard underwood ribbon

BRGEM10 80 Column* Printer List Price: $399.00

SALE PRICE: ***$359.00***
(Shipping Weight 20 lbs.)

BRGEM15 132 Column* Printer List Price: $649.00

SALE PRICE: ***$489.00***
(Shipping Weight 26 lbs.)

*Based on 10 characters per inch

SERIAL INTERFACE CARD FOR GEMINI 10 & 15

BRGEMSERINT Serial Interface Module (Sh. Wt. 1 lb.) **$85.00**

IBM® MULTICARD

Vista™ MEMORY & I/O CARD

- 64K RAM Expandable to 256K
- One RS232 Serial Port
- One Parallel Printer Port
- Real Time Clock Calendar with Battery Backup

(Sh. Wt. 1 lb.)

BRVIS025665 List Price $595.00

SALE PRICE:

$329.00

IBM® MAXICARD

Vista PERSONAL COMPUTER RAM CARD

POPULATED IN 64K, 256K, or 576K

- Runs at full speed with no wait states
- Parity can be disabled at User's option
- On board parity bit on each Byte
- Fully expanded, a full 576KB on one card
- One board fills entire primary RAM address space available
- Full Vista 120 Day Warranty

64K ***$219.00***
BR VIS057064 List Price $379.00
SAVE $160.00

256K ***$489.00***
BR VIS0576256 List Price $789.00
SAVE $320.00

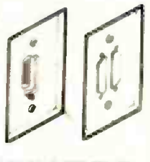
576K ***$849.00***
BR VIS0576576 List Price $1299.00
SAVE $450.00

*Available with 256K & 576K boards only (Sh Wt 6 lbs)

(IBM is a trademark of International Business Machines)

EIA/RS232 WALL PLATES

(Does not include connectors)



BRIIIWPDB251 Single punched
4/$10.00

BRIIIWPDB252 Dual Punched
4/$12.00

RS-232 "D" SUB-MINIATURE CONNECTORS

		1-9	**10-24**	**25-99**	**100-UP**
BR CNDDB25P	25 Pin Male	$2.75	$2.50	$2.25	$1.95
BR CNDDB25S	25 Pin Female	$4.00	$3.50	$3.25	$3.00
BR CNODB51212	1 Pc. Grey Hood	$1.65	$1.40	$1.25	$1.15
BR CNDP25H	2 Pc. Grey Hood	$1.50	$1.25	$1.10	$1.00
BR CNDDB51226	2 Pc. Black Hood	$1.75	$1.50	$1.35	$1.20
BR CN0020418	Hardware set 2/Pr.	$1.00	$ .80	$ .70	$ .60

TEXAS INSTRUMENTS

16 PIN GOLD AND TIN DIP SOLDERTAIL SOCKETS

QTY	**TIN** **BRTIS16LP**	**GOLD** **BRTIG16LP**
50 (Sh Wt 4 oz.)	$ 8.00	$ 10.00
1000 (Sh. Wt. 4 lbs.)	$ 60.00	$ 80.00
4500 (Sh Wt 15 lbs.)	$225.00	$315.00

DIRECT CONNECT MODEM

$79.00 **MURA**

0 - 300 BAUD
MURA MM-100

NEW!

- 0 - 300 baud
- RS232C interface
- Full duplex
- Carrier detect indicator
- Bell 103 compatible
- Low voltage
- Originate/Answer switch selectable

		List Price	**SALE**
BR MURMM100	0 - 300 baud modem *(Shipping Weight: 2 lbs.)*	$99.95	**$79.00**
BR CNDRS2328F	RS232 cable		**$19.95**

ULTRA MAGNETICS 5¼" FLOPPY DISKETTES

LIFETIME WARRANTY!

DOUBLE DENSITY!

SALE!

FEATURES:

- Includes reinforcement ring
- Write protect with tabs
- 100% Surface tested
- Lifetime warranty

SINGLE SIDED

40 TRACKS — DOUBLE DENSITY

ORDER INFORMATION:

BRPULT51401 Soft Sector
BRPULT51410 10 Sector
BRPULT51416 16 Sector

BOX OF 10 ***$25.00***
2 BOXES: ***$40.00***
10 BOXES: ***$180.00***

Description		**Box of 10**	**2 Boxes**	**10 Boxes**
BR ULT52401 **BR ULT52410** **BR ULT52416**	Soft sector, 40 track, 2 side 10 sector, 40 track, 2 side 16 sector, 40 track, 2 side	**$35.00**	**$60.00**	**$280.00**
BR ULT51801 **BR ULT51810** **BR ULT51816**	Soft sector, 80 track, 1 side 10 sector, 80 track, 1 side 16 sector, 80 track, 1 side	**$30.00**	**$50.00**	**$220.00**
BR ULT52801 **BR ULT52810** **BR ULT52816**	Soft sector, 80 track, 2 sided 10 sector, 80 track, 2 sided 16 Sector, 80 track, 2 sided	**$40.00**	**$70.00**	**$320.00**
		(Sh. Wt. 2 lbs)	(Sh. Wt. 4 lbs.)	(Sh. Wt. 20 lbs.)

PRIORITY ONE ELECTRONICS

VISA MasterCard NEDA

9161 DEERING AVE. CHATSWORTH, CA 91311

ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (213) 709-5111

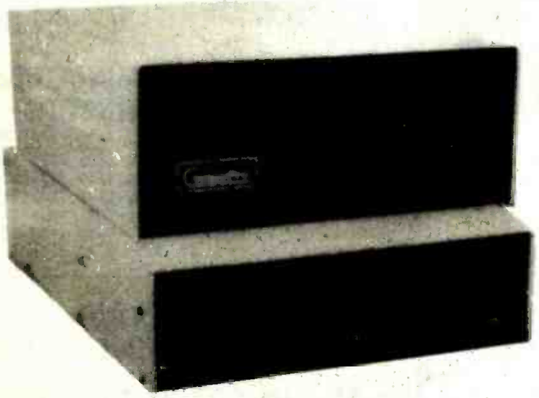
Terms. U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through June, 1983. Credit Card orders will be charged appropriate freight. If you haven't received your Winter '83 Engineering Selection guide, send $1.00 for your copy today! Sale prices for prepaid orders only.

RETAIL STORE PHONE NUMBERS: (Chatsworth:) (213) 709-5464 - (Irvine:) (714) 660-1411

Circle 309 on inquiry card.

PRIORITY ONE ELECTRONICS

COMPLETE 8 BIT ENTRY LEVEL CP/M® BASED COMPUTER SYSTEM



CompuPro®

- Z80B 6MHz CPU
- 2.4 Mbytes of floppy disk storage using the best QUME DATATRAK 8 drives
- Fast DMA disk controller
- 64K low power static RAM
- 3 serial RS-232 ports
- 1 parallel port
- 1 centronics printer port
- 20 slot S-100 IEEE mainframe
- Constant voltage transformer
- CP/M 2.2® included
- I/O and disk drive cables included

LOOK AT WHAT YOU GET!

		List Price
BRGBT160A	6 MHz Z80 CPU	$325.00
BRGBT171A	DMA Disk Controller	$495.00
BRGBT200SP	Dual QUME Drives and Cabinet	$2395.00
BRGBT187A	3 Serial, 1 Parallel, 1 Centronics I/O	$300.00
BRGBTRAM17	64K Static RAM	$499.00
BRGBTENC20BK	20 Slot S-100 Mainframe	$825.00
BRGBTCPM80	CP/M 2.2® with BIOS	$175.00
BRGBTCBL4	3 Port Serial Cable to Cabinet	$ 44.00
BRGBTCBL9	Centronics Cable to Cabinet	$ 29.50
BRPBC50S80S	5' Drive Cable	$ 19.77

TOTAL PURCHASE VALUE: *$5206.27*

BUY IT NOW FOR ONLY:

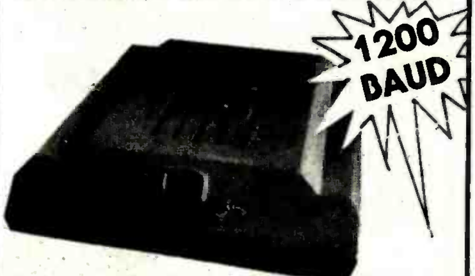
$3495

BRPDBGBT8BT

SAVE $1711.27!

NEW!! PASSWORD by U.S. ROBOTICS

BELL 212A AUTO/DIAL MODEM HAYES SMARTMODEM COMPATIBLE



$425.00

PASSWORD puts any micro computer into a telecommuting network with 300/1200 baud speed, programmable auto dial and auto answer capability, auto mode and auto speed select, audio phone line monitor, and other advanced features. So simple, one button operates it. So compact it mounts on the back of a computer with Velcro®. The PASSWORD features all of the same operating specifications as the AUTODIAL 212A modem at only a fraction of the cost!

Part No.		List Price	SALE
BRUSRPASSWORD	(sh wt 4 lbs)	$449.00	$425.00

TELPAC SOFTWARE PACKAGE

TELPAC, the USR software package, programs computers to exploit all the automatic dialing features of the USRPASSWORD and USRADIAL212A modems, inlcuding timed calls, login-logoff, custom phone directories, access passwords, and much more!

BRUSRTELPAC5A	on APPLE II soft sector	$79.00
BRUSRTELPAC8	on 8" single density	$79.00

(Shipping Weight 1 lb)

SUPER DMM SALE

HITACHI
Hitachi Denshi America, Ltd.

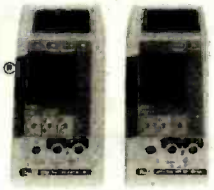
AUTO RANGING 3½ DIGIT LCD

- Eight measurement functions with auto ranging
- Data hold feature
- Continuity beeper
- Temperature measurements (except HITVR3550)
- .5 to .1% accuracy
- 10 M input impedance
- 250V overload protection on all resistance functions
- 1100 VDC or 850 VAC overload protection on volt scales

		List Price:	SALE
BR *HITVR3550*	.5% Autoranging DMM	$127.00	$105
BRHITVR3525	.25% with temp.	$157.00	$130
BRHITVR3510	.1% with temp	$187.00	$160
BRHIT8703	Soft carrying case		$ 15

FLUKE®

DMMs



BRFLU8022B	Handheld DMM .25% Accuracy	$144.00
BRFLU8021B	Handheld DMM .5% Accuracy w/cond	$159.00
BRFLU8020B	Handheld DMM .1% Accuracy	$184.00
BRFLU8024B	Handheld DMM .1% Accuracy, Pk & Hold	$248.00
BRFLU8010A	10A Tru RMS Bench DMM	$259.00
BRFLU8010A01	FLU8010A w/battery	$299.00
BRFLU8012A	Low Ohms Tru-RMS Bench	$339.00
BRFLU8012A01	FLU8012A w/battery	$379.00
BRFLU8060A	4½ Digit DMM w/Frequency Counter	$349.00
BRFLU8062A	4.5 digit Handheld DMM	$279.00
BRFLU8050A	4.5 digit tru-RMS Bench	$389.00
BRFLU8050A01	FLU8050A w/battery	$439.00
BRFLUC90	Soft carrying case	($18.00) 1¢*

KEITHLEY

DMMs

BRKTH130	3.5 digit .5% Acc handheld DMM	$129.00
BRKTH131	3.5 digit .25% Acc handheld DMM	$139.00
BRKTH128	3.5 digit handheld DMM w/beeper	$139.00
BRKTH132C	3.5 digit handheld DMM/thermometer Cent.	$199.00
BRKTH132F	3.5 digit handheld DMM/thermometer Far.	$209.00
BRKTH135	4½ digit handheld DMM	$239.00
BRKTH169	3.5 digit bench LCD DMM	$189.00
BRKTH178	4.5 digit bench LCD DMM	$299.00
BRKTH179A	4.5 digit bench LED DMM	$359.00
BRKTH191101B	5.5 digit bench	$870.00
BRKTH191102B	5.5 digit bench true RMS	$940.00
BRKTH1304	Soft carrying case	(18.00) 1¢*

BUY A SOFT CARRYING CASE FOR 1¢

***WITH THE PURCHASE OF ANY FLUKE OR KEITHLY HANDHELD DMM!**

1200 BAUD AUTO DIAL DIRECT CONNECT MODEMS WITH 10 NUMBER MEMORY

RIXON INC.

STANDALONE OR IDM PC CARD

- 0-300 baud or 1200 baud operation
- Auto dial
- Tone or pulse dial
- Redial last number
- Auto answer
- 5 second dial delay
- link to another number
- wait for dial tone
- 10 number memory of up to 60 characters in length -60 character field can include ID code, password, and a description of the called station - single keystroke actuates a number
- PC COM™ modem operating software package for IBM PC™ optional
- Shipping weight 2 lbs.

		List Price	SALE Price
BRRIXR212A	Standalone Unit	$495.00	$475.00

IDM PC™ COMPATIBLE MODEM CARD

Features all the same specifications as standalone unit.

BRRIXPC212A	IBM PC™ modem (2 lbs.)	$495.00	$475.00
BRRIXPCCOM1	IBM modem software (1 lb)		$ 88.00

BUY THE CARD AND SOFTWARE TOGETHER AND SAVE!!

BRPDBRIXIBM	Card and Software (3 lbs.)	$539.00

(SEE PAGE 431 IN MAY ISSUE OF BYTE)

1200 BAUD AUTO-DIAL HAYES SMARTMODEM COMPATIBLE

U.S. ROBOTICS INC.

MODEMS

$495.00

The **AUTO DIAL 212A** Modem is a direct connect 0-300 or 1200 baud modem capable of dialing and calling for you. **The AUTO DIAL 212A is compatible in function to the DC Hayes SMARTMODEM™.**

Part No.	Description	List	SALE Price
BRUSRADIAL212A	0-300 1200 baud dialing modem	$599.00	$495.00

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Circle 309 on inquiry card.

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LAST CHANCE FOR SCOPE REBATE!!

NO ONE ELSE HAS LOWER SCOPE PRICES!!

DIRECT FACTORY CONSUMER REBATE CERTIFICATE INCLUDED!
(Valid through June 30, 1983)

DUAL TIME BASE!
CALIBRATED DELAYED SWEEP!

B+K PRECISION

$75.00 REBATE!

100 MHz
8 TRACE - 4 CHANNEL
BRBKP1590 List Price: $1995.00
$1449.00
(Shipping Weight 18 lbs.)
SAVE $546.00!!

70 MHz
8 TRACE - 4 CHANNEL
BRBKP1570 List Price: $1395.00
$995.00
(Shipping Weight 18 lbs.)
SAVE $400.00!!

2 Probes Included With Each Scope!

35 MHz
DUAL TRACE - TRIGGERED
BRBKP1535 List Price: $950.00
$695.00
(Shipping Weight 20 lbs.)
SAVE $430.00!!
INCLUDING REBATE

30 MHz
DUAL TRACE - DELAYED SWEEP
BRBKP1530 List Price: $875.00
$599.00
(Shipping Weight 20 lbs)
SAVE $326.00!!
INCLUDING REBATE

TAXAN

12" RGB COLOR MONITOR
380 HORIZONTAL LINE RESOLUTION

BQTAXRGB1
List Price: $399.00
(Sh. Wt. 29 lbs.)
$329

BQTAXIBMRGB
Interface cable to IBM **$19.00**

BQTAXRGBAPL
Apple IIe & III cable **$19.00**

WITH APPLE II RGB INTERFACE

BQPDBTAXRGBAPL
List Price: $528.00 **$359.00**

12" RGB SUPER HIGH RESOLUTION MONITOR
630 HORIZONTAL LINE RESOLUTION

- 18MHz bandwidth
- Linear RGB input provides unlimited color combintations
- Compatible with APPLE III and IBM P/C

BQTAXRGB3
LIST PRICE:
$699.00
(Sh. Wt. 29 lbs.)

SALE PRICE: $595.00

SUPER HIGH RESOLUTION RGB MONITOR WITH AN APPLE INTERFACE CARD
BQPDBRGB3APL $695.00

RGB VIDEO INTERFACE WITH 80 CHARACTER ALPHANUMERIC FORMAT FOR THE APPLE IIe
BRTAX41080 APPLE IIe RGB Int. List: $199.00 **SALE: $189.00**

HIGH RESOLUTION 12" GREEN OR AMBER VIDEO MONITOR

- >18 MHz bandwidth
- 800 line horizontal resolution
- Composite video input

BQTAXKG12N Green
BQTAXKG12NUY Amber
LIST PRICE: $179.00
(Shipping Weight 19 lbs.)

SALE PRICE: $129.00

THE LEMON™ SOURS SURGES

The LEMON, LIME, ORANGE, and PEACH are solid state and EMI-RFI noise filters designed to protect all mini and micro computers, word processors, printers, disc drives, and other computer-controlled equipment that is plugged into an AC power line. There may be nothing more terrifying than to lose all of your software or data files due to a high voltage spike or noise from an adjacent elevator, air conditioner, or any other high powered equipment being operated in the nearby area. With a LEMON, LIME, ORANGE, or PEACH, you can be sure that the FRUITS of your computer will be protected from most voltage spikes and EMI-RFI interferences.

AC SURGE PROTECTORS

Part No.	Description	List Price	SALE PRICE
BREPDLEMON	6 outlet wall mount	$59.95	$44.95
BREPDLIME	6 outlet 4½" cord w/power switch	$89.50	$69.95

(Shipping Weight 4 lbs each)

EMI-RFI FILTERED AC SURGE PROTECTOR

BREPDORANGE	6 outlet 4½" cord w/power switch	$139.95	$104.95
BREPDPEACH	6 outlet wall mount	$ 97.50	$ 74.95

(Shipping Weight 4 lbs each)

COLOR IS INDICATED BY PART NUMBER

MURAPHONE CORDLESS
CORDLESS TELEPHONE

$95

600' RANGE!!

- 12 button dial pad - last number called auto redial - hide-away base unit - battery charger plugs into AC outlet - includes carry case

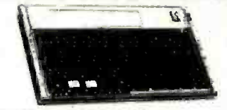
BRMUR600/601 (Sh. Wt. 3 lbs.) List Price: $129.95

ON SALE NOW FOR ONLY $95

H-P QUALITY & PERFORMANCE AT OUR *LOW* PRICES!!

HEWLETT PACKARD

SERIES 10 PROGRAMMABLE CALCULATORS



- RPN Logic - Continuous memory - Automatic turnoff - LCO - Self diagnosis - Rugged construction

		List Price	*SALE*
BR HP-10C	Scientific	$ 70.00	***$59.00***
BR HP-11C	Adv. scientific	$ 90.00	***$79.00***
BR HP-12C	Adv. financial	$120.00	***$99.00***
BR HP-15C	Adv. sci. w/matrix	$120.00	***$99.00***
BR HP-16C	Digital & Computer science	$120.00	***$99.00***

(Shipping Weight 3 lbs.)

HP-41C/CV HANDHELD COMPUTER SYSTEM

Part No.	Description	List Price	*SALE*
BR HP-41C	Handheld computer	$195.00	***$159.00***
BR HP-41CV	Handheld computer w/5x the memory	$275.00	***$219.00***
BR HP82104A	Card reader	$195.00	***$159.00***
BR HP82153A	Optical Wand	$125.00	***$ 99.00***
BR HP82161A	Cassette drive	$450.00	***$349.00***
BR HP82162A	Thermal Printer	$450.00	***$349.00***
BR HP82163A	Video interface	$225.00	***$179.00***

(Shipping Weights 5 lbs. for each item above)

ENHANCEMENT MODULES:

BR HP82160A	HP-IL module	$125.00	***$95.00***
BR HP82170A	Quad RAM module	$ 75.00	***$59.00***
BR HP82180A	Extended functions/ memory module	4 75.00	***$59.00***
BR HP82181A	Ext. memory module	$ 75.00	***$59.00***
BR HP82182A	Time module	$ 75.00	***$59.00***

(Shipping Weights 1 lb. for each item above)

HP-75C PORTABLE COMPUTER

- Accepts 48K of applications ROM
- Touch type typewriter like keyboard
- Powerful BASIC language
- Expandable using the Series 41 peripherals and modules

BR HP-75C (Sh. Wt. 9 lbs.)
List Price: $995.00

ON SALE NOW FOR ONLY
$795.00

VISA

PRIORITY ONE ELECTRONICS

9161 DEERING AVE. CHATSWORTH, CA 91311

MasterCard NEDA

ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (213) 709-5111

Terms: U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through June, 1983. Credit Card orders will be charged appropriate freight. If you haven't received your Winter '83 Engineering Selection guide, send $1.00 for your copy today! Sale prices for prepaid orders only.

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Circle 309 on inquiry card.

4164 64K DYNAMIC 200 NS **$5.95** **TMM2016** 2KX8 STATIC 200 NS **$4.15**

STATIC RAMS

2101	256 x 4 (450ns)	1.95
5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	.99
2102L-2	1024 x 1 (250ns) (LP)	1.49
2111	256 x 4 (450ns)	2.49
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/9.95
2114L-4	1024 x 4 (450ns) (LP)	8/12.95
2114L-3	1024 x 4 (300ns) (LP)	8/13.45
2114L-2	1024 x 4 (200ns) (LP)	8/13.95
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.75
HM6116-3	2048 x 8 (150ns) (cmos)	4.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/12.95
4116-150	16384 x 1 (150ns)	8/14.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	5.95
4164-150	65536 x 1 (150ns) (5v)	6.95

5V = single 5 volt supply

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns) (5v)	5.95
2716	2048 x 8 (450ns) (5v)	3.95
2716-1	2048 x 8 (350ns) (5v)	5.95
TMS2516	2048 x 8 (450ns) (5v)	5.50
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns) (5v)	5.95
2732	4096 x 8 (450ns) (5v)	4.95
2732-250	4096 x 8 (250ns) (5v)	8.95
2732-200	4096 x 8 (200ns) (5v)	11.95
2764	8192 x 8 (450ns) (5v)	9.95
2764-250	8192 x 8 (250ns) (5v)	14.95
2764-200	8192 x 8 (200ns) (5v)	24.95
TMS2564	8192 x 8 (450ns) (5v)	17.95
MC68764	8192 x 8 (450ns) (5v)(24 pin)	39.95

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	4.49
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	4.49
Z80-SIO/0	16.95
Z80-SIO/1	16.95
Z80-SIO/2	16.95
Z80-SIO/9	16.95

4.0 Mhz

Z80A-CPU	4.95
Z80A-CTC	4.95
Z80A-DART	11.95
Z80A-DMA	16.95
Z80A-PIO	4.95
Z80A-SIO/0	16.95
Z80A-SIO/1	16.95
Z80A-SIO/2	16.95
Z80A-SIO/9	16.95

6.0 Mhz

Z80B-CPU	11.95
Z80B-CTC	13.95
Z80B-PIO	13.95
Z80B-DART	19.95

ZILOG

Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

CRT CONTROLLERS

6845	14.95
68B45	35.95
HD46505SP	15.95
6847	12.25
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95

8000

8035	5.95
8039	6.95
INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	6.95
8155-2	7.95
8156	6.95
8185	29.95
8185-2	39.95
8741	39.95
8748	24.95
8755	24.95

8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8231	call
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

DISC CONTROLLERS

1771	16.95
1791	24.95
1793	26.95
1795	49.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
UPD765	39.95
1691	17.95
2143	18.95

CONNECTORS

RS232 MALE	2.50
RS232 FEMALE	3.25
RS232 HOOD	1.25
S-100 ST	3.95

6800

68000	59.95
6800	3.95
6802	7.95
6808	13.90
6809E	19.95
6809	11.95
6810	2.95
6820	4.35
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B45	19.95
68B50	5.95

68B00 = 2 MHZ

6500

1 MHZ

6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	7.95
6532	9.95
6545	22.50
6551	11.85

2 MHZ

6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95

3 MHZ

6502B	14.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
TMS6011	5.95
IM6402	7.95
IM6403	8.95
INS8250	10.95

GENERATORS

BIT-RATE

MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95

FUNCTION

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	.99
74LS26	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	.99
74LS113	.39	74LS374	.99
74LS114	.39	74LS377	1.39
74LS122	.45	74LS378	1.18
74LS123	.79	74LS379	1.35
74LS124	2.90	74LS385	1.90
74LS125	.49	74LS386	.45
74LS126	.49	74LS390	1.19
74LS132	.59	74LS393	1.19
74LS133	.59	74LS395	1.19
74LS136	.39	74LS399	1.49
74LS137	.99	74LS424	2.95
74LS138	.55	74LS447	.37
74LS139	.55	74LS490	1.95
74LS145	1.20	74LS624	3.99
74LS147	2.49	74LS640	2.20
74LS148	1.35	74LS645	2.20
74LS151	.55	74LS668	1.69
74LS153	.55	74LS669	1.89
74LS154	1.90	74LS670	1.49
74LS155	.69	74LS674	9.65
74LS156	.69	74LS682	3.20
74LS157	.65	74LS683	3.20
74LS158	.59	74LS684	3.20
74LS160	.69	74LS685	3.20
74LS161	.65	74LS688	2.40
74LS162	.69	74LS689	3.20
74LS163	.65	74LS783	24.95
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

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2114 450 NS $8/\$9^{95}$ 2114 250 NS $8/\$10^{95}$

7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74190	1.15
7453	.23	74191	1.15
7454	.23	74192	.79
7460	.23	74193	.79
7470	.35	74194	.85
7472	.29	74195	.85
7473	.34	74196	.79
7474	.33	74197	.75
7475	.45	74198	1.35
7476	.35	74199	1.35
7480	.59	74221	1.35
7481	1.10	74246	1.35
7482	.95	74247	1.25
7483	.50	74248	1.85
7485	.59	74249	1.95
7486	.35	74251	.75
7489	2.15	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.35	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.75	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.49	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
74128	.55	74490	2.55

LINEAR

LM301	.34	LM340 (see 7800)		LM566	1.49	LM1800	2.37
LM301H	.79	LM348	.99	LM567	.89	LM1812	8.25
LM307	.45	LM350K	4.95	NE570	3.95	LM1830	3.50
LM308	.69	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308H	1.15	LM358	.69	NE592	2.75	LM1872	5.49
LM309H	1.95	LM359	1.79	LM709	.59	LM1877	3.25
LM309K	1.25	LM376	3.75	LM710	.75	LM1889	1.95
LM310	1.75	LM377	1.95	LM711	.79	LM1896	1.75
LM311	.64	LM378	2.50	LM723	.49	ULN2003	2.49
LM311H	.89	LM379	4.50	LM723H	.55	LM2877	2.05
LM312H	1.75	LM380	.89	LM733	.98	LM2878	2.25
LM317K	3.95	LM380N-8	1.10	LM741	.35	LM2900	.85
LM317T	1.19	LM381	1.60	LM741N-14	.35	LM2901	1.00
LM318	1.49	LM382	1.60	LM741H	.40	LM3900	.59
LM318H	1.59	LM383	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM384	1.95	LM748	.59	LM3909	.98
LM319	1.25	LM386	.89	LM1014	1.19	LM3911	2.25
LM320 (see 7900)		LM387	1.40	LM1303	1.95	LM3914	3.95
LM322	1.65	LM389	1.35	LM1310	1.49	LM3915	3.95
LM323K	4.95	LM390	1.95	MC1330	1.69	LM3916	3.95
LM324	.59	LM392	.69	MC1349	1.89	MC4024	3.95
LM329	.65	LM394H	4.60	MC1350	1.19	MC4044	4.50
LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
LM337K	3.95	NE558	1.50	LM1488	.69	RC4558	.69
LM337T	1.95	NE561	24.95	LM1489	.69	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM13700	1.49

H = TO-5 CAN   T = TO-220   K = TO-3

RCA

CA 3023	2.75	CA 3082	1.65
CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
CA 3160	1.19		

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
75494	.89		

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
LF357	1.40		

CMOS

4000	.29	4527	1.95
4001	.25	4528	1.19
4002	.25	4531	.95
4006	.89	4532	1.95
4007	.29	4538	1.95
4008	.95	4539	1.95
4009	.39	4541	2.64
4010	.45	4543	1.19
4011	.25	4553	5.79
4012	.25	4555	.95
4013	.38	4556	.95
4014	.79	4581	1.95
4015	.39	4582	1.95
4016	.39	4584	.75
4017	.69	4585	.75
4018	.79	4702	12.95
4019	.39	74C00	.35
4020	.75	74C02	.35
4021	.79	74C04	.35
4022	.79	74C08	.35
4023	.29	74C10	.35
4024	.65	74C14	.59
4025	.29	74C20	.35
4026	1.65	74C30	.35
4027	.45	74C32	.39
4028	.69	74C42	1.29
4029	.79	74C48	1.99
4030	.39	74C73	.65
4034	1.95	74C74	.65
4035	.85	74C76	.80
4040	.75	74C83	1.95
4041	.75	74C85	1.95
4042	.69	74C86	.39
4043	.85	74C89	4.50
4044	.79	74C90	1.19
4046	.85	74C93	1.75
4047	.95	74C95	.99
4049	.35	74C107	.89
4050	.35	74C150	5.75
4051	.79	74C151	2.25
4053	.79	74C154	3.25
4060	.89	74C157	1.75
4066	.39	74C160	1.19
4068	.39	74C161	1.19
4069	.29	74C162	1.19
4070	.35	74C163	1.19
4071	.29	74C164	1.39
4072	.29	74C165	2.00
4073	.29	74C173	.79
4075	.29	74C174	1.19
4076	.79	74C175	1.19
4078	.29	74C192	1.49
4081	.29	74C193	1.49
4082	.29	74C195	1.39
4085	.95	74C200	5.75
4086	.95	74C221	1.75
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	4.18	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C910	9.95
4508	1.95	74C911	8.95
4510	.85	74C912	8.95
4511	.85	74C914	1.95
4512	.85	74C915	1.19
4514	1.25	74C918	2.75
4515	1.79	74C920	17.95
4516	1.55	74C921	15.95
4518	.89	74C922	4.49
4519	.39	74C923	4.95
4520	.79	74C925	5.95
4522	1.25	74C926	7.95
4526	1.25	74C928	7.95
		74C929	19.95

74S00

74S00	.32	74S163	1.95
74S02	.35	74S168	3.95
74S03	.35	74S169	3.95
74S04	.35	74S174	.95
74S05	.35	74S175	.95
74S08	.35	74S181	3.95
74S09	.40	74S182	2.95
74S10	.35	74S188	1.95
74S11	.35	74S189	6.95
74S15	.35	74S194	1.49
74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
74S30	.35	74S197	1.49
74S32	.40	74S201	6.95
74S37	.88	74S225	7.95
74S38	.85	74S240	2.20
74S40	.35	74S241	2.20
74S51	.35	74S244	2.20
74S64	.40	74S251	.95
74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
74S86	.50	74S260	.79
74S112	.50	74S274	19.95
74S113	.50	74S275	19.95
74S114	.55	74S280	1.95
74S124	2.75	74S287	1.90
74S132	1.24	74S288	1.90
74S133	.45	74S289	6.89
74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
74S138	.85	74S374	2.45
74S139	.85	74S381	7.95
74S140	.55	74S387	1.95
74S151	.95	74S412	2.98
74S153	.95	74S471	4.95
74S157	.95	74S472	4.95
74S158	.95	74S474	4.95
74S161	1.95	74S482	15.25
74S162	1.95	74S570	2.95
		74S571	2.95

INTERFACE

8T26	1.59
8T28	1.89
8T95	.89
8T96	.89
8T97	.89
8T98	.89
DM8131	2.95
DP8304	2.29
DS8835	1.99
DS8836	.99

MISC.

ULN2003	2.49
3242	7.95
3341	4.95
MC3470	4.95
MC3480	9.00
11C90	13.95
95H90	7.95
2513-001 UP	9.95
2513-002 LOW	9.95

VOLTAGE REGULATORS

7805T	.75	7905T	.85
7808T	.75	7908T	.85
7812T	.75	7912T	.85
7815T	.75	7915T	.85
7824T	.75	7924T	.85
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79
78H05K	9.95	LM323K	4.95
78H12K	9.95	UA78S40	1.95

T = TO-220   K = TO-3
L = TO-92

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MM5369	3.95
MM5375	4.95
MM58167	8.95
MM58174	11.95
MSM5832	6.95

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ICL7103	9.50
ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	3.95
ICM7207A	5.59
ICM7208	15.95

9000

9316	1.00
9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
96S02	1.95

EXAR

XR 2206	3.75
XR 2207	3.75
XR 2208	3.75
XR 2211	5.25
XR 2240	3.25

DATA ACQUISITION

ADC0800	15.55	DAC0808	2.95
ADC0804	3.49	DAC1020	8.25
ADC0809	4.49	DAC1022	5.95
ADC0817	9.95	MC1408L6	1.95
DAC0800	4.95	MC1408L8	2.95

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76489	8.95
AY3-8910	12.95
AY3-8912	12.95
MC3340	1.49

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CAPACITORS

TANTALUM

	6V	10V	15V	20V	25V	35V	50V
.22uf						.40	
.27						.40	
.33						.40	.45
.47				.35			.50
.68						.45	.50
1.0			.40	.40	.45	.45	
1.5				.45		.50	.60
1.8							.75
2.2		.35	.40	.45		.65	.85
2.7		.40	.45				.90
3.3		.45	.50	.55	.60	.65	.90
3.9		.45					
4.7	.45	.55		.60	.65	.85	.90
6.0			.60				
6.8			.70		.75		
8.2							1.00
10	.55	.65	.80	.85	.90	1.00	
12	.65		.85	.90			
15	.75	.85	.90				
18			1.25				
22		1.00	1.35				
27			2.25				
39		1.50					
47	1.35						
56	1.75						
100		3.25					
270	3.75						

DISC

10pf	50V	.05	470	50V	.05
22	50V	.05	560	50V	.05
25	50V	.05	680	50V	.05
27	50V	.05	820	50V	.05
33	50V	.05	.001uf	50V	.05
47	50V	.05	.0015	50V	.05
56	50V	.05	.0022	50V	.05
68	50V	.05	.005	50V	.05
82	50V	.05	.01	50V	.07
100	50V	.05	.02	50V	.07
220	50V	.05	.05	50V	.07
330	50V	.05	.1	12V	.10
			.1	50V	.12

MONOLITHIC

.1uf-mono	50V	.18	.47uf-mono	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
.47uf	50V	.14	1uf	50V	.14
1	25V	.14	4.7	16V	.14
2.2	35V	.15	10	16V	.14
4.7	50V	.15	10	50V	.16
10	50V	.15	22	16V	.14
47	35V	.18	47	50V	.20
100	16V	.18	100	15V	.20
220	35V	.20	100	35V	.25
470	25V	.30	150	25V	.25
2200	16V	.60	220	25V	.30
			330	16V	.40
			500	16V	.42
			1000	16V	.60
			1500	16V	.70
			6000	16V	.85

COMPUTER GRADE

26,000uf	30V	3.95

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FR-4 Epoxy Glass Laminate
With Gold-Plated Contact Fingers

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2N2218A	.50	2N3906	.10
2N2219	.50	2N4122	.25
2N2219A	.50	2N4123	.25
2N2222	.25	2N4249	.25
PN2222	.10	2N4304	.75
MPS2369	.25	2N4401	.25
2N2484	.25	2N4402	.25
2N2905	.50	2N4403	.25
2N2907	.25	2N4857	1.00
PN2907	.125	PN4916	.25
2N3055	.79	2N5086	.25
3055T	.69	PN5129	.25
2N3393	.30	PN5139	.25
2N3414	.25	2N5209	.25
2N3563	.40	2N6028	.35
2N3565	.40	2N6043	1.75
PN3565	.25	2N6045	1.75
MPS3638	.25	MPS-A05	.25
MPS3640	.25	MPS-A06	.25
PN3643	.25	MPS-A55	.25
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16 pin ST	.17	.08
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
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14 pin WW	.69	.52
16 pin WW	.49	.49
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW = WIREWRAP		
16 pin ZIF	6.75	call
24 pin ZIF	9.95	call
28 pin ZIF	10.95	call
ZIF = TEXTOOL (Zero Insertion Force)		

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6, 9, 12 VDC selectable with universal adapter 8.95

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SIEMENS

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PERTEC

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CABINET #1 $29.95

- DIMENSIONS 8⅝ x 5 15/16 x 3 15/16"
- COLOR MATCHES APPLE
- FITS STANDARD 5¼" DRIVES, INCL. SHUGART
- INCLUDES MOUNTING HARDWARE AND FEET

CABINET #2 $79.00

- COMPLETE WITH POWER SUPPLY, SWITCH, LINE CORD, FUSE & STANDARD POWER CONNECTOR
- DIMENSIONS: 11½ x 5¾ x 3 15/16"
- +5V @ 1 AMP, +12V @ 1.5 AMP
- FITS STANDARD 5¼" DRIVES
- PLEASE **SPECIFY** GRAY OR TAN

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SA400 $189.95

- 35 TRACKS
- REPEAT OF A SELLOUT
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- MODIFY FOR USE IN APPLE (EXPERIENCED TECHNICIANS)
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2114 450NS (TMS4045)	8/9.95	100 FOR .99 ea.
2114 250NS (TMS4045)	8/10.95	100 FOR 1.99 ea.
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MOUNTED ON PC BOARD
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+5 VOLT 4 AMP
±12 VOLT 1 AMP

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44 pin WW	4.95
72 pin ST	6.95
72 pin WW	7.95

RIBBON CABLE

CONTACTS	SINGLE COLOR		COLOR CODED	
	1'	10'	1'	10'
10	.50	4.40	.83	7.30
20	.65	5.70	1.25	11.00
26	.75	6.60	1.32	11.60
34	.98	8.60	1.65	14.50
40	1.32	11.60	1.92	16.80
50	1.38	12.10	2.50	22.00

D-SUBMINIATURE

DESCRIPTION	SOLDER		RIGHT ANGLE SOLDER		RIBBON CABLE		HOODS	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	BLACK	GREY
ORDER BY	DBxxP	DBxxS	DBxxPR	DBxxSR	IDBxxP	IDBxxS	HOOD-B	HOOD
CONTACTS 9	2.08	2.66	1.65	2.18	3.37	3.69	—	1.60
15	2.69	3.63	2.20	3.03	4.70	5.13	—	1.60
25	2.50	3.25	3.00	4.42	6.23	6.84	1.25	1.25
37	4.80	7.11	4.83	6.19	9.22	10.08	—	2.95
50	6.06	9.24	—	—	—	—	—	3.50

For order instructions see "IDC Connectors" below.

IDC CONNECTORS

DESCRIPTION	SOLDER HEADER	RIGHT ANGLE SOLDER HEADER	WW HEADER	RIGHT ANGLE WW HEADER	RIBBON HEADER SOCKET	RIBBON HEADER	RIBBON EDGE CARD
ORDER BY	IDHxxS	IDHxxSR	IDHxxW	IDHxxWR	IDSxx	IDMxx	IDExx
CONTACTS 10	.82	.85	1.86	2.05	1.15	—	2.25
20	1.29	1.35	2.98	3.28	1.86	5.50	2.36
26	1.68	1.76	3.84	4.22	2.43	6.25	2.65
34	2.20	2.31	4.50	4.45	3.15	7.00	3.25
40	2.58	2.72	5.28	4.80	3.73	7.50	3.80
50	3.24	3.39	6.63	7.30	4.65	8.50	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "xx" of the "order by" part number listed. **Example:** A 10 pin right angle solder style header would be IDH10SR.

Circle 208 on inquiry card.

SPRING APPLE SALE!

FD-35 DISK DRIVE

By MA Systems

- ★ Direct **Replacement** for **Apple Disk II**
- ★ Compatible with Apple Controller or other Apple compatible controllers
- ★ Specially designed electronics with **low power consumption**
- ★ DOS 3.3 and 3.2 compatible
- ★ Owner's Manual and Warranty Card included
- ★ 90-day Warranty

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From the Keyboard Co.

- ★ Brand New Rev. 7 keyboard — NOT an imitation
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- ★ +5V @ 5A, +12V @ 3A, -5V @ .5A, -12V @ .5A
- ★ Shielded enclosure: 10¾" x 3½" x 2³⁄₁₆"

VIEWMAX 80

A **Full Function** 80 column card for Apple II*

2 YEAR WARRANTY

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NEW IMPROVED JDR COOLING FAN

FOR YOUR APPLE II

- ★ Easy modification — no modification of Apple required
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- ★ Centronics Standard Parallel Interface for Apple II
- ★ Simple to use — Yet supports custom driver applications from ROM or Disk
- ★ Includes card, cable and user's manual
- ★ 1 Year Warranty

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- ★ Connects virtually any RS-232 serial device
- ★ 6 switch selectable drivers:
  - - 4 printer drivers
  - - Terminal Driver — 40 or 80 driver
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- ★ 1 Year Warranty

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- ★ 50% faster than EPSON
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ML-83A	$\$699^{95}$
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- ★ Highest quality card features: gold edge connector, sockets for all IC's

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Circle 209 on inquiry card.

Unclassified Ads

NEEDED: Would greatly appreciate any unprotected science, math, engineering, or utility programs for use by a blind student studying engineering with an Apple II Plus and an Echo II voice synthesizer who cannot use protected software. Also, would like to correspond with anyone knowledgeable about synthesizers, unprotecting software, and/or altering programs to work with voice. Willing to pay for altered programs that work. Lawrence Silvermintz, 148 Waverly Ave., East Rockaway, NY 11518, (516) 887-2638.

WANTED: An Apple II Plus club is forming in Sarajevo, Yugoslavia, city of the XIV Winter Olympic games. All donations in software and optional hardware will be greatly welcomed. In return will send Olympic games memorabilia. A. Salihbegovic, Mlade Bosne 1C, 71210 Ilidza, Yugoslavia.

WANTED: Church youth group needs computers, printers, monitors, or firmware cards for education program; particularly Apple-compatible equipment. All donations are tax deductible. Mike Yard, Westchester Christian Church, 8740 La Tijera Blvd., Los Angeles, CA 90045, (213) 645-4344.

WANTED: Christian organization seeks TRS-80 Model III as donation. Gifts are completely tax deductible. Rev. Wallace Schulz, RR#5, Box 65, Pacific, MO 63069, (314) 257-4444.

WANTED: A progressive high school needs small personal computers (Apple, Commodore, Franklin, IBM, etc.) for teaching literacy and programming. Your donations are fully tax deductible. Wm Martin, Department of Math and Science, Naples Academy, Naples, FL 33999, (813) 455-1087.

WANTED: A nonprofit public TV station is seeking tax-deductible donations of computer systems, modems, terminals, and Datapoint-compatible peripherals. Certified receipts will be furnished. KBDI-TV 12, POB 427, Broomfield, CO 80020, or ask for Jane or Paul at (303) 469-5234.

ATTENTION: System operators, bulletin-board owners, and modem users: I am compiling a list of nationwide public bulletin-board and time-sharing systems as a research project that will be published later this year. To have your favorite systems listed, send all updated lists and descriptions. (Sysops and owners: include details about your hardware, software, operating system, and hours, etc.) Thomas Baird, 6592 South Steele, Littleton, CO 80121, (303) 795-7363.

WANTED: Young, creative individual. Must be a mathematician, computer specialist, and a logical systems analyst. Familiarity with all aspects of ring theory and advanced theory of logic. Willing to spend two to three years in original analysis in a three-way partnership to develop new, diagnostic programs that learn by experience. Algebraic aspect has been partially developed by a former research mathematician and businessman. E.D. Goodrich, 1744 Lamont NW, Washington, DC 20010.

WANTED: Anyone interested in contributing or subscribing to a new newsletter. Languages, devoted to the improvement of existing microcomputer languages and the development of better ones. The first issue should be published soon, depending on the response received. Send a SASE. Ronnie Hunter, Harrington Hall, Saint Thomas University, POB 77, Fredericton, New Brunswick, E3B 5G3 Canada.

WANTED: A Timex-Sinclair users group is forming in the Cincinnati, Ohio, area. Anyone interested, please call Richard Johnson: (513) 825-1449.

WANTED: Information for a new users group forming for the Commodore VIC-20. Tips, programming, articles, etc. all welcome. J.M. Mott Jr., 800 Lea Crest, Memphis, TN 38109.

WANTED: Information concerning LITTON ABS Model 30 Printer. Need circuit diagram, service manual, data rate, etc. I am trying to interface it with a Sinclair ZX81. Wayne Finger, POB 16422, Jacksonville, FL 32245.

FOR SALE: 48K Apple II Plus, Apple Silentype printer with controller, and M & R fan. Manuals included: $1000. Jerry Kozak, 55 Van Siclen Ave., Brooklyn, NY 11207, (212) 227-3251 before noon.

FOR SALE: NSC800 evaluation board. Won in contest, never used. New $495, sell $250. Jim Peter, 16012 Falls Rd., Sparks, MD 21152, (301) 771-4062.

FOR SALE: Heath H-19 with anti-glare white screen. Fully assembled, in excellent condition, all manuals included: $500. William E. Severance Jr., Center Lovell, ME 04016, (207) 925-1515.

FOR SALE: TRS-80 Model II, CP/M software, and some hardware, unused. Upgrading my systems. Send SASE for list. Rob Lee, 25 Amaryllis Ave., Waterbury, CT 06710.

FOR SALE: TRS-80 software: nearly 50% off on original cassette tapes for TRS-80 Models I and III. These are all new originals mostly of arcade-type games, also some utilities and educational programs. Will consider trading. Send a SASE for a free list. Dr. Michael W. Ecker, Luzerne 8, Viewmont Village, Scranton, PA 18508.

FOR SALE: TRS-80 Model I, Level 2, all original equipment with keypad and lowercase driver. 48K system with expansion interface, Vista V-80 40-track disk drive, NEC PC-8023-AC printer with 8.5 by 11-inch tractor-feed paper (about 1500 forms). Excellent software library includes BIG 5, Scripsit, Deathmaze, and others; $1625 or best offer; shipping included, cashier's check or cleared bank check. Karl Ryan, 16408 Mount Ararat Cr., Fountain Valley, CA 92708, (916) 752-4744.

FOR SALE: Atari 400 personal computer with 32K of memory, BASIC cartridge, 11 games and programs on cassette. Almost new, $350 firm. Also, 21 games on cassette for Atari computers: $10 each. Rick Bloom, 100 Dehaven Dr., Yonkers, NY 10703, (212) 986-9666 between 9 and 5.

FOR SALE: SSB 6809 microcomputer with OS9, 32K, DCB 4A, dual 8-inch disks, four serial and two parallel ports. Software includes OS9 Level 1, Basiconine, ASMX, editor, super debugger. A little over a year old, $4200 retail value; $3000 or best offer. Harry Fair, 1952 South Holland, Lakewood, CO 80227, (303) 773-1313 or 985-7419.

FOR SALE: Altair 8800 with 48K, Pro Tech VDM board, video modulator, one serial and four parallel ports, North Star disk and controller, keyboard, PR-40 printer, 4K and 8K cassette BASIC, North Star BASIC, FORTH, Allen Ashley Macro Assembler, all manuals, extra 4K board, cassette interface, and hardware: $1200 plus shipping. Damian Bonicatto, 13401 Morgan Ave. S #108, Burnsville, MN 55337, (612) 894-2794.

FOR SALE: Televideo Model 950 video terminal and Teletype Model 43/20 with tractor-feed attachment. Both in mint condition: $750 each. Ricki B. Rovner, 944 Robin Rd., West Amherst, NY 14228, (716) 688-8974.

WANTED: Used Sorcerer S-100 expansion unit or Exidy S-100 interface card. Yvon Mayo, 930 Pembridge Cr., Kingston, Ontario K7M 6C5, Canada, (613) 384-3081 evenings.

WANTED: College student needs surplus, used, or damaged computers, parts, or other related equipment. I will pay shipping for reasonably priced equipment. Scott R. Gagnan, Box 2232, APO, NY 09130.

FOR SALE: Used printed circuit boards from an IBM computer system, 20 to 30 components per board (transistors, resistors, diodes, etc.); minimum 20 boards, 10¢ per board. Check or money order. Stephen Grot, RD #1, Chadds Ford, PA 19317.

WANTED: Data (articles, books, etc.) relating to floppy-disk directories and disk layout to recreate a blown disk. Interest is in personal computers, word processors, etc. Bill Ott, ADC, 14272 Chambers Rd., Tustin, CA 92680, (714) 731-9000.

FOR SALE: Brand new Microdasys System 2 kit: 6-slot S-100 with enclosure, 64-key keyboard, processor board with both 6802 and 6809, VB1B video board, 32K (8K populated) 2114-RAM board, power supply, BASIC, assembler, disassembler, and games. Still in box, was $729. Asking $350, best offer, or swap for AIM65. Used Dynatyper IBM Selectric interface for TRS-80 Model I with software: $220 or best offer. I'll pay shipping. Joseph Lo, 9215 Benchley, Houston, TX 77099, (713) 495-4359.

WANTED: Existing package to convert civil calendar dates to their equivalent Jewish calendar dates. Harry Edwards, POB 403, West Hartford, CT 06107.

FOR SALE: Commodore PET 4032 with graphic keyboard, 3.0 and 4.0 BASIC, 40-40 dual-disk drive unit, and two cassette drives. Software and other accessories available. Bruce Loe, 322 South Bonner, Hope, AR 71801, (800) 643-1577 ext. 126 days and (501) 777-5080 evenings and weekends.

WANTED: Motorola user manual and documentation for MEK 6802 D3, MEK 68MM32, MEK 68RR, MEK 6810. Scott Tillman, 4910 West Mossman Rd., Tucson, AZ 85746.

FOR SALE OR TRADE: New Osborne 1 with all software and manuals. Will consider Apple II or Commodore including VIC-20 or 64. R. C. Nicklin, Physics Dept., Appalachian State Univ., Boone, NC 28608, (704) 262-3091 or 264-2921.

WANTED: I have a growing and diverse collection of programs for the TRS-80 Model I, Level II. Am interested in swapping or trading games, utilities, and home programs. Send listing of your programs along with name and address. Clifford Albury, 6252 North Lee St. #41, Morrow, GA 30260.

FOR SALE: Texas Instruments editor/assembler for the TI 99/4A home computer on 5¼-inch disk with 470-page manual and Tombstone City on 5¼-inch disk with the Command Module cartridge. Never used, best offer over $85. Wm del Solar, (212) 797-7239 weekdays 1-4 p.m. ET.

FOR SALE: H-11A 128K total; one parallel and two serial ports, LTC, KEV11, H-27 controller, boxes of documentation, extra backplane, wire-wrap cards, and software: $2500 or best offer. Warren Burwell, 1171 Boylston St. #33, Boston, MA 02116, (617) 266-4822.

WANTED: Netronics Explorer-85 Level A terminal and Fasterm-64 terminal or the special Microsoft BASIC pak. Robert W. Schu, 8304 West Summerdale Ave., Chicago, IL 60656, (312) 631-5286.

FOR SALE OR TRADE: F-10 Star Writer, 40 cps, letter-quality printer, with optional tractor-feed. Can support either parallel or serial interface. Owned almost a year, hardly used, perfect condition. $1100 (50% off list price). Lionel Geltman, 63 Radtke Rd., Randolph, NJ 07869, (201) 328-0719 after 7 p.m.

WANTED: Owner of new Epson HX-20 computer would like to correspond and exchange programs and ideas with other Epson owners. James Phillips Jr., 14226 Woodland Ridge, Baton Rouge, LA 70816.

FOR SALE: Printer terminal with full keyboard and DEC writer 2 (LA-36) with RS-232C. Up to 14-inch-wide paper tractor feed: 110, 150, and 300 data rates. Upgradable to 1200 + bits per second. In mint condition with original user manual; a real workhorse. First offer over $1000 (plus shipping). Abbott Rhoades, POB 5551, Santa Monica, CA 90405.

WANTED: Used Apple II Plus computer. Advise on age, condition, accessories (if any), and price. M. Ajmani, 2355 Corona Court., Berkeley, CA 94708, (415) 548-2228.

FOR SALE: IMSAI 8080 microcomputer with 40K-byte high-speed RAM (4MHz), and one parallel and two serial I/O ports: $800. Micropolis 1053 Model II dual floppy-disk drives with controller: $800. Hazeltine 1500 display terminal: $600. Mint condition, willing to sell separately. Dale Pischke, 2914 Rising Star Dr., Diamond Bar, CA 91765, (714) 598-9401.

WANTED: Quest Super ELF owners to form an "ELFnet" and exchange ideas and experiences by mail. I have a Super ELF Version 4.0 with 32K dynamic memory, 256 by 192 Super Color Graphics board, serial and parallel I/O, Quest Super Monitor V2.1, and Super BASIC V5.0. I am eager to hear from people who run this version of BASIC, or later. ELFnet, Bob Margolis, 11357 Columbia Pike #D-6, Silver Spring, MD 20904.

FOR SALE: IMSAI 8080 computer with 10-slot S-100 bus, 64K dynabyte RAM, MPU-A 8080 processor board, ZPU Z80 processor board, Z16, SMB, SIO, MIO, Godbout terminator: $900. R. Pollock, 2315 Lee Ave., Melbourne, FL 32901.

FOR SALE: Cromemco System III, 64K, two 8-inch disk drives, Tuart board: $1900. SOROC IQ 120 terminal: $200 with above. QUME Sprint 5 printer (cost $3400): $2000. All in excellent condition. Will ship UPS on receipt of certified check. J. Maley, 7625 Northwest McDonald Place, Corvallis, OR 97330.

WANTED: Time Zone player needs help through the mazes. Will assist through or purchase master solutions. Ben Bennett M.D., 2809 Plum Court, Kokomo, IN 46902.

WANTED: Schematic for TRS-80 Model 1 computer and expansion interface. Also, want inoperative Model 1 computers and equipment for parts. Send details and prices. Michael Ulik, #12 Mar Wey, St. Peter, MN 56082.

FOR SALE: Hewlett-Packard 85A desktop computer: includes 32K RAM, ROM drawer, Advanced Programming ROM, documentation programs, and cartridges. Excellent condition, about a year and a half old, reasonable offers only. R. H. Sekaly, Apt. 7-1179, Esquimalt Rd., Victoria, BC V9A 3N6, Canada, (604) 382-0978.

FOR SALE: Carrying cases for the TRS-80 Model I: one case holds the keyboard with a power plug and cassette; the other is for the TRS-80 video monitor: $50. Also, I would like a copy of the JPC TC 8 cassette. Ben Leff, 2134 Mountain Vista Dr., Encinitas, CA 92024, (619) 436-1990.

FOR SALE: Texas Instruments 810 RO dot-matrix printer, RS-232C serial interface, 150 cps, full options including vertical-forms control and compressed print. Factory maintained and in mint condition. Asking $900 or best offer. John Mulligan, POB 3461, Van Nuys, CA 91407, (213) 486-2304.

WANTED: Apple II programs to swap: games, home, and business. Send tape or disk with your name and address. Also looking for people interested in corresponding. Gil Nedjari, Via Mauro Rota, 8 Milan, Italy, Tel. 02/6880387; Telex 333504 KIN MI'I.

FOR TRADE: I would like to swap TRS-80 Models I and III games or utilities. Send a cassette with some of your programs, and I will return it with the best of mine. Gary Harper, POB 371, Fuquay-Varina, NC 27526.

FOR SALE: Complete microprocessor training computer, Heathkit ET3400, ETA3400 with 4K RAM plus H-9 video terminal: $500. Pick-up only. John Siegel, 181 Columbia Ave., North Plainfield, NJ 07060, (201) 753-6507.

WANTED: Processor Tech software and/or documentation for use on SOL-20 computer. Also, software and/or documentation for Explorer-85 which uses Exatron Stringy Floppy. Will buy or trade. F. Iorio, 22 Midship Lane, Patchogue, NY 11772, (516) 758-6625 evenings.

UNCLASSIFIED POLICY: Readers who have computer equipment to buy, sell, or trade or who are requesting or giving advice may send a notice to BYTE for inclusion in the Unclassified Ads section. To be considered for publication, an advertisement must be non-commercial (individuals or bona fide computer clubs only), typed double-spaced on plain white paper, contain 75 words or fewer, and include complete name and address. This service is free of charge; notices are printed once only as space permits. Your confirmation of placement is appearance in an issue of BYTE as we engage in no correspondence. Please allow at least three months for your ad to appear. Send your notices to Unclassified Ads, BYTE/McGraw-Hill, POB 372, Hancock, NH 03449.

Unclassified Ads

FOR SALE: H-89 with 48K, disk drive, anti-glare screen, HDOS, and HUG subscription. Hardly used: $1400. Heath H-14 printer, never used: $350. Steve Ha, 10855 Meadowglen #710, Houston, TX 77042, (713) 977-6539.

FOR SALE: SSB68b09 system in excellent condition, 56K, DCB4aFDC, two DSDD(760K) drives, 2S/2P I/O, clock, OS9L1 multitasking, MWBASIC09, ED, ASM, Debug, Screeneditor, and Database software. H-19 terminal with utilities. Complete system less printer: $3800. Doug Ramers, 245 Cambridge Rd. Camden, DE 19934, (302) 674-6386 or 697-3444.

FOR SALE: TRS-80 16K Level 2. Includes all original equipment, lots of books and software, three editor-assemblers, and eight instruction cassettes. Joe Smith, 296 Spanish Dr., Las Vegas, NV 89110.

FOR SALE OR TRADE: Tektronix 4013 graphics terminal, RS-232C, hi-res green storage display, with maintenance and user manuals. Scope communicates but will not display characters — can be repaired by Tektronix or fix yourself. Price new, over $7800; asking $995 or agreeable trade. Send SASE for copy of description from catalog. If I fix it before it's sold, the price will increase. Brent Carter, 3906 Sedgegrove Rd., Greensboro, NC 27407, (919) 854-2764.

FOR SALE: BYTE issues #1,#5, and #7. Mint condition, make an offer. Robert A. Martin, 32 Orlea St., Westville, IL 61883, (217) 267-2484 after 5 p.m.

FOR SALE: Sorcerer 48K Model II, Amdex 12-inch monitor, Exidy floppy-disk subsystem, two Exidy floppy-disk add-on units, C. Itoh dot-matrix printer, C. Itoh daisy-wheel printer, and CPM 2.2. In original boxes, never used. All for $3000 or best offer, R. L. Mouser, Trinity University, 715 Stadium Drive, Box 2079, San Antonio, TX 78212, (512) 828-0583 or 546-7111.

FOR SALE: AIM-65 Memory-Mate expansion board by Forethought Products 16K, new, still in box. Complete with manual: $250. R. C. Estler, 1825 Florida Rd., Durango, CO 81301, (303) 247-1963 after 7 p.m.

FOR SALE: ExpandaPET memory-expansion board with installation instructions. Adds 24K to Commodore PET or CBM computers: $140. John Wilcox, 10051 Boyce Rd., Chelsea, MI 48118, (313) 475-1224.

FOR SALE: Two MITS/Altair 8800b systems. System #1 with 64K, 3 disks and controller, Lear-Seigler ADM3A, QUME Sprint 3/35 and interface, Auto-start, DOS, and BASIC: $3750. System #2 with 32K, cassette interface, BASIC in ROM, QUME interface, 2-SIO serial card, Lear-Seigler ADM3: $2750. Also, 16K 2716 PROM card, 8K Program Saver PROM programmer card, and diagnostic card. Claude Hill, 820 Redwood Dr., Nashville, TN 37220, (615) 331-4743 evenings and weekends.

FOR SALE: Back issues of BYTE in good condition beginning with #1: 9/75 to 5/76 and 12/76 to 3/77. Asking $5 per issue. Prefer to sell all issues at once. Robert Erickson, 1426 Boulevard Ave., Havre, MT 59501.

WANTED: Does anyone know of a company that sells disk controller boards for the TRS-80 Model III? Also, controllers that will handle 8-inch disks (and/or hard drives). Need information on what RAM location DOS (LDOS, NEWDOS, TRSDOS, etc.) loads. Scott Hamilton, 225 Grandview St., Bennington, VT 05201, (802) 447-7994.

FOR SALE: Altair 8800b, 32K RAM, two active parallel ports, SSM video card, and Selectric terminal with special parallel interface; all with complete schematics. Also, modified 12-inch black-and-white TV, keyboard, and two 5¼-inch floppy-disk drives. Disk software includes DOS, extended BASIC, user-developed word processing, and disk read/write in hexadecimal or text, disk editing, and others. All original documentation plus program instruction for $3500. Earl Sanders, 519 Oxford Court, Orlando, FL 32803, (305) 894-4917.

FOR SALE: BYTE: 9/76 to present. Microcomputing 2/80 to present. 73 Magazine: 5/79 to 4/82. Also, Motorola Micor X83RTA3404AA 110W hi-band with preamp, wide-spaced exciter and receiver, all accessories, Multi-PL control head, and six reeds. Main receiver: 142-105.8, 2nd receiver: 150.8-162, exciters: 140-155, and three channel elements: T143.9, T148.15, and R148.15. Good working condition, but sold as is. Manual available. Make an offer. K. Varley, 1740 Chew St., Allentown, PA 18104, (215) 433-8696.

FOR SALE: DEC VT-132 with RS-232 printer-port option. Excellent condition: $1500. Mitch Che, Suite 201, 5221 Central Ave., Richmond, CA 94804, (415) 527-9876.

FOR SALE: Motorola display XM701-10A in good shape with an F8 processor board. The board could be easily repaired. Display and board contained in a video-game cabinet. You pay shipping. First $250 takes. Also, TRS-80 Model 1 disk-editor, assembler, Macro-80, Edit-80, Link-80, Cref-80, and FORTRAN library: $50. Barry Nicholson, Rt. 1, Box 78, Ingalls, KS 67853

FOR SALE: Extended BASIC TRS-80 Color Computer 32K (64K with modification) with disk drive, two disks (one with homebrew utilities), dust covers, disk-storage box, and cassette cable: $900. Also, Joysticks: $15, Space Assault: $20, Skiing: $20, Chess: $30, Editor/Assembler: $35, and printer cable: $4. About a year and a half old, in new condition, with original boxes and manuals. N. T. Schneck, 221 Fancher Ave., Buffalo, NY 14223, (716) 835-9075.

FOR SALE: Microsoft BASIC in ROM: four 2716s for Netronics Explorer-85 computer. All documentation included; only a few months old. Paid $99, asking $45; check or money order. I will pay postage. Ken Hoffman, 2112 110th Lane NW, Coon Rapids, MN 55433, (612) 451-5600 days and 757-3404 evenings.

FOR SALE: S-100 boards: Polymorphic video interface with graphics, 128 by 48: $50, modified TV monitor: $30, Tarbell cassette interface: $45, cassette recorder: $15, SSM 8K static RAM: $65, Godbout 8K static RAM: $65, Vector Graphic PROM/RAM: $25, IMSAI 4K static RAM (less RAMs): $20. Documentation included. Dan Golowka, (213) 705-6631 evenings.

FOR SALE: Heath H-8, serial I/O, cassette interface, 32K RAM, 3-port parallel board, disk controller and drive, H-9 terminal, complete software package, cassette and DOS. Asking $1100. G. Arseneau, 19 Zwicks Farm Rd., Plantsville, CT 06479, (203) 621-4109 after 5 p.m.

FOR SALE: The following back issues of BYTE: July, September, October, November, and December of 1976; all but August of 1977; all of 1978; and January through June and December of 1979. In excellent condition, will sell all or part. Best offer plus shipping. Ronnie Powell, 2306 South 126 E Ave., Tulsa, OK 74129.

WANTED: BIOS to run CP/M on Spacebyte processor. J. Weldon Bellville, 926 Malcolm Ave., Los Angeles, CA 90024.

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BYTE's Ongoing Monitor Box

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March BOMB Winners

"Build the ECM-103, an Originate/Answer Modem" by Steve Ciarcia is the first-place winner in the March BOMB contest. He'll receive the $100 kitty. Second place and the $50 award goes to Tom Moran for his article "New Developments in Floppy Disks." Larry Sarisky earned third place for his discussion of improved data-storage technologies in "Will Removable Hard Disks Replace the Floppy?"

Correspondence

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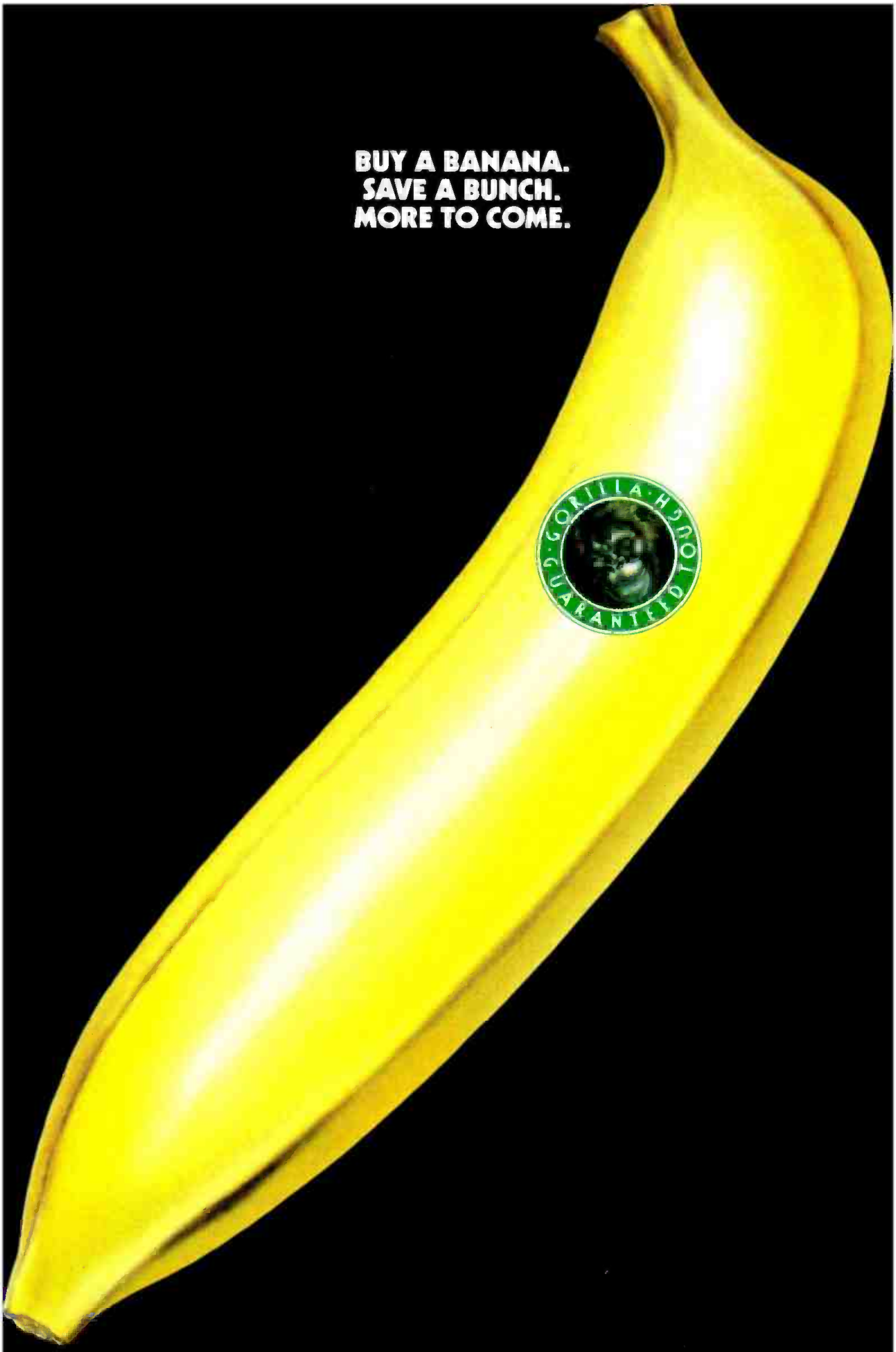

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