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# BYTE

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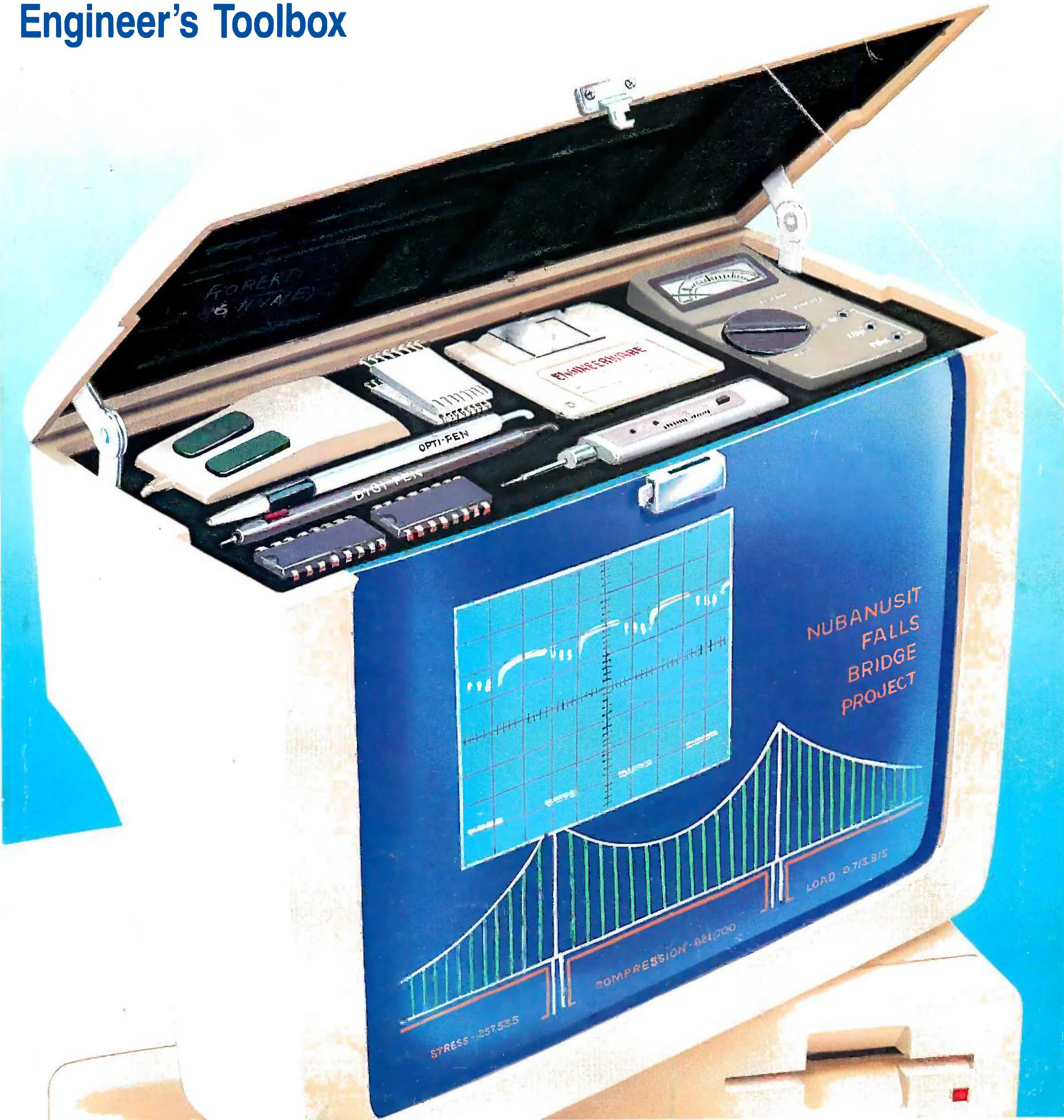
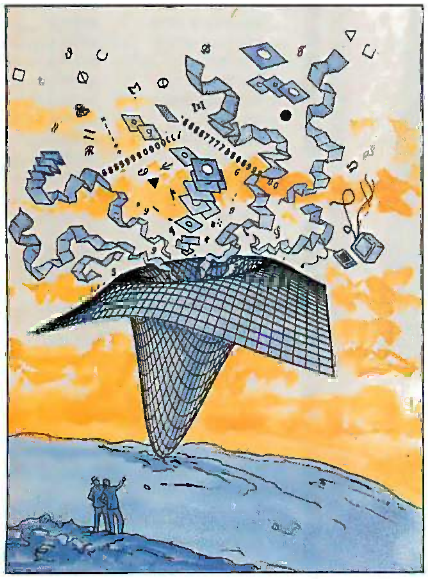
## Engineer's Toolbox



# C·O·N·T·E·N·T·S



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## FEATURES



## THEME: ENGINEER'S TOOLBOX



## REVIEWS




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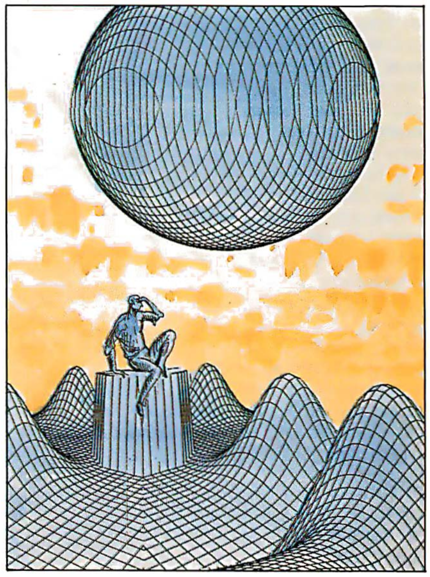

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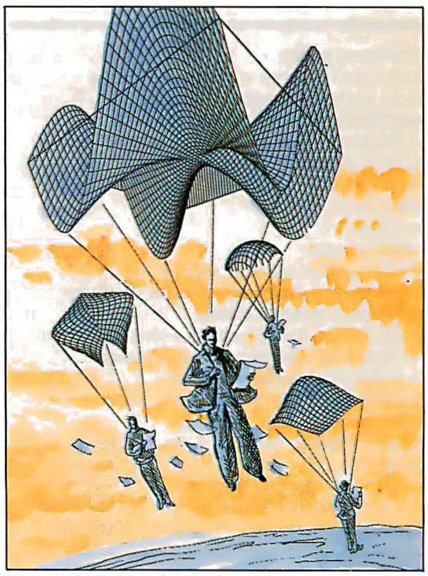
## KERNEL





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## BEST OF BIX



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SECTION ART BY ELLIOTT BANFIELD

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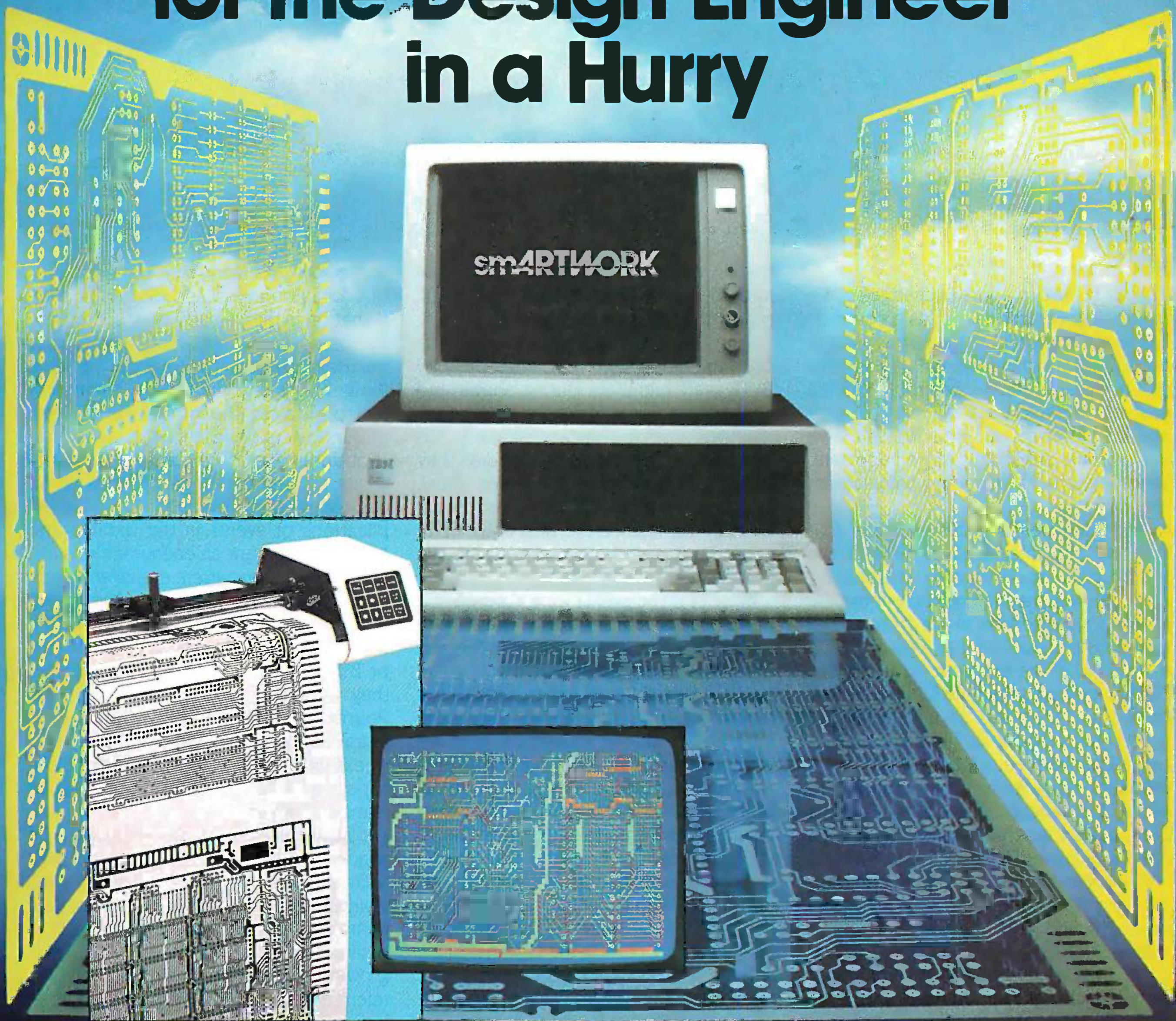


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## BIX UPDATE

The BYTE Information Exchange—BIX—is entering its ninth month as a commercial venture. After more than a year of testing software and hardware, BIX was born as a business on November 1, 1985. In the ensuing months, we have learned a lot about what works and what doesn't work in electronic publishing. More important, we have learned a lot about what you want and don't want.

One thing we have discovered is that you are very interested in news of the microcomputing community. As an experiment, we took the idea behind our monthly Microbytes section in the front of the magazine and applied it as a daily on-line news service. The first item in Microbytes Daily appeared, with little fanfare, on BIX on January 17. It was an instant hit and quickly became one of the busiest areas on BIX. Since then, we have added hundreds of news items from around the world. Incidentally, Microbytes Daily is also available through McGraw-Hill's X•PRESS cable TV service.

This effort is coordinated by Glenn Hartwig and Dennis Barker here in Peterborough, who work regularly with BYTE staffers Rich Malloy in New York City and Ezra Shapiro, Phillip Robinson, and Brenda McLaughlin in the Bay Area. They also work with correspondents David Needle in the Bay Area and Lynne Nadeau in New England and contributing editors Dick Pountain in London and William M. Raike in Tokyo.

At crunch times, other members of the BYTE staff pitch in to be sure we get good coverage of important events. Primarily, this means trade shows and conferences, but they also play key roles at other times. For example, in mid-May Bob Pariseau posted a "first contribution as a 'civilian'" on BIX late one Wednesday afternoon. He had, Pariseau said, been laid off from his job as Commodore-Amiga's vice president of software development. BYTE Senior Editor Gregg Williams quickly got on the phone to one of his contacts, Commodore-Amiga General Manager Jay Miner, and was able to confirm that some Amiga software people had been laid off. A short confirming note was placed in the Amiga conference that afternoon, and the information gathered was passed on to the Microbytes Daily staff, who got a full report posted the next day.

Less flashy but just as important has been the help given Microbytes Daily by BYTE staff members during shows and conferences. Some of the first items to appear were from the MacWorld Expo in San Francisco. Other events reported as they happened were the Hannover Faire, Winter and Spring COMDEX, Microsoft's CD-ROM conference, the West Coast Computer Faire, and the National Computer Conference.

Most of these events were covered in a more-or-less conventional way, with reporters filing stories about what *they* thought was important or interesting. We now are beginning to experiment with a new way of reporting shows—interactive coverage, to give us a chance to find out what *you* think is important or interesting.

Larry King, Dr. Ruth, and a horde of other talk-show hosts have been practicing interactive entertainment, if not news, for years. Television has flirted with interactive pseudonews through 900-number call-in voting—"Who is right in the *Tonight Show* flap: Johnny or Joan?"; "Did President Reagan act properly in the Libyan crisis?"; and so on. In some instances, viewers have been able to phone in questions to interview shows. But interactive coverage of news is a new concept. There has been little real interaction between reporter and reader.

We are changing this. Before the National Computer Conference began last month, we established a special area on BIX where members could leave requests for us to collect information *they* were interested in at the show. Our people added these requests to the lists of information they were collecting and posted reports on-line, while the show was still going on.

We want to do more of this and are interested in your reactions and suggestions. You can send them to me on BIX (mail to gbond) or as paper mail to our Peterborough address (One Phoenix Mill Lane, Peterborough, NH 03458).

Your participation on BIX has shown us that you are interested in more than microcomputers. When the space shuttle *Challenger* exploded, many of you turned immediately to the Space conference on BIX for information and discussion. Participation in that already busy conference mushroomed and stayed high throughout the investigation of the tragedy. The same thing happened during the Chernobyl reactor disaster. The modest activity level of our Soviets conference spontaneously shot up as you sought a place to get information and exchange opinions about nuclear energy, Soviet policy, and the implications of events in the Ukraine and Moscow. We want to encourage this airing of opinion on current events and again welcome your suggestions and criticisms.

BIX is not all news, of course. It is the electronic component of BYTE, and many of BYTE's features appear there before they appear in print. Columnists Jerry Pournelle, Bruce Webster, and Ezra Shapiro all post their work on BIX several weeks before it is published in BYTE. An expanded What's New section is a regular feature of BIX. Many product reviews that get squeezed out of BYTE because of space limitations now appear on BIX. Technical information from the Amiga, Atari, IBM, and Macintosh conferences appears regularly here as the Best of BIX (it begins on page 393 of this issue). An ever-growing Listings area includes programs referred to in BYTE articles and a large collection of public domain software. But most important, BIX is the more than 180 conferences where you, our readers, share your information and opinions with each other.

*—George Bond*
*Executive Editor*

Joining BIX

You can join BIX literally within the next few minutes. More information about BIX—including detailed log-on instructions—is found on pages 378 and 379 of this issue. If you can't join now but are interested in BIX, circle number 450 on the reader service card.

If you have additional questions, write to BIX, One Phoenix Mill Lane, Peterborough, NH 03458, or call (603) 924-9281 from 8:30 a.m. to 4:30 p.m., weekdays, eastern time. We look forward to seeing you soon on BIX.


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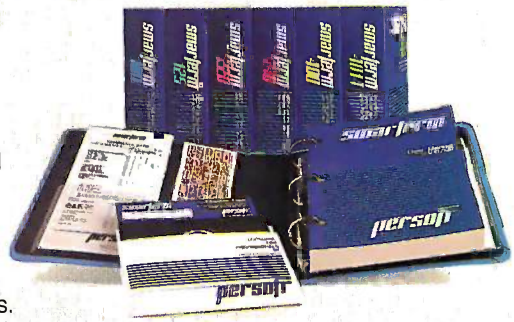
# Before you invest in a DEC* VT240 terminal, consider the software alternative.



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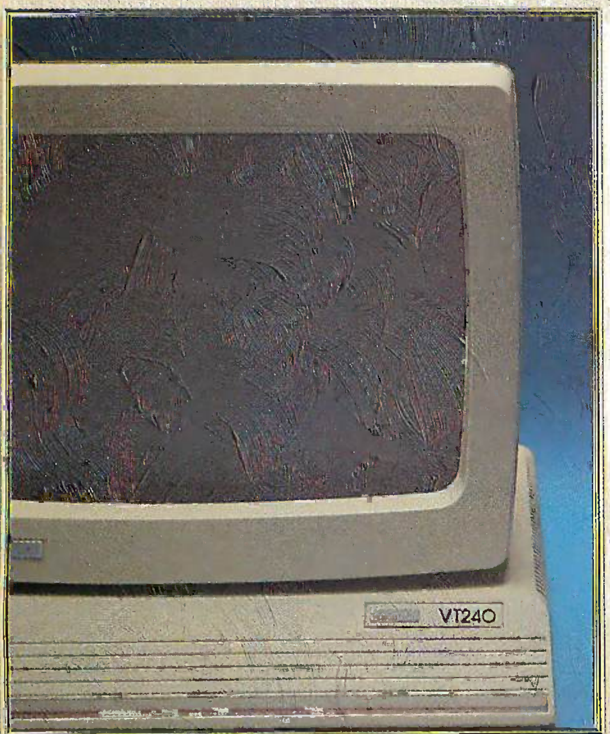



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# M·I·C·R·O·B·Y·T·E·S

Staff-written highlights of developments in technology and the microcomputer industry.

## Massively Parallel Machine Breaks BIPS Barrier

Thinking Machines Corp. (Cambridge, MA) has introduced commercially a massively parallel computer containing more than 65,000 individual processors. The company says its Connection Machine can handle vast quantities of data at speeds exceeding one billion instructions per second.

Each of the custom processors, which compute simultaneously, has its own memory. The company says that the processors function at the level of the data itself, and that the processors are linked by the machine into patterns matching the structure of the problem being solved. When a problem has more data elements than the machine has processors, the chips act as virtual processors. (Each chip has 4096 bits of memory.) Thinking Machines says its system can handle as many as 1 million virtual processors.

The Connection Machine housing looks like eight black cubes, four on the bottom and four on top (it stands about five feet tall). It comes in two configurations: The model that contains 65,536 processors is selling for $3 million; the model with 16,384 processors is $1 million.

Who's buying the BIPS machines? The Artificial Intelligence Laboratory at MIT, the Media Laboratory at MIT, the Department of Computer Science at Yale, Perkin-Elmer, and the U.S. government's Defense Advanced Research Project Agency.

As the debut of the Connection Machine indicates, performance capabilities are going up. Way up. Now, Culler Scientific Systems (Santa Barbara, California) says it's bringing the costs of such performance down to "less than $6000 per MIPS."

At the National Computer Graphics Association show, Culler demonstrated its Personal Supercomputer (PSC), reportedly capable of handling 18 million instructions per second. The machine costs $98,500 (although the price of a complete system would be higher because you need to hook the PSC to a workstation). At the NCGA convention, Culler had the PSC functioning as a compute server for a Sun workstation network.

## Zenith Develops Flat-Face CRT; Claims Tube Improves Resolution, Eliminates Glare

Zenith Electronics Corp. (Chicago) has developed a new cathode ray tube with a perfectly flat faceplate that the company says is glare-free and provides better resolution and better color fidelity than CRT units now in use. Zenith scientists discussed the "flat tension mask" (FTM) tube at the Society for Information Display's annual symposium, which was held in San Diego.

According to Zenith the ultrahigh-resolution FTM tube offers higher brightness and increased contrast ratio compared to conventional displays. Because the flat tube face doesn't reflect ambient light, unlike a convex face, it is free of glare and reflections, the company says.

Like a conventional color CRT, the FTM tube uses a shadow mask, a thin sheet of metal with thousands of perforations. This mask helps direct beams from the tube's electron gun to the screen, where they excite RGB phosphors and create the video image. In Zenith's FTM, the shadow mask is stretched flat and tense directly behind the tube's flat glass faceplate. Unlike the mask in typical CRT displays, the FTM mask doesn't move, even at high brightness levels that can cause discolored images ("doming") in conventional tubes. The square-cornered FTM display gives text and graphics a more natural look, a Zenith spokesperson said, "as if you were looking at a sheet of paper."

Zenith is initially selling a 14-inch hi-res version of the FTM unit to OEMs. Pilot production has begun, and shipments are expected to start next year.

## Ancient Greeks on CD-ROM Disks

Researchers at Brown University have undertaken the Homeric process of transferring approximately 250 megabytes of classical Greek literature to a single CD-ROM disk. The disk

*(continued)*

will also include approximately 150 megabytes of index. According to Paul Kahn, an applications specialist at the university, Greek scholars will soon be able to find, for example, every occurrence of a particular word in the work of an ancient author.

The text-retrieval system is being designed for the IBM RT PC, a RISC-based computer. The Greek text will be handled by the Interleaf document-processing system for the RT, which is being modified for the ancient Greek alphabet.

To facilitate access to the system, a terminal program is being written for the Macintosh computer. This program will allow the Mac to function as a terminal on the UNIX-based RT and to display the Greek text accurately.

The massive library of literature currently resides on nine-track tapes and is available from the University of California at Irvine. The collection reportedly includes all known works by 178 authors, from the time of Homer to approximately 600 A.D. The CD-ROM system is slated to be completed this summer.

## COMDEX Briefly: Sidecar, OS-9, Imaginet

Commodore (West Chester, PA), which had one of the most crowded booths at COMDEX/Spring in Atlanta, prominently displayed Sidecar, its IBM PC–compatibility add-on box for the Amiga. The new peripheral is about the size of a shoebox and attaches to the Amiga expansion bus. The unit reportedly contains an 8088 microprocessor running at the same speed as that of the IBM PC, a socket for an 8087, a single 5¼-inch floppy disk drive, and three IBM expansion slots. The emulator also contains 256K bytes of memory, which is expandable to 512K. Commodore said Sidecar would be available in the fall for a price that would be "substantially under $1000."

Microtrends (Schaumburg, IL) introduced versions of OS-9, a multiuser, multitasking operating system, for the Atari ST, the Macintosh, and the Amiga. Specified by Philips and Sony as the operating system for their CDI (Compact Disk Interactive) standard for CD players, OS-9 can provide multiuser capabilities, allowing several users to access one CD-ROM drive. The operating system, originally developed by Microware Systems for the Motorola 6809, is similar to UNIX but smaller and less complex.

BMB Compuscience Canada (Milton, Ontario) announced a network called Imaginet that connects IBM PCs with Atari 520STs. The network costs $900 for the first IBM PC, which functions as the file server, $800 for each additional PC, and $500 for each ST. Transmission rate is 2 megabits per second. The company said Imaginet will be available this month.

## NANOBYTES

Baseball fans at Philadelphia's Veterans Stadium this season can check out the graphics capabilities of **Commodore's** Amiga. The computer is linked to the 42-foot-wide Phanavision scoreboard. Images are being created with the computer, a video digitizer, a Kurta graphics tablet, and various software, including Aegis Animator, Aegis Images, and Electronic Arts' DeluxePaint. . . . Researchers at **Rensselaer Polytechnic Institute** (Troy, NY) are working with semiconductor materials from chemical compounds, including gallium arsenide, cadmium telluride, and mercury cadmium telluride. Potential applications: optical sensors and optical integrated curcuits. . . . **Steve Gibson**, developer of the Gibson Light Pen, has developed a RAM-resident program to smooth the display of PC- and MS-DOS data or text packages. According to Gibson, his $39 Flickerfree scrolls full screens, whereas the standard IBM PC BIOS makes programs account for individual line feeds when scrolling. You can phone Gibson at (714) 854-1520. . . . **Chips and Technologies** (Milpitas, CA) has a 10-MHz version of its PC AT CHIPSet; the speedier chips could mean AT work-alikes faster than the original. . . . **Stanford University** researchers are using a Macintosh and a 700-line BASIC program to simulate the fabrication of composite materials. Professor Alan Miller says he chose the Mac because its "graphics commands were very accessible." . . . **Applied Reasoning Corp.** (Cambridge, MA) reports it's working on a 16-MHz 80386 coprocessor board for the IBM PC and compatibles; availability depends on when Intel begins volume shipment of its chip. . . . State rankings compiled by the American Electronics Association show that **California** leads the nation in electronics employment with 598,000 workers. Another AEA study says that graduates with B.S. degrees will enter the working world with an average salary of $28,300. . . . **Symbolics Inc.** (Concord, MA) rolled out a machine the company says makes symbolic processing more accessible to mainstream users; the 3610AE delivery system ($31,500 in volume) executes software applications written on larger computers. . . . **Addison-Wesley** (San Francisco) has published *The Amiga Hardware Reference Manual* and *The Amiga Intuition Reference Manual*, reportedly available in bookstores selling technical texts. Addison-Wesley said two volumes about the Amiga ROM kernel will be in stores before you read this.

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## International Graphics Standards

We are becoming increasingly aware of the possibility that ISO TC97/SC21/WG2 may approve graphics standards which are conflicting, competing, and incompatible. It is our understanding that formal standards-development activities are intended to harmonize and stabilize both the technology and the marketplace. Competing alternative standards introduce additional conflict rather than cooperative solutions. We acknowledge that strict compatibility between standards is not always possible; nevertheless, it is vital that the results of our work be readily understandable and easily perceived as belonging to the same family. Different standards in the family produced by WG2 should fulfill clearly defined roles, providing an easy choice between different standards. This implies that, for example, at the same functional level, it should be easy to migrate users of computer graphics from systems of lower capabilities to systems of higher functionality, in particular from GKS (Graphical Kernel System) to PHIGS (Programmer's Hierarchical Interactive Graphics Standard).

Recent reporting in the trade press demonstrates conclusively that PHIGS is perceived as an alternative to GKS instead of being a functional outgrowth of it.

We therefore ask for your assistance and support in providing one family of graphics standards. We believe that with only minor technical changes, PHIGS could be presented as an evolutionary step forward for the family of graphics standards, in which GKS was the first to be adopted.

If PHIGS continues to develop and be perceived as an alternative to GKS, the spirit of international cooperation within ISO TC97/SC21/WG2 will be compromised. This will have an impact on other WG2 standards and could preclude the potential positive effect of genuine international enthusiasm and cooperation.

The adoption of GKS by ISO has resulted in significant worldwide investment. If an alternative, competing standard is approved, this will serve to compromise those investments as well as to damage the credibility of ISO within the international graphics vendor community. If no compatibility is achieved, this will also cause unnecessary additional costs.

We therefore urge that the progression of PHIGS within ANSI be frozen until international consensus is achieved. This would allow synchronization with the international processing. We assure you our cooperation in achieving this goal in the shortest time possible.

A. Ducrot
*French Representative to ISO TC97/SC21/WG2*
J. Encarnação
*Member of the DIN Steering Committee*
G. Enderle
*German Representative to WG2*
W. Herzner
*Austrian Representative to WG2*
J. Schönhut
*Convenor of ISO TC97/SC21/WG2*
P. ten Hagen
*Dutch Representative to WG2*

## Standardizing ANSI C

After reading Steve Hersee and Dan Knopoff's article "An ANSI Standard for the C Language" (March), I would like to offer my humble suggestions in light of the following observations:

1. C is already very standard, based on the K&R publication and the AT&T implementation, except for operating system differences, which are generally hidden in standard library procedures. This fact is evident in the limited scope of the ANSI proposal.
2. An attempt to "wrest C away from the developers and implementors" may be unfair to K&R and AT&T, since they gave us not only a standard language, but also a relatively standard operating system, UNIX.
3. Asking the apparently disparate group of "developers and implementors" of the X3J11 Committee to generate a language standard is like asking a group of feudal warlords to propose a common government.

Let's hope that the X3J11 Committee understands that standardization requires both a desire for uniformity as well as a commitment to underlying principle, giving the ANSI C proposal a better chance than ANSI FORTRAN.

G. A. Young
*Yardley, PA*

## Runge-Kutta Subroutine

Out of curiosity, I coded the machine epsilon routine as given by Benku Thomas ("The Runge-Kutta Methods," April) in two different languages on our Prime 750. I was especially careful to code them as close to identical as possible. Upon running them, I was surprised to find two different results. My PL/I version returned 1.192092E−07 and the FORTRAN-77, 7.105427E−14. It became clear that the difference was due to the use of floating-point hardware on the Prime. The PL/I result is $2^{-23}$. Since the mantissa for this data type is 23 bits wide, this is the proper result. (Purists would say $2^{-22}$ is the correct result, but factors of 2 are not guaranteed anyway.) The FORTRAN result is $2^{-47}$, corresponding to the width of a double-precision (REAL*8) number. Our floating-point hardware is double precision. The FORTRAN compiler has left intermediate results in the floating-point registers, thus producing false accuracy.

This result is not unique to the Prime, however. Sliding over to the IBM PC AT, I found machine epsilon to be $2^{-64}$, the width of the mantissa on the 80287. I therefore propose the following subroutines to calculate the machine epsilon:

```
      Subroutine Epsilon
C
      Real*4 Eps, Temp
      External Null
C
      Eps = 1.0
```

*(continued)*

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```
C
10  Eps = Eps/2.0
    Temp = Eps + 1.0
    Call Null
    If (Temp .GT. 1.0) Goto 10
C
    Write(*,*) 'Eps', Eps
    Return
    End
C
C
    Subroutine Null
    Return
    End
```

On all machines I am familiar with, a call to a subroutine forces the storage of intermediate results, since registers may be changed in the subroutine. The use of the variable Temp before the subroutine call ensures that things don't get back into the wider registers before the comparison is done. This new routine returns the more reasonable ≈ 23 bits on all my machines.

MIKE UTTORMARK
*Ithaca, NY*

## BEST OF BIX

I wish to thank you for adding "Best of BIX" to the editorial content of BYTE. I am a charter subscriber to BYTE, and derived a significant amount of immediately useful information from the earlier issues. In recent years the shift in editorial content has transformed BYTE (for me) into an excellent reference source for many high-level topics. I would like more hardware topics in BYTE, but you probably have a good balance for your readership.

You may be interested in the special attraction "Best of BIX" has for a dedicated hardware hacker whose major programming interest is assembly language. I always choose computing hardware based on which microcomputer is used. My current target is the 68000, so the BIX interchanges on Atari, Mac, and Amiga give me valuable insights to these three candidates. I'm sure that whatever choice I make will be much more informed as a result of having this resource. I wish also to praise "According to Webster." This series is surpassed only by Pournelle and Ciarcia in my interest and enjoyment. Ciarcia is a crackerjack hardware guru, and, after reading Pournelle's science fiction, I will read anything he writes.

RALPH TENNY
*Richardson, TX*

## CUTTING COMPILE TIMES

Recently, I needed to compile very large Pascal programs on my 5-year-old Apple II+. Using the units offered by the Apple's

(continued)

UCSD Pascal, my system is quite capable of compiling large programs, but the cost is very long compile times and disks which run continuously for minutes at a time. I decided to either upgrade my Apple II+ or get a more powerful machine. After almost giving up and buying a Leading Edge, I discovered that Apple's new Pascal 1.3 and Memory Expansion Card can be very useful in this area.

Because it was almost impossible to find any technical information on this configuration, with Apple's "authorized" sales centers totally ignorant about the matter, I wish to pass on what I have learned to my fellow BYTE readers.

Pascal 1.3 is available from Apple on a trade-in basis if you have Pascal 1.1. The cost is $125, compared to the normal retail of $250.

If your system consists of two 5¼-inch disk drives then Pascal 1.3 is not worth the cost. Pascal 1.3 uses more memory than 1.1, so you must almost always use the compiler's swapping option. On a disk system this is intolerably slow. For example, a 399-line program that compiles in 1 minute, 30 seconds under Pascal 1.1 (without swapping) requires 2:35 under Pascal 1.3 because swapping must be invoked. Swapping means that the disk drive with the compiler runs almost continuously, and the compilation is much slower.

In conjunction with the Apple II Memory Expansion Card, however, Pascal 1.3 may be worth considering. Pascal 1.3, unlike earlier versions, can use the MEC like a disk drive; it does not, however, use the additional memory as it would use the additional 64K bytes on the 128K Apple IIe. By putting the compiler and source file on this "RAM disk," the program mentioned above compiles in 1:23, with swapping, for a net improvement in compile time.

The big improvement, however, comes when you wish to compile large programs that are broken up into Pascal Units. Units require the swapping option in both versions, and swapping and reading in units used by other units is painfully slow in a two-disk configuration in either version. For example, a 590-line program that uses 9 units and requires swapping takes 3:09 using the disks, and one disk runs continuously. With the compiler and source on the MEC, however, the time is reduced to 1:21, and no disk runs at all.

One can get excellent system performance by putting the editor, filer, system syntax, compiler, and linker files, as well as the program source, on the MEC. You must, however, rename the editor and filer files on the boot disk to force the system to access these files on the MEC. I cheat

*(continued)*

by booting the system, transferring the above-mentioned files onto the RAM disk, setting the default disk to the RAM disk, then inserting a boot disk identical to the original but with the appropriate files renamed.

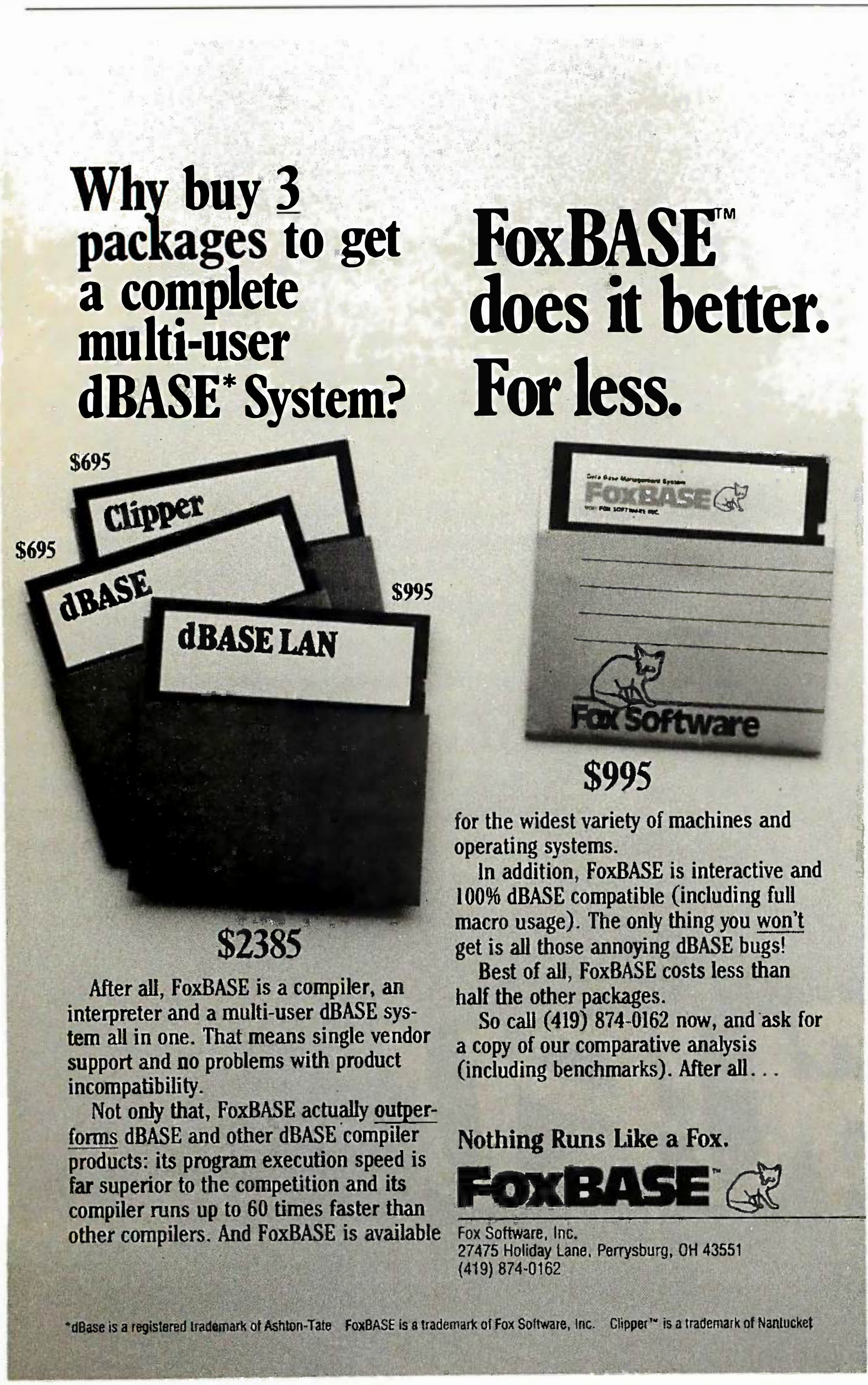
An additional speed advantage occurs in running programs that rely heavily on overlays (non-resident segments); one program took 6:25 using disks and 2:20 on the RAM disk.

A very useful enhancement on version 1.3 permits the user to assign the boot disk to the RAM disk. As it is, the system still insists that the System.Pascal file be on the boot disk, and if one invokes swapping (at the command level, not the compiler option), all swapping is done on the boot disk, which, once again, gets the disks running, slowing things down and making an unnecessary clatter.

One problem I have found is that if the version 1.3 compiler aborts due to stack overflow (which it will without swapping), some pointer or other is not reset when the system is rebooted, and the compiler will overflow almost immediately. You have to turn off power to reset the system properly. (I haven't bothered to see if 1.1 contains this flaw.) A system crash and reboot does not destroy what is on the RAM disk, but cycling the power obviously does; thus, the above-mentioned problem can be costly in terms of lost work.

In summary, the Pascal 1.3/Memory Extension Card configuration is a good way to upgrade an older 64K Apple for those interested in Pascal. It offers good system response and compile times on complex projects. I bought my MEC with 512K bytes of memory for $300, and the Pascal 1.3 upgrade for $125. While I s ill own a 64K machine, I can compile and run very large programs in a reasonable amount of time.

PHILIP MAHLER
*Carlisle, MA*




### LOCK UP DIRECTORIES

I enjoyed reading "Making UNIX Secure" by Alan Filipski and James Hanko (April). It was very informative, and the authors were quite thorough in pointing out some of the obscure tricks that can be used to breach security, such as the use of terminal page mode buffering (terminals with programmable answer-back messages suffer the same weakness). However, I feel the authors should have emphasized more strongly the importance of write-protecting directories.

To protect a file from attacks, it is not sufficient to write-protect only the file itself; one must also protect the directory in which it resides. Operations such as file renaming *and removing* require write permission only on the directory containing the filename, and not on the file itself.

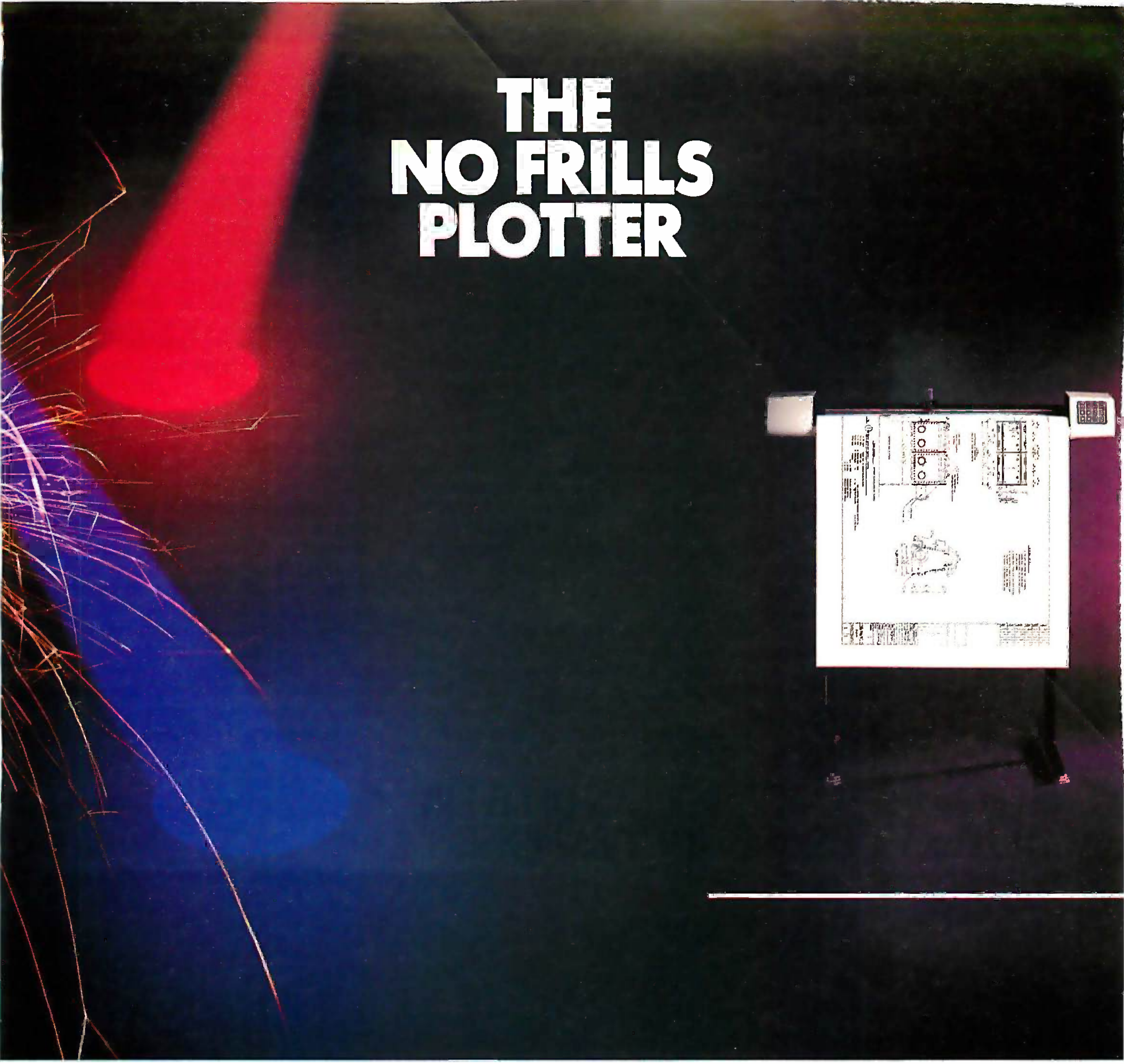
Consider the following scenario: the password file, /etc/passwd, is write-protected, but a user has write permission on the /etc directory. The user can simply rename (mv) the password file and install his or her own. The user can then become superuser, remove his or her password file, reinstall the old one, and wreak havoc. Similarly, if the /etc directory is write-protected but the root directory is writable, the user can substitute a dummy /etc directory, containing a dummy password file, for the real one. Thus, the only way to ensure the password file is safe from attack is to write-protect the file and all directories leading to it.

Such holes in the security of a system may seem quite obvious and unlikely to occur, but it is surprising to find that there are systems out there that are so vulnerable to attack. The preceding trick is one

*(continued)*



Inquiry 147

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Inquiry 168

I had to resort to when I was called in to "repair" the password file on a demo system, where the superuser password had been changed by a user and subsequently forgotten. I then took it upon myself to lecture the owners of the system on the importance of maintaining proper security. The security mechanisms provided by UNIX won't help anyone if they are not used correctly.

GILBERT DETILLIEUX
*President, Info West*
*Winnipeg, Manitoba*
*Canada*

## "LOOK AND FEEL" ISN'T EVERYTHING IN THIS CASE

James E. Bransfield's letter in the April BYTE (page 14) applauding Apple's "victory" over DRI by no means represents the thoughtful opinion of all of the computer law community. Indeed, the letter sounds more like a brief written in support of Apple's position than a reasoned exposition of a difficult issue.

All of the cases cited by Bransfield are inappropriate in some critically important way. For example, in *SAS Institute, Inc. v. S&H Computer Systems, Inc.*, 605 F. Supp. 816 (M.D. Tenn. 1985), the defendants took much more than just the "look and feel" of SAS's product. They licensed a copy with the express purpose of adapting it to run on a VAX. They used SAS's source code to design and write their own program. The facts of this and the other cases on which Mr. Bransfield relies hardly support his contention that all the defendants did was to misappropriate a "look and feel."

The Supreme Court of the United States has stated many times that ideas themselves are not copyrightable; only the expression of an idea can be copyrighted. Courts have often had trouble determining where the idea ends and its expression begins, but the distinction must remain. In my opinion, Apple has tried to appropriate an idea (and someone else's idea at that) to itself and extend the law of copyright beyond its constitutional bounds.

If Apple's screen design was sufficiently unique, then it could have been copyrighted in its own right as an audiovisual work. If the screen design was so trivial as not to warrant a copyright, then Apple should not be permitted to gain legal protection for it through the back door by claiming such protection through the copyright on the software which produces the design.

If DRI truly misappropriated Apple's software, then they should be made to pay. But if they did not, then we, the computer users, should not be made to pay by allowing Apple to usurp through force that to which it has no legal right.

MICHAEL GEMIGNANI
*Muncie, IN*

I wish to point out that if you accept James E. Bransfield's comments as an authoritative statement of the law without qualification, then you are doing your readers a grave disservice. It is apparent from the marked bias of his comments that either he has not done his research carefully or he is intentionally providing only one very selective view of the cases and concepts related to this area of litigation. I would like to balance that view.

I have been following with interest the articles, editorials, letters, and news concerning the issue of visual copyrights and software "clones" in both your magazine and periodicals such as *InfoWorld*. This area

*(continued)*

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Inquiry 353 for End-Users. Inquiry 354 for DEALERS ONLY.

of controversy is not only unsettled in the user community, it is also unsettled in the law. The issue is not terribly complex technically, which is unusual when one is presented with a legal problem involving computers, but it is very complex legally. Copyrights and intellectual property rights in general are not easily understood. Also, since software is not only a written work but is also a functional artifact of man's intelligence, copyrights are not very well tailored to meet the needs of protecting both developers and users of microcomputer software.

Copyrights do not protect ideas. (Although Broderbund's attorney seems to think so. . . see *InfoWorld*'s "'Look and Feel' Discussed as Major Copyright Issue," 11 November 1985, page 13.) Copyrights protect the expression of an idea. The idea need not be original, only the method of expressing it. The idea must be "fixed in a tangible medium of expression." This includes written on paper, recorded on magnetic disks, chiseled on stone tablets, etc. When the author has complied with all of the requirements of the copyright laws, the holder of the copyright is protected from an unauthorized person making a copy of the work. The ideas themselves are not protected from copying, only the author's particular expression of them. Works directly derived from that expression of ideas are also prohibited.

In order to prove that someone has infringed upon the rights of the copyright holder, one normally must show access to the copyrighted work and a substantial similarity between the copy and the original. This is where many of the problems of copyrights and computers crop up. There was at one time a significant doubt that the copyright laws actually protected the object code of a functioning program. The copyright act was amended to make that protection clear. While that doubt existed, many software companies, particularly games producers, copyrighted the screen displays of their programs to prevent piracy of their products. This way, at least, a large portion of the work was protected. Such graphic and visual screens could be protected in the same way video images (TV programs, films, etc.) are protected. With the explicit recognition by Congress and the courts of copyright protection for both source and object code—which, of course, includes the screen information—the practice of copyrighting the screen displays or attract modes of games was no longer important. However, the idea of preventing the copying of such "screens" is obviously once again becoming important to many people.

In addition to the *Apple v. DRI* case, the controversy between MicroStuf and SoftKlone over the Crosstalk clone Mirror is an obvious example of this concern. I can easily see why companies that produce expensive but popular software would be interested in legal methods to stop people from using the unreasonably large profit margin of their product to cut them out of a part of their market share. In producing a product that does not have any connection with the actual code of the popular program but has similar appearance, identical command sets, and perhaps improved features for a more reasonable price, the competition can often capture a large portion of the market that would otherwise belong to the first company by default. One might take note that Borland International doesn't have much of a problem with this phenomenon.

While I agree with Mr. Bransfield's analysis that the protection of the source

(continued on page 387)

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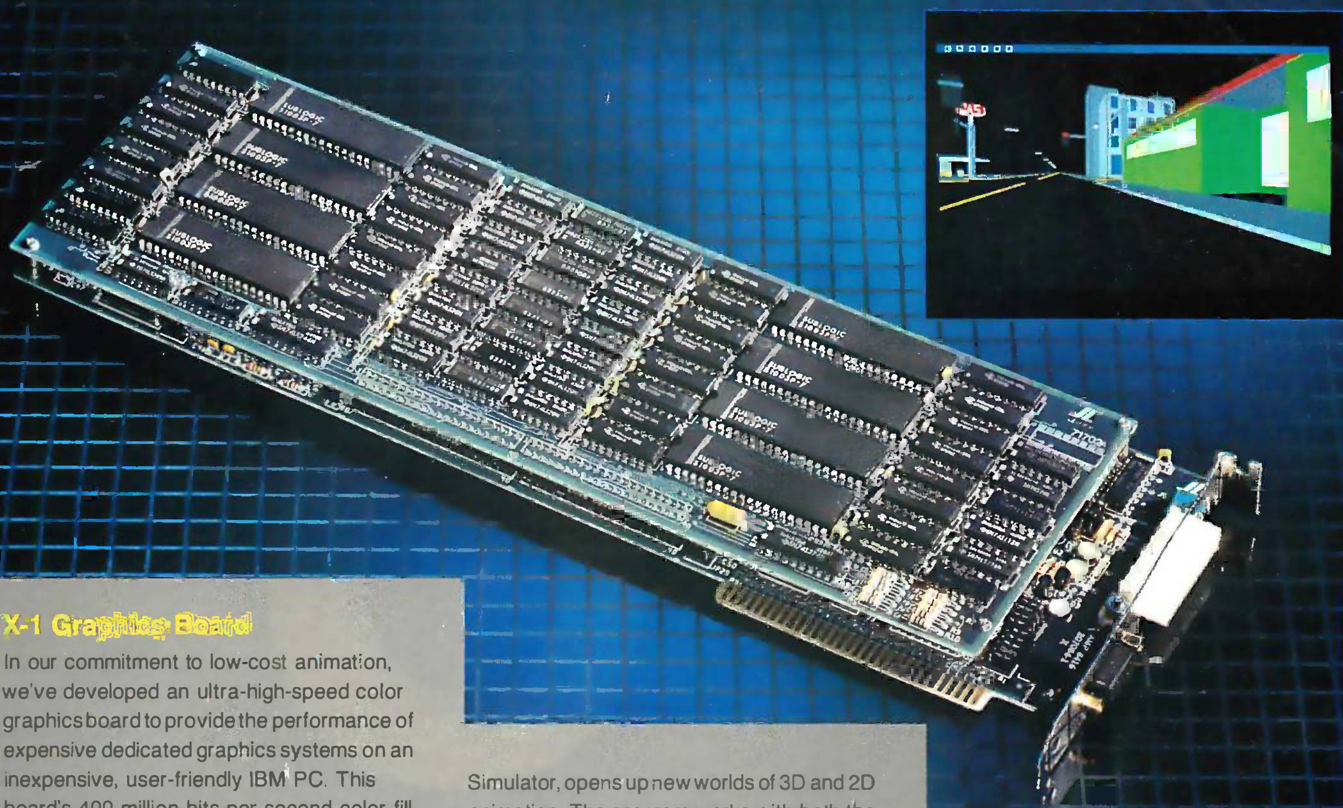

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Imagine making source program changes with the CLARION EDITOR. A single keystroke terminates the EDITOR, loads the COMPILER, compiles the program, loads the PROCESSOR and executes the program. It's that easy!

Our data management capabilities are phenomenal. CLARION files permit any number of composite keys which are updated dynamically.

A file may have as many keys as it needs. Each key may be composed of any fields in any order. And key files are updated whenever the value of the key changes.

Like SCREENER and REPORTER, CLARION's FILER utility also has a piece of the CLARION COMPILER. To create a new file, you name the Source Module. Then you name the Statement Label of a file structure within it.

FILER will also automatically rebuild existing files to match a changed file structure. It creates a new record for every existing record, copying the existing fields and initializing new ones.

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Inquiry 2 for End-Users. Inquiry 3 for DEALERS ONLY.

## TeleVideo's $2995 AT Compatible

TeleVideo Systems introduced the TeleCAT-286, an IBM PC AT–compatible computer priced at $2995. Designed primarily as a single-user computer rather than a multiuser system or file server, the TeleCAT-286 is 28 percent smaller than the IBM PC AT, the company says, and uses custom-designed chips that reduce the number of components on the system board.

The TeleCAT-286 runs on an Intel 80286 microprocessor operating at 6 or 8 MHz and comes with 512K bytes of RAM that can be expanded to 1 megabyte on the main board. Equipped to hold three internal storage devices, the base model has a 1.2-megabyte 5¼-inch floppy disk drive and a 20-megabyte hard disk drive. The system comes with an AT-compatible keyboard as well as a 14-inch, tiltable monochrome monitor with a graphics resolution of 640 by 400 or 640 by 200 pixels. Other features include one serial and one parallel port and five AT-compatible expansion slots, two of which are occupied by video driver and disk controller cards.

The TeleCAT-286 can be connected to a TeleVideo Personal Mini network file server, as well as to some PC networks. Besides running PC AT software, the new TeleVideo machine can take PC AT and PC XT expansion boards. A system with a 30-megabyte hard disk drive costs $3495. MS-DOS 3.1 and GW-BASIC 3.1 sell for $85. For more information, contact TeleVideo Systems Inc., 1170 Morse Ave., Sunnyvale, CA 94086, (408) 745-7760.
**Inquiry 550.**

*The TeleCAT-286, an AT-compatible computer from TeleVideo.*

## Modeling/Analysis Package for IBM PCs

Pacific Crest Software likens its modeling and analysis program, Point Five, to a word processor for numbers. At its basic level, the package is similar to a programmable calculator; it has 150 mathematical, financial, statistical, and data-manipulation functions.

The program displays a split screen. In the lower part, the "Scratchpad," you enter functions and formulas. When you press Enter, the software executes the commands and then shows the results in the top part of the screen. Simple commands convert the results from numerical to graphic form. The data and the programs written to manipulate the data are saved separately. Pacific Crest says this makes it easy to analyze the same sets of data with different methods or develop applications that can be applied to different data sets for recurring calculations.

Point Five runs on IBM PCs and compatibles that have at least 256K of memory and two floppy disk drives. It requires MS-DOS 2.0 or later and can be used with an IBM- or Hercules-compatible graphics card and the 8087 coprocessor. Point Five costs $195; site licenses are available. Contact Pacific Crest Software, 887 Northwest Grant Ave., Box 2098, Corvallis, OR 97339, (503) 754-1067.
**Inquiry 551.**

## Portable Unit Has Printer, Smart Keyboard

Datavue, Quadram Corp.'s offshoot that specializes in portable computers, introduced its FreeStyle system, which includes a new portable daisy-wheel printer and an "intelligent" keyboard. The 6-pound battery-powered printer, called the WriteStyle, is reported to print at 14 characters per second.

The 3-pound keyboard, called the KeyStyle 80, features its own Z80 processor, 96K bytes of memory, word processing and communications software, and an 80-column by 8-line LCD. The KeyStyle 80 also has an infrared link that can connect with either the WriteStyle printer or the Datavue 25, Datavue's portable IBM PC–compatible computer.

The WriteStyle has a list price of $349. The KeyStyle 80 keyboard costs $349. Both products will sell together for $599. An optional modem is available for the keyboard. Contact Datavue, One Quad Way, Norcross, GA 30093-2919, (404) 564-5668.
**Inquiry 552.**

*(continued)*

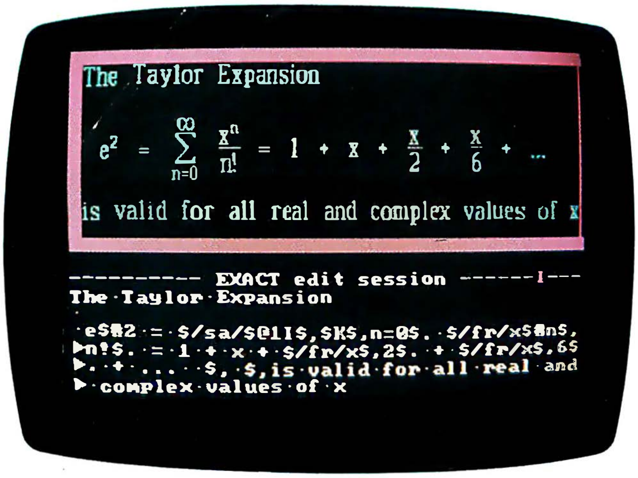
## 'rogram Helps Word ›rocessors Print Math Expressions

Technical Support Software has developed a program that enables many word processors to print mathematical and scientific expressions within documents. One of the key features of EXACT (expression and character typography) is a split-screen editing space you can use without exiting your text program.

EXACT loads into RAM before your word processor. At any time, you can call up the split screen. You type EXACT commands in the bottom half, and the program flashes the math expressions in the top half in a "what you see is what you get" fashion. Expressions can be edited by changing command lines. Radicals, fractions, brackets, and tables change automatically when you alter the material they contain. When you return to your word processor, you place the cursor where the expression belongs in the document. When you tell your text package to print, EXACT scans the print stream, finds its commands, and sends a graphics image to the printer to draw the expression.

The software has 20 fonts with more than 1000 symbols and characters, a font editor, a complete Greek set, script and italics, and automatic selection of smaller characters for superscripts and subscripts.

TSSI says its typesetting package works with XyWrite II Plus, WordStar, Volkswriter, Word, Final Word, Easy Writer, Perfect Writer, WordPerfect, DisplayWrite 2 and 3, and several other word processors. EXACT runs under MS-DOS 2.0 or later and requires 128K of memory and a color or monochrome graphics card.




TSSI's EXACT *enables word processors to print math expressions.*


*WordTech's* dBXL *has a "tutor" to help construct commands.*

Drivers are available for dot-matrix and laser printers. EXACT costs $475; a demo costs $5. Contact Technical Support Software Inc., 72 Kent St., Brookline, MA 02146, (617) 734-4130.
**Inquiry 553.**

## Low-Cost Database Works with dBASE III Plus

WordTech Systems is selling a database management system it says is fully compatible with Ashton-Tate's dBASE III Plus. Called dBXL, the $169 system uses the same data and index files as dBASE III Plus; supports the same syntax, reports, and format files; and provides networking capability.

With dBXL, you can have as many as ten files open simultaneously, each with seven open index files. The package has two levels of context-related on-line help.

Initial versions run under MS- and PC-DOS 2.0 or later. The program needs 192K of RAM clear of the operating system or device drivers. Contact WordTech Systems Inc., P. O. Box 1747, Orinda, CA 94563, (415) 254-0900.
**Inquiry 554.**

## Color Ink-Jet Printer Uses Plastic Ink

Howtek has developed a color ink-jet printer, the PixelMaster, that uses 32 ink jets to produce what the firm calls "near offset quality" printing. The $2995 device provides raised text and color graphics output with a resolution of 240 by 240 dots per inch on standard 8½- by 11-inch paper.

The PixelMaster is distinguished from other color printers in its use of solid plastic ink, which is designed to minimize, if not eliminate, the problems of smudging and clogging that often occur with traditional water- or oil-based ink-jet printers. In the PixelMaster, plastic ink from a crayon-like rod is melted, allowing the ink to be sprayed as a liquid that solidifies instantly on contact with the paper.

The printer's proprietary Thermo-Jet ink jets use four basic colors: magenta, yellow, cyan, and black. It's capable of producing over 250,000 shades of color, the firm claims, and has 20 black ink jets for printing text at a rate of about 30 seconds per page. The PixelMaster also has 16 fonts contained in plug-in ROM cartridges and can reproduce images entered into computers from optical and image scanners.

The printer is designed as a freestanding floor model and is expected to ship this September. Parallel and serial interfaces will be available, according to a company spokesman, who also said that the firm is currently negotiating with other vendors to sell the machine. For more information, contact Howtek Inc., 21 Park Ave., Hudson, NH 03051, (603) 882-5200.
**Inquiry 555.**

*(continued)*

# You need Borland's Traveling SideKick because wherever you go, there's work to be done

Traveling SideKick™ is the only personal organizer developed from and designed for the Computer Age.

An electronic leap ahead of traditional diaries, day-timers and organizers, Traveling SideKick is BinderWare™ that includes a software program, a report generator, reference materials, maps, addresses, appointments, telephone numbers, calendars, customer lists, travel itineraries, a calculator, and much much more.

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Traveling SideKick is an organizer, a binder, a software program and a report generator that picks your SideKick's brain, then prints out your appointments, daily, weekly, monthly, or yearly calendar, your phone lists, and mailing labels, itinerary, or whatever else you need.

## *Traveling SideKick is your SideKick's® sidekick*

More than half a million of you already know how indispensable SideKick, the RAM-resident desktop manager, is on your IBM® PC (So do many Macintosh™ owners who are now using our SideKick/Mac version). While SideKick enjoys the rank of #1 best seller for the IBM PC, it can only go where your computer goes—so if your computer stays in your office or den, so does SideKick. Traveling SideKick changes all that.

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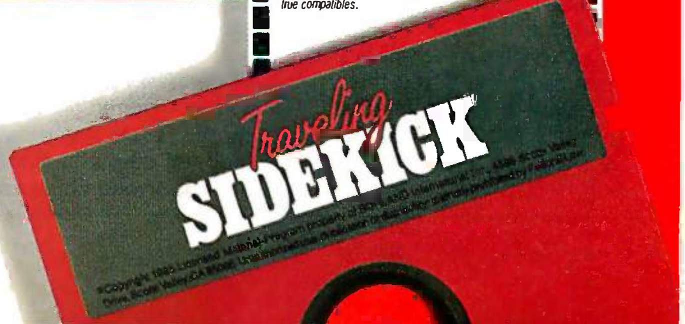




Inquiry 47 for End-Users. Inquiry 48 for DEALERS ONLY.

## Toshiba's Portable AT Compatible

Toshiba America introduced its T3100 portable computer, which is compatible with the IBM PC AT and features a gas-plasma display and built-in hard disk drive.

Priced at $4499, the 15-pound portable runs on an 8-MHz 80286 processor and comes with 640K bytes of memory, expandable to 1.6 megabytes with an optional 1-megabyte add-on board. The computer has a 720K-byte 3½-inch floppy drive, an internal 10-megabyte hard disk drive, and an optional 5¼-inch floppy drive.

The portable's fold-up gas-plasma screen displays 80 characters by 25 lines with a resolution of 640 by 400 pixels. Compatible with software written for the IBM Color Graphics Adapter, the computer is equipped with an interface for an RGB color monitor and parallel and serial ports.

Options include an internal Hayes-compatible 1200-bps modem and an expansion chassis with five full-length IBM PC–compatible slots that plugs into a bus on the back of the computer. Among the other options are an external 15-key numeric keypad and PC Floppy Link ($99), a half-length interface card and cable for IBM PC and XT compatibles that enables you to use those computers' drives as external drives for the portable. According to the company, a version of PC Floppy Link for the IBM PC AT and compatibles will be available soon. Prices for other options had not been established as of this writing.

Toshiba says it will begin shipping the T3100 this month. It will be bundled with MS-DOS 2.11, GW-BASIC, a power cord, and a carrying case. Contact Toshiba America Inc., Information Systems Division, 2441 Michelle Dr., Tustin, CA 92680, (800) 457-7777; in California, (714) 730-5000.
**Inquiry 556.**

*Toshiba's T3100, a portable with a gas-plasma display and internal hard disk drive.*

## LCD Panel Links with Projector

Sayett Technology introduced a projection system that weds LCD technology to an overhead projector. The Sayett System 10 uses a standard LCD panel that you connect to a computer and place on the glass plate of an overhead projector. Instead of taking light in and reflecting it out as LCDs normally do, the system passes the light through to the overhead projector.

The system includes an electronic control board and an LCD panel that allows for the projection of digitized text or graphics generated from an IBM PC or compatible. A standard 9-pin RGB port on the computer (or a modem for remote presentation) is required for connecting the Sayett system, which supports output in monochrome or one tinted color.

The $1200 system will include a graphics presentation program called Show Partner (from Brightbill-Roberts in Syracuse, New York) that can be used to develop slideshow-like presentations of graphic and textual material in a pretimed sequence. Show Partner can be used to create original graphics or incorporate images from other programs that can then be shown on the Sayett unit. A standard 5¼-inch disk can store "several hundred image cells," according to the company.

Sayett Technology, a wholly owned subsidiary of Eastman Kodak, says the system should be available this month. Contact Sayett Technology, 1133 Mt. Read Blvd., Rochester, NY 14606, (716) 458-0177.
**Inquiry 557.**

## Amiga Database

Transtime Technologies has developed a database software package for Commodore's Amiga. Datamat is a relational database program written in C with an interface that uses English-language menu selections. It incorporates the major features of high-end DBMSs, the company says, and also provides statistical functions.

Using Datamat, you build the database with a data dictionary that contains facilities for adding, modifying, listing, calculating, and shifting variables, as well as for extracting variables from existing dictionaries. The program also has math functions, sort and merge capabilities, user-definable procedures, multilevel passwords, database scanning, and one-step data conversion. A single query can have as many as 26 selection criteria.

The suggested price for Datamat is $350. In addition to running on the Amiga, it runs on MS-DOS, ZDOS, XENIX, and UNIX machines. Contact Transtime Technologies Corp., 797 Sheridan Dr., Tonawanda, NY 14150, (716) 874-2010.
**Inquiry 558.**

## Iomega Develops 20-megabyte Floppy Drive

Iomega, maker of the Bernoulli Box line of high-density floppy disk drives, announced a 5¼-inch half-height drive that can store 21.4 megabytes of data. The new drive uses a special floppy disk enclosed in a hard plastic case. The medium—the plastic substrate and magnetic coating—is similar to that of a standard floppy disk.

The drive, called the Beta 20, will be sold only to OEMs. In quantities of 10,000 units, the drive will have a price of $370 and is slated to be available in the third quarter of this year. A controller, which can work

*(continued)*

with up to two drives, costs an additional $180. Contact Iomega Corp., Holly Pond Plaza, 1281 Main St., Stamford, CT 06902, (203) 359-9858.
Inquiry **559.**

## Page Scanners for Text and Images

Vision Research announced a 300-dots-per-inch scanner that comes with image- and text-editing software and an interface board for IBM PCs and compatibles. The $2495 Desktop Page Composition System digitizes an 8½- by 11-inch page in 7 seconds. The scanner has four contrast levels, accepts gray-scale or color originals, and can create halftones by dithering. Scanned images are stored in the MegaBuffer interface board, which provides 1.3 megabytes of RAM, enabling you to pan and zoom to any section of an image.

The MegaScan software lets you merge ASCII text with scanned images or documents. The software provides six zoom levels and enables you to edit individual pixels. It includes such capabilities as move, copy, scale, rotate, reverse, lighten, and vertical flip. An optional memory-resident program, called MegaFreeze, lets you transfer a screen image from an application program to a document you're working on and can capture up to 64 screens per document.

The system runs on an IBM PC, XT, AT, or compatible with 512K bytes of RAM and an IBM Color Graphics Adapter or equivalent. Contact Vision Research, 1590 Old Oakland Rd., Suite B-112, San Jose, CA 95131, (408) 298-8700.
Inquiry **560.**

Datacopy's JetReader scanner provides optical character recognition and image processing. The JetReader comes with an interface board and Datacopy's OCR software and Word Image Processing System (WIPS) software. Prices for the system start at $2950.

The scanner has an automatic paper feed and accepts a stack of up to ten sheets of paper. For images, its scan rates are about 43 seconds per page at 300 dots per inch and 28 seconds at 200 dpi. The scanner typically takes about a minute, the company says, to scan and convert a page of text into ASCII code.

The OCR software can read 12 typefaces; the optional OCR Plus package can be trained to recognize other typefaces. The WIPS software provides image scanner control, image manipulation, file management, image display, and hard-copy output. It lets you integrate images into documents prepared with standard word processors and provides editing capabilities such as scaling, rotation, cropping, and zoom. The optional WIPS Editor package ($245) enables you to edit images at the level of individual pixels.

A second model, the JetReader Plus, includes the OCR Plus software and sells for $3250. Contact Datacopy, 1215 Terra Bella Ave., Mountain View, CA 94043, (415) 965-7900.
Inquiry **561.**


ITT's XTRA XL, *a multiuser computer that runs* DOS *and* Xenix.

## ITT's XTRA XL Runs DOS and XENIX

ITT introduced the XTRA XL computer, which is based on Intel's 80286 and runs both DOS and XENIX. The XTRA XL has a mass storage capacity of 144 megabytes and a reported average hard disk access time of 28 milliseconds.

The machine also features 8-MHz zero-wait-state memory, dynamic disk I/O caching, and an 8-MHz 80186-based communications coprocessor. An 80287 math coprocessor is an option. Depending on model, other standard features include 640K bytes or 1.6 megabytes of RAM, a 1.2-megabyte floppy disk, and a 40- or 72-megabyte hard disk. Multiuser configurations come with a 60-megabyte streaming tape backup unit and can handle as many as four coprocessor boards.

The XTRA XL comes in four models. Models *I* and *II* can be used as LAN servers. Models II and III can be used as multiuser systems. The LAN server configurations use ITT DOS 3.1, which eliminates the 32-megabyte disk partition requirement, the company says. The multiuser machines run ITT's XENIX System V, licensed from The Santa Cruz Operation and developed by Microsoft.

System prices begin at $5299 for a Model I with 640K bytes of RAM, a 1.2-megabyte floppy disk, and a 40-megabyte hard disk. Contact ITT Information Systems, 2350 Qume Dr., San Jose, CA 95131, (800) 321-7661; in California, (800) 368-7300.
Inquiry **562.**

## C for Atari ST

Mark Williams Company's C Programming System for the Atari ST features a complete implementation of Kernighan and Ritchie (plus recent extensions to the language) and UNIX-compatible libraries. Along with utilities such as make, diff, cmp, sort, wc, and egrep, the package provides an interface to GEM's AES and VDI libraries, an assembler, a loader, and an archiver.

A shell provides a UNIX-like environment and supports I/O redirection, pipes, variable substitutions, history substitutions, and path search capabilities. The full-screen editor is based on EMACS.

The C Programming System for the ST costs $179.95. It requires two double-sided floppy disk drives (or one floppy and one hard disk). Contact Mark Williams Co., 1430 West Wrightwood Ave., Chicago, IL 60614, (312) 472-6659.
Inquiry **563.**

*(continued)*

*Turbo Pascal® Source Code Included*

# Borland's new Turbo Editor Toolbox, "Best of the Year" award winner, lets you build your own word processor for only $69.95!

Turbo Editor Toolbox™ lets you build the best of all word processors into your own word processor. All the modules, techniques, instructions, and Turbo Pascal source code are at your fingertips. You'll quickly learn how to integrate editor procedures and functions into your programs, or you can use Turbo Editor Toolbox "as is," because it has everything.

### *You get Turbo Pascal source code and everything you need to build your own word processor*

The modules, the manual, ready-to-compile source code, and a full-featured word processor called MicroStar,™ which we probably ought to sell separately because it's an excellent text editor. But anyway, you get it *free* as part of our new Turbo Editor Toolbox. (Maybe this is why Jerry Pournelle of BYTE magazine recently wrote that *"Borland International is a public benefactor. The company continues to pour out good, well-documented products at reasonable prices."*) Your free MicroStar includes a complete pull-down menu user interface which you can use "as is," or you can modify it for inclusion in your Turbo Pascal programs.

As well as MicroStar, you also get a complete editor ready to include in your programs. Windows, block commands, and memory-mapped screen routines come with it.

### *How to turn good stuff into great stuff—maybe even green stuff!*

With your new Turbo Editor Toolbox, you can make WordStar® behave like MultiMate.™ You can support windows just like Microsoft's® Word. And do it as fast as WordPerfect® does it. In other words, you can do what they should have done. You just go in there, tinker, fiddle, fool around, and come up with your own version—which will be the best word processor you've never seen before. (And if you want to sell it, go for it; we're not the kind of company that'll send bean-counters and ambulance-chasers after you for royalties.)

### *How to do windows without jamming your fingers back in your wallet*

State-of-the-art "windowing" techniques are part of our new Turbo Editor's repertoire. Sophisticated but easy-to-learn techniques let you design your word processor to show several documents—or several parts of the same document—all at once.

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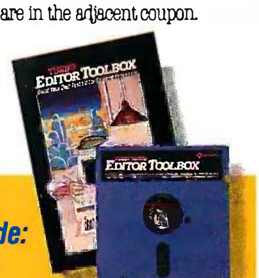

## *Standard Turbo Editor Toolbox features include:*

- Wordwrap
- UNDO last change
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- Tab, insert and overstrike modes, centering, etc.
- Multiple windows
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> "The new Turbo Editor Toolbox is the Turbo Pascal source code to just about anything you ever wanted a PC-compatible text editor to do, along with a really excellent book of instructions on what text editors are and how to use the Toolbox to build a custom text editor ... you can't afford to be without this."
>
> *Jerry Pournelle, BYTE Magazine, discussing Turbo Editor Toolbox, to which he gave his "Best Of The Year" Award*

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*†You must have an IBM or true compatible running DOS 2.0 or later.*
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*The disk size I use is: ☐ 3½" ☐ 5¼"* TE15

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***†Minimum System Requirements:** 192K*
*Runs on IBM PC, XT, AT, PCjr., and true compatibles*


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Inquiry 51 for End-Users. Inquiry 52 for DEALERS ONLY.

SYSTEMS

## AT Compatibles Run at 10 and 12 MHz

PC's Limited has introduced the 286[10] and 286[12] computers, which are compatible with the IBM PC AT and run at 10 and 12 MHz, respectively. Both computers come with 1 megabyte of RAM on the motherboard, six AT-compatible expansion slots, and two PC-compatible slots. Both can hold three half-height or a full- and a half-height drive and come with a 1.2-megabyte floppy drive, a dual floppy and hard disk controller, and an AT-compatible keyboard.

The base model of the 286[10] sells for $2295; the 286[12] sells for $2695. Contact PC's Limited, 1611 Headway Circle, Building Three, Austin, TX 78754, (512) 339-6800.

**Inquiry 564.**

## Compucorp Workstations

Compucorp announced two Connection workstations that both have one 20-megabyte hard disk drive and one 360K-byte floppy disk drive, a motherboard with 640K bytes of RAM, two serial and two parallel ports, a keyboard, a monitor, and the capacity for up to four internal drives.

The Connection 16 has a 16-bit 8088 processor. The Connection 32 has two processors: an 8088 and a National Semiconductor 32-bit 32032, which run MS-DOS and XENIX, respectively. The 32's two processors can work concurrently and allow for data transfer. The 32 also comes with XENIX software and features a database management system with word-processing, spreadsheet, and database functions.

Connection workstations can be networked with like machines as well as other IBM PC compatibles.

The 16-bit system costs $3595. The 32-bit system, including XENIX and MS-DOS, costs $4995. Contact Compucorp, 2211 Michigan Ave., Santa Monica, CA 90404, (213) 829-7453.

**Inquiry 565.**

*Panasonic's Business Partner* 286.

## Two Panasonic Computers

Two desktop personal computers, the Business Partner and the Business Partner 286, have been introduced by Panasonic. Both systems have four slots for half-height hard disk drives or tape backup systems and come with a keyboard but not a monitor.

The Business Partner, which is compatible with the IBM PC, runs on a 4.77- or 7.16-MHz 8086-2 processor and has six expansion slots. It comes with 256K bytes of RAM expandable to 640K. A unit with a single 5¼-inch 360K-byte floppy disk drive is priced at $1295. A machine with two floppy drives costs $1495.

The Business Partner 286 is compatible with the IBM PC AT and has five AT-compatible and five PC-compatible expansion slots. The computer has an 80286 processor that can run at 6 or 8 MHz and 512K bytes of RAM expandable to more than 1 megabyte. With a single 5¼-inch 1.2-megabyte floppy disk drive, the Business Partner 286 costs $2795.

Contact Panasonic, One Panasonic Way, Secaucus, NJ 07094, (201) 348-7000. 348-7000.

**Inquiry 566.**

## PC Designs' Turbo AT

The PC Designs' Turbo AT is an IBM PC AT compatible that runs on an 8-MHz 80286 microprocessor. Standard features include a monochrome graphics card, a high-resolution monochrome monitor, two serial and two parallel ports, an AT-compatible keyboard, and 1 megabyte of on-board RAM. The computer also has five 16-bit expansion slots, one 8-bit slot, a clock/calendar with battery backup, and a controller for two floppy and two hard disk drives.

The Turbo AT offers a choice of a 360K-byte or a 1.2-megabyte floppy disk drive. Other options include a math coprocessor, second floppy drive, hard disk drives, and 20-, 60-, and 100-megabyte streaming tape backups.

The Turbo AT is priced at $1995. Contact PC Designs Inc., 5837 South Garnett, Tulsa, OK 74146, (918) 252-5550.

**Inquiry 567.**

## Franklin's First PC Compatible

Franklin Computer, long known for its series of Apple-compatible computers, announced its first IBM PC compatible. Called the PC-8000, it runs on a 4.77-MHz 8088 processor and comes with 512K bytes of RAM and two half-height 5¼-inch floppy disk drives. Of the machine's four expansion slots, three are filled with a disk controller card, a parallel/serial interface card, and a video adapter card that's compatible with IBM's Color Graphics Adapter.

Either a monochrome or RGB monitor (not included in the base price) can be connected to the computer.

The PC-8000 costs $995 and should be available in August. Contact Franklin Computer Corp., Route 73 and Haddonfield Rd., Pennsauken, NJ 08110, (609) 488-0666.

**Inquiry 568.**

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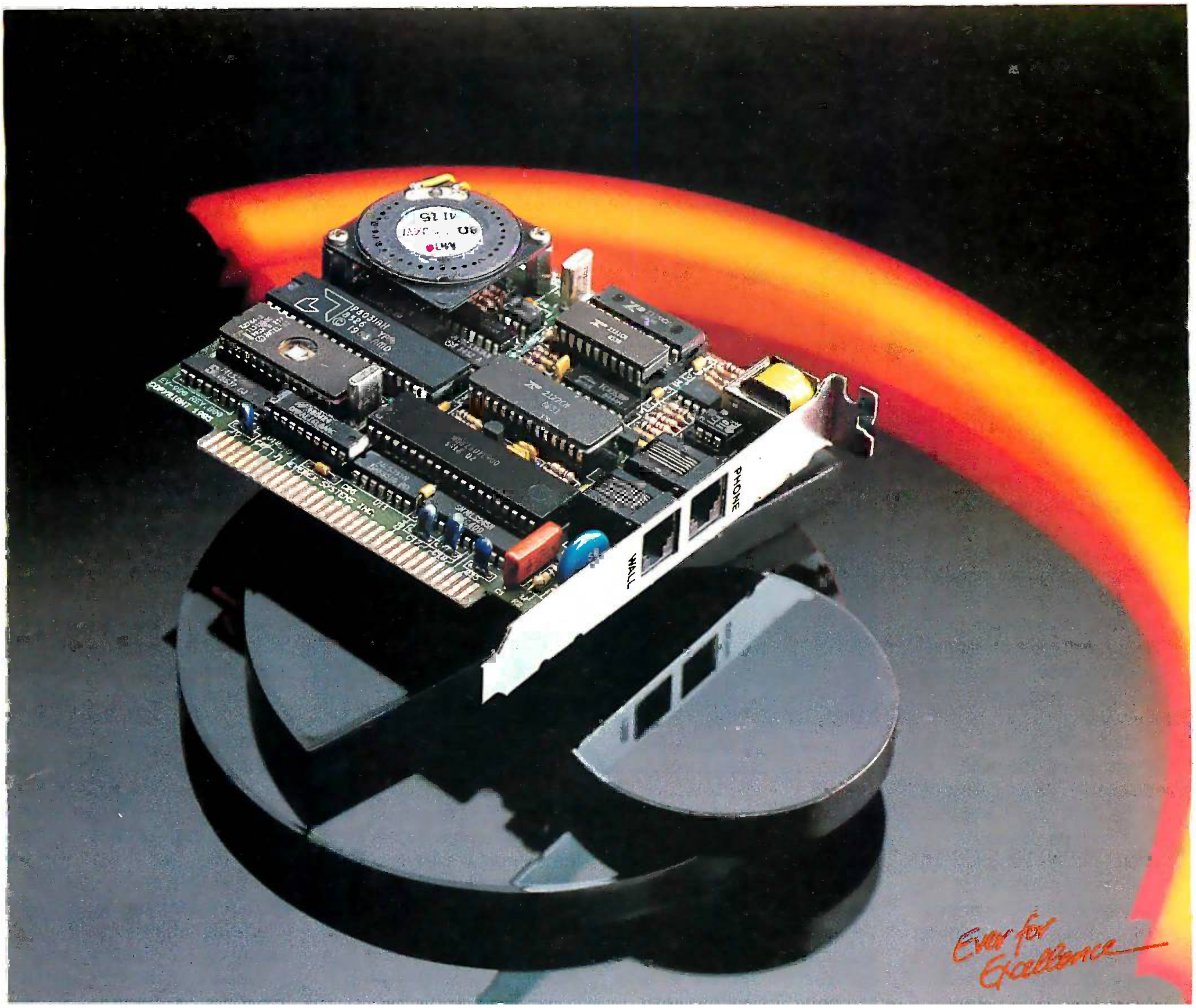


# Evercom™... 1200 baud, $249

Now the EVEREX Evercom modem is available on a half-size card, perfect for the short slots in the IBM XT, Portable, and many compatibles. EVEREX has combined innovative engineering and technology to produce a quality Hayes-compatible 1200 baud modem that out performs the competition at a lower price. EVEREX engineering is the key ingredient that delivers QUALITY and FEATURES without sacrificing PRICE.

## Before you buy a modem, check these features:

| | EVEREX EVERCOM | HAYES NEW 1200B |
|---|---|---|
| • Automatic dialing, answering, and redialing | YES | YES |
| • Half-size card | YES | YES |
| • Call progress monitoring | YES | YES |
| • Works in short slot of XT and PC Jr. | YES | NO |
| • Automatic data-to-voice transition | YES | NO |
| • Reports serial port speed mismatch | YES | NO |
| • Detects receiver off-hook | YES | NO |
| • Configurable from COM1 - COM4 | YES | NO |
| • Supports 132 columns | YES | NO |
| • Communications software included | YES | $80 extra |
| • **List Price** | **$249** | $489 |

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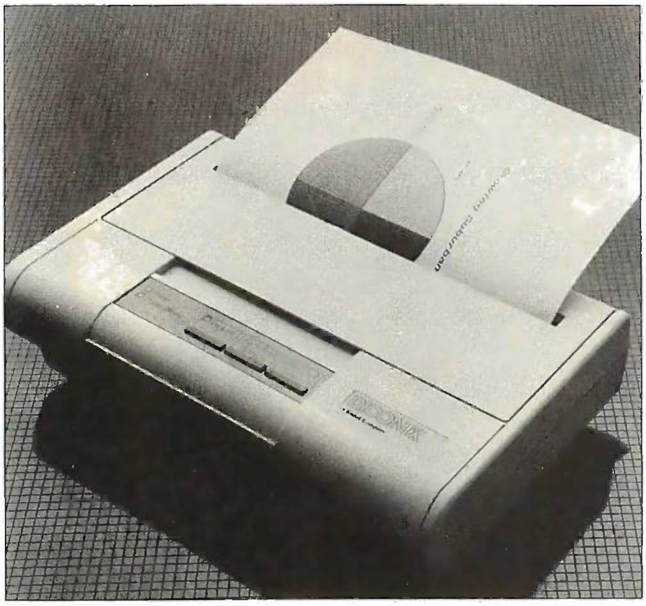
Inquiry 133 for End-Users. Inquiry 134 for DEALERS ONLY.

PERIPHERALS

## Ink-Jet Printer Weighs 4 Pounds

Designed for use with portable computers, a 4-pound ink-jet printer called the Diconix 150 operates at 150 characters per second in draft mode and can produce near-letter-quality text as well as italic, emphasized, and other print styles. The printer, which measures about 2 by 6½ by 11 inches, connects to computers through a standard parallel port. The device emulates the IBM Proprinter or Epson FX and will print on single sheets of paper, continuous-feed paper, and transparencies.

Priced at $479, the Diconix 150 works with replaceable ink-jet cartridges ($9.95). Its C-size batteries are contained inside the platen, and it's supplied with an AC power adapter. A serial version of the printer and a variety of color ink-jet cartridges will be available. Contact Diconix Inc., 3100 Research Blvd., P.O. Box 3100, Dayton, OH 45420, (513) 259-3100.
**Inquiry 569.**



*The Diconix 150, a portable ink-jet printer.*

## EPROM Burner

Hippopotamus Software announced an EPROM burner that works with the IBM PC and compatibles, Atari ST, and Commodore Amiga. The burner lets you read, verify, modify, and burn most popular EPROMs.

No personality modules are required for the different EPROM types. The system controls the burn voltage levels required by different chips and changes pin-outs on the zero insertion force socket to accommodate 2764-, 27128-, 27256-, and 27512-type EPROM chips. The software enables you to edit the EPROM's contents and to read or write files in binary, Intel, or Motorola formats.

To install the burner you connect it to an 8-bit parallel printer port. All necessary voltages are generated by the wall-plug transformer that comes with the unit. The burner costs $139.95 for the Atari ST and $199.95 for the IBM PC and Amiga. Contact Hippopotamus Software Inc., 985 University Ave., Suite 12, Los Gatos, CA 95030, (408) 395-3190.
**Inquiry 570.**

## Optical Disk Drive from N/Hance

The N/Hance 525, an optical disk drive from N/Hance Systems, provides 230 megabytes of formatted storage for IBM PCs and compatibles. The drive comes with a 5¼-inch optical disk, a short-slot controller card, and device driver software. The system is priced at $3495.

The drive's data transfer rate is 2.5 megabits per second; its average access time, the company says, is comparable to that of a hard disk drive. You can use the drive externally with its own power supply or mount it inside the computer. An optional $1000 software package lets you index and search for up to 1 million words. Contact N/Hance Systems, 908R Providence Highway, Dedham, MA 02026, (617) 461-1970.
**Inquiry 571.**

## Tape Backup for Apples

The B-Sider is a tape backup system that works with either the 10-megabyte Sider or 20-megabyte Sider II hard disk drives for the Apple IIe and II+. The tape drive uses a 20-megabyte streaming cassette tape and attaches to the same host adapter that the hard disk drives use. Contact First Class Peripherals, 3579 Highway 50 E, Carson City, NV 89701, (800) 538-1307.
**Inquiry 572.**

## Two Megabytes for the Amiga

Comspec Communications of Canada announced the Microshare AX 2000, a 2-megabyte RAM expansion unit for the Commodore Amiga that you install in the expansion port on the right of the system unit. Other peripherals that you might want to install in the Amiga's expansion port can be installed in the AX 2000's port.

The AX 2000 sells for $1079 in the U.S. ($1307.95 in Canada). Contact Comspec Communications Inc., 153 Bridgeland Ave., Unit 5, Toronto, Ontario M6A 2Y6, Canada, (416) 787-0617.
**Inquiry 573.**

## Digitizing Tablet

Jandel Scientific has released the Sigma-Scan, a digitizing tablet and software designed for digitizing and measuring areas on photomicrographs, x-rays, maps, strip charts, and other two-dimensional surfaces. The 12- by 12-inch tablet can measure areas, distances, perimeters, curved lines, angles, and slopes. It can make object counts and determine *x,y* coordinates.

The software lets you perform statistical analysis on the data, including means, standard deviation, correlations, t-test, transforms, linear regression, and screen plots. You can save data on disk in ASCII or DIF files and use it in other applications programs. The unit will also work with user-written BASIC programs.

The system retails for $1195 and works with IBM PCs and compatibles. Contact Jandel Scientific, 2656 Bridgeway, Sausalito, CA 94965, (415) 331-3022.
**Inquiry 574.**

*(continued)*


Clipper is the fastest dBase III and dBase III Plus™ compiler available. Nothing else comes close. When performance counts, experts rely on Clipper for more speed, more power, and more creative freedom. You can, too. Call for details.
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ADD-INS

## Speaker-independent Voice Recognition

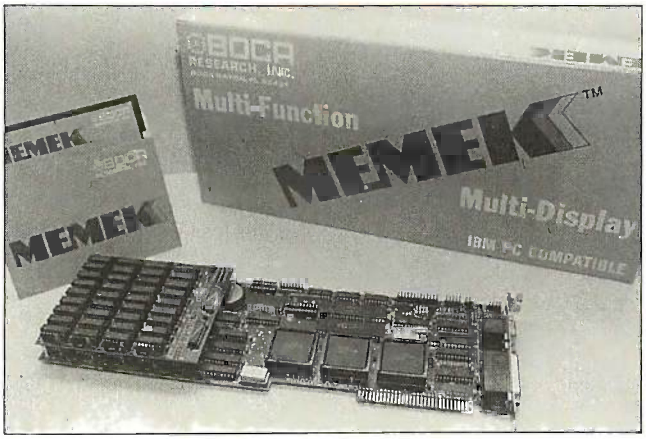
Votan has announced a speech-recognition add-on board for the IBM PC and compatibles that doesn't require training for a specific voice. This Speaker Independent Recognition (SIR) system recognizes digits, yes and no, and customized vocabularies. The board also provides continuous speech recognition in speaker-dependent mode, can perform all of its functions over the telephone, and offers digital recording and playback of speech.

Votan sells an optional telephone interface that includes auto-dial, auto-answer, call progress monitoring, and Touch Tone sending and receiving functions. The telephone management capability lets you set up your PC to handle background answering of the phone with stored templates for general or privileged caller responses.

The SIR card sells for $1350. An optional telephone interface costs $350. Contact Votan, 4487 Technology Dr., Fremont, CA 94538, (415) 490-7600.
**Inquiry 575.**

## Coprocessor Plus Expanded Memory

The Number Smasher/ECM, a coprocessor board from MicroWay, offers up to 1 megabyte of extended memory and a 9.54- or 12-MHz math coprocessor. The board runs in two modes. In the first, you can boot DOS with 512K to 704K bytes of memory. The memory above 640K that does not conflict with existing hardware can be turned on using switches for use as a RAM disk, print spooler, or disk cache.



*The Memek board adds graphics and memory to* IBM PCs.

In the second mode, you can configure the board with the optional Megaswitch MMU and Megabank software so that a megabyte of memory is available for DOS applications. Software that does not write directly to the screen will work in this mode, which the company calls Extended Conventional Memory. The company will also offer drivers for programs such as 1-2-3, SideKick, and others that write directly to the screen.

The Number Smasher with 512K bytes costs $599. Options include a 12-MHz clock, real-time clock/calendar, and reset switch ($149); a 12-MHz 8087 coprocessor ($250); and the Megaswitch MMU ($100). Contact MicroWay, P.O. Box 79, Kingston, MA 02364, (617) 746-7341.
**Inquiry 576.**

## 68020 Board for IBM PCs

The QT 20x is a 68020 upgrade for IBM PCs and compatibles. The multiuser, multitasking board replaces the computer's motherboard and runs the OS-9/68K operating system.

The basic system includes a 12.5-MHz 68020 microprocessor, 2 megabytes of RAM, one parallel port, four serial ports, a real-time clock with battery backup, and room for additional ROM. Also, six full-size expansion cards with 2 megabytes of RAM and four serial ports each can be added, which allows for a total of 14 megabytes of RAM and up to 28 users.

The price for the basic board with 2 megabytes of RAM is $2995. For more information, contact Frank Hogg Laboratory Inc., 770 James St., Syracuse, NY 13203, (315) 474-7856.
**Inquiry 577.**

## Logic Analyzer on a Board

The Logic-20 from Bitwise Designs is a 20-MHz logic analyzer that plugs into a single slot in an IBM PC. The company says the board is capable of a 2-nanosecond setup time and, with the use of the optional Doubler pod, is capable of 40-MHz sampling over eight channels with a 512-word memory depth.

The pods that are standard with the analyzer provide 16 channels of sampling; the standard sampling rate is 20 MHz with a minimum period of 50 ns. The trace size is 16 bits by 256 words and is expandable to 64 bits. Samples can be made synchronously with an external clock for state analysis or asynchronously with an internal variable-speed clock for timing analysis. The board's software enables you to specify trace type, label data points, and display the data in timing diagrams or state tables.

The Logic-20 is priced at $1495. The optional pod is $225. Contact Bitwise Designs Inc., 1223 Peoples Ave., Troy, NY 12180, (518) 274-0755.
**Inquiry 578.**

## More Boards in One

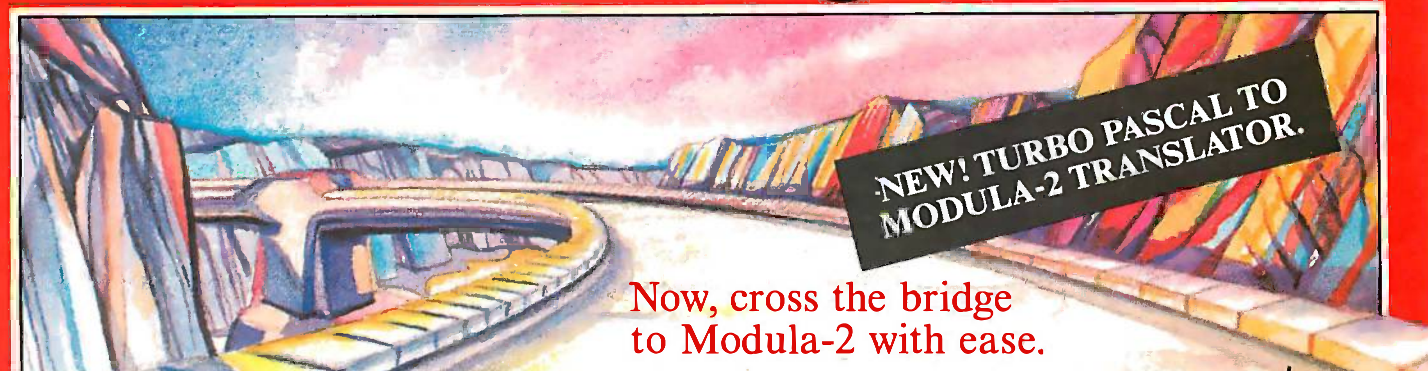
Boca Research's Memek is a multifunction display board for the IBM PC, XT, and compatibles that includes a color graphics adapter, monochrome graphics adapter, and up to 2 megabytes of expanded (EMS) memory. The board's VLSI chips emulate Hercules Graphics and Plantronics color adapters as well as IBM Color Graphics and Monochrome Display adapters.

Other features include a serial and parallel port, installation and diagnostic software, and RAM disk and print spooler utilities. A game port and clock/calendar are optional. You install the board in one slot in the PC or XT; no switches or jumpers need be set.

The price of the basic board with 256K bytes of RAM is $645. A 1-megabyte board costs $795, and an additional 1-megabyte board costs $345. Contact Boca Research Inc., 6401 Congress Ave., Boca Raton, FL 33431, (305) 997-6227.
**Inquiry 595.**

(continued)

# This is the Modula-2 compiler *everybody's* been waiting for...




# LOGITECH MODULA-2/86

This is Modula-2 at its *absolute* best. It's a fully integrated development environment that takes into account what you need as a programmer. Without leaving the Editor, you can call the compiler, linker and utilities.

With Logitech's Modula-2, you'll have the ability to edit several files at once, comparing, window to window, various code modules. You can even move from window to window compiling, linking, debugging and running.

The compiler has the kind of power and room to breathe that you really need in today's complex applications. It is as *easy* to use as Turbo Pascal, without your programs being limited to 64K of code.

At your command will be the libraries of modules that make Modula-2 a programmer's dream. It has essentially the same structure as Pascal with the major addition of a library organization of code modules that allow you to put together programs on a solid, block-by-block, foundation of proven code.

Whether you're working with a module of your own making, or one of the many in our library, you'll find the system by which each module is identified, described and stored an organizational masterpiece. And that's at the heart of Modula-2.

Underneath the sophisticated system is a Modula-2 compiler that is the result of years of development and proven use in industry. We run on the Vax*, and we run on the IBM PC. And the code is portable–from one to the other.

*Best of all . . . you can have it right now!*

**Logitech Modula-2/86** Complete with Editor, Run Time System, Linker, Cursor-positioning debugger, 8087 Software Emulation, BCD module, Logitech's extended library, Utility to generate standard .EXE files, Turbo Pascal (and standard Pascal, too) to Modula-2 translator *(included without charge until 8/1/86)*, and much, much more! $89

**Logitech Modula-2/86 with 8087 support** Even if you haven't yet gotten an 8087 co-processor, you can still use this version. $129

**Logitech Modula-2/86 Plus** For machines with 512K or more. Takes advantage of the larger memory to increase compilation speed by 50%! Supports 80186 and 80286 as well as 8086 and 8088. Includes 8087 and 80287 support, too. $189

**Window Package** Now you can build true windowing into your Modula-2/86 code with ease, too. Very powerful and very full, yet only 15K in size. Features virtual screens, color support, overlapping windows and a variety of borders. $49

**Run Time Debugger** (source level) Much more powerful than just a symbolic RTD. Display source code, data, procedure call chain and raw memory. Set break points, assign values to variables, pinpoint and identify bugs in your source. The ultimate professional's tool! $69

**Utilities Package** Features a post-mortem debugger for static debugging. If a program you've written crashes at run time, the situation is frozen, and you can pinpoint, in source, the cause of the error and the data at that moment. Also includes a disassembler, a cross reference utility and a "version" utility that allows conditional compilation. $49

**Make Utility** Automatically selects modules affected by code changes for quick and minimal re-compilation and relinking. Even figures out dependencies for you. $29

**Library Sources** Source code for our major library modules is now available–for customization or exemplification. $99

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|---|---|
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| ☐ Logitech Modula-2/86 $129 with 8087 support | ☐ Run Time Debugger $69 (source level) |
| ☐ Logitech Modula-2/86 Plus $189 | ☐ Utilities Package $49 |
| *Please add $6.50 for shipping and handling.* | ☐ Make Utility $29 |
| | ☐ Library Sources $99 |

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Inquiry 212

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SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

## Quartet for Modula-2 Programmers

Star Value Software has released four software-development tools for Modula-2 programmers.

TEXTIO, a display and printer library, offers pop-up windows, foreign representations of numbers and dates, and interconnecting line-drawing routines.

GRAPHIX is an interface to MetaWindow, a graphics package from MetaGraphics that features dynamic hardware determination, hardware independence, and local virtual coordinates systems.

MAKE is designed to help you find modules that need recompiling and relinking after you've been editing.

XREF is a cross-reference tool that can process a list of source files (DEF or MOD or both) to clarify module relationships. It prints the line number and module name for each identifier reference.

All four tools are sold separately. TEXTIO and GRAPHIX cost $79 each; MAKE and XREF, $59 each. Contact Star Value Software, 12218 Scribe Dr., Austin, TX 78759, (512) 837-5498.
**Inquiry 579.**

## System-Generation Facility

Tominy's MACH I PAD (Professional Application Developer) for IBM PCs and compatibles is a single-user system-generation facility the company says is designed for "serious" programmers working on business applications. Components include a relational DBMS, a fourth-generation language called LOGIC, a program generator, an automatic screen editor, and a query/report generator. The environment also contains 80 utilities.

Among MACH I PAD's other features are menu and screen painting, program framing, interactive test facilities, on-line help, and global directories.

PAD requires PC-DOS 2.1 or later, 128K of memory, and at least 8 megabytes of disk storage. The system is upwardly compatible with Tominy's MACH I for multiuser micros, mainframes, and minis. It sells for $199.95. Contact the MACH I PAD Division at Tominy Inc., 4221 Malsbary Rd., Cincinnati, OH 45242, (800) 543-8628; in Ohio, (800) 445-1737 or (513) 984-6605.
**Inquiry 580.**

## Program Converter

Metamorphosis is a program designed to facilitate the transformation of any syntactically reducible character-oriented file to any other form and maintain the synonymy. Shannon Associates says its product will translate any source program from one language to another, any language to C, and will also perform dialect conversions.

You can use Metamorphosis to implement compilers, assemblers, macro processors, and query-language processors; reformat character-oriented database files; and analyze grammars, natural languages, sequential and parallel procedures, and computational signatures.

Metamorphosis runs on the IBM PC and compatibles with 384K of RAM, two 360K floppy disk drives, and MS- or PC-DOS 2.0 or later. It costs $387. Contact J. H. Shannon Associates Inc., P. O. Box 597, Chapel Hill, NC 27514, (919) 929-6863.
**Inquiry 581.**

## Amiga FORTRAN 77 Compiler

Absoft Corporation, which developed Microsoft's FORTRAN compiler for the Macintosh, has adapted that compiler to run on the Commodore Amiga. AC/FORTRAN is an ANSI FORTRAN 77 compiler that comes with a full-screen source-level symbolic debugger, linker, library manager, IEEE single- and double-precision floating-point software, VAX extensions, and C interface. Additional development tools are support of overlays and virtual arrays, as well as dynamic linking of programs at run time.

The disk-based compiler takes only 46K of RAM. Because Microsoft's FORTRAN compiler for the Mac is a version of AC/FORTRAN, programs written with the Microsoft package can be ported directly to the Amiga, Absoft says.

AC/FORTRAN for the Amiga costs $295. Contact Absoft Corp., 4268 North Woodward, Royal Oak, MI 48072, (313) 549-7111.
**Inquiry 582.**

## Multiuser OS Designed for Intel 80286

THEOS 286-Virtual, a multiuser, multitasking operating system designed for Intel's 80286 chip in protected virtual address mode, can address as much as 16 megabytes of real memory space. Using an 8-MHz 80286, the system can support 14 to 20 users.

The OS provides security features that prevent someone from crashing a system or writing over files.

The 16-bit operating system appears just like its counterpart for Intel's 8086/8088/80186 chips (THEOS 86), but it executes instructions two to three times faster, according to THEOS Software.

The company has also developed a program that runs MS-DOS packages in a multiuser environment under 286-V. THEOS says THEO-DOS enables standard MS-DOS programs and single applications under Microsoft Compiled BASIC to run without modification under 286-V; the programs, however, must be hardware-independent, and software that's copy-protected or requires a key disk will not work in the multiuser mode.

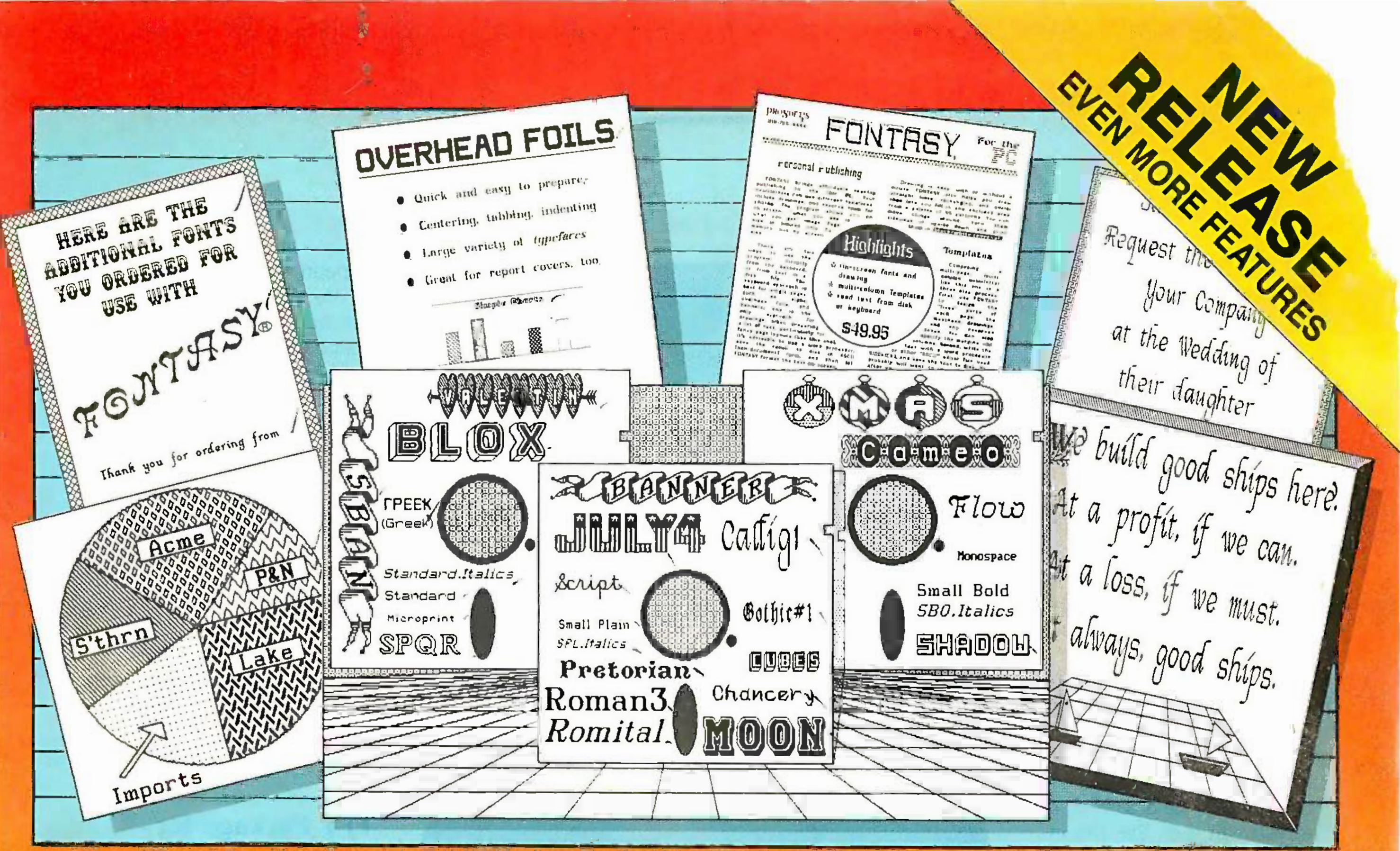
THEOS 286-V is available for the IBM PC AT and compatibles; the Altos 886, 1086, and 2086; and the Third Coast Technologies 286V Supermicro. It costs $695 ($895 for high-end machines). THEO-DOS costs $250, or you can get it bundled with THEOS 286-V at a star ing price of $845. Contact THEOS Software Corp., 201 Lafayette Circle, Suite 100, Lafayette, CA 94549-4370, (415) 283-4290.
**Inquiry 583.**

## BASIC Subprograms for Macintosh

Cut & Paste BASIC—Overview Library is a collection of subprograms you can incorporate into your own applications. The subprograms use generic calling conventions. Library categories include data manipulation, math routines, finance, decision management, statistics, and cryptology. Each subprogram comes with an example you can run to demonstrate it.

Cut & Paste BASIC for the Macintosh costs $24.95. Contact Technisoft Engineering, P.O. Box 563, Bremerton, WA 98310, (206) 598-4177
**Inquiry 584.**

*(continued)*

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Inquiry 287

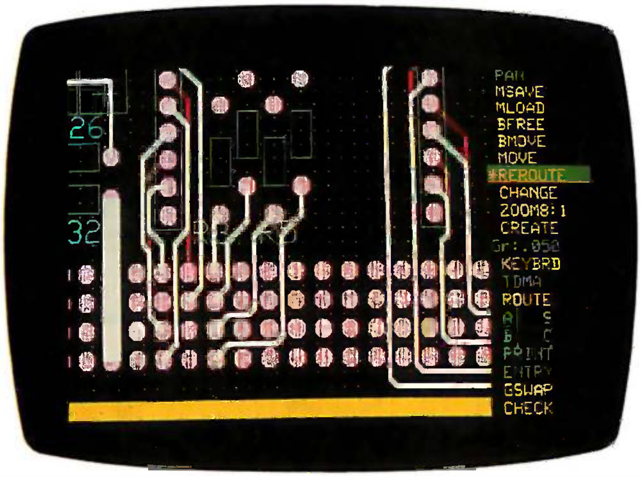
SOFTWARE • SCIENTIFIC AND ENGINEERING

## CAE/CAD Package for IBM PCs, Compatibles

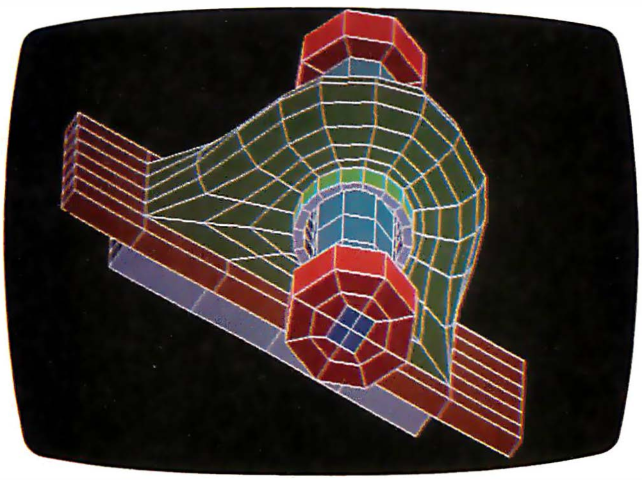
EE Designer consists of three integrated programs for schematic design, circuit simulation, and layout of printed circuit boards. The software lets you position component elements, lines, and graphics shapes using a mouse, keyboard, or digitizer pad. You can take schematic symbols from a library that comes with the package or make your own.

A schematic-capture module maintains connectivity between components and symbols in the database. Another program moves design data to a disk file; you can then use the information for circuit simulation, reports, and input to the physical layout module. The circuit-simulation module contains 150 common TTL and CMOS devices. The simulator lets you enable any subset of the circuit you're analyzing. Schematics can be sent to a dot-matrix printer or plotter.

EE Designer runs on IBM PCs and compatibles with 512K of memory, an IBM color adapter or equivalent or a hi-res Tecmar Graphics Master color card, and input and output devices. The program costs $975. Contact Visionics Corp., 1284 Geneva Dr., Sunnyvale, CA 94089, (408) 745-1551.
**Inquiry 585.**




*EE Designer, software for drawing and simulating circuit boards.*



*Model analysis with* PCTRAN Plus.

## PC XT, AT Package for Finite-Element Analysis

Brooks Scientific offers an equation solver for finite-element analysis on an IBM PC, XT, or AT. The size of the problems it can tackle is limited only by hardware, the company says.

PCTRAN Plus uses an "out of core" approach coupled with a bandwidth optimization routine for solving problems. The package can also solve extremely large 3-D solid models by transferring preprocessing files to mainframe FEA programs for analysis. Small- to medium-size FEA models can be built with a fine element mesh. Brooks Scientific says there's no limit to the number of nodes, elements, constraints, forces, and degrees of freedom in an analysis with PCTRAN Plus.

The software runs on the IBM PC XT and AT or compatibles with 512K of RAM, a floating-point math chip, and a graphics display card. PCTRAN Plus prices start at $1295. Contact Brooks Scientific Inc., 55 Wheeler St., Cambridge, MA 02138, (617) 491-9220.
**Inquiry 586.**

## Mac Package Captures Schematics

McNet turns a Macintosh into a workstation for digital logic design. The program includes a tool for schematic entry, a net list and parts list generator, and a component library. Argus says the package is intended to relieve engineers of repetitive design tasks.

The schematic-capture software provides commands for copying, moving, rubberbanding, undoing, and selecting by area. An automatic bus function features bus-rip, bus-ripper numberer, bus width tracker, and bus name tracker. You need to name only the bus signals entering or leaving the design page.

McNet runs on a 512K Mac or Mac Plus. It costs $150. Contact Argus Software, Musgrove Bldg., 2 Elm Square, Andover, MA 01810, (617) 475-8952.
**Inquiry 587.**

## FFT Package for IBM PCs

Snap-FFT converts time-domain data acquired with HEM's Snapshot Storage Scope (see What's New, December 1985, page 432) to the frequency domain using a fast Fourier transform algorithm. Like Snapshot, Snap-FFT is menu-driven and requires no programming.

The analysis package calculates amplitude and phase for four channels of data and takes the amplitude ratio of any two sets of channels. It also takes the difference in phase angle to determine phase lag. Data output can be tabular or graphic and shown on the screen, stored on disk, or printed.

Snap-FFT runs on the IBM PC, XT, AT, or compatibles with 256K of RAM, an IBM or comparable graphics adapter, a monochrome monitor with graphics capability, and a DS/DD floppy disk or hard disk. It costs $295. Contact HEM Data Corp., 17025 Crescent Dr., Southfield, MI 48076, (313) 559-5607.
**Inquiry 588.**

*(continued)*

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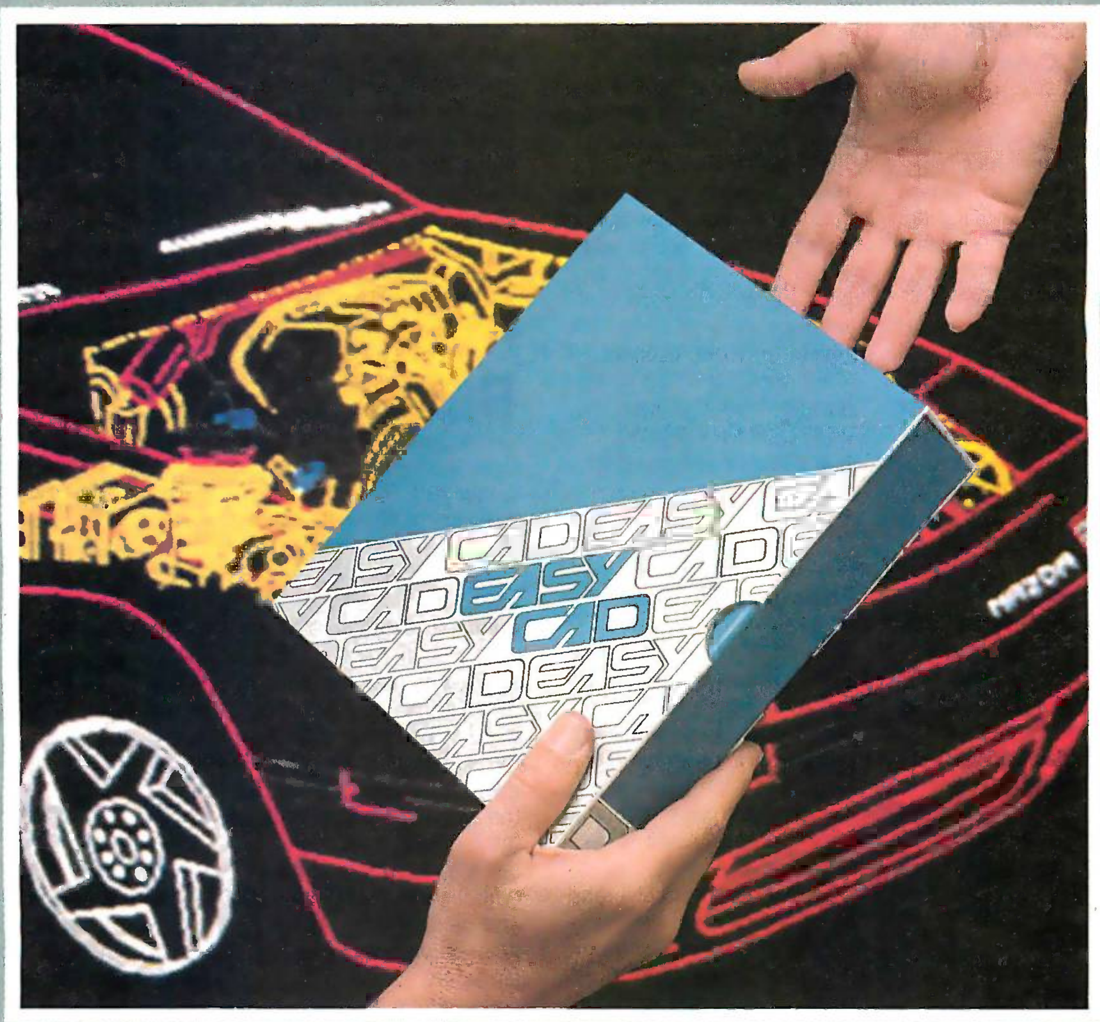


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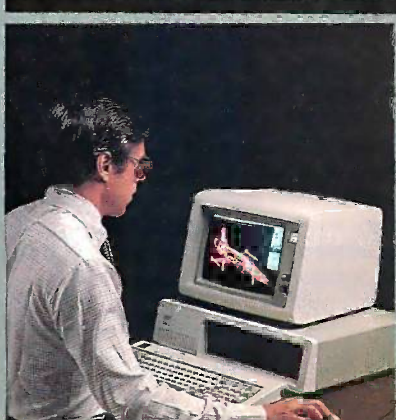
Inquiry 347



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## Communications Tools for Commodore Amiga

A-Talk, a communications and terminal program for the Commodore Amiga, lets you send files using Kermit and XMODEM (Amiga loadable files are stripped of extra data sent by XMODEM programs), exchange ASCII data with systems that don't support advanced protocols, and set parameters. A script language called Dial-A-Talk, coupled with a phone-number directory, lets you log on automatically through Tymnet, Telenet, or Uninet. The software also provides full ANSI terminal emulation, with options for resizable and full-screen windows.

The program, which is not copy-protected, sells for $49.95. Contact Felsina Software, 3175 South Hoover St., #275, Los Angeles, CA 90007, (213) 747-8498.
**Inquiry 589.**

## Spreadsheet Functions in an APL Environment

STSC's APL*Plus PC Spreadsheet Manager lets you enter and examine data in an APL environment and move data between APL workspaces and Lotus or ASCII files. APL spreadsheets can consist of character and numeric data. The package's editor is similar to that of a spreadsheet program. You can execute and store APL formulas for cells or ranges of cells, and you can sort columns or rows.

The Spreadsheet Manager incorporates direct import and export facilities for non-APL data formats. Data from Lotus spreadsheets or ASCII files can be transferred into APL variables or an APL spreadsheet file.

To use the program, you need STSC's APL*Plus PC System (release 5 or later), an IBM PC or true compatible, and at least 384K of RAM (more memory is recommended for working with large files). The Spreadsheet Manager works with Lotus 1-2-3 releases 1, 1A, and 2 and Symphony releases 1.0 and 1.1. It retails for $195. Contact STSC Inc., 2115 East Jefferson St., Rockville, MD 20852, (800) 592-0050; in Maryland or Canada, (301) 984-5123.
**Inquiry 590.**

## Four for ST Line

Solid Applications is offering four programs for the Atari 520ST and 1040ST.

STKey is memory-resident software for programming function keys; programming can be done from within an application. STKey costs $29.95.

DiskMenu, an archive and backup utility, provides a means of backing up a hard disk to a floppy disk. It comes with a tool for verifying disk directories and allocation tables. DiskMenu costs $49.95.

PCalc is a calculator package that can record, to disk or printer, any calculations performed. Simple programs can be set up in conjunction with STKey. PCalc lists for $29.95.

And PCommand, a command-line interface to TOS, supplies a command and batch-file facility compatible with PC-DOS. It can run TOS and GEM applications. It sells for $39.95. Contact Solid Applications Inc., 1333 Moon Dr., Yardley, PA 19067, (215) 736-2449.
**Inquiry 591.**

## Bulletin Board for Commodore 64/128

Blue Board, a bulletin-board system for the Commodore 64 or 128 (in C-64 mode) from SOTA Computing Systems, supports more than 200 on-line messages (maximum 1023 characters), as many as 220 users, and 25 sysop-definable subboards. It also provides "Scribbles," little subboards that can handle messages of 80 characters or less. The company says the software is designed to give the sysop total control; the operator can reconfigure most operational characteristics, including connect time, access levels, user IDs, and mail editing. The program is written in machine language.

Blue Board requires a disk drive (Commodore 1541 or equivalent) and a 300-bps auto-answer modem (C-1650 or comparable unit). It's priced at $69.95. Contact SOTA Computing Systems Ltd., 213-1080 Broughton St., Vancouver, British Columbia V6G 2A8, Canada (604) 688-5009. You can check out a system demo by dialing (604) 683-1914.
**Inquiry 592.**

## Mac HFS Accessory Bypasses Finder

PBI Software has developed a desk accessory for the Macintosh Hierarchical File System that's designed to provide quick access to files without going to the Finder. From within an application, you can use the program to locate files and the folders they're in by date or by partial/matching name. After finding a file, HFS Locator Plus can show information about it or delete, rename, move, or copy it.

HFS Locator Plus is compatible with all programs using the HFS format. The software costs $24.95. Contact PBI Software Inc., 1111 Triton Dr., Foster City, CA 94404, (415) 379-8765.
**Inquiry 593.**

## Telecommunications Package for Apple IIe/IIc

CommWorks, a telecommunications program for the Apple IIe and IIc, uses the AppleWorks file-folder format and features a text editor that can handle any ProDOS files (up to 35K), an automatic log-on facility, and on-line utilities that let you format disks and make subdirectories. You can define and save communications parameters and define as many as 18 sets of macros in each communications file.

The software supports ProDOS/AppleWorks and XMODEM file transfers. CommWorks functions with any Hayes (including the 2400-bps model), Apple, or Novation AppleCat modem. It runs on a IIe (with extended 80-column card and 128K) or IIc and costs $95. Contact PBI Software Inc., 1111 Triton Dr., Foster City, CA 94404, (415) 349-8765.
**Inquiry 594.**

WHERE DO NEW PRODUCT ITEMS COME FROM?
*The new products listed in this section of* BYTE *are chosen from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers, distributors, designers, and readers. The basic criteria for selection for publication are: (a) does a product match our readers' interests? and (b) is it new or is it simply a reintroduction of an old item? Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get further information, to* New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

# C·L·U·B·S A·N·D N·E·W·S·L·E·T·T·E·R·S

WESTERN INDIANA COMMODORE USERS (WICU), P.O. Box 1898, Terre Haute, IN 47808. Newsletter, BBS at (812) 232-0313, monthly meetings, public domain software. Dues: $12 annually.

INDEPENDENT COMPUTER CONSULTANTS ASSOCIATION (ICCA), Phoenix Chapter, P.O. Box 32115, Phoenix, AZ 85064, (602) 962-8010. Newsletter: $20 per year. Membership and monthly meetings: $50 per year.

NEC PC-8000 USERS GROUP, David Clark, 18 Provence St., MacGregor, Queensland 4109, Australia. Meetings, newsletter, public domain software library.

BAY AREA VICTOR*GROUP, M. J. Knobelsdorf, P.O. Box 50893, Palo Alto, CA 94303, (415) 820-5622. Newsletter, public domain library, meetings, and BBS.

*SPE MICROCOMP NEWS*, P.O. Box 833836, Richardson, TX 75083-3836, (214) 669-3377. Bimonthly newsletter published by the Society of Petroleum Engineers.

CLEVELAND AREA AMIGA USERS' GROUP, 3715 Townley Rd., Shaker Heights, OH 44122, (216) 295-1624. Meetings, public domain software library, and BBS. Membership fee: $30.

ENABLE USERS GROUP, 38 Glen Dr., Mill Valley, CA 94941. Meetings, newsletter. Membership: $5 sign-up fee; $20 annual dues.

SOUTH SHORE PORTABLE COMPUTER USERS GROUP (SSPCUG), Andrew Moore, P.O. Box 121, North Quincy, MA 02171, (617) 479-9208, evenings. Public domain software library, newsletter.

PROFESSIONAL COMPUTER CLUB EUROPE, Merle Spongberg, Box 6, Goerresstr. 10, D-6904 Eppelheim, Germany. Monthly meetings and newsletter for professional users of IBM PC-DOS and CP/M.

QL USERS AND TINKERERS ASSOCIATION (QUANTA), Brian Pain, 24 Oxford St., Stony Stratford, Milton Keynes MK11 1JU, England. Open to all Sinclair QL users. Monthly newsletter.

*HANDS ON!*, Technical Education Research Centers, 1696 Massachusetts Ave., Cambridge, MA 02138. $10 contribution requested for newsletter.

OMNIMUG, Dan Shafer, 1220 Edgewood Rd., Redwood City, CA 94062, (415) 361-8562. For users of Omnis-3 and Omnis-3–based applications. Newsletter, public domain disk exchange, referral service. Dues: $36 per year.

COMMODORE HARDWARE USER'S GROUP (CHUG), 1322 Fairview Dr., Greenfield, IN 46140. Includes a SIG for Amiga Computer Enthusiasts (ACE), meetings, newsletter, BBS at (317) 898-5027.

WASHINGTON AREA RAINBOW USERS GROUP (WARUG), P.O. Box 1940, Vienna, VA 22180. Monthly newsletter, BBS at (703) 359-6549. Dues: $16.

ADAM & EVE APPLE USERS' GROUP, P.O. Box 5344, Madison, WI 53705, (608) 255-1856. Monthly newsletter, public domain library, meetings, SIGs, 24-hour BBS at (608) 255-2755. $15 annual dues.

NATIONAL X/LISA USERS GROUP, P.O. Box 450676, Miami, FL 33145-0676. Free membership, semiannual newsletter, BBS at (305) 445-6481.

THE BOSTON COMPUTER SOCIETY'S ATARI ST USERS GROUP, One Center Plaza, Boston, MA 02108, (617) 296-8286. Bimonthly newsletter (*J-BUG*), regular meetings, public domain disks.

MAINE MACINTOSH OWNERS & OPERATORS SOCIETY (MMOOS), Mike Roderick, Pickard Theater, Bowdoin College, Brunswick, ME 04011, (207) 725-8731, ext. 5344. Meetings twice a month, newsletter, library, discounts, BBS at (207) 725-8456. Dues: $40 annually.

CLUBS AND NEWSLETTERS *is an acknowledgment of new clubs and newsletters received at* BYTE. *Allow at least four months for your club's mention to appear. Send information to* BYTE, *Clubs and Newsletters, One Phoenix Mill Lane, Peterborough,* NH 03458.

## FIXES

### Improving the Runge-Kutta BASIC Program

Several readers wrote to David M. Leo about the fourth-order Runge-Kutta BASIC program accompanying his "Response of a System to Complex Driving Forces" (listing A on page 197 of the April issue). He agrees with J. C. Sprott, of Madison, Wisconsin, that the variable COUNT should be reset to zero after each time step. This is done most simply by adding:

```
285 COUNT=0
```

Mr. Leo noted the step was deleted unintentionally while removing the plotting statements from the program. "I didn't catch the omission since the error in peak amplitude was small," he said.

The program can be further improved, as suggested by John McCoy of Sam Houston State University, by changing four other statements. First, rewrite line 230 like this:

```
230 COUNT=COUNT+1:ON COUNT
  GOTO 240,260,270,280
```

And then, in lines 250, 260, and 270, IF . . .THEN 210 can be shortened to GOTO 210.

### More on Runge-Kutta

Benku Thomas, author of "The Runge-Kutta Methods" (April), writes to inform us of errors in his article.

In tables 7 and 8, which are labeled "Absolute Global Errors," the negative signs should not appear on the global errors obtained using the RKG method.

In the algorithm in figure 3, the condition in step 8 should be: for $|x| \neq 0$.

### The Real Price of GCLISP 286 Developer

We erred by $800 in a What's New description of the GCLISP 286 Developer from Gold Hill Computers (April, page 387). The real price is $1195, not $1995. Our apologies to the company.

For more information on the package, contact Gold Hill Computers Inc., 163 Harvard Ave., Cambridge, MA 02139, (617) 492-2071.

## UPDATE

### Author Adapts Navigation Program to Run on IBM PC

Frederic N. Rounds reports that since his article "Navigation: Putting the Microcomputer to Work at Sea" appeared in our March 1985 issue, he has received hundreds of letters from people, many of whom were interested in an IBM PC version of the Sunfix program listing, which was written for the TRS-80.

Well, sailors, Mr. Rounds has adapted Sunfix for the IBM PC. He has also rewritten the user interface for greater suitability on small boats. The new version is available on disk for $19.95. You can order it from the author at 894 Persimmon Ave., Sunnyvale, CA 94087.

## BYTE'S BITS

### Italy Calling

Organizers of the Second International Joint Conference on Theory and Practice of Software Development (TAPSOFT) have put out a call for papers. The conference consists of three events.

The Colloquium on Trees in Algebra and Programming (CAAP '87). Topics include formal languages and automata, semantics of sequential and concurrent programs, theory of data structures and databases, and formal specification of software systems.

The Colloquium on Functional and Logic Programming and Specifications (CFLP). Topics include logic of programming, programming language notions, and practical development of applications.

The Advanced Seminar on Foundations of Innovative Software Development focuses on new directions in software development.

Deadline for submission of drafts is September 1. Papers for CAAP should go to Professor Ugo Montanari, Dipartimento di Informatica Università di Pisa, Corso Italia 40 I-56100 Pisa, Italy. Papers for CFLP should be sent to Professor Giorgio Levi at the same address. For information about the conference, write to Dr. Pierpaolo Degano, also at that address.

TAPSOFT '87 is scheduled for March 23–27, 1987, in the city with the leaning tower.

### Do-It-Yourself Compaq Upgrade

Applied Foresight is selling a 57-page report that's supposed to help Compaq computer owners upgrade their machines. Written by R. H. Martin, "*Upgrading Your Compaq Plus or Portable with* 20–40 MB *Disk Space &* A 640K *Motherboard*" is reportedly based on real updates of those machines. Martin notes that the upgrade is a complex job because of "portability constraints, the 120-watt power supply. . . , and the limited number of slots available." The report costs $17.50 in the U.S. and Canada, and $30 everywhere else. You can order it by sending the money to Applied Foresight Inc., P.O. Box 20607, Bloomington, MN 55420.

# A·S·K B·Y·T·E

*Conducted by Steve Ciarcia*

## CROSS ASSEMBLER

Dear Steve,

I am desperately in need of an Intel 8051 microcontroller cross assembler, written in any high-level language. Where can I possibly get one?

CLAUDIO ROLAND SONNENBURG
*São José dos Campos, Brazil*

*I don't know of anyone supplying cross assemblers in a high-level language. By this I mean source code to be compiled on your computer. Cross compilers that will run on most MS-DOS or CP/M systems are available from*

*Avocet Systems Inc.*
*P.O. Box 490-B7*
*Rockport, ME 04856*
*(207) 236-9055*

*Another source for cross compilers that will run on some UNIX and PCOS systems in addition to MS-DOS and CP/M is*

*2500 AD Software Inc.*
*17200 East Ohio Dr.*
*Aurora, CO 80017*
*(303) 369-5001*

*If you are using a minicomputer or a mainframe, you might be able to obtain the cross assembler you need from the computer's manufacturer.*—Steve

## IMAGE BUFFER

Dear Steve,

The articles in the November 1985 BYTE on the state of image processing reminded me of an integrated circuit I've heard about. It is a high-density serial image buffer. Is such a memory chip available? If so, where can I get it?

GREG SMITH
*Florissant, MO*

*Texas Instruments manufactures a line of video RAM chips similar to what you describe. These are dual-port memory chips with a built-in high-speed serial buffer (shift register) capable of speeds up to 150 megahertz. One port is sequential access, connected to the serial buffer; the other port is random access. The usual method of using this chip in video applications is to input the data through the random access port and output it to the video controller through the sequential access port. These chips, known as the TMS4161 family, are available in modules of 64K by 4 or 5 bits, 256K by 4 or 5 bits, and 64K by 1 bit. Contact Texas Instruments at P.O. Box 809066, Dallas, TX 75240, for more information and data sheets.*

*NEC manufactures a similar series of chips. Its address for technical data is NEC Electronics Inc., 401 Ellis St., P.O. Box 7241, Mountain View, CA 94039-9978.*
—Steve

## OPERATING SYSTEMS

Dear Steve,

I recently started a project to design and build a computer based on the 68000 microprocessor. I have almost finished construction, and I've already built a serial EPROM programmer as shown in your February 1985 article. My plan is to put my bootstrap loader and monitor in EPROM and then use this to install a serious operating system. I'd like to use one of the more advanced systems, perhaps one of the many UNIX derivatives. However, I have already contacted several manufacturers, including Microware and Digital Research, and was told that they sell only to OEMs. Writing to magazine advertisers offering operating systems with their systems proved fruitless as well. No one will sell me a single copy that I could install myself. Can you give me some sources? What are the chances of successfully converting a system configured for a Cromemco or a CompuPro computer?

JIM CASTLEBERRY
*Windermere, FL*

*It seems that most companies that catered to the hobbyist market now find they can't make a profit that way. One obvious problem is that if you buy an unconfigured operating system, the company must also deliver enough source code to enable you to configure it to your system. Ads from a few companies indicate that they might sell single copies.*

*Oasys (60 Aberdeen Ave., Cambridge, MA 02138, (617) 491-4180) sells lots of compilers, interpreters, and programming tools. The company also lists operating system kernels in its ads.*

*I know you contacted Microware Systems Corporation (1866 Northwest 114th St., Des Moines, IA 50322, (515) 224-1929), but its current advertising mentions a PortPak that lets you configure Microware's OS-9 to custom systems. Maybe this company will tell you where to buy a copy if it doesn't sell direct to the public.*

*Another possibility is presented in the article "A Simple Multitasking Operating System for Real Time Applications" by Nicholas Turner in the January 1986 issue of* Dr. Dobb's Journal. *Contact Turner at*

*Terra Nova Communications*
*10 McGranahan Court*
*Boulder Creek, CA 95006*
*(408) 338-9510*

*You could probably adapt an operating system like CP/M-68K from Cromemco or CompuPro (Viasyn) if they deliver the BDOS source code. CP/M was designed to be easy to configure to most systems, and I assume CP/M-68K is written with the same philosophy. Without the source code, however, it would be nearly impossible to get it running on a foreign system.*—Steve

## SANYO SOFTWARE

Dear Steve,

I bought a Sanyo MBC 555-2 about a year ago and have been extremely dis-

(continued)

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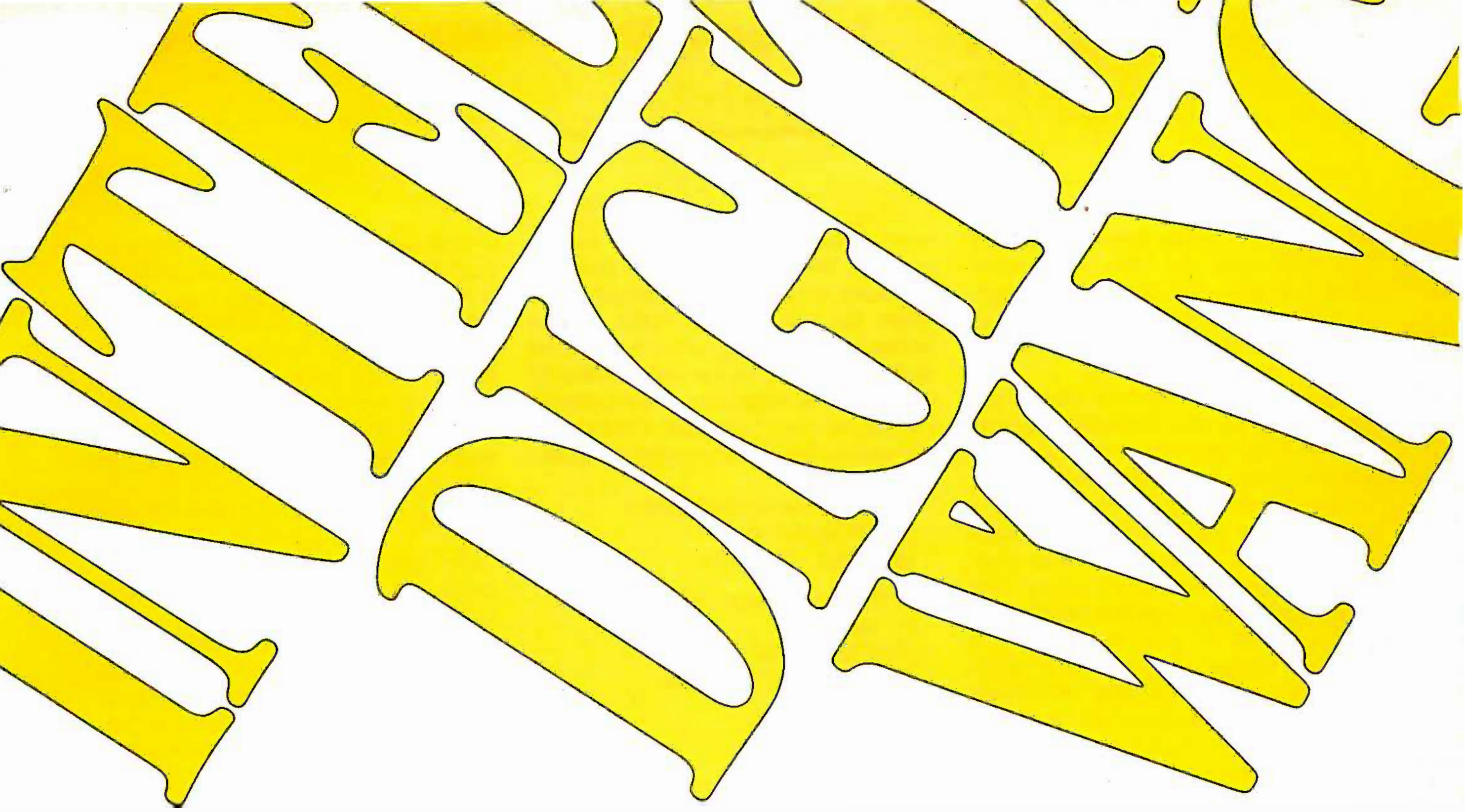
*The Ask BYTE staff includes manager Harv Weiner and researchers Eric Albert, Bill Curlew, Ken Davidson, Jeannette Dojan, Jon Elson, Roger James, Frank Kuechmann, Dave Lundberg, Edward Nisley, Dick Sawyer, Andy Siska, and Robert Stek.*



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1430 West Wrightwood
Chicago, Illinois 60614

*In Illinois call 312-472-6659.

Inquiry 220

satisfied with its performance. I upgraded it to 256K bytes and have two double-sided disk drives. Its IBM PC compatibility is relatively poor. As far as I'm concerned, it has not fulfilled the advertising claims of the company.

I have had a difficult time finding any software that will run on it, especially software involving graphics. I was aware of problems with graphics compatibility at the time I purchased the machine, but I assumed there would be Sanyo software available to offset the shortcoming. That idea has since been proven wrong. The only IBM software I have been able to run without a hitch is Turbo Pascal.

Can you suggest a solution to my problem? How can I make the MBC 555-2 more PC compatible, and where can I find software to run on it? I have heard of a video RAM board that will produce IBM graphics; is it all it's cracked up to be? I would appreciate any comments or suggestions you might have.

VAUGHN S. BURCH
*Lancaster, CA*

*There probably isn't much you can do in a general way to make your MBC 555-2 more compatible with software written for the IBM PC.* Computer Shopper *magazine runs a monthly column, "The Silver Box" by Richard Fujita, on the Sanyo, and you may find some tips there that will help you locate compatible software. Another suggestion is users groups. I found two Sanyo groups in California in the current issue of* Computer Shopper:

*Sanyo-PC-Hacker/Newsletter*
*12450 Skyline Blvd.*
*Woodside, CA 94062*

*Sanyo User Group SFBA*
*c/o Valcon*
*1260 Westwood St.*
*Redwood City, CA 94061*

—Steve

### HIGH-DECIBEL FANS

Dear Steve,

A source of constant annoyance to me is the loudness of the fan on my Heath/Zenith Z-110. Loud noise close to the operator can cause stress and hearing loss. It definitely makes concentration more difficult for me. Availability of quieter machines should discourage future sales of loud machines, despite their other good qualities. Decibel volume is not mentioned in BYTE's hardware reviews. I suggest that this information be included in reviews.

The Z-110's fan, which is part of the power supply, seems intended to cool only the power supply; convection should take care of the circuit boards. A power source located at some distance from the operator (outside the computer housing) could be baffled or enclosed to minimize noise.

Why don't designers use these general principles: A small fan has to run fast to do the job that could be done at a lower speed and hence more quietly by a fan with a larger blade diameter; those annoying ceiling fans and kitchen range-hood fans come to mind as analogies. If direction is changed 90 degrees, the sound required loses half its volume.

JAY H. BECKERMAN
*Fort Lauderdale, FL*

*I, too, am annoyed by the loud fans on some computers. Several factors should be considered when selecting a fan. Fans with the same airflow rating have*

(continued)

*markedly different amounts of noise, and fans in each standard physical size (boxer, miniboxer, sprite, etc.) trade airflow for silence. In many cases, computer fans are overspecified, and a quieter whisper-type fan can be substituted.*

*The reduced airflow can be compensated for by putting internal baffles in the computer to ensure that fan air gets to the components rather than passing the nonelectronic areas of the cabinet. These baffles can be made of cardboard and are taped inside the computer with duct tape or a similar material. The most annoying part of some axial-flow fan noise is the high-frequency noise peaks produced by the blades crossing the motor supports. Centrifugal or tangential blowers are free from these peak frequencies and produce only white noise. This is much less annoying than the whine of a fan. These blowers are usually larger than a fan, but since you are already considering external devices, you should look at them.*

*Other solutions include replacing the fan with a larger boxer-size fan of the whisper type. These rotate at about half the speed of smaller fans and yet produce higher airflow. Adding a speed control to the fan allows the speed to be reduced until an acceptable combination of airflow and noise is achieved.*—Steve



### RGB TO RF

Dear Steve,

Is there a relatively inexpensive device or kit available that converts the RGB output of the IBM PC color card to an RF signal so that the PC's color graphics can be displayed on an ordinary color TV set?

I know there are modulators to translate the composite video output of the color card to an RF signal that will produce graphics in shades of gray on TV sets, so it seems that people would also be interested in a device for translating RGB output to an RF signal.

RONALD PANNATONI
*Morristown, NJ*

*The composite video signal put out by the IBM PC Graphics Adapter Card contains color information, not just gray scale. If you modulate this signal and send it to a color TV, you get a color picture. Modulators, such as the ones sold by Radio Shack and some computer stores, will do the job for you.*

*The picture produced is satisfactory for noncritical graphics applications like games and marginal for text at 40 characters per line. Text at 80 characters per line is readable on a black-and-white TV but shimmers awfully on a color TV.*
—Steve ■

## CIRCUIT CELLAR FEEDBACK

### CLOCKS

Dear Steve,

As a result of reading your book *Build Your Own Z-80 Computer*, I have a few questions regarding microprocessor clock frequencies.

When using a Z80, which calls for a 2.5-megahertz clock, how close do you have to be to that frequency? I have noticed that Z80As used in Sinclair computers are operated at 3.25 MHz, yet the Z80A is listed as a 4-MHz CPU. Is there ever a situation when the CPU should be operated at its listed frequency? What is

(continued)

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# CIARCIA FEEDBACK

the clock signal used for, besides operating the CPU and synchronizing peripherals?

CORTNEY E. SMITH
*Tuba City, AZ*

*Crystal specifications for a microprocessor or microcontroller chip are maximum values. The Z80A, listed as a 4-MHz device, can be used with a crystal or other oscillator whose value is less than or equal to 4 MHz. Many system designers use a higher-value crystal frequency and divide it down to the required value. For example, a 12-MHz crystal oscillator may be divided down to 4 MHz through a couple of flip-flops connected as a divide-by-three circuit. The resultant 4-MHz signal can then be used to drive a Z80A.*

*Typically, oscillator frequencies are based on system performance requirements, the microprocessor or microcontroller being used in the design, and other devices on the board that require an oscillator. Keeping these considerations in mind, a designer will often use a device at its listed frequency—it is most common.*

*The clock signal found in all microprocessor and microcontroller applications is required to time events in the CPU, for example, instruction fetches, decodes, and operations. The clock is also responsible for generating device-select pulses (based on the microcomputer's output on the address bus) and reading and writing information from and to peripheral devices like memories, I/O ports, etc. A whole number used for the clock frequency (i.e., 4 MHz) simplifies timing calculations but is not essential.*—Steve

## ATARI SOFTWARE

Dear Steve,

I read your article in the June 1982 BYTE about building an interface for the VP-1000 videodisc player. I enjoyed it a great deal, except that I'm not quite good enough to write the software required for the less hardware-intensive version. Do you know of any such software written for the Atari 800? I have versions of Dragon's Lair and Space Ace that I would like to rewrite with the controller in software.

HARRY BROWN
*Las Vegas, NV*

*An Atari version of this software is probably out there somewhere, but I am unaware of anyone who has written the code. I can give you some basic guidelines to help you write the code yourself, but I suggest that you use the interface*

(continued)

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Listing 1: A BASIC *program to control a* VP-1000 *videodisc player.*

```
10 GOSUB 1000
20 GOSUB 1000
30 GOSUB 2000
40 X=PEEK (memory loc)
50 IF (X AND 16)=16 THEN GOSUB 2000 ELSE GOSUB 1000
60 IF (X AND 8)=8 THEN GOSUB 2000 ELSE GOSUB 1000
70 IF (X AND 4)=4 THEN GOSUB 2000 ELSE GOSUB 1000
80 IF (X AND 2)=2 THEN GOSUB 2000 ELSE GOSUB 1000
90 IF (X AND 1)=1 THEN GOSUB 2000 ELSE GOSUB 1000
100 GOSUB 1000
110 GOSUB 1000
120 END
1000 OUT port #,0:FOR CT=1 TO determined value: NEXT CT
1001 RETURN
2000 OUT port #,1:FOR CT=1 TO (determined value*2):NEXT CT
2001 RETURN
```

*version in figure 5 of the article, as this will make the project easier to understand. We are causing the interface to output the pulse train in time with the serial output of the computer. That is, the output timing of the serial bits, and therefore their value to the videodisc, is totally controlled by the computer program.*

*The software flowchart of figure 6 (left side) shows the concept. Essentially, this will be a subroutine to pass values placed in memory by the application program to the interface. As explained in the article, you will need to send 10 bits to the machine, the first three always having the values 0, 0, and 1, and the last two always being 0. If the application program formats the five remaining bits into a stored byte in memory, you have all you need to begin.*

*Simply put, the routine needs only to send an* OUT *instruction to the desired port address (the data sent is irrelevant), wait either 1.05 milliseconds (in case data bit=1) or 2.1 ms (in case data bit=0), send the* OUT *instruction again, wait the appropriate time as determined by the bit value, and so on until the cycle has been completed 10 times. In BASIC, the routine might look like the program in listing 1.*

*The only remaining problem would be to assign the value to the* FOR . . . NEXT *loops. You could determine this using the timer found in your computer; just write a short program that prints real time, goes to a* FOR . . . NEXT *loop in which you vary the end value to vary the delay, then prints real time again. Since the value you are looking for is in the neighborhood of 0.10 second, this should help you find a value sufficiently close for this application.*

*I have shown what is obviously an overly simplified, inefficient approach. However, my aim was to provide enough explanation of the concept so you can easily adapt the premise to your machine. The totally software-dependent approach is not easily undertaken unless you are comfortable with assembly language programming, but the concepts shown here can be applied to that project as well.*

*I hope this has been some help to you. Good luck on your project.*—Steve ■

*Between Circuit Cellar Feedback, personal questions, and Ask* BYTE, *I receive hundreds of letters each month. As you might have noticed, in Ask* BYTE *I have listed my own paid staff. We answer many more letters than you see published, and it often takes a lot of research.*

*If you would like to share the knowledge you have on microcomputer hardware with other* BYTE *readers, joining the Circuit Cellar/Ask* BYTE *staff would give you the opportunity. We're looking for additional researchers to answer letters and gather Circuit Cellar project material.*

*If you're interested, let us hear from you. Send a short letter describing your areas of interest and qualifications to Steve Ciarcia, P.O. Box 582, Glastonbury, CT 06033.*

*Over the years I have presented many different projects in* BYTE. *I know many of you have built them and are making use of them in many ways.*

*I am interested in hearing from any of you telling me what you've done with these projects or how you may have been influenced by the basic ideas. Write me at Circuit Cellar Feedback, P.O. Box 582, Glastonbury, CT 06033, and fill me in on your applications. All letters and photographs become the property of Steve Ciarcia and cannot be returned.*

# MICROSOFT LANGUAGES NEWSLETTER Vol. 1, No. 7

## News about the Microsoft Language Family

### Microsoft® muMATH™ used as a tool for teaching college calculus

In the fall of 1985, Cornell University began using Microsoft muMATH in its sophomore level math course that is taught to over 500 students. Professor Richard H. Rand and his colleagues at Cornell have developed a series of computer lessons that introduce the students to the power of computer algebra. Dr. Rand says that without a powerful product like muMATH, "...the point of the problem can be lost in the detail of the solution." Microsoft muMATH makes it possible to ..."assign 'tough' homework problems and to reinforce and clarify the mathematical principles with practice on the computer."

The lessons involving muMATH include (a) an introduction to its symbolic capabilities, (b) solving differential equations, (c) computing Fourier series coefficients, (d) computing eigenvalues and eigenvectors, and (e) deriving Laplace's equation in orthogonal curvilinear coordinate systems. For additional information, see "Teaching Engineering Analysis Using Symbolic Algebra and Calculus," *Engineering Education*, November 1985.

Microsoft muMATH is a symbolic algebra manipulation system. Calculations in typical scientific and engineering languages are arithmetic evaluations, requiring variables to have known values before they can be used. In contrast, calculations in muMATH are algebraic evaluations, performed symbolically. "?" prompts the user for an input. "@" identifies the answer determined by muMATH. The example shows how intermediate muMATH results can be used in later calculations.

```
A> MUSIMP MATSOL
?   LOAD (CALCULUS);
?   E1:EXPAND ((107 - 4 X^2 Y)^3);
@:  1225043 - 137388 Y X^2 + 5136 Y^2 X^4 - 64 Y^3 X^6
?   E2: DIF (LN COS(A Z^2),Z);
@:  -2 A Z SIN (A Z^2)/COS(A Z^2)
?   E1 + E2;
@:  1225043 - 2 A Z SIN (A Z^2)/COS(A Z^2) - 137388 Y X^2 + 5136 Y^2 X^4 - 64 Y^3 X^6
```

### T.N.T. Software Develops Low Cost—High Function Applications in Microsoft QuickBASIC

Bruce Tonkin, president, says, "I wrote MY WORD!, a complete word processor with mail merge, macros, undelete, sort, calculator, and device-independent I/O, using the Microsoft QuickBASIC Compiler. I think Microsoft QuickBASIC is the best available language for any product needing dynamic character string operations. The new structured language features make for efficient, modular, and exceptionally readable code. Also, the Microsoft QuickBASIC Compiler takes advantage of the full capabilities of the latest versions of DOS. This increased efficiency can make the difference between a mediocre product and a good one, or between a good product and an outstanding one. I want to sell the best software I can. That's why I use Microsoft QuickBASIC."

T.N.T. Software also distributes a spelling checker and sort utility routines written in Microsoft QuickBASIC. Source code is available.

For more information on the products and features discussed in the Newsletter,
**write to: Microsoft** Languages Newsletter
16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717
**Or phone:**
(800) 426-9400. In Washington State and Alaska, call (206) 882-8088. In Canada, call (416) 673-7638.

**Latest DOS Versions:**

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| Microsoft C Compiler | 3.00 |
| Microsoft COBOL | 2.10 |
| Microsoft FORTRAN | 3.31 |
| Microsoft Macro Assembler | 4.00 |
| Microsoft Pascal | 3.31 |
| Microsoft QuickBASIC | 1.02 |



Look for the Microsoft Languages Newsletter every month in this publication.

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87, 1988,
1990, 19

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DIFFERENTIAL AND DIFFERENCE EQUATIONS THROUGH COMPUTER EXPERIMENTS
Hüseyin Koçak
Springer-Verlag
New York: 1986
224 pages, $44 including disk

THE C WIZARD'S PROGRAMMING REFERENCE
W. David Schwaderer
John Wiley & Sons
New York: 1985
200 pages, $19.95

INTRODUCTION TO MACHINE AND ASSEMBLY LANGUAGE PROGRAMMING
Philip J. Gust
Prentice-Hall
Englewood Cliffs, NJ: 1986
421 pages, $39.95

## DIFFERENTIAL AND DIFFERENCE EQUATIONS THROUGH COMPUTER EXPERIMENTS

Reviewed by Mark Bridger

Anyone with an IBM PC–compatible computer and color board and an interest in differential or difference equations should buy Hüseyin Koçak's *Differential and Difference Equations Through Computer Experiments*. Both the book and its accompanying software are of the highest quality in terms of mathematical taste, pedagogical usefulness, and professional programming technique. The package provides the software and explanation necessary to study equations approachable only by experts just a few years ago.

### The Software

At the heart of Professor Koçak's package is a program called Phaser, an "Animator/Simulator for Dynamical Systems." Phaser enables you to enter a system of differential equations or to choose an equation from a fairly extensive library of interesting and important ones. Phaser can then draw the vector field of the system and draw one or more orbits through initial points you select. Furthermore, the screen can be split and different views can be simultaneously plotted in the top and bottom halves. For example, the top half might contain the plot of the orbit, while the bottom shows the plot of one of the variables versus time. Another possibility is to have one window show the vector field, the axes, and the orbits, while the other shows actual numerical values for the variables.

This, however, is just the beginning. Many useful systems are at least three-dimensional (satellites, for example). Their orbits can be quite complicated, involving elaborate spiralings and oscillations through space. Phaser provides three-dimensional perspective and three axes for reference. You can rotate the entire plot around one or more axes to obtain better views of the orbits; the perspective viewpoint can also be changed.

Phaser also provides the option of displaying the Poincare plane/map. Here, you select a plane in three-space, with one side determined as "up," the other "down." As an orbit is being drawn—in the top window, for instance—it may encounter the plane. If it encounters it while crossing from up to down, a point is drawn on the plane, which may be shown in the bottom window. A down-to-up encounter results in nothing being drawn. To make things clearer, the section of the orbit lying "above" the plane

(continued)

ILLUSTRATED BY CLAUDIA TANTILLO

is drawn in one color, while that below is drawn in another color. The Poincare plane turns out to have theoretical use in studying differential equations. Starting with a point on the plane, you can construct an orbit passing through it, hence a sequence of points, as described above, where that orbit encounters the plane. The nature of this sequence provides information about the orbit.

For complicated systems, the computation of solutions involves a lot of number crunching. Phaser comes with two versions: one that requires the 8087 numeric data-processing chip and one that doesn't. It is substantially faster to work with the 8087 version. Users should also be warned that Phaser will run only on a PC equipped with the IBM color graphics adapter. Clones of this board may cause problems.

Phaser also lets you study difference equations. Briefly stated, a difference equation is a way of getting a sequence of points, where each successive point is obtained from the previous one by applying a fixed formula. You might write New Point = $f$(Old Point). The properties of the sequence of points so obtained shed light on the function $f$. You will encounter phenomena such as "fixed points" $P$ where $f(P) = P$, or "cycles" where $f(P_1) = P_2$, $f(P_2) = P_3, \ldots, f(P_n) = P_1$. Differential and difference equations are related in many ways: The sequence of points provided by the Poincare plane's intersection with an orbit is only one example. Much of the terminology and many of the concepts are similar. Starting with a given point and applying $f$ over and over produces the "orbit" of $P$. As an aid in visualization, Phaser provides "stair-step" plots of the orbits. These display the graph of $f$ and the line $y=x$ and compute the orbit by alternately moving vertically to the graph and horizontally to the line.

There are two very interesting questions you can ask about difference and differential equations. The first is, If two initial points are close together, are their orbits necessarily close together? This is especially interesting in studying what happens to orbits as time becomes infinite. The second question is, What happens to the solutions of an equation if some of its parameters (e.g., coefficients or exponents) are changed slightly? Study of this "bifurcation" question leads to very important applications to the study of pattern and shape formation in nature.

### Hard Copy

The book begins with three chapters explaining the various topics I've mentioned. It is not a textbook, but it does review some of the theory from a modern and geometrical point of view. (Its elementary material is geared to the same audience as William E. Boyce and Richard C. Di Prima's *Elementary Differential Equations*, 3rd ed., John Wiley & Sons, 1977.)

The middle third of the book contains detailed instructions for using the Phaser program. This is extremely well-written documentation, with keystroke-by-keystroke descriptions of actual plots, demonstrating many changes of windows and viewpoints.

The final section of the book, nearly 100 pages, is

*(continued)*

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devoted to descriptions of each of the equations in Phaser's basic library. These vary from the simplest linear systems encountered in an introductory course to systems that are the subject of current research. Attractors and "strange" attractors are pointed out, and each example is accompanied by actual reproductions of phaser plots and references to the literature. My only complaint is that these descriptions are little more than thumbnail sketches. The differential-equations beginner might want a few specific hints on how to get more informative plots, while the more advanced user might enjoy more background and mathematical "gossip."

The Phaser program contains a very useful feature that enables you to create lessons and slide shows. As each plot is created, all the data needed to recreate it can be stored in a disk file. Data for successive plots can be appended to this file. At any point you can retrieve this file and display the plots automatically by consecutively pressing the space bar. This is an excellent way of preparing a demonstration or an exercise for students.

The best teaching aids are tools that enable students to discover mathematics by experimentation. Furthermore, these tools must be powerful enough to solve interesting problems. Ideally, they should be useful and interesting to the introductory student as well as the researcher. Finally, they should be reasonably priced. This package fulfills all these requirements.

*Mark Bridger is associate professor of mathematics at Northeastern University (Boston, MA 02115).*

## THE C WIZARD'S PROGRAMMING REFERENCE

Reviewed by John D. Unger

*The C Wizard's Programming Reference* by W. David Schwaderer is not the sort of book you'd read during the evening in front of a fireplace, but you may want it nearby when you're writing C-language programs, especially if you are exploring some of the more esoteric features of C. It is the kind of book that should be included with every C compiler because it is a comprehensive reference guide to the usage and syntax of the language.

### PORTABILITY A PLUS

This book will not teach you how to program in C, but it can make you a better C programmer. It contains few examples of complete C programs. Most of the source code that is included consists of program fragments used to provide examples to key points in the text. Basically, the book is written for intermediate and advanced C programmers. The author's approach assumes a fairly thorough understanding of C syntax, and he uses programming jargon frequently and without reference to explanatory material. It is a book to have ready when you are in the midst of writing a program and suddenly decide that you need a feature of C that you don't understand well or have never attempted to use before. The author

*(continued)*

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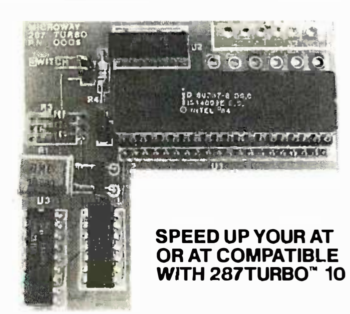

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emphasizes using C to write source code that is as portable as possible. He demonstrates how to avoid syntax that is permissible but not robust.

Schwaderer uses the proposed ANSI X3J11 standards as the criteria for defining usage. What this means is that the book describes the language with some extensions that are not considered in the standard developed in Brian W. Kernighan and Dennis M. Ritchie's *The C Programming Language* (Prentice-Hall, 1978). Therefore, in many ways this reference book is more up to date than other books in its description of the C language as it is implemented on the most recent versions of C compilers used on microcomputers. The author is careful to point out which proposed ANSI standards are not in general use, and he states in the preface that your compiler must remain your definitive description of the language.

## A New Reference

It is in his explanations of the more difficult to understand areas of C that the author shines. The sections on library functions related to file I/O, structures and unions, and pointers are clear and complete.

The relationship between arrays and pointers is particularly important to programmers trying to get the most out of the C language. Schwaderer offers good examples of equivalent expressions for multidimensioned arrays and their members by using traditional subscript nomenclature as well as pointer variables.

Many books on C tend to give only brief treatment to the C preprocessor and its directives. Although the preprocessor is not technically part of the C language, all the compilers I have used include such a capability. Taking advantage of C's preprocessor can add a lot to your programming capability, and *The C Wizard's Programming Reference* stands out by giving a complete description of the preprocessor directives. The code fragments used as examples in this section were particularly valuable to me because it seemed that time and again I would look at an example and find myself thinking, "Gee, that's a clever way to handle that problem or to write code that makes the program truly portable."

As befits a useful reference book, both the table of contents and the index are detailed and comprehensive and make it easy to find specific sections that deal with particular aspects of the C language. A valuable asset to this book's utility as a reference is the presence of a removable, double-page-size, light cardboard reference card in the back of the book. The card contains a well-organized and complete summary of all of C's main features. As is true with any reference-type text, a certain amount of redundancy creeps in: I counted at least five separate places in the book where the author warns the reader about confusing the = and == operators.

## Beyond Appearances

The author's style is generally terse and to the point, an acceptable approach to a reference-type text. But it does make the reading seem dry and academic. I do not want

(continued)

to give the impression, however, that Schwaderer's treatment of the subject matter is not thorough.

Some relatively minor things detract from what the author is trying to say. For example, while reading through the book, I was frequently distracted by references to figures (usually fragments of source code) that appeared on a subsequent page and occasionally after the next major subject heading. Also, the figures in the book appear to have been constructed on a word processor screen using normal ASCII characters instead of having been drafted. As a result, some of the figures have an amateur look and are harder to read.

The book's layout, lightweight stock, and coil binding all detract from its overall appearance, usability, and longevity. Fortunately, however, the book's content represents a much better value than first appearances would lead you to believe.

John D. Unger (P. O. Box 95, Hamilton, VA 22068) *is a geophysicist for the U.S. government who uses computers to study the structure of the earth's crust in earthquake-prone regions.*

## INTRODUCTION TO MACHINE AND ASSEMBLY LANGUAGE PROGRAMMING
Reviewed by Larry G. Clark

*Introduction to Machine and Assembly Language Programming* by Philip Gust provides virtual machine simulators to assist the student. A simulator is provided for two machines (one uses a 16-bit word, the other a 32-bit word) so that you can immediately evaluate examples given in the text. Assemblers are provided for both machines as well. The assemblers and simulators are written in standard Pascal syntax to minimize the effort needed to adapt them to your compiler. The source code is listed in an appendix and is also available on an optional disk. The largest of five programs occupies about 40K bytes when the include files are taken into account.

Instructors will find these training aids versatile because they won't succumb to hardware obsolescence. When your software is upgraded, you simply recompile the programs on the new machine, and class continues. If you want to add new mnemonics, you have the source code to the assembler and can make the modifications yourself.

### EFFICIENT INSTRUCTIONS

Gust uses a simple instruction set for his first model, a 16-bit machine with one accumulator. Twelve instruction types, such as LOAD, ADD, and MUL, work with the direct, indexed, indirect, and immediate addressing modes. The instructions are quickly explained so that you can begin immediately with examples that are always short and to the point. Don't let the small instruction set mislead you; Gust demonstrates a wide range of assembly language programming methods, such as loops, procedures, arrays, parameter passing by value and reference, and the use of pointers. Examples are given in Pascal source code

*(continued)*

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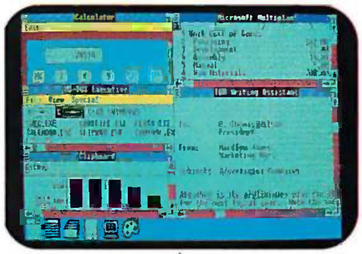

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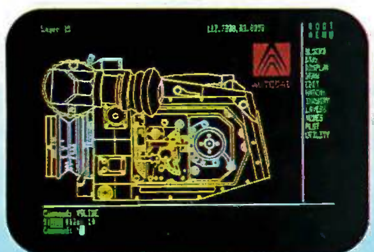

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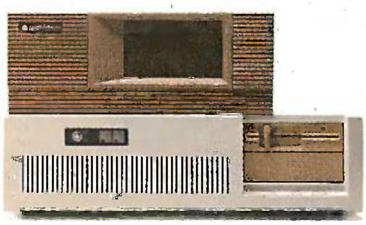

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alongside the assembly listing so that readers can better understand the algorithm. The author assumes you've had no more than a basic introduction to Pascal; a knowledge of any language would help you to understand the examples. Gust drops the Pascal examples after you've had time to become proficient at reading assembly code.

Examples demonstrate how to minimize the number of instructions used in branching and looping. Important concepts, such as arithmetic and logical negation, are introduced that reduce the number of branch test instructions. The author also shows a compact arrangement of instructions to minimize the instruction count. But Gust disappointed me by not explaining how the initializer section, code body, and exit test arrangement were developed. However, his examples are consistently written and easy to understand.

FOR loops are written in assembly language using the precalculated "trip count" and "index" methods and are accompanied by an explanation of the circumstances that determine which method should be used. The WHILE. . . ENDWHILE and REPEAT. . .UNTIL loops are coded as well. These examples expose the student to the tasks that a compiler must perform and therefore serve as an introduction to later course work in computer science.

Array manipulations are programmed in both one and two dimensions using both the row- and column-major formats. A good explanation of the "base-offset" address calculation model used in address calculations is an excellent programming tool whose use is reinforced frequently.

### Stacks and Recursion

Limitations imposed by the 16-bit machine's return address storage method are alleviated by introducing a 32-bit machine. This second machine is much more powerful, with multiple registers that can serve as indexes, accumulators, stack pointers, and a set of 30 instructions with six basic addressing modes. As with the 16-bit machine, the author first gives an invaluable explanation of data flow inside the imaginary machine as instructions are executed. Short examples of the assembler's syntax are provided as well. Register management is then introduced to show you how to use the wealth of power that eight 32-bit registers offer. Even though the 32-bit machine readily supports separate data and return stacks, Gust demonstrates how to use the return stack to pass data while holding return addresses. He presents several examples of recursion before going on to bit-manipulation techniques.

Floating-point formats and floating-point algorithms give the reader a basic exposure to the concepts behind this aspect of programming. Although Gust shies away from a full discussion in this introductory text, he does mention advanced topics such as how to control rounding error. One point that was not explained regards format conversion between base 10 and base 2 floating-point formats. The topic was instead deferred to a homework question in the next chapter on character conversion and string manipulation. Incidentally, the author's treatment of strings

*(continued)*

is straightforward and carefully avoids algorithms that are dependent upon the character code being used. Character packing, string concatenation, and character-to-number conversion techniques are demonstrated.

A short chapter on machine I/O discusses keyboard and display communications so that the reader can evaluate a sample program that simulates a four-function calculator. Disk I/O is discussed in an elementary manner that includes sample assembly language program code. Interrupts are briefly mentioned as a useful tool in doing I/O.

A discussion of multiple-precision arithmetic is not possible because neither of the virtual machine models offers a carry or overflow flag. This is the only major omission I found.

I had to complete this review without spending a lot of time with an executable copy of the assemblers and emulators. Because a disk with simulator and assembly language programs in Pascal for the IBM PC (for an additional $24.95; ISBN 0-13-486432-8) arrived at the last minute, I did take a little time for a cursory examination.

I could not resist adapting the one-address assembler to my Turbo Pascal compiler's syntax to learn what must be done to get the software running. I had to change a few conflicting keywords and remove the only GOTO statement used. Instructions on how to prepare the source for compilation is given in the appendix and involves merging text files. Though I was largely successful, the assembler recognized mnemonics but not pseudo op codes. I may have induced this problem by making keyword changes. I was rewarded with a compiled program that occupied about 25K bytes. Although I have not tried the other three programs, I am reasonably confident that my compiler will compile them also. I do, however, have reservations about assembling large examples, as the assembler may demand more dynamic storage than Turbo Pascal can provide.

## SUMMARY

The author clearly explains assembly language programming using basic instruction types. The virtual machine models use simplified yet capable and realistic instruction sets to confirm that many instructions go unused because they are seldom needed. The instruction count reduction also allows the reader more time for learning programming techniques by requiring less time to learn how they operate. Although he does not address interrupts or hardware details, I still recommend that the book be considered for use in engineering courses where assembly language programming is taught.

This book provides more than just an explanation of assembly language programming: It offers an introductory glimpse of more advanced programming challenges. Gust introduces programming functions such as variable storage allocation and describes simple aspects of code generator optimization. ■

*Larry G. Clark (8103 Thornewood Dr., Hixson, TN 37343) works as an electrical systems engineer and teaches after hours at Chattanooga State College. His interests include computer language development, control applications, and robotics.*

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ROCKY MOUNTAIN INSTITUTE OF SOFTWARE ENGINEERING 1986 SUMMER PROGRAM, Boulder, CO. rMise, P.O. Box 3521, Boulder, CO 80303, (303) 499-4782. *July*

UNDERSTANDING AND USING THE IBM PC XT & PC AT, various sites throughout the U.S. The American Institute Inc., Carnegie Building, 55 Main St., Madison, NJ 07940, (800) 822-2473; in New Jersey, (201) 966-1134. *July*

SUMMER INSTITUTE IN COMPUTER SCIENCE, Tyngsboro, MA. Wang Institute of Graduate Studies, Tyng Rd., Tyngsboro, MA 01879, (617) 649-9731. *July–August*

TELECOM PACIFIC '86: ASIAN REALITIES FOR USERS AND SERVICE PROVIDERS, Hong Kong. Pacific Telecommunications Council, 1110 University Ave., Suite 308, Honolulu, HI 96826, (808) 941-3789. *July 3–4*

AUSGRAPH 86: INTERNATIONAL COMPUTER GRAPHICS CONFERENCE & EXHIBITION, Sydney, Australia. Ausgraph 86 Secretariat, P.O. Box 29, Parkville, Victoria 3052, Australia, telephone: (03) 387 9955; Telex: AA 33761. *July 7–11*

SIMULATION TECHNIQUES FOR PERSONAL COMPUTERS, Washington, DC. Continuing Engineering Education Program, George Washington University, Washington, DC 20052, (800) 424-9773; in DC, (202) 676-6106; in Canada, (800) 535-4567. *July 7–11*

PC EXPO, Jacob K. Javits Convention Center, New York, NY. PC Expo, 333 Sylvan Ave., Englewood Cliffs, NJ 07632, (201) 569-8542. *July 9–11*

CRITERIA FOR NEW PRODUCT SUCCESS, Madison, WI. Gregg Johnson, Department of Engineering Professional Development, University of Wisconsin–Madison, 432 North Lake St., Madison, WI 53706, (800) 262-6243; in Wisconsin, (800) 362-3020. *July 10–11*

dBASE III BY ADAM GREEN, Seattle, WA. Software Institute of America Inc., 8 Windsor St., Andover, MA 01810, (617) 470-3880. *July 14–17*

THE STEPS CONFERENCE: SOFTWARE TRENDS FOR EXECUTIVE PLANNING AND STRATEGY, Boston, MA. Software Institute of America Inc., 8 Windsor St., Andover, MA 01810, (617) 470-3880. *July 14–17*

GOVERNMENT COMPUTER EXPO86, Sheraton Washington Hotel, Washington, DC. Government Computer Expo86, 1620 Elton Rd., Silver Spring, MD 20903, (301) 445-4400. *July 14–18*

DESIGNING EFFECTIVE MANUALS: STANDARDS AND PROCEDURES/GRAPHICS, New York, NY. Comtech Services Inc., 133 South Van Gordon St., Suite 206, Denver, CO 80228, (303) 986-9534. *July 14–18*

BUYING AND SELLING RIGHTS TO SOFTWARE, HARDWARE, AND SERVICES, Anaheim, CA. Data-Tech Institute, Lakeview Plaza, P.O. Box 2429, Clifton, NJ 07015, (201) 478-5400. *July 15*

1986 ASME INTERNATIONAL COMPUTERS IN ENGINEERING CONFERENCE AND EXHIBITION, Hyatt Regency Hotel, Chicago, IL. American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017, (212) 705-7788. *July 20–24*

INTRODUCTION TO LOCAL AREA NETWORKS, Washington, DC. Chip Blouin, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in DC, (202) 676-6106; in Canada, (800) 535-4567. *July 21–22*

HANDS-ON TROUBLESHOOTING, Washington, DC. The American Institute Inc., Carnegie Building, 55 Main St., Madison, NJ 07940, (201) 966-1134. *July 21–23*

SYMSAC '86: THE 1986 ACM-SIGSAM SYMPOSIUM ON SYMBOLIC AND ALGEBRAIC COMPUTATION, University of Waterloo, Ontario, Canada. Prof. Richard Fateman, EECS Dept., 573 Evans Hall, University of California, Berkeley, CA 94720, (415) 642-1879. *July 21–23*

FOURTH INTERNATIONAL CONFERENCE: THE FUTURE OF OPTICAL MEMORY TECHNOLOGY, Hyatt on Union Square, San Francisco, CA. Technology Opportunity Conference, P.O. Box 14817, San Francisco, CA 94114-0817, (415) 626-1133. *July 22–24*

MICROCOMPUTER-BASED COMPUTER-AIDED DESIGN DRAFTING, Worcester, MA. Kathy Shaw, Office of Continuing Education, Higgins House, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517. *July 24–25*

PERSONAL COMPUTER INTERFACING FOR SCIENTIFIC INSTRUMENT AUTOMATION, Blacksburg, VA. Dr. Linda Leffel, C.E.C., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848. *July 24–26*

SCSC '86: 1986 SUMMER COMPUTER SIMULATION CONFERENCE, MGM Grand Hotel, Reno, NV. The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117, (619) 277-3888. *July 28–30*

TEACHING COMPUTERS AND THE HUMANITIES COURSES, Poughkeepsie, NY. Elle Gohl, Workshop Coordinator, Department of Computer Science, Box 252, Vassar College, Poughkeepsie, NY 12601, (914) 452-7000, ext. 2430. *July 31–August 2* ■

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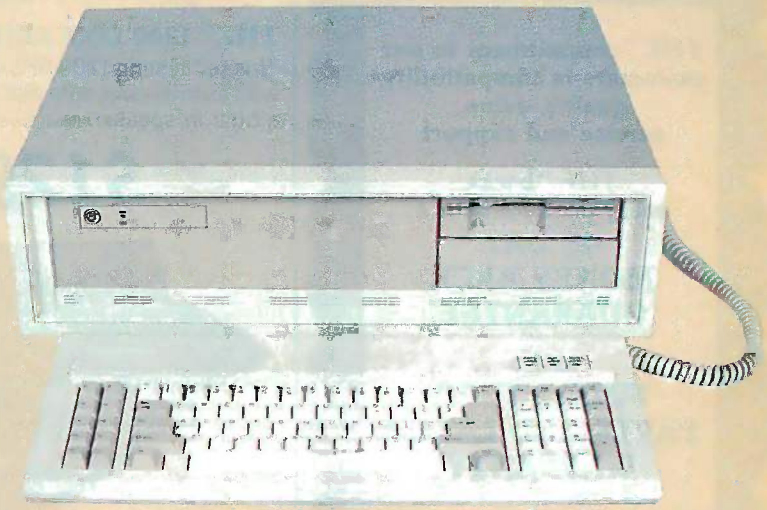

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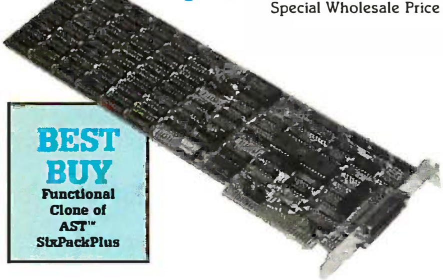


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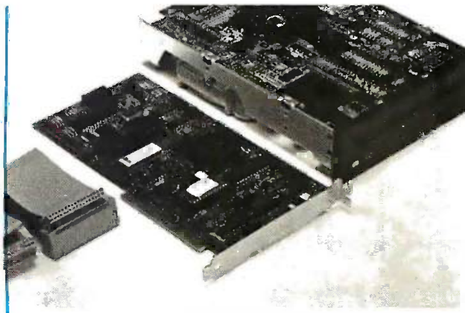

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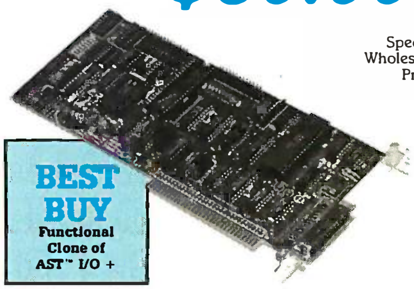


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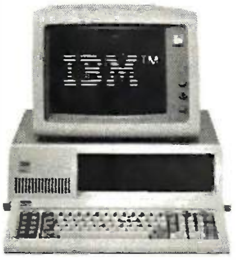

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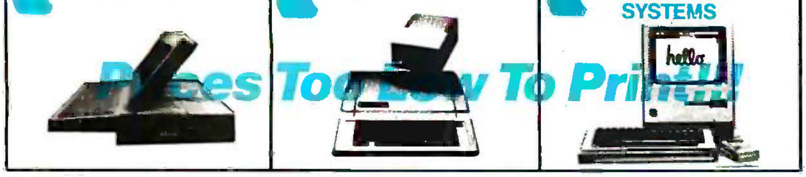


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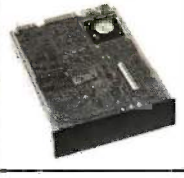

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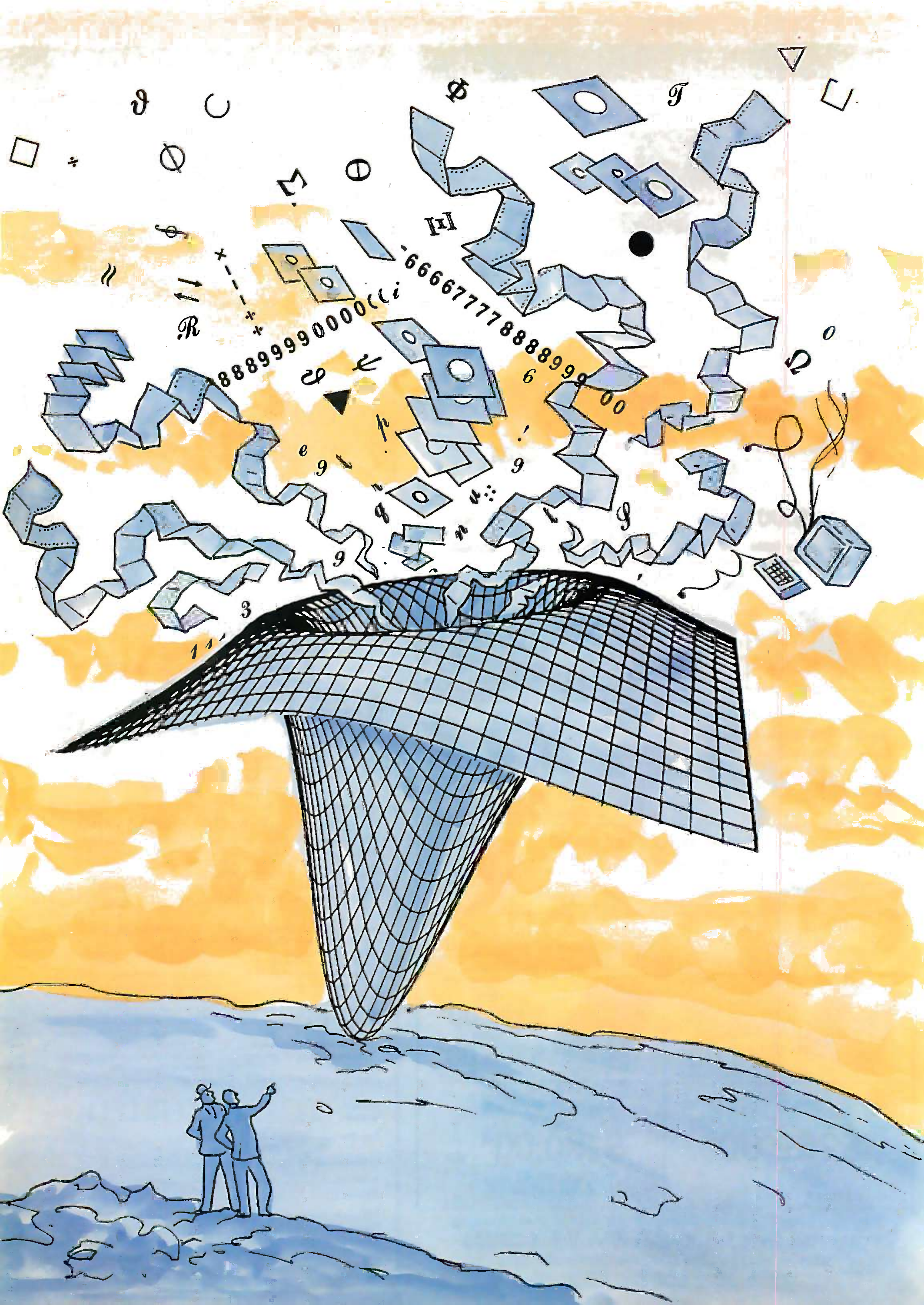

# Features



EVERY ONCE IN A WHILE, Steve Ciarcia forsakes the construction of a hot new device and returns to basic electronics. This month is one of those occasions. Steve believes it is important to provide basic knowledge for newcomers, and the subject for the next two months is parallel interfacing. This month's article is primarily introductory in nature but also includes application examples that might be of value to knowledgeable experimenters.

Jonathan Amsterdam's Programming Project, "Build a Spreadsheet Program," describes four implementations of a spreadsheet program written in Modula-2. The construction of a spreadsheet raises some interesting issues in the design of data structures. The designer of a spreadsheet program faces two especially difficult problems: dependency maintenance and size. These issues make for a challenging project.

If you've ever delighted in turning *excitation* into *intoxicate*, you'll be interested in "Anagram Solving in Pascal" by Bob Keefer. This Programming Insight discusses how to use a probability table to decipher anagrams. Poet John Dryden called the practice "the torturing of one poor word ten thousand ways."

Next, Trevor Marshall, Christopher Jones, and Sigi Kluger look at the hardware and operating system of the Definicon 68020 Coprocessor in the first part of a two-part article. BYTE readers first learned of Definicon Systems Inc. with the introduction of the company's DSI-32 coprocessor board (August 1985 BYTE). This board plugged into an IBM PC slot and featured a National Semiconductor 32032 microprocessor with floating-point unit, memory management chip, and 256K bytes to 1 megabyte of RAM. Now, by special arrangement with BYTE, Definicon has designed a Motorola 68020-based version of this board, allowing 68020 hardware and software development on the IBM PC, XT, AT, and compatibles at an affordable price. The board includes the MC68020 processor and the 68881 floating-point chip, and it will accommodate the 68851 PMMU (paged-memory-management unit) when it becomes available. It contains 1 megabyte of fast RAM.

The last feature in our lineup is related to this month's Engineer's Toolbox theme. In "Engineering on a Micro," Chris Pedicini takes us on a walking tour of Truss2, a BASIC program that helps engineers in the design of truss-type structures.

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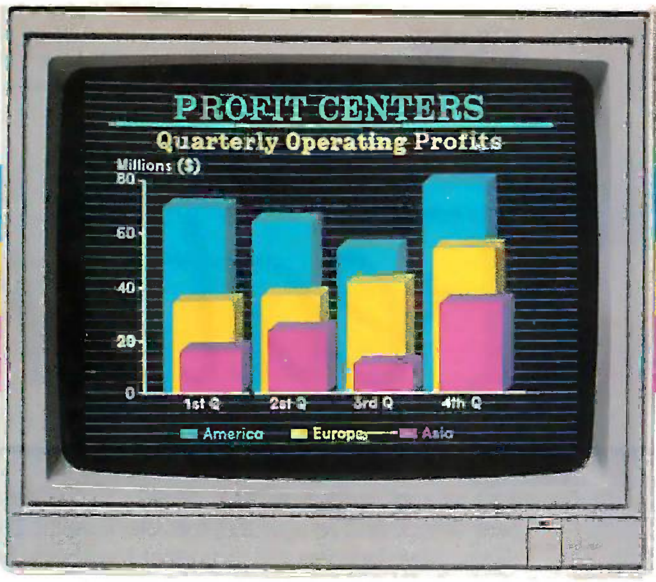


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Inquiry 149

# PARALLEL INTERFACING: A TUTORIAL DISCUSSION

## PART 1: BASICS

BY STEVE CIARCIA

*An introductory article concentrating on non-*LSI *chip parallel interfacing*

Recently I was thumbing through some of my old articles. The reason wasn't nostalgia; instead, I was doing a historical review of the topics. It's too easy to fall into the newest and best craze all the time, so I have to be continually aware that I allocate a portion of my projects to basic electronics.

While an IBM PC bus–compatible image-enhanced Doppler radar interface might make a wonderful Circuit Cellar project, some converts to our electronic religion wouldn't have the slightest idea what I'm talking about. It has been a long time since I've presented anything specifically about parallel interfacing. During the intervening time, I've published many schematics incorporating the same—as well as more sophisticated—circuitry as what I'm about to describe.

Unfortunately, it is often difficult to absorb basic concepts from nonspecific presentations. Before subjecting you to more mad scientist projects, like those planned for the fall, I thought I'd take a quick break and reintroduce parallel interfacing. Rather than making it a pure introductory-level article, however, I'll concentrate on application examples that might be of value to knowledgeable experimenters as well.

Beyond a fast review of TTL connection basics and MSI/SSI-level parallel I/O port circuits, I'll include the specialized interface devices that are now more cost-effective to use and discuss the differences among them. I hope that you'll then know when to use a parallel input/output or a peripheral interface adapter.

This month's article is primarily introductory in nature and concentrates on non-LSI chip parallel interfacing. The circuit examples include a parallel keyboard and a Centronics printer interface. Next month, I'll describe the various PIAs and programmable peripheral interfaces in general use. Specific circuit examples include an LSI version of the same keyboard and printer interface and a dual PIA card for the Apple II, configured for control and analog data acquisition.

### THE BASICS

A typical microcomputer system may have components from several different logic families: Microprocessors and interface adapters are often NMOS or the newer CMOS, which contains both negative-

*(continued)*

*Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, you can write to him at P.O. Box 582, Glastonbury, CT 06033.*

channel and positive-channel transistors and consumes significantly less power.

Most of the better-known microprocessors are NMOS: 8080A, 8086, 6502, 6809, and others. Some newer ones are CMOS: 65C02, 68020, HD64180, 80C85, and others. The gates, latches, and buffers—the "glue" in most systems—are usually from the TTL family because it can effectively drive the high capacitance of a typical microcomputer system bus.

### TOTEM-POLE OUTPUT

Several subfamilies are found within the TTL family: LS, or low-power Schottky; S, or Schottky; F, or fast; ALS, or advanced low-power Schottky; and others. Various types of these circuits are equipped with totem-pole, open-collector, or three-state outputs.

The totem-pole output is the standard type, found in most gate, counter, multiplexer, and decoder chips. Its name derives from the fact that it consists of two transistors (or sometimes Darlington pairs of transistors) stacked one atop the other, like a totem pole. The output is located between the two transistors. When the upper transistor is on, the output is high; when the lower transistor is on, the output is low. Figure 1a shows the circuit diagram for a typical totem-pole output. One advantage of this output is that the low driving-source impedance enables it to drive highly capacitive loads without significantly degrading switching times.

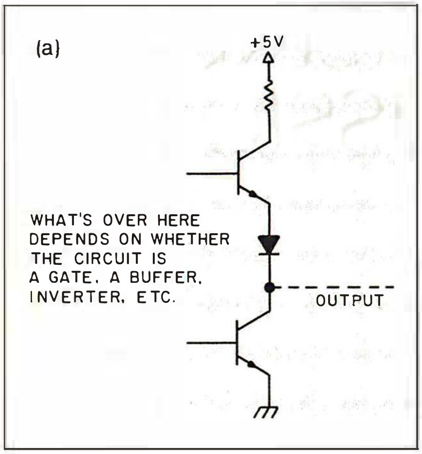
The rest of the circuitry in the IC is designed so that both transistors in the totem pole are not on at the same time, except during transitions between logic levels. During transitions, the transistors are on simultaneously for a very brief period of time. When that happens, a direct connection is made, via the transistors, between ground and +5 volts. The result is TTL's notorious *noise spike*. This is why all those noise-decoupling capacitors are needed with TTL logic.

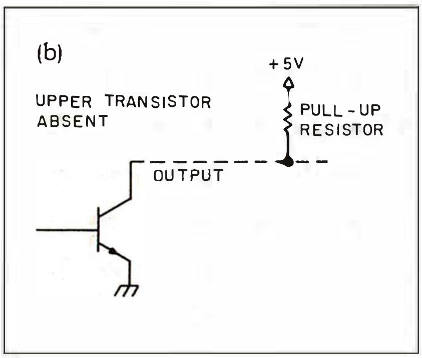
Photo 1 shows an abnormal pulse produced by such a noise spike. Photo 2 shows jitter on the leading edge of a TTL pulse, another symptom of poor noise decoupling.

### OPEN-COLLECTOR OUTPUT

We sometimes might want to connect the outputs of two or more circuits together, such as when several system components are driving a common data bus. This can be accomplished through the use of open-collector or three-state outputs.

Figure 1b shows a typical open-collector output: It is the same as figure 1a except that the upper transistor in the totem pole is missing, and the collector of the lower transistor is open, that is, unconnected to anything except the output pin. Because no active circuit elements are con-



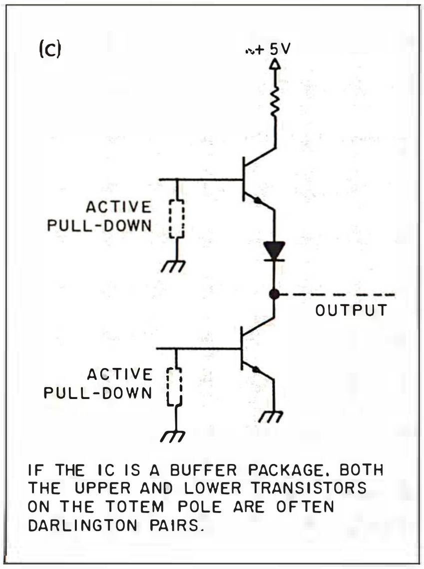




Figure 1: *(a) Totem-pole output; (b) open-collector output; (c) three-state output.*

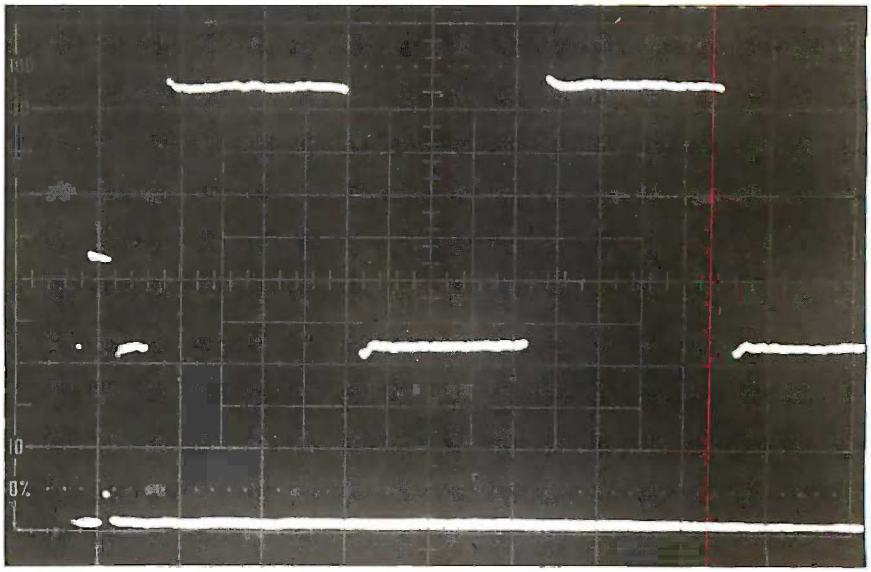


Photo 1: *At the extreme left of the upper scope trace is an abnormal pulse produced by the positive-going noise spike shown immediately below. (Photo courtesy of Tektronix Inc.)*

necting the output with the positive supply, this type of output can go high only if something external, usually a pull-up resistor, forces it there.

While open-collector outputs permit many circuit elements to be bused together, the lack of active components on the "high" side generally degrades the switching time. Use of the pull-up resistor also results in leakage currents through that resistor. Switching time can be improved by reducing the value of the resistor, but this approach increases the leakage currents.

## THREE-STATE OUTPUT

The third common output option is shown in figure 1c: three-state (or tri-state). This type of output behaves like a normal totem-pole output when the active pull-down circuits are "off." When the pull-downs are "on," both the upper and lower output transistors are off, their bases held near ground. The output is now in its third, high-impedance, state.

This type of output combines the high switching speed of the totem-pole output with the common-bus capability of the open-collector output. There is a possibility that the totem-pole output will consist of Darlington pairs rather than single transistors, especially if the logic element is a buffer or line driver.

Open-collector and three-state outputs are most commonly used when many outputs are bused together, like the data and control buses of a microcomputer system. In photo 3, the fainter trace is a single abnormal pulse produced by bus contention. Two three-state circuits are simultaneously active on the bus, one attempting to switch high, and the other attempting to switch low.

## PARALLEL KEYBOARD INTERFACE

A microcomputer frequently consists of a microprocessor, memory (both RAM and ROM/EPROM), I/O peripheral devices like disk drives and printers, and the miscellaneous components needed to "glue" (or interface) everything else in the system together so they can communicate with each other. In the discussion that follows, handshaking refers to the ability of the microprocessor and the peripheral device to coordinate data transfers by signaling each other that an action is completed.

A good example of an essential hardware interface is the connection of a keyboard to a microcomputer bus. For the purposes of this part of the discussion, I am using memory-mapped input. When a microprocessor with separate ports for input and output, like the Z80, is used, input and output can be either through directly addressed ports or "mapped" into available memory space.

Figure 2a shows how a typical parallel ASCII keyboard might be connected. A 74LS138 three-line-to-eight-line decoder, IC1, is partially enabled by a three-input (74LS10) NAND gate, IC2a, whose inputs are connected to address lines A15, A14, and A13 on the bus. An active-high system clock signal drives G1, pin 6.

*(continued)*

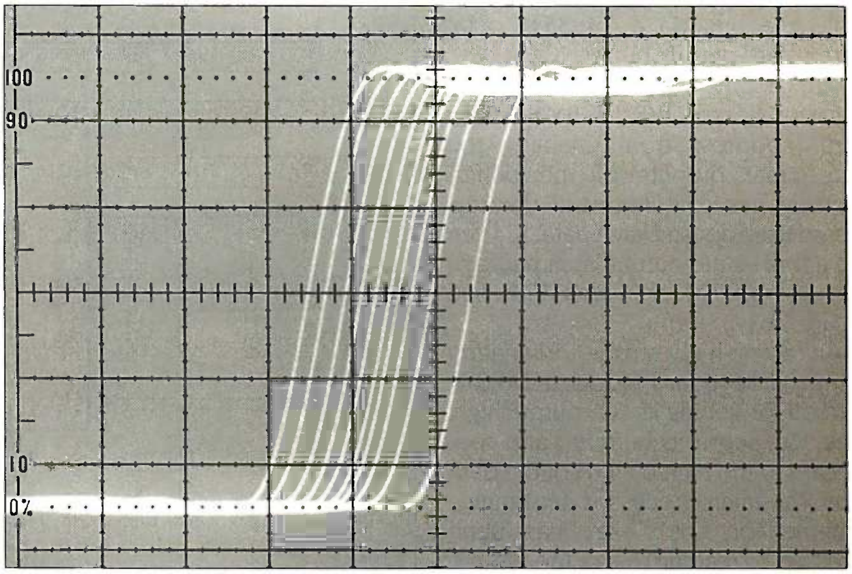



**Photo 2:** *Jitter on the leading edge of a pulse caused by poor noise decoupling. (Photo courtesy of Tektronix Inc.)*

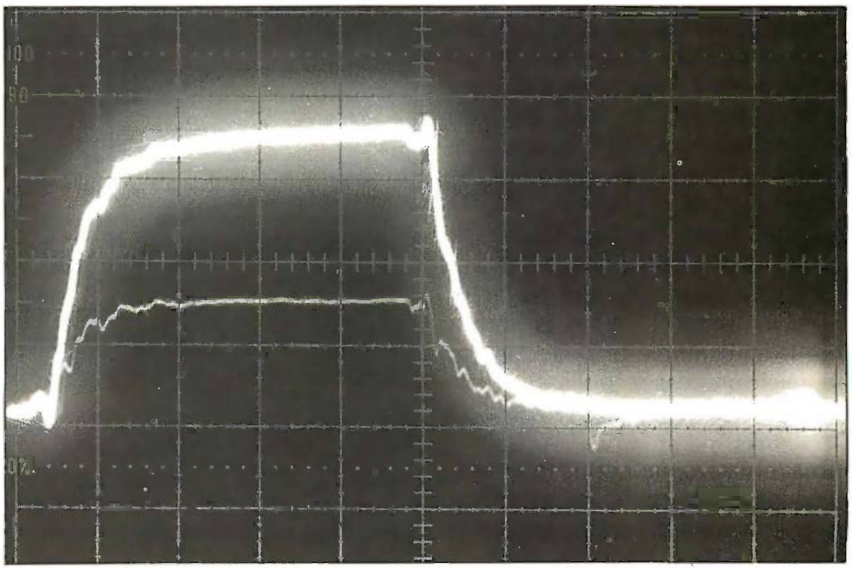


**Photo 3:** *The fainter trace is a single abnormal pulse produced by bus contention between two three-state circuits; one is attempting to switch high, and the other is attempting to switch low. (Photo courtesy of Tektronix Inc.)*

With the three address inputs of IC1 attached to address lines A12, A11, and A10, the decoder will divide the top 8K bytes of a 64K-byte address range into eight 1K-byte blocks. We can further divide one of these 1K-byte ranges into eight 128-byte blocks by adding a second 74LS138 decoder, IC3. One of IC3's decoded outputs is used in conjunction with inverter IC5a (74LS04 or 74LS05, typically) and OR gate IC6a (74LS32) to gate the keyboard data, latched by the keyboard onto the bus via a 74LS541 octal three-state-output buffer, IC4.

The OR gate and inverter prevent a microprocessor WRITE to the keyboard address from enabling the three-state outputs of the buffer, causing bus contention. (If the keyboard itself doesn't latch data, IC4 can be a three-state-output latch package like a 74LS374 or 74ALS574; see figure 2b.)

An active-high strobe originating with the keyboard clocks a 74LS74 latch, IC7a, setting its "Q" output high. The "Q" output is buffered and connected to the high bit (D7) of the data bus. The microprocessor determines whether or not a key has been pressed by reading one of the 128 addresses decoded by output Y0 of the decoder.

The microprocessor reads the address, then tests the high bit to see if it is set. If the high bit is not set, the keyboard is read again. When the microprocessor determines that a key has been pressed, it clears the high bit by referencing one of the addresses decoded by output Y1 of the decoder. Output Y1 clears the 74LS74 latch that drives the high bit.

In 6502 assembly language, the process might look like the segment shown in listing 1. What is shown there is an example of polled input. The microprocessor polls the keyboard to determine if any new data is available.

An alternative method is interrupt-driven input, where the microprocessor is interrupted by the keyboard when new data is available. Figure 3 shows the circuit in figure 2a modified for an interrupt-driven input. The only change is the addition of a 74LS05 open-collector inverter, which drives

Listing 1: *An example of polled input.*

```
FETCH  LDA KEYBD    ; read keyboard address
       BPL FETCH    ; high bit clear, read keyboard again
       AND #$7f     ; mask high bit, low ASCII now in A-REG
       BIT CLEAR    ; clear the high bit by resetting latch
```

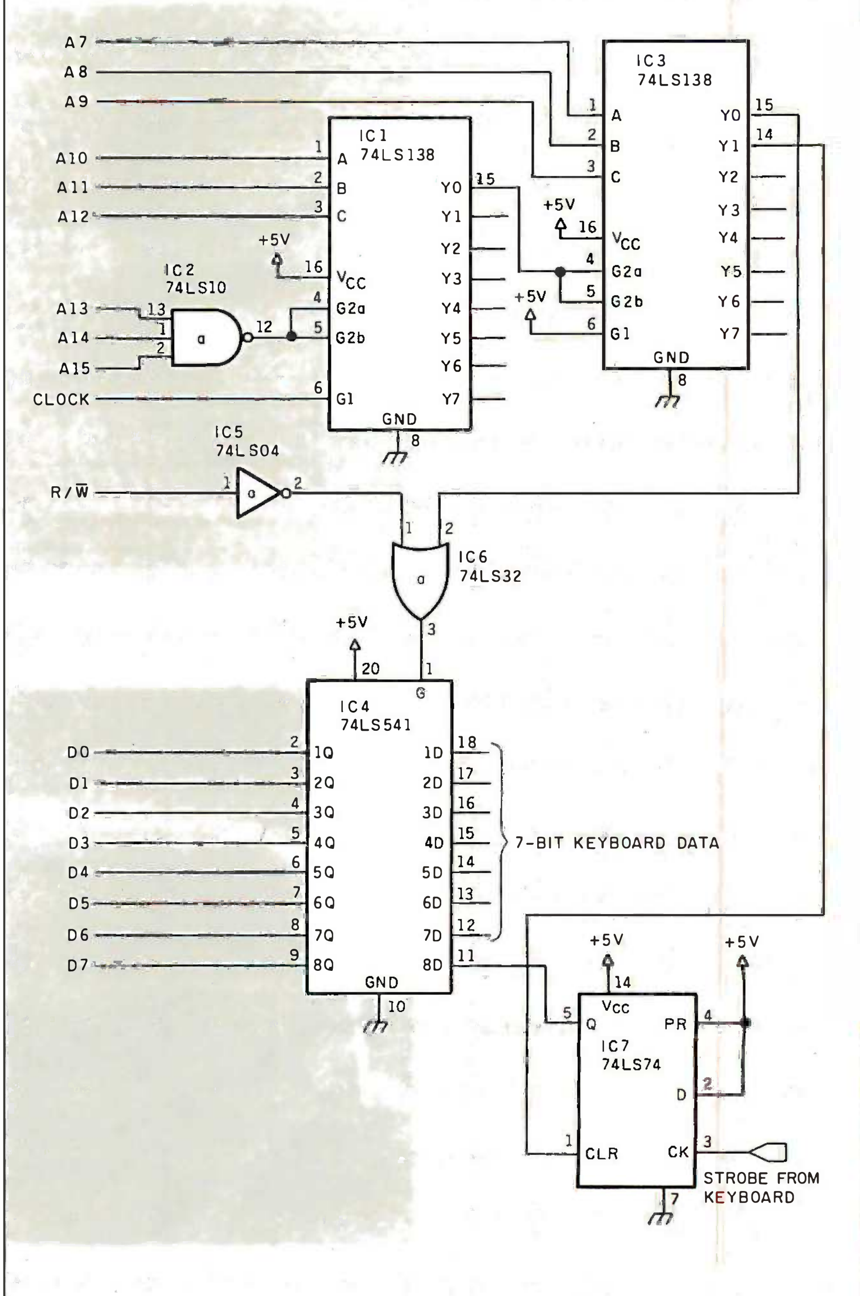
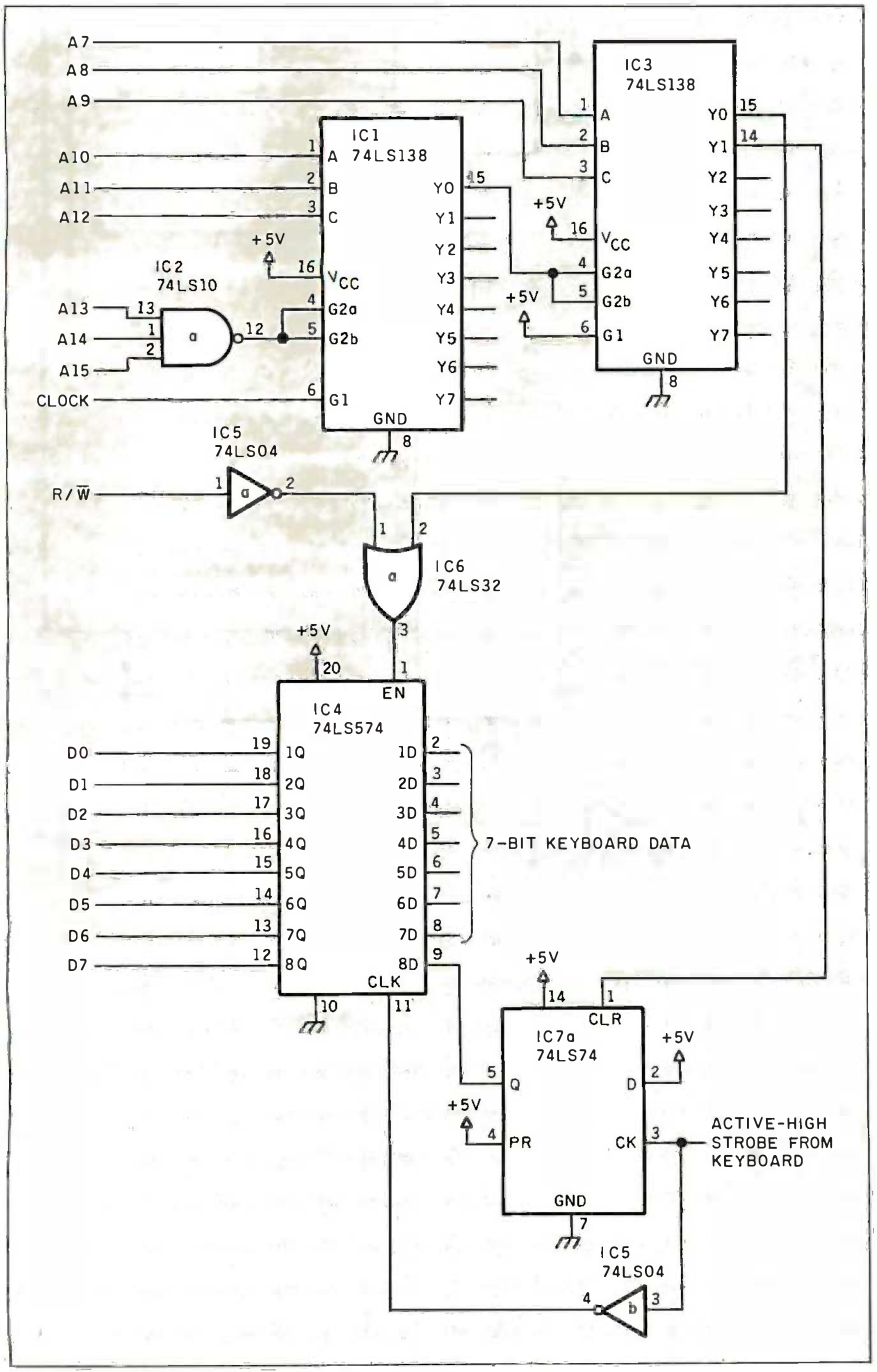



Figure 2: *(a) Keyboard buffer input using buffer package* (74LS541);

the interrupt input of the microprocessor. The inverter's input is controlled by the "Q" output of IC7a. This inverter and IC5a can be from the same package, in which case a pull-up resistor, typically 2 to 3 kilohms, should be added to the output of IC5a. For simplicity, we'll assume that the microprocessor has a single active-low interrupt input that is shared by many interrupt sources, each of which drives it with an open-collector output. (A discussion of how various microprocessors and operating systems handle interrupts could fill a large book.)

Note that the high bit is still controlled by the latch. This is so the microprocessor can determine that the keyboard is the source of the interrupt by polling. The 6502 assembly language code for doing this might be similar to that shown in listing 1.




*(b) keyboard input using octal latch package* (74ALS574).

## Parallel Printer Interface

Another common peripheral interface is for a Centronics-protocol parallel printer. We can add this capability to the circuit in figures 2 and 3 by making the additions shown in figure 4. Although this protocol has no formal specification, the timing diagrams in the documentation for the Centronics 737 printer call for data to be stable for a minimum of 1 microsecond, then a minimum 1-microsecond-width active-low DATA strobe is sent from the computer to the printer. The output data must remain stable for a minimum of 1 microsecond after the rising edge of the DATA strobe.

When the printer is ready for more data, it sends a minimum 1-microsecond active-low ACKnowledge strobe to the computer. Although additional signals are defined by the protocol (BUSY, DEMAND, ON-LINE, etc.), they aren't often used for interfacing printers with microcomputers. The interface was developed by Centronics for interfacing printers with larger computers before the microcomputer as we know it today even existed. The large number of signals defined allowed relatively easy interfacing to a wide variety of equipment. Most of these signals, however, are not needed for a usable microcomputer interface.

In the circuit of figure 4, the rising edge of the Y2 output of decoder IC3 clocks a 74ALS574 latch, IC9, and triggers IC10a, half of a dual one-shot. IC10a generates an output pulse 1 microsecond wide. The trailing edge of IC10a's output triggers IC10b, which provides the active-low DATA strobe to the printer.

If we need to be able to poll the printer port to determine if it is the source of an active interrupt, IC7b is clocked by the ACK from the printer. It drives IC5c, which generates an interrupt signaling that the printer is ready for more data. IC7b also drives the input of IC11a, a 74LS125 three-state buffer enabled by one of the decoded outputs of IC3.

*(continued)*

*We can eliminate interrupt generation by using polled output.*

IC11a's output drives the high bit on the data bus. The microprocessor can poll the address of IC11a to determine whether the printer is the source of an interrupt. IC7b is reset, and the interrupt thus cleared, by another of IC3's decoded outputs.

We could also eliminate the interrupt generation, and IC7b, by using polled rather than interrupt-driven output. In general, multitasking systems use interrupt-driven I/O, while single-tasking systems will frequently rely on polled I/O.

The interfaces just described use memory-mapped I/O address decoding. (Each output of IC3 is active for a range of 128 addresses rather than a single address. It is seldom necessary to completely decode unique addresses for I/O functions.) Some microprocessors, like the Z80 and the newer HD64180, have I/O "ports" whose locations are not part of the microprocessor's defined memory range but instead lie within a special I/O-only addressable space.

The Z80 accesses 64K (65,536) bytes of memory plus 65,536 I/O ports. The HD64180 accesses 512K bytes of memory plus 65,536 I/O ports. Both can use either the ports or memory-mapped locations for communications with the outside world. Other microprocessors, like the 6502 and 6809, lack the I/O-specific addressing and must perform all I/O within the bounds of the 64K-byte memory-mapped address range.

Figure 5 shows the printer output port on the SB180 system described in the September and October 1985 Circuit Cellar project. The SB180 uses a 74LS374 octal latch for data output and the two "D" latches from a 74LS74 package to coordinate handshaking, and it uses an output port rather than memory mapping. The hardware differences between it and the interface described in figure 4 dic-

(continued)

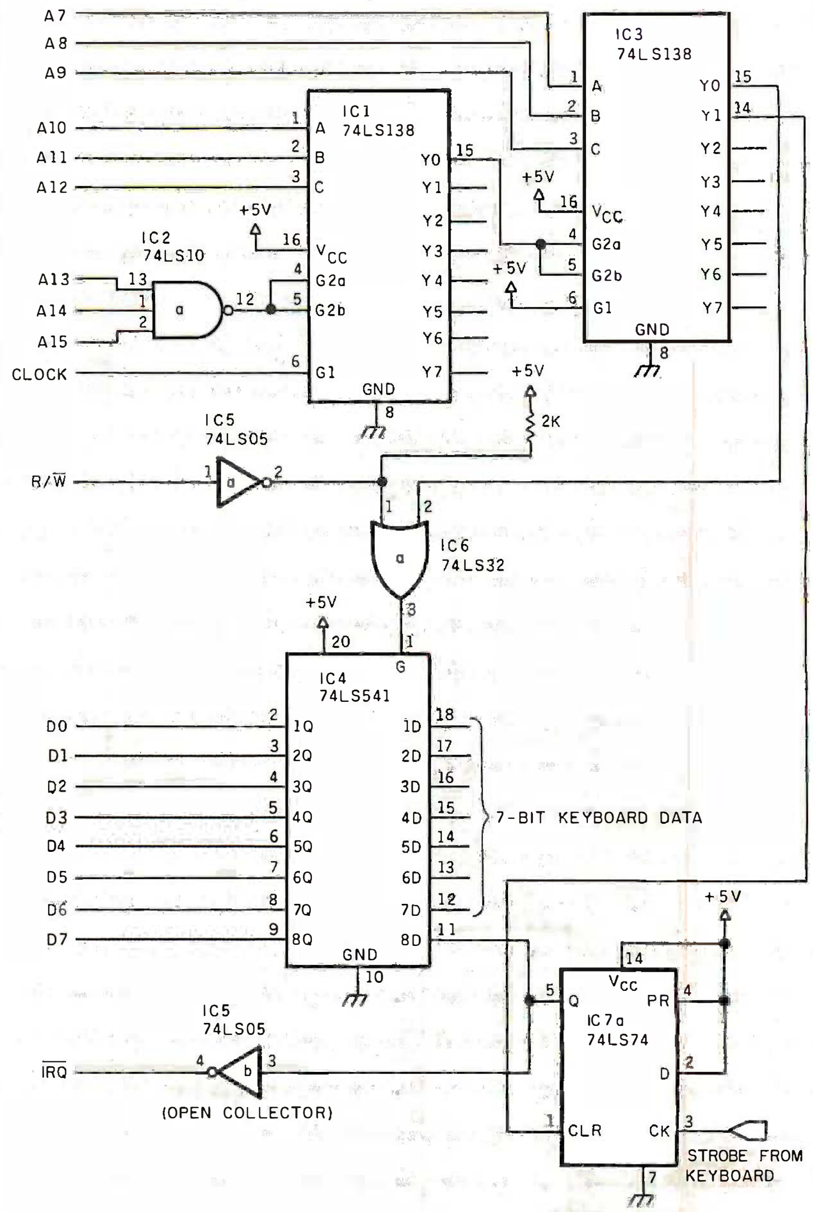



Figure 3: *Interrupt-driven keyboard input using buffer* (74LS541).

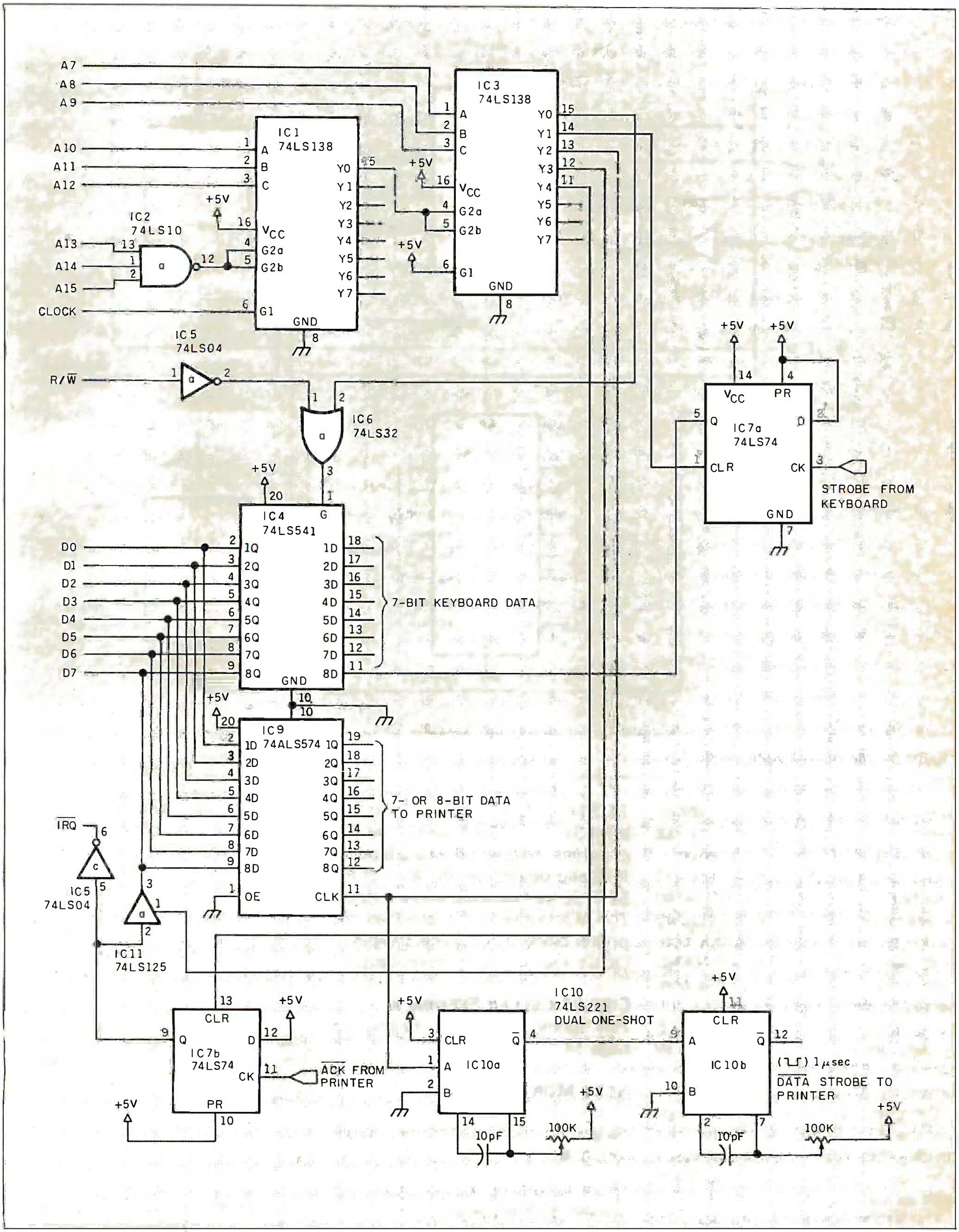



Figure 4: *Keyboard and printer using 74ALS574 octal latch.*

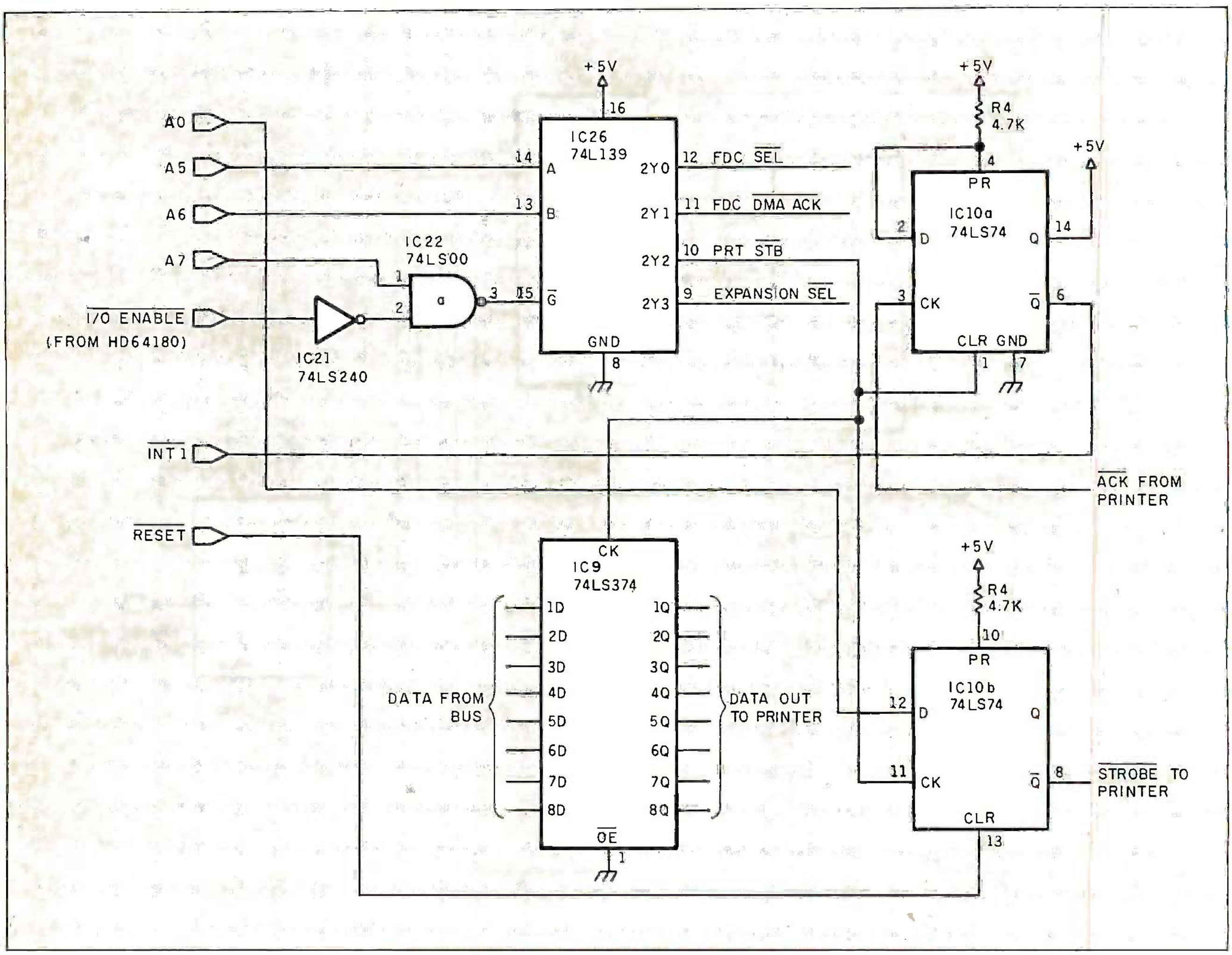



Figure 5: *The* SB180 *printer port.*

tate corresponding software differences when controlling the ports, but there is relatively little difference.

In the circuit in figure 5, the I/O ENABLE strobe from the HD64180 drives inverter IC21, from a 74LS240 package. The inverter's output controls one input of the 74LS00 NAND gate, IC22. IC22's other input is connected to address line A7. IC22's output controls the (active low) ENABLE of decoder IC26, half of a 74LS139 package. IC26's address inputs are driven by A6 and A5.

The effect is that when A7 is high and the I/O STROBE low, the decoder divides the upper 128 I/O addresses into four 32-address groups, each with its own strobe.

The strobe active for addresses C0 through DF is the PRINTER strobe. The PRINTER strobe resets IC10a, a 74LS74 clocked latch, and clocks IC9, a 74LS374 octal latch, and IC10b. Address line A0 drives the data input of IC10 and determines the level of the STROBE (active low) to the printer. The ACK (active low) strobe from the printer clocks IC10a, generating INT1 (active low) to the microprocessor.

## Circuit Cellar Feedback

This month's feedback begins on page 54.

## Next Month

I'll discuss some of the more specialized components and their application. ■

*Special thanks to Frank Kuechmann for his contributions to this project.*

There is an on-line Circuit Cellar bulletin board system that supports past and present projects. You are invited to call and exchange ideas and comments with other Circuit Cellar supporters. The 300/1200-bps BBS is on-line 24 hours a day at (203) 871-1988.

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**Editor's Note:** Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, P.O. Box 400, Hightstown, NJ 08250.

*Ciarcia's Circuit Cellar, Volume* I covers articles in BYTE from September 1977 through November 1978. *Volume* II covers December 1978 through June 1980. *Volume* III covers July 1980 through December 1981. *Volume* IV covers January 1982 through June 1983. *Volume* V covers July 1983 through December 1984.

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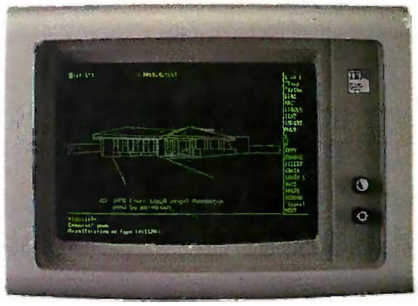

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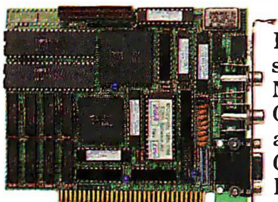

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| CGA compatible | X | (1) | (2) | (2) |
| MDA compatible | X | X | X | X |
| Chip count | 24 | 29 | 86 | 40 |
| Hercules compatible 720 x 348 graphics | X | X | | |
| No Software Patches required | X | | X | X |
| Boot from: | | | | |
| — Flight Simulator | X | | | |
| — Pin Ball | X | | | |
| — Jet | X | | | |
| Runs Lotus 1-2-3 version 1A: | | | | |
| — Hercules mode | X | (1) | | |
| — Color mode | X | (1) | | |
| Two Video Jacks | X | X | X | |
| Display Memory | 256K | 256K | 64K | 256K |
| Light Pen connector | X | X | X | X |
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(1) Needs software driver patches.
(2) Compatible only to the BIOS level, but not the hardware level. Will not be compatible with most games software.

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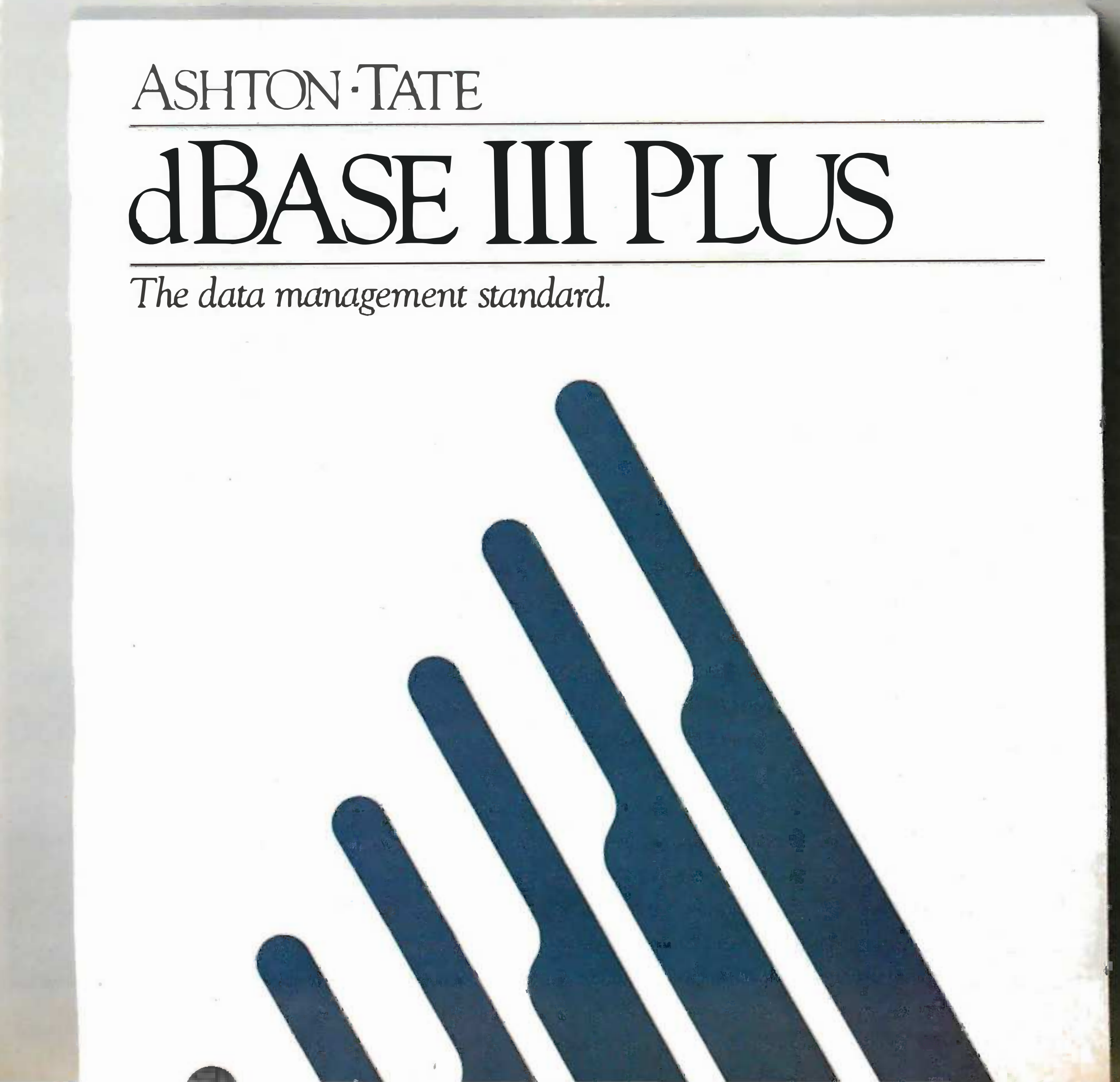

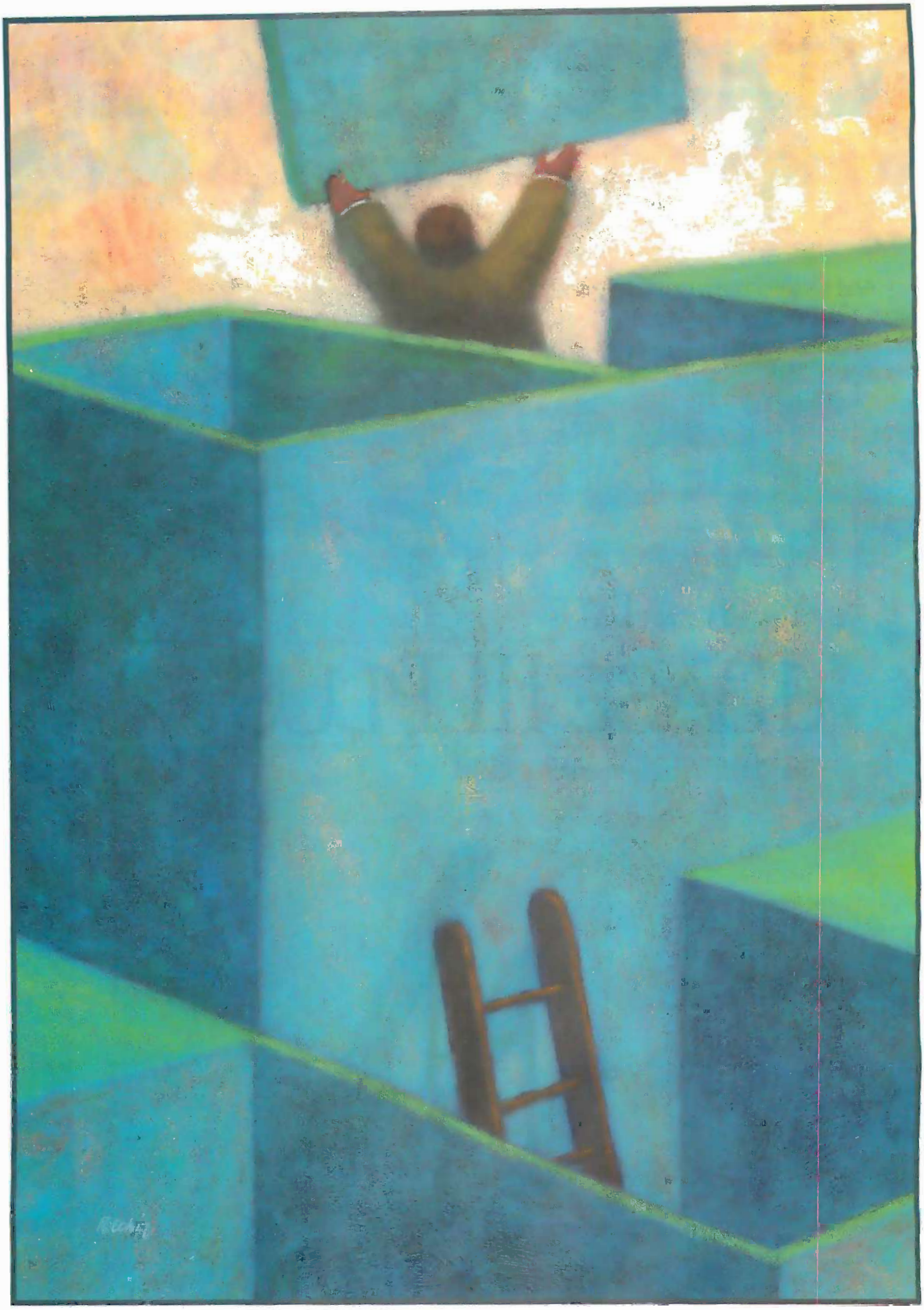



ILLUSTRATED BY ROB COLVIN

# BUILD A SPREADSHEET PROGRAM

BY JONATHAN AMSTERDAM

## *Four implementations of a spreadsheet in Modula-2*

The construction of a spreadsheet program raises some interesting issues in the design of data structures. These issues make for a challenging Programming Project. A spreadsheet is, of course, a program that provides you with a large grid of cells into which you can stuff numbers and formulas. A cell that contains a number causes the program to display that number; a cell that contains a formula causes the program to display the formula's value and automatically recalculate the formula whenever any cell on which it depends is changed.

A spreadsheet, then, is a special case of what we might call a dependency maintainer: It keeps track of dependencies between cells, and it updates affected cells whenever data is changed. In a spreadsheet, a formula that mentions cell A sets up a dependency between cell A and the cell containing the formula, cell B. Whenever A changes, the spreadsheet recalculates the formula and updates B's value. But that dependency goes only one way—when B changes, A is not affected.

I go into this detail because dependency maintenance is one of two difficult problems one faces when designing a spreadsheet. The second problem is size. Spreadsheet users want bigger and bigger spreadsheets, and the designer must aim to please.

For this project, I've written a spreadsheet program on an Apple Macintosh in Modula-2. [*Editor's note: The source code for this spreadsheet is available in a variety of formats. See pages 459–461 for details.*]

### USING THE SPREADSHEET

The user interface to my spreadsheet program is far from being the state of the art. In fact, it is downright primitive. The screen of my spreadsheet is divided into four sections (see figure 1). The top line of the screen is reserved for messages the spreadsheet displays. The second line displays the formula contained in the current cell. The third line displays the row and column of the current cell and is where you enter commands.

The command structure of the spreadsheet is simple. Each command begins with a single letter. The V command is used to enter a value into the current cell. Entering "V3.14" will put 3.14 into the current cell. You can also use a formula with the V command: V2.67+0.47 will give you the same result as entering V3.14. Similarly, the F

(continued)

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*I haven't provided commands for saving, restoring, or printing a spreadsheet.*

command is used for entering a formula into the current cell.

Since the F and V commands access only the current cell, it's important to be able to choose the current cell. You can do this in two ways. Typing U, D, L, or R will change the coordinates of the current cell to reflect a relative move of up, down, left, or right from the present current cell. For example, if the coordinates of the current cell are row 3, column 5, entering U will cause the cell at row 2, column 5, to become the current cell. Another way to choose the current cell is to enter a cell's coordinates directly. To choose the cell at row 3, column 5, for example, you enter "|3,5|:"

When the spreadsheet starts up, the upper left-hand corner of the display contains cell |1,1|. You can set a new corner with the N command. For example, "N|90,217|" will put cell |90,217| in the upper left-hand corner, with cell |90,218| to its right, and so on.

Another command, C, lets you copy the current cell's contents (both formula and value) to another cell. For example, "C|2,17|" will copy the current cell to cell |2,17|.

All the columns of my spreadsheet have the same width. You can change the column width by using the W command. For example, "W18" sets the width to 18 spaces. If a number is too large to fit in a column, it's truncated.

You can also change the precision (number of decimal places) displayed with the P command, and you can clear the contents of the entire spreadsheet by entering K (for "Klear"; a misspelling forced by my choice of C for "Copy").

Finally, three important commands complete the set. The A command sets the spreadsheet on automatic, which is the default mode: Any change to a cell immediately causes a recalculation of the spreadsheet. The M (for manual) command turns off the automatic mode, requiring you to give the explicit command "!" each time you want to recalculate.

I haven't provided commands for saving, restoring, or printing a spreadsheet. Such features should not be difficult to add, but they are outside the scope of this article.

### SPECIFYING FORMULAS

The simplicity of commands also carries over to formulas. A formula in the spreadsheet can contain numbers, references to cells, the four standard arithmetic operators, relational operators, and conditional expressions. The syntax of formulas is most easily explained by examples. A formula like 1+3*4/5 represents the obvious mathematical expression. All standard precedence rules are obeyed, so the program would first multiply 3 by 4, divide by 5, and then add 1.

References to cells can be absolute or relative. An absolute reference looks just like the cell references mentioned earlier: The cell at row 3, column 8, is written as |3,8|. In a relative cell reference, the row and column numbers are preceded by a plus or a minus sign and indicate the amount to be added to or subtracted from the position of the cell in which the formula resides. So, for example, if a formula in cell |3,8| includes the reference |+3,−1|, the referenced cell is |6,7|. If the referenced cell is on either the same row or column, a signed 0 can be used. For example, the formula that adds the two cells stacked directly above the formula cell is |−1,+0|+|−2,+0|; using −0 instead of +0 would work just as well. Also, you can combine the relative and absolute notations in a single cell reference; the cell that is three rows down from the formula cell's row and in column 12, for example, is referenced |+3,12|.

You can compare cell values using the IF expression and relational operators. An IF expression consists of the word IF followed by a condition and two other expressions, separated by commas. If the condition is true, the first expression is evaluated; if false, the second. An IF expression might be used to prevent division by 0: A formula that computes the ratio of cell |1,2| to |1,3| when |1,3| is nonzero, but displays 0 otherwise, could

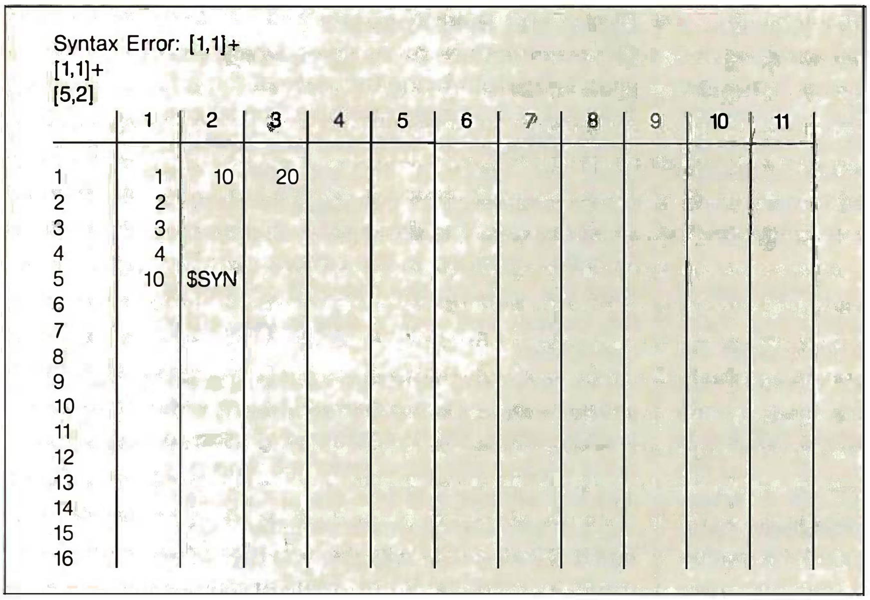


**Figure 1:** *The screen of the spreadsheet consists of four major components. At the top is a line reserved for messages displayed by the spreadsheet program. Beneath that, a line displays the formula contained in the current cell. The third line displays the row and column of the current cell. The fourth and largest component is the spreadsheet proper—the grid of cells.*

be written as IF |1,3| = 0, 0, |1,2|/|1,3|. Also, IF expressions can be nested. For example, if you want to display a different value depending upon whether cell |1,1| is negative, 0, or positive, you could write IF |1,1|<0, −1, IF |1,1|>0, 1, 0. This formula results in −1 if |1,1| is negative, 1 if the cell is positive, and 0 if the cell is 0.

Although only a few constructs are contained in the formula language, they interact in a regular way to produce a surprising variety of expressions. An IF expression can appear as an operand, as in 3*IF |1,1|>0, 1, 0. This will yield 3 if |1,1| is greater than 0 and 0 if it isn't. Relational expressions yield 1 if they are true and 0 if false, so the above could be expressed more concisely as 3*(|1,1|>0). The parentheses are necessary to ensure that the relational expression is evaluated before the multiplication.

This regularity breaks down in one important place, however. Although it would be useful to allow cell references like ||2,3|, 1|, such expressions are disallowed: A cell reference can contain only constants, optionally preceded by plus or minus.

**IMPLEMENTATION**

I now want to consider the uninteresting parts of the spreadsheet program, namely, everything but the spreadsheet data structure itself. Most of these—the input of commands, the handling of the display, and so on—are too straightforward to deserve mention, but I would like to discuss a couple of important points. The first has to do with formulas. Ideally, the parsing of a formula should be separated from its evaluation, as it has been in my earlier projects ("Context-Free Parsing of Arithmetic Expressions," August 1985; "A SIMPL Compiler, Part 1: The Basics," December 1985). The parser should produce a parse tree, which is then interpreted by an evaluator. The problem in doing that for a spreadsheet is space; a parse tree occupies considerably more storage than the equivalent string. In my spreadsheet, formulas are represented as strings, and the parser and evaluator are combined into one program. This arrangement

*(continued)*

slows down and complicates things, but in a spreadsheet, saving space is paramount.

On a related note, the formulas are not stored in fixed-length character arrays. Since the length of a cell's formula can vary considerably, this too would be wasteful. Instead, I used Modula-2's ALLOCATE procedure to apportion just enough storage to hold the string, plus one additional byte to hold an ASCII NUL character (ASCII value 0) to mark the end of the string. My spreadsheet's formula data type is actually a pointer to such a variable-length piece of storage.

The other consideration concerns the division between the spreadsheet proper—the part of the program that deals with manipulating and changing cells—and the rest of the program. The spreadsheet data structure is not directly visible to the rest of the program and can be accessed only by a few well-defined procedures.

### ABSTRACT DATA TYPE

The heart of any spreadsheet program is, of course, the spreadsheet itself—the data structure containing the cells. From now on, I'll use the term "spreadsheet" for the data structure and "spreadsheet program" to refer to the entire program. We can view a spreadsheet as a kind of data type, like an integer or a set, and we can separate the implementation of the data type from its specification, or abstract description of its behavior. The other parts of the spreadsheet program can access the spreadsheet only by using the operations defined in the specification.

My spreadsheet allows the following operations. The init procedure should be called once before any other action is taken; it initializes the spreadsheet. The procedures getValue and getFormula take a row and column number and return either the value or the formula of the cell at that row and column. The setValue procedure takes a row, column, and value and sets the cell's value; likewise setFormula. The set procedures also redisplay the specified cell. If the spreadsheet is on automatic, they will redisplay any cells whose values are affected.

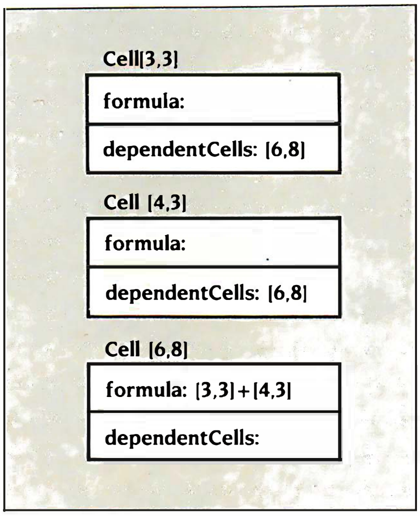


Figure 2: *Dependency maintenance. The references in cell [6,8]'s formula to cells [3,3] and [4,3] make [6,8] a dependent cell of both [3,3] and [4,3].*

You can set the recalculation mode of the spreadsheet with setManual and setAutomatic, and you can recalculate the entire spreadsheet with recalculate, which redisplays the changed cells. The procedures maxRow and maxColumn return the largest row and column that the spreadsheet allows (the minimum row and column are both 1). The clearAll procedure frees all storage associated with the spreadsheet and empties all the cells.

Each cell has a status that indicates whether the cell is empty, contains a valid value, or contains an erroneous value. A cell can contain an erroneous value if its formula does something wrong. For instance, a cell whose formula causes a division by 0 will have a status of DivByZero; a cell whose formula references a cell off the spreadsheet will have a status of RangeError. The status of a cell can be obtained by calling the status procedure with the cell's row and column. Since the procedures getValue, setValue, getFormula, setFormula, and status can be called with row and column values that are off the spreadsheet, a variable, operationStatus, is provided to determine if these operations were successful. The variable is set to OK if the operation was successful or to RangeError if the row and column values indexed a cell outside the bounds of the spreadsheet.

It's important to keep in mind that the procedures and variable I've described are the only interfaces to the spreadsheet from the rest of the program. Without using the interfaces, the program cannot manipulate the spreadsheet data structure or even a cell. This allows the implementer (that is, me) a great deal of freedom, which I have exploited by designing four very different but interchangeable implementations of the spreadsheet program.

### NAIVE IMPLEMENTATION

In the first implementation, a cell is a record containing a value, a formula, and a status, and the spreadsheet is represented as a two-dimensional array of cells. A global Boolean variable indicates whether the spreadsheet is in manual or automatic mode. Getting and setting values and formulas are straightforward operations. In automatic mode, the setting procedures force the entire spreadsheet to be recalculated; in manual mode, the recalculate procedure is called when you enter "!".

This implementation isn't bad, but I find it unsatisfactory for two reasons. First, it limits the size of the spreadsheet to a fixed, and fairly small, number of rows and columns. Second, it performs poorly in automatic mode, because a change to even a single cell will force every cell in the sheet to be recalculated. If you were using a sheet with many filled cells, the delay in automatic mode would become intolerable, and you'd almost certainly switch to manual. That's too bad, because one of the great beauties of the spreadsheet idea is the ability to see your changes take effect instantly.

### DEPENDENCY IMPLEMENTATION

Since a spreadsheet is a dependency maintainer, my second implementation remedies the recalculation problem by taking the dependencies seriously. This implementation keeps track of dependencies between cells, so when a cell is changed, the program need recalculate the formulas for only those cells that depend on the changed cell.

This implementation uses the same data structures as the first but adds a new field to the cell record, dependentCells. Each cell's dependentCells field contains a linked list of the row and column numbers of those cells that depend on the cell. Initially, the dependentCells field of each cell contains an empty list. When a formula is entered into a cell via setFormula, the formula is scanned for references to other cells, and those cells' dependentCells lists are updated accordingly. For instance, if the formula |3,3|+|4,3| is entered into cell |6,8|, a record containing the numbers 6 and 8 is added to the dependentCells lists of cells |3,3| and |4,3| (see figure 2).

When a cell's value is changed, each cell on its dependentCells list is recalculated. Each recalculated cell may itself have dependent cells, which must be recalculated as well. The process is most simply coded as the recursive procedure recalc, shown in listing 1.

It is important to note that this procedure, while much quicker than recalculating the entire spreadsheet, will handle some things differently. Say you have a dependency loop: Cell A depends on cell B, which depends on A. If the entire sheet is recalculated, row by row (or column by column), A and B will change once at most. But recalc will change one, then the other, then the first, then the second, and so on, until the machine's stack blows. You could fix this looping problem by associating with each cell a Boolean value that is cleared before recalculation begins, set when the cell is recalculated, and tested before recalculating a cell to see if it was done already.

Looping can be a useful tool, however. Putting the formula "IF |1,1| = 10, 10, |1,1|+1" in cell |1,1| and setting the cell to 0 will display the numbers 1 through 10 in |1,1| and then stop. Once you can do controlled loops like this, a whole gamut of programming techniques are available. Since looping is sometimes useful and sometimes not, it might be wise to provide an option to turn it on or off. My spreadsheet combines this option with the automatic/manual feature. Automatic recalculation uses the dependency scheme and can loop, but when the spreadsheet's automatic mode is turned off, the program recalculates each cell (as in the first implementation) and will never loop.

Remember that expressions inside cell brackets, like ||2,3|, 1|, are not allowed. This is because the dependency-based recalculation scheme breaks down. A little reflection shows why. If a cell contained this formula, on which cells does it become a dependent? Presumably, it is the cell whose row is the value of |2,3| and whose column is 1. But which cell this is depends on the value of cell |2,3|, which can itself change. The simple dependency-tracking scheme I discussed above will no longer suffice.

My solution to the problem is to banish all such "indirect" cell references. If you really want them (and I

(continued)

Listing 1: *This recursive procedure recalculates a cell's formula. If the result differs from the current value of that cell, the procedure writes the new value and updates all other affected cells.*

```
Procedure recalc.  Takes as input row and column numbers
   of a cell to recalculate
Begin
 If the cell contains a valid formula, then
   Evaluate the formula;
   If the formula results in a value or status that differ
         from what the cell currently contains, then
      Update the cell's value and status;
      Display the cell;
      For each row and column number on the cell's
           dependentCells list,
         Call recalc with that row and column
End
```

don't dispute that they can be useful), you have a couple of choices. One is to elaborate the dependency scheme to handle the problem. In addition to the usual dependency, there would be a second, indirect, dependency. Say that the formula ||2,2|,1| was put in cell |9,9|, and the current value of |2,2| is 5. We would put |9,9| on the dependentCells list of |5,1|, as before, and we would also put |9,9| on a different list in cell |2,2|. A change to |5,1| is handled as before, but a change to |2,2| requires more work. If |2,2| is changed from 5 to 6, |9,9| must be deleted from the dependentCells list of |5,1| and added to that of |6,1|; then the value of |9,9| must be updated to reflect |6,1|. Such a complicated procedure could probably be made to work, but it is not clear that the benefits outweigh the costs, both in programming effort and run-time efficiency.

A simpler way to handle indirect cell references is to keep track of all cells whose formulas contain indirect references and recalculate these cells whenever any change to the spreadsheet is made. If indirect references aren't used too frequently, this method should be a reasonable compromise between total recalculation and carefully maintained dependencies.

## SPARSE IMPLEMENTATION

Now let's consider spreadsheet size—remember, spreadsheets never seem to be big enough. My third implementation provides a spreadsheet of arbitrary size. Actually, the size is limited by the largest value of Modula-2's CARDINAL data type, which in the implementation I use is about 65,000; so my spreadsheet has 65,000 rows and 65,000 columns. But you could use any integer type—say a 32-bit integer, allowing spreadsheets 4 billion square—with no fundamental change to the spreadsheet program.

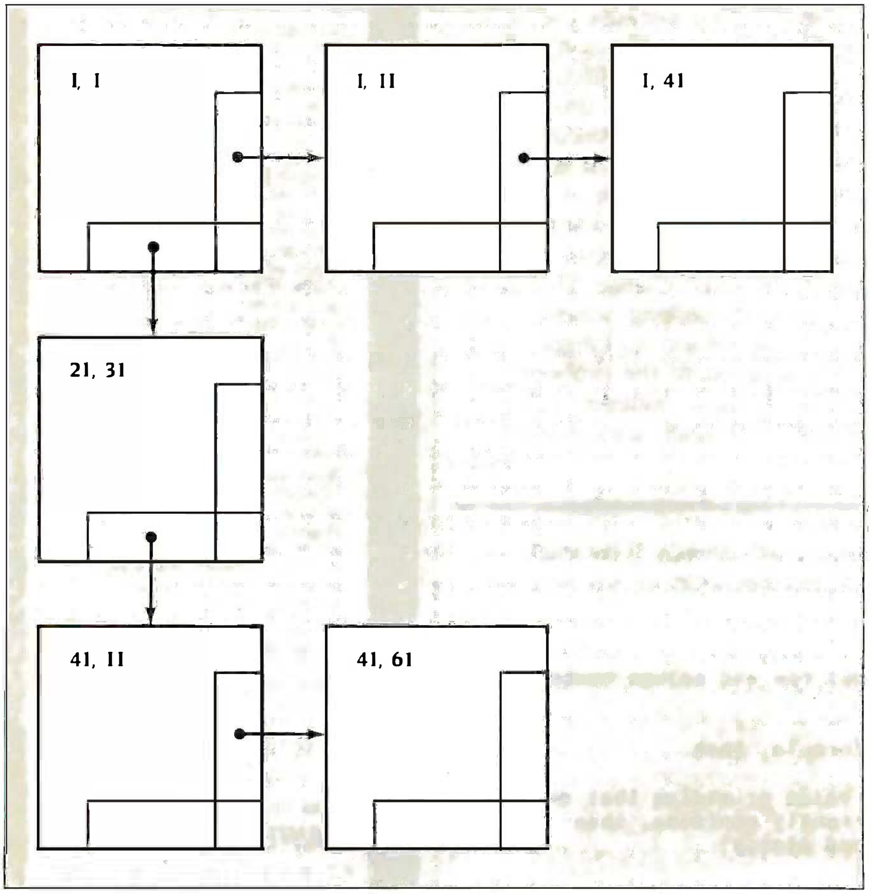


**Figure 3:** *The data structure of the sparse implementation uses 10-row by 10-column chunks of spreadsheet cells. The numbers inside the boxes represent possible starting coordinates (row and column).*

Of course, these numbers indicate only the largest legal row and column numbers of the data structure; I certainly don't claim that you could fill all the cells of such a gargantuan sheet. That is a matter of memory, and the issue then becomes one of memory management. Only portions of the spreadsheet will actually exist at any given time—those cells that are occupied. Empty cells need not take up space; that is, any portions of a data structure whose behavior is constant need not be explicitly represented.

We could just allocate enough of the upper left-hand corner of the spreadsheet to contain the user's work. But doing so will cramp the user, who might, after all, want to use cells |1,1| and |65000,65000| simultaneously. To support such a sparsely populated spreadsheet we could use linked lists of cells, creating a cell only when actually needed. For efficient access, the cells should be linked both horizontally and vertically. But since that adds up to two pointers for every cell—a significant overhead—it might be wiser to allocate cells in groups, or chunks as I call them, and link the chunks together. That is how my third implementation works. Each cell contains a value, a formula, a status, and a list of dependent cells, just as used earlier.

A cell chunk is a 10 by 10 array of cells (you could make it larger or smaller), with two numbers indicating the starting row and column of the chunk and two pointers, one to the chunk below and one to the chunk on the right. True, using cell chunks means that space will be allocated for some empty cells; but I am banking on the assumption that cells tend to be used in clusters rather than spread out randomly on the sheet. If they are used in clusters, the cell-chunk implementation will waste little space. If they are used randomly, cell chunks will prove to be inefficient.

Initially, only a single chunk spanning rows and columns 1 through 10 is present. By convention, a cell chunk's starting row and column are always multiples of 10, plus 1. When a cell's formula or value is set, the program first checks to see if the cell is on an existing chunk. If so, the operation proceeds as usual. If not, a new chunk is created, its starting row and column are set to 1 plus the nearest multiples of 10 just below the row and column of the cell being accessed, and the chunk is linked into the data structure in the appropriate place. A cell whose chunk has not been created is an empty cell, so any attempt to examine its contents (via status, getValue, or getFormula) returns just what you would get with an existing empty cell. There's no need to create a cell chunk in such a case.

The chunks could be linked together into a single list, but it's more efficient to use two dimensions. All chunks with the same starting row are linked horizontally, from lowest to highest. The lowest chunk of each row—the chunk with the lowest starting column—is linked to the row below. To find a cell, we first search down until the appropriate row is found, then across until we hit the correct column. The data structure is illustrated in figure 3. It is faster to search a two-dimensional list than a one-dimensional list. When searching for the row, we can skip over whole chunks that we would otherwise have to examine.

When the spreadsheet is cleared, the storage for the cell chunks can be deallocated. If my spreadsheet program allowed clearing of individual cells or groups of cells, such operations could check to see if any cell chunks were thereby rendered blank and could free them.

### THE VIRTUAL SPREADSHEET

The sparse implementation does a nice job of giving the illusion of a mammoth spreadsheet while using a much smaller amount of memory, but it still falls quite short of the ideal. To give you an idea of the ratio of memory to spreadsheet size, my spreadsheet allows $65{,}000^2$ (or about 4 billion) cells; but even with a conservative 8 bytes per cell, 1 megabyte of RAM can hold only about 256,000

(continued)

cells. The ratio is about 1 to 32,000. We can improve the situation somewhat by providing a further illusion: splitting the available memory between RAM and disk. This technique is not new to anyone familiar with virtual memory, in which a large address space is used by shuffling fixed-size pages of memory words between disk and memory. A virtual spreadsheet uses the same techniques, but it does so at the level of the cell, not the memory word.

Can a virtual spreadsheet be implemented efficiently? Efficiency is partly a matter of technology. I certainly wouldn't recommend using floppy disks for secondary storage, but a fast hard disk might be reasonable. More important, the success of virtual memory depends on the principle of locality of reference: The observation that memory accesses occurring at about the same time tend to reference memory locations that are close to each other. A program that observes the principle of locality will, at any given time, access mostly those pages that are already in memory; therefore, disk traffic is low, and performance is only slightly worse than if the entire address space were present in RAM.

One lesson from virtual memory does not apply here: It was quickly learned that hardware support is essential for virtual memory, because every memory access involves a translation from a virtual address to the corresponding physical address. Translating every address in software is just too slow. But in a virtual spreadsheet, the references of interest are not to memory words, but to spreadsheet cells, and the references occur much less frequently—a reference to a single cell might involve a hundred memory references. It is at least plausible, then, that a purely software approach will do.

Surprisingly little of the sparse implementation has to be changed to accommodate the virtual-memory scheme. Initially, things proceed as before, with new chunks being allocated as required. Eventually a time will come when there is not enough memory to allocate a chunk. In the sparse implementation, the program says "Out of memory" and leaves it at that. In the virtual implementation, however, a three-step process takes place. First, one of the existing cell chunks is chosen to be removed from memory. Second, the chunk is written to the disk. Finally, its memory is released, to be reallocated for the new chunk. When a chunk whose contents are on the disk is referenced, the chunk is read back into memory, possibly causing another chunk to be written to disk.

A few details are left to be attended to. First is the matter of tracking the locations of all the chunks. Actually, only the chunk's array of cells is written to the disk and freed. The other fields of the chunk, like the starting row and column and the pointers to other chunks, are kept in memory. Additional fields in the chunk provide the necessary bookkeeping information. One such field is diskAddress. It contains the location on the disk where the chunk's cell array is located. (The diskAddress field of a newly allocated chunk is empty.) When the chunk is first written to disk, it is assigned a disk address. Another new field, inMemory, contains a Boolean value that indicates whether or not the chunk's cell array is in memory or on the disk.

Since part of a chunk is never deallocated once the chunk is allocated, the danger exists that memory can be filled if many chunks are created, even if the chunks' cell arrays are all on disk. For our purposes here, my solution to this problem is to ignore it. The "immortal" part of each chunk is a very small 26 bytes, so it will take very many of them to fill memory.

How do we choose which chunk to discard from memory when the inevitable time comes? One idea is to throw out the chunk that was referenced least recently, that is, furthest in the past. As a matter of fact, this so-called least recently used, or LRU, policy works quite well.

True virtual-memory implementations use an approximation to LRU for efficiency reasons, but for our purposes the additional overhead is negligible, so we might as well implement it in full. A counter, touchCount,

*(continued)*

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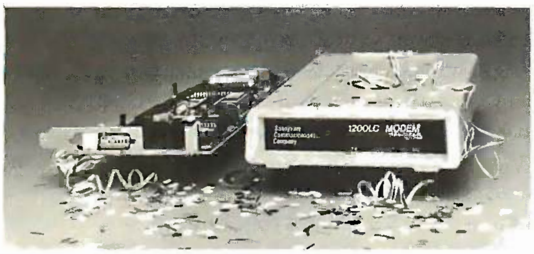


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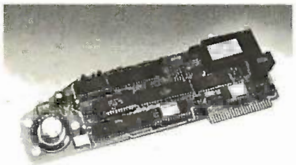

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*The last piece of the virtual spreadsheet algorithm is a simple optimization.*

is initialized to 0 and incremented on every cell reference. A field of each chunk, touchedLast, is assigned the value of touchCount when a cell in the chunk is referenced. The chunk with the lowest counter value is the one least recently used. For instance, say there are two chunks, A and B, and touchCount is initially 0. When a cell in chunk A is referenced, the counter is incremented to 1, and that value is stored in A's touchedLast field. Then one of B's cells is referenced. Again, touchCount is incremented, and its new value, 2, is stored in B's touchedLast field. A search for the chunk with the lowest-valued touchedLast field will yield A, which is indeed the least recently referenced chunk.

It's possible for touchCount to overflow. The simplest solution to the problem is to check for overflow and set the counter and all the chunks' touchedLast fields to 0 when it happens. We thus lose the information about which chunk was the least recently accessed, but that's not a problem; nothing will go fatally wrong if we pick some other chunk to get rid of instead. It is only for efficiency that we strive to pick the least recently used chunk.

The last piece of the virtual spreadsheet algorithm is a simple optimization. Each chunk has a Boolean field called dirty, which is set to true if any cell in that chunk is changed while that chunk is in memory. The first time the chunk is to be written to disk, the chunk is written regardless of the value of the dirty field. But on subsequent write attempts, the dirty field is checked. If the value is false, the chunk's contents do not differ from the version already on disk, so there is no need to write its cells to disk. This optimization is easy to implement and can greatly improve the performance of the algorithm.

Now everything is in place for a detailed description of what happens when a cell is referenced. Two procedures are used to reference cells. The getCell procedure returns the cell at a given row and column, and the setCell procedure sets the contents of a cell at a given row and column. The procedures work similarly. First, the cell chunk containing the desired cell is searched for. If it doesn't exist and the cell is being set, the cell chunk is created; this action may involve some other cell chunk being written to disk if there's not enough memory. If the desired cell chunk doesn't exist and the cell is being read, there's no need to create the chunk; instead, getCell just returns an empty cell.

If the cell chunk is found, the next question is whether its cell array is in memory; this is easily answered by looking at the chunk's inMemory field. If it isn't in memory, it is read in from the disk, using the chunk's diskAddress field. Reading this chunk in may cause another chunk to be written out. Once the chunk is in memory, the access can proceed. The cell's contents are read or written, touchCount is incremented, and its value is stored in that chunk's touchedLast field. Also, setCell sets the chunk's dirty field to true.

So far, I've ignored the low-level details involved in writing and reading cell arrays from disk. In standard virtual-memory systems, the problem is easy because pages are a single fixed size, which is a multiple of a disk sector's size. A page's disk address is just the address of a sector on the disk, and reading or writing a page involves transferring one or more contiguous sectors between disk and memory. Our cell arrays, however, are not of fixed size. Of course, they always contain a fixed number of cells; but cells can differ in size because both formulas and lists of dependent cells can be of different lengths. This wouldn't be so bad, but what really causes trouble is that a cell's size can change; the user can add or change a cell's formula or by changing another cell's formula affect this cell's dependency list. A problem occurs when we try to write a cell array whose size has changed back to the place on the disk from whence it came. If the cell array has shrunk, we will have some wasted space left over on the disk when we are done writing. What's worse, if the cell array has grown, it won't fit in the original space.

This problem indicates the disk-storage-allocation scheme used for fixed-size pages won't work for our variable-size cell arrays. A simple solution would be to determine the maximum size of a cell array and pretend that cell arrays were really fixed-size objects of that size. But that won't work for our application. Since a cell can theoretically have every other cell in the spreadsheet as a dependent, there is no reasonable upper bound on the size of a cell and, therefore, on the size of a cell array.

A more sophisticated storage-allocation scheme is necessary. The scheme should conserve disk space, but it also must be fast since we don't want to keep the user waiting. The scheme I use takes its inspiration from the design of a typical file system. File systems have to allocate disk space for variable-size files. In a typical file system, the disk is divided into fixed-length segments called sectors. A file always occupies an integral number of sectors, but it may not occupy contiguous sectors. Each sector points to the next sector in the file. The disk's directory contains, for each file on the disk, the number of its first sector. The directory also contains the number of the first free sector on the disk, that sector contains the number of the second free sector, and so on. The free sectors form a linked list on the disk, as do the sectors for each file.

My method is similar, but I've tried to minimize the number of disk accesses required to read or write a cell array by keeping more information in memory. I use a single file I call the scratch file to hold all the cell arrays that are written to disk. Initially, the file is empty; as cell arrays are written, it grows.

In my scheme, a disk address is an array of sector numbers. The size of

*(continued)*

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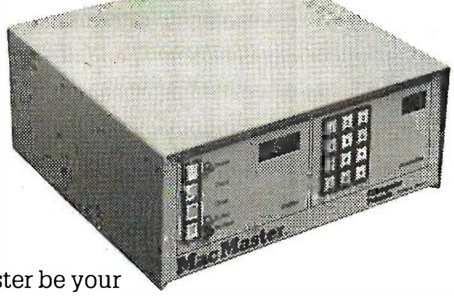


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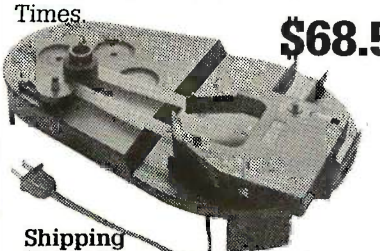

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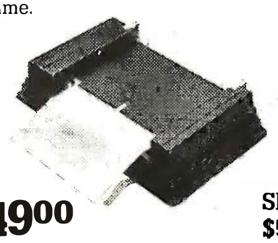

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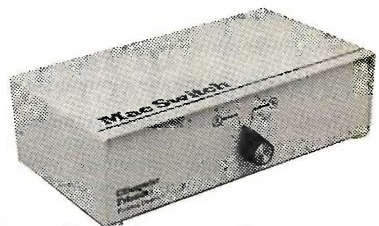


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the array may vary, depending on how many sectors a cell array actually occupies. Keeping the locations of all the sectors of a cell array together in memory, rather than linking the sectors together on the disk, reduces the number of disk accesses when rewriting a cell array.

I also keep a list of free sectors; again, the list is in memory to speed access. The list need not contain every sector on the disk but only those sectors in the scratch file that have been freed. There probably won't be many of these at any given time, so the free list should be short.

When a cell array is written to disk for the first time, it is assigned enough free sectors to hold its contents. The sectors are drawn first from the free list; when the free list is exhausted, the scratch file is extended. When the cell array is subsequently rewritten to disk, the sectors allocated to it are overwritten. If the cell array requires the same number of sectors as originally, nothing changes. If it requires fewer, the unused sector numbers are removed from its disk address and placed on the free list. If the cell array requires more sectors, additional sectors are allocated from the free list or the end of the scratch file, and their numbers are appended to the disk address of the cell array. Reading a cell array from the disk is a simple matter of reading each sector mentioned in its disk address.

In an effort to achieve some portability, I use Modula-2's file system module to implement the scratch file. You may, however, want to bypass your computer's file system and access the disk directly.

### ADDITIONS

As always, numerous improvements and additions can be made to my program. Of course, the user interface could use some work. There are also, I am sure, many other reasonable spreadsheet implementations that differ significantly from the four I've described; you can trade off the parameters of speed, size, and convenience in limitless ways. Finally, many minor improvements could be made to my implementations. Opportunities for clever space-time trade-offs abound. ■

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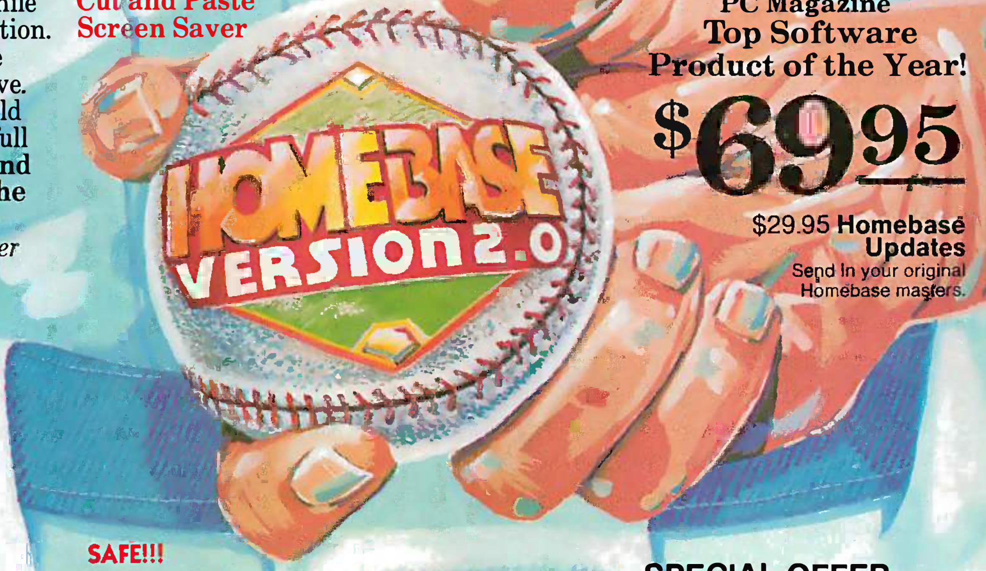


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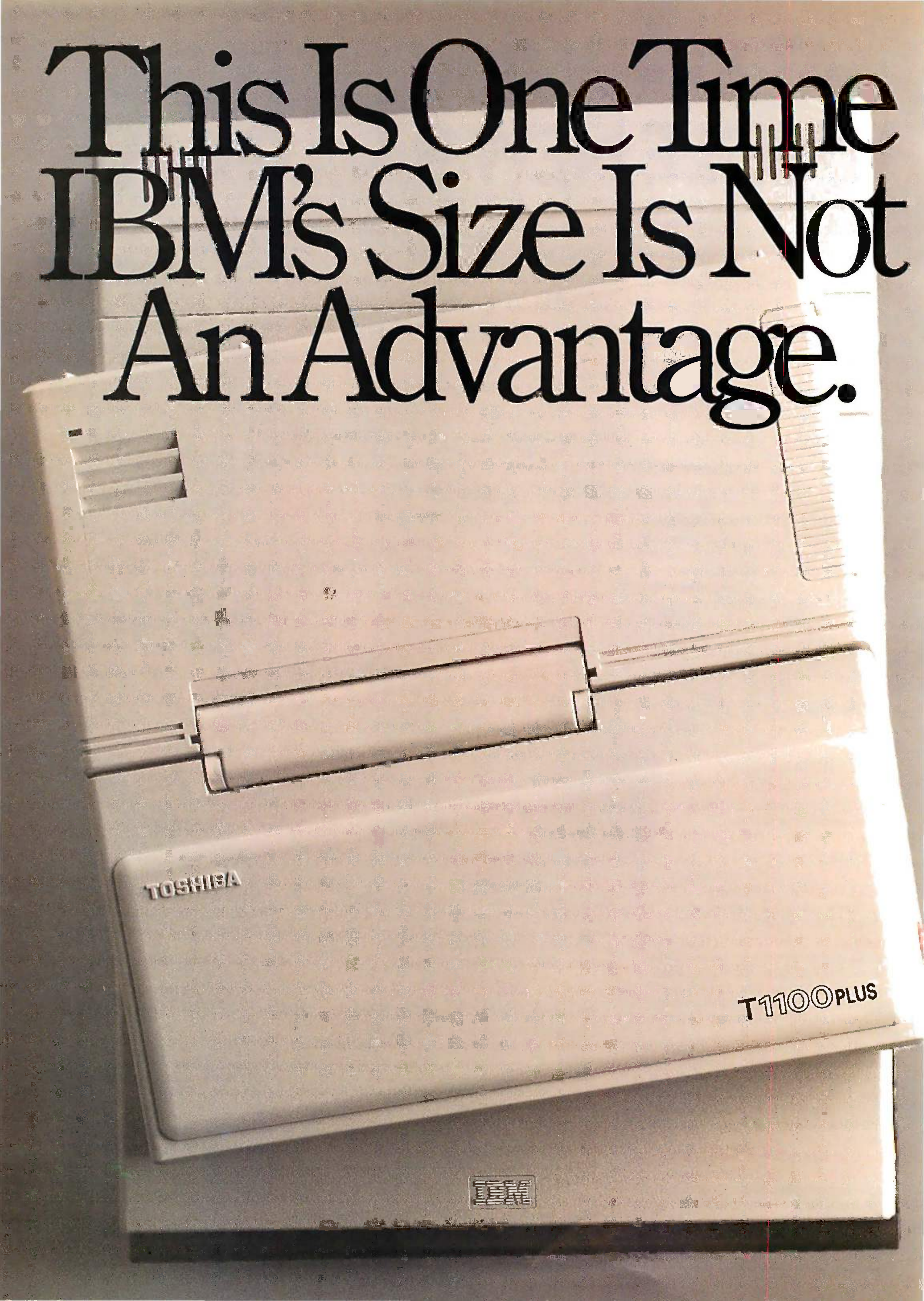
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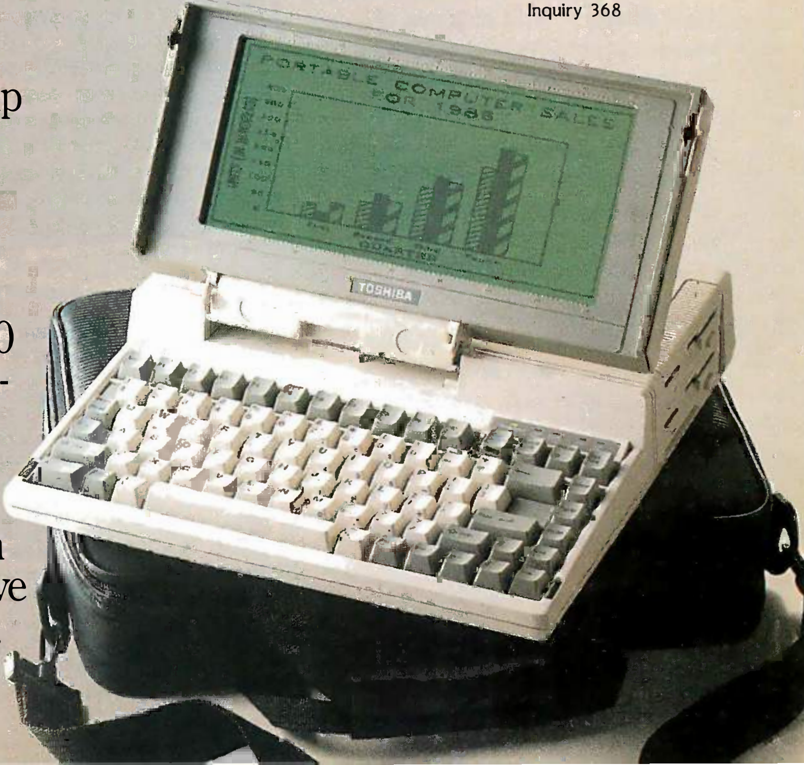


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# ANAGRAM SOLVING IN PASCAL

BY BOB KEEFER

## *Use a probability table to decipher anagrams*

THE JOY OF ANAGRAMMING is the joy of language itself. Although English poet John Dryden called the practice "the torturing of one poor word ten thousand ways," people have been rearranging the letters of words at least since ancient Greek times, and very likely since the first alphabet was devised. Some anagrammatists work for the sheer pleasure of seeing *intoxicate* turn into *excitation*. Others have gone from lofty *heights* to the very *highest*, seeking religious meaning in the mysterious transposition of one word into another.

Part of the pleasure comes from the jolt of recognition when a word is anagrammed. Even short words have an astounding number of possibilities. The number of permutations of a word *N* letters long is *N* factorial, so that a five-letter word has 5!, or 120 possible anagrams. An eight-letter word has 40,320, and a ten-letter word has more than 3.6 million. Nevertheless, the human eye can look at *anagrams* and easily see *ars magna*—the great art.

Can a microcomputer be programmed to do the same thing? A February 1984 BYTE article ("Deciphering Word Games" by Mark C. Worley) outlined a BASIC program that generates all permutations of words up to six letters long and displays them on the screen. At that point, it's up to the operator to pick the English words out from the nonsense combinations.

My program, ANAGRAM.PAS, goes a step further. [*Editor's note*: ANAGRAM.PAS *and* SETPROB.PAS *(mentioned later) are available in a variety of formats. See pages* 459–461 *for details.*] Written in Turbo Pascal, the program generates all possible permutations of words up to ten letters long (it can do even longer words, but the program would take a very long time to run). Then, using a surprisingly mechanical method, it tries to solve the anagram—that is, to pick out the English among the random nonsense. The program doesn't, however, look words up in a dictionary; that would, after all, be cheating. What it does instead is evaluate the probability that each of the three-letter combinations, or trigrams, that make up the permutations could occur in normal English.

The method is based on the fact that in English, as in any other language, certain patterns of letters are more likely to occur than others (see "A Travesty Generator for Micros" by Hugh Kenner and Joseph O'Rourke, November 1984 BYTE). A basic example is that *q* is almost invariably followed by *u*. In a more typical case, it is easy to determine that *th* is frequently followed by *e*, *a*, *i*, or *o*, more rarely by *u*, and almost never by *p* or *z*.

This property allows your computer to evaluate the likelihood that any given combination of letters is an English word and not nonsense. For example, you can permute the letters *d*, *g*, and *o*, into six arrangements:

DGO
DOG
GDO
GOD
OGD
ODG

When you put these trigrams in order

*(continued)*

*Bob Keefer (35995 East Wills Rd., Creswell, OR 97426) is a feature writer for* The Register-Guard *in Eugene, Oregon.*

of their likely appearance in English, the two words *god* and *dog* rise to the top:

GOD
DOG
ODG
GDO
DGO
OGD

This is exactly what ANAGRAM.PAS does. Given a list of letters in any order—including an English word—it produces every permutation of those letters. Then it scores each permutation by totaling the probabilities of the trigrams that make up the permutation. Finally, the program prints out the top 15 scorers, presumably including any English words buried among the nonsense permutations. Table 1 shows the results of entering the letters *claaps*, which ANAGRAM.PAS unravels to *pascal* on line 4.

But where does ANAGRAM.PAS look up the probabilities? That's where a second program comes in.

## SETPROB.PAS

SETPROB.PAS creates a probability table for ANAGRAM.PAS by reading natural English text from a disk file and counting the occurrences of each trigram. The results are tabulated in a three-dimensional array, Probability [X,Y,Z], which is then stored in a disk file (PROB.DAT) for use by ANAGRAM.PAS.

Probability[X,Y,Z] is a big array. With each dimension extending for 27 units—26 letters plus the blank space—it has 19,683 elements. In a Turbo Pascal integer array, which requires 2 bytes per element, that's 40K bytes for the probability table alone. Using Turbo Pascal on my 64K-byte Osborne I means the program cannot be compiled and run in memory but must be compiled into a command file (.COM) and run without the Turbo Pascal system.

I ran SETPROB.PAS on several chapters of an unfinished novel, since that was the largest chunk of text I had sitting around on floppy disks. The English text was about 35,000 words. A bit of experimentation showed that the performance of ANAGRAM.PAS improved dramatically, at first, as more text was digested into the probability table. When the table included the results of reading about half the text, though, the program's performance seemed to top out. It may be that adding English text from a source other than my own hand would once again broaden the program's horizons; I haven't yet tried this.

To use SETPROB.PAS on more than one text file, such as separate chapters contained on more than one disk, you must alter the procedure ZeroProb so that instead of setting the array elements in Probability[X,Y,Z] to zero at the beginning of the program, it reads in existing results from the file PROB.DAT. Notes in the program listing show how to do this easily.

SETPROB.PAS treats everything that is not a letter as a blank space and turns all letters into capitals. Then it collapses strings of blanks into single blanks before evaluating the characters of the trigram (Ch1, Ch2, Ch3) and incrementing the appropriate array element in Probability[X,Y,Z]. A procedure called ScaleProb makes sure that the highest value in the array never exceeds Pascal's maximum integer value, 32,767.

An interesting feature of ANAGRAM.PAS is that probability tables can easily be generated for different languages. When I used SETPROB.PAS to create a probability table for Latin by counting a 300-word excerpt from Cicero, *ourtt* no longer unscrambled to *trout*, as it does when the table is based on English text, but to *tutor*, a good Latin word. Similarly, *eeunq* unscrambled to *neque*, the Latin word for *nor*, and not *queen*, as it would in English.

## ANAGRAM.PAS

ANAGRAM.PAS contains two Pascal procedures of interest. Permute, a recursive procedure, generates all possible permutations of the string obtained by procedure GetInput. I must admit I was stumped for a long time by the problem of generating permutations of a word of any length without resorting to an endless number of nested for loops; I finally stumbled across the solution in Charles Seiter and Robert Weiss's *Pascal for BASIC Programmers* (Addison-Wesley, 1983) and have borrowed their general structure for Permute. To them, thanks.

The second procedure, Score, is incorporated into Permute. It consults the probability table to look up the relative likelihood of each trigram making up the word. A space is added to the beginning and ending of each permutation before scoring because the blank space is the most frequently appearing character in English text, and its location, marking the beginning and ending of words, is accordingly significant. The total probability for each permutation is stored in the variable Total, which is then compared to the list of winners kept by procedure KeepScore in the array ScoreBoard. If the new total is higher than any score on the ScoreBoard array, Total and the string WordToScore are plugged into place and the rest of the contenders are shuffled down one slot in the ranking.

The one refinement I have made to the basic scoring method is that an anagram's score is cut in half for every

*(continued)*

Table 1: *In a typical run, ANAGRAM.PAS unscrambles a group of letters and finds, on line 4, the word "pascal." The number to the right of the word shows relative probability.*

Enter word: *claaps*

| | | | | | |
|---|---|---|---|---|---|
| 1 | CASPAL | 539 | 9 | PLASAC | 358 |
| 2 | SACLAP | 481 | 10 | LASPAC | 351 |
| 3 | SAPACL | 458 | 11 | CASLAP | 346 |
| 4 | PASCAL | 452 | 12 | PLACAS | 337 |
| 5 | CASPLA | 418 | 13 | SAPLAC | 332 |
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Inquiry 99

*ANAGRAM.PAS does not handle very long anagrams well.*

trigram it contains with a zero probability. This prevents an anagram made up of both a very likely trigram, such as *she*, and an impossible one, such as *dqt*, from scoring well and overwhelming other possibilities. This is handled in the procedure Score by the variable Unlikelihood, which counts the number of zero-probability trigrams.

## PERFORMANCE

How well does ANAGRAM.PAS work? That depends on the length of the word. To establish some kind of standard for performance while testing the program, I drew up a list of 70 common words, including 20 four-, five-, and six-letter words and 10 seven-letter words. The program was declared to have solved the anagram if the original word appeared anywhere in the list of 15 top choices.

At its best, ANAGRAM.PAS "solved" all 20 of the four-letter words, 16 of the five-letter words, 9 of the six-letter words, and 6 of the seven-letter words. Table 2 shows a list of the 70 test words and the rank number each received during one run of the program. Overall, then, it appears that ANAGRAM.PAS will unscramble a four- or five-letter word about 90 percent of the time. That is, of course, little to boast of for four-letter words, which have only 24 anagrams. But five-letter words have 120 possible combinations, and it is sometimes startling to watch the program flash the correct unscrambled word on the screen a few seconds after you have typed in its letters in random order. For six- and seven-letter words, the success rate falls to slightly more than 50 percent. Eight-, nine- and ten-letter words take quite a long time to compute (my Osborne takes about 20 minutes for eight letters and 30 hours for ten letters), and I've not tried enough of them to be able to generalize. The success rate is undoubtedly quite low.

I've tried various methods for improving the program's performance—jiggling the way in which the Unlikelihood factor is calculated, for example, or the amount of text used to establish the probability table. My conclusion is that the basic method is sound, and extra bells and whistles only get in the way, except for the simple rescoring of words containing zero-probability trigrams. The best way to improve performance would undoubtedly be to count the probability of four- or five-letter segments instead of three-letter segments. The size of such a probability table, though, would exceed the memory of most microcomputers. While it is possible to write a program that would score anagrams without a probability table, less memory-intensive algorithms run very much slower and would be ungainly for words longer than five or six letters, which ANAGRAM.PAS already solves fairly well.

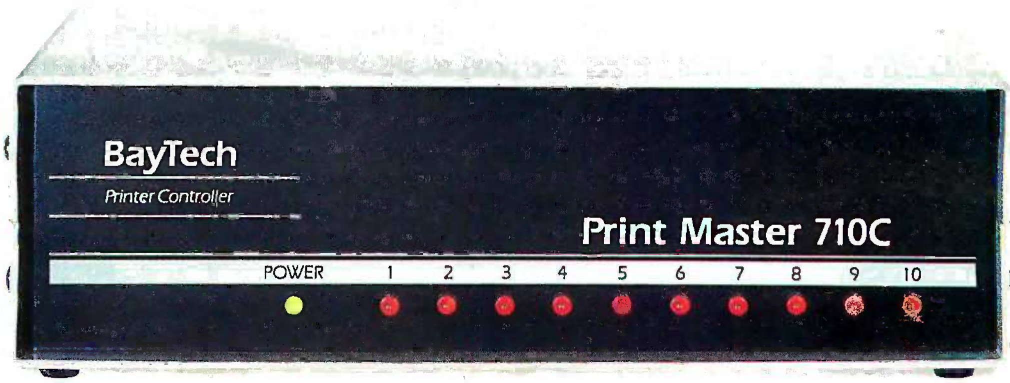
One area that might bear examination is elimination of extremely high probabilities from the existing table. The occurrence of *th* is so common, for example, that any time a word contains both *t* and *h*, those permutations containing the diphthong *th* score extremely high and wipe out all other possibilities. Thus *heater* is lost, in favor of such nonsense as *therea*, *eareth*, and *eather*. It may be that massaging the probability table to temper extremes would produce better results.

One thing that ANAGRAM.PAS does not do well at all is handle very long anagrams, such as full sentences. This could be another problem for further study. Lengthy anagrams are not only possible for humans to solve, but they have at times been the occasion of considerable intellectual passion. During the seventeenth century, perhaps the heyday of anagramming, a hermit of St. Paul named Nieszporkowitz produced more than 3000 metrical anagrams of the "Angelic Salutation" in the Gospel According to St. Luke: *Ave Maria, gratia plena, Dominus tecum*. ("Hail Mary, full of grace, the Lord is with you.") One example is *Virgo serena, pia, munda et immaculata*. ("Virgin serene, pious, elegant and immaculate.") Not to be outdone, the Belgian abbot Lucas de Vriese turned out 3100, with apparently few repetitions. It would take ANAGRAM.PAS about 7.8 × $10^{24}$ years to compute and score its favorite 15 anagrams of the Angelic Salutation. That is about 5 × $10^{14}$ times the estimated age of the universe. ■

Table 2: *Seventy common English words and the probability rank each received from ANAGRAM.PAS. An asterisk indicates a rank higher than 15, meaning the program did not solve the anagram. Of course, the probability rank will vary depending on the text you use in calculating the probability of trigrams.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FOUR | 2 | TROUT | 2 | SEXTET | * | TERRIER | 2 |
| WITH | 1 | STORE | 1 | BANANA | 12 | COUNTRY | 1 |
| THEY | 1 | BREAD | 12 | FRIEND | 11 | BISCUIT | * |
| BOAT | 3 | STEAM | 7 | VOLUME | 10 | SPEAKER | 6 |
| SHIP | 5 | HORSE | 13 | DONKEY | * | PICTURE | * |
| CORE | 1 | NUTTY | 5 | FLOWER | 4 | COCONUT | * |
| HATE | 6 | AWFUL | 15 | SKATER | * | BELIEVE | 1 |
| SKIN | 1 | CREEP | * | BORING | 4 | ARCHERY | * |
| KIND | 1 | ADOBE | * | ACTION | * | CALVARY | 1 |
| LOVE | 1 | CREAM | 13 | INDIAN | 1 | LIZARDS | 3 |
| SING | 1 | SKIPS | * | PENCIL | * | | |
| CRAM | 4 | NEEDY | 14 | NAUSEA | * | | |
| JAZZ | 1 | PLATE | 2 | ALIGHT | * | | |
| ZERO | 10 | QUEEN | 2 | ENGINE | * | | |
| EXAM | 1 | PIZZA | 8 | CORRAL | 2 | | |
| PAIR | 4 | ZILCH | * | DIMPLE | 2 | | |
| QUIT | 1 | JELLO | 4 | GANTRY | * | | |
| SKIM | 5 | CLOCK | 2 | STREET | * | | |
| OBOE | 6 | HAPPY | 1 | ARTIST | * | | |
| SPRY | 1 | SHAPE | 15 | BANGLE | 10 | | |

# PRINTER SHARING AND PRINT BUFFERING ALL IN ONE VERSATILE UNIT




Print Master from BayTech is an intelligent printer controller that connects between your computers and printers. It allows you to share one printer automatically, contend for multiple printers automatically, or switch between several printers by sending a simple code. Plus, Print Master's built-in buffer spools data until your printer can receive it.

## A VERY FLEXIBLE PRINTER SHARER

You configure Print Master's ports for any combination of printers and computers by answering questions from the easy-to-follow menus. For example, with the ten-port Print Master, nine computers can share one printer, eight computers can share two printers, seven computers can share three printers, and so on, to one computer which can share nine printers. You can also menu-select these features: the baud rate, word size, stop bits, parity, and XON/OFF handshaking; the disconnect time-out; and form feeds. Ports may be configured individually to translate for printers and computers using different configurations. All changes you make are saved in non-volatile memory.

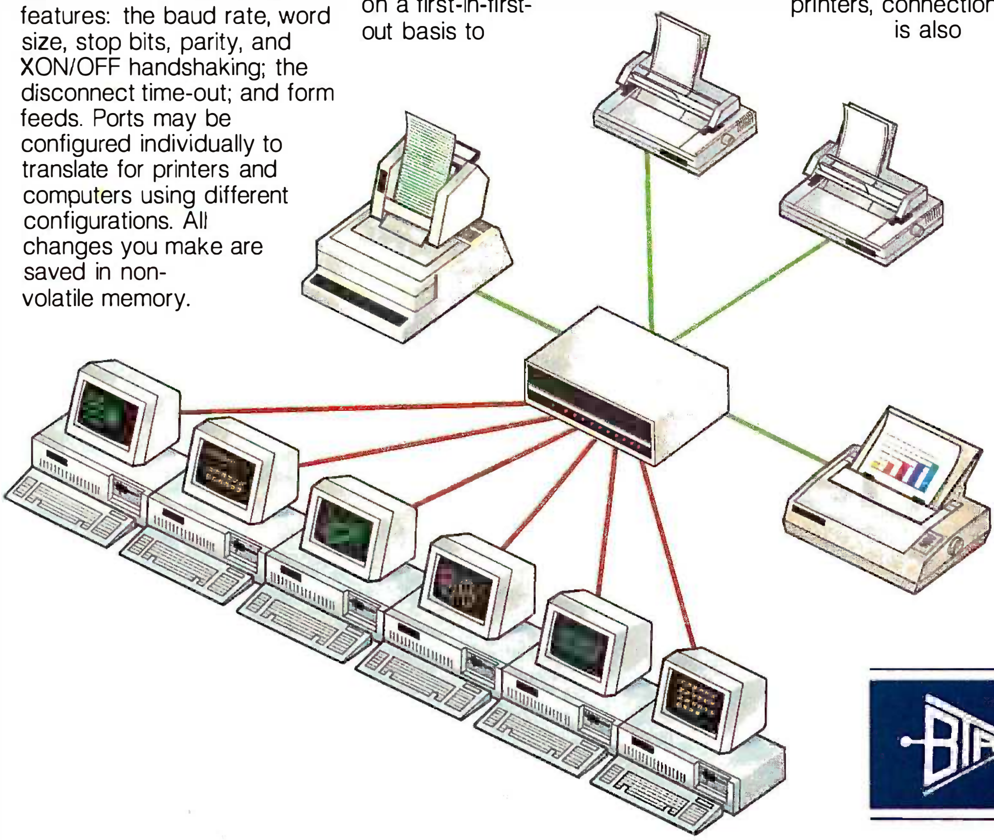
## PRINT MASTER'S BUFFER KEEPS YOU WORKING

Since Print Master can accept data faster than your printer, you can dump a print job into Print Master's 512K buffer and then go on to another project. All connected users can send data to this common pool buffer, and they can be doing it at the same time, even if no printer is available. Data is stored in the buffer until it can be sent on a first-in-first-out basis to the selected printer. If you need more memory, Print Master is optionally available with one megabyte buffer.

## CONTROL PRINT OUTPUT FROM YOUR COMPUTER

If several users are sharing one printer, printer sharing is completely automatic. There are no codes to send. You simply perform your normal print operation. If you are sharing several identical printers, connection is also automatic. Again, you perform your normal print operation and are connected to the next available printer on a first-come-first-serve basis. Print Master will send data to all printers simultaneously to keep your printers running at full capacity.

If you are sharing several different printers, such as a letter printer, a laser-jet and a plotter, you do your normal print routine but insert a short printer select code (which you can define yourself) as the first characters of your data. The data is then routed to the selected printer. It's that easy.



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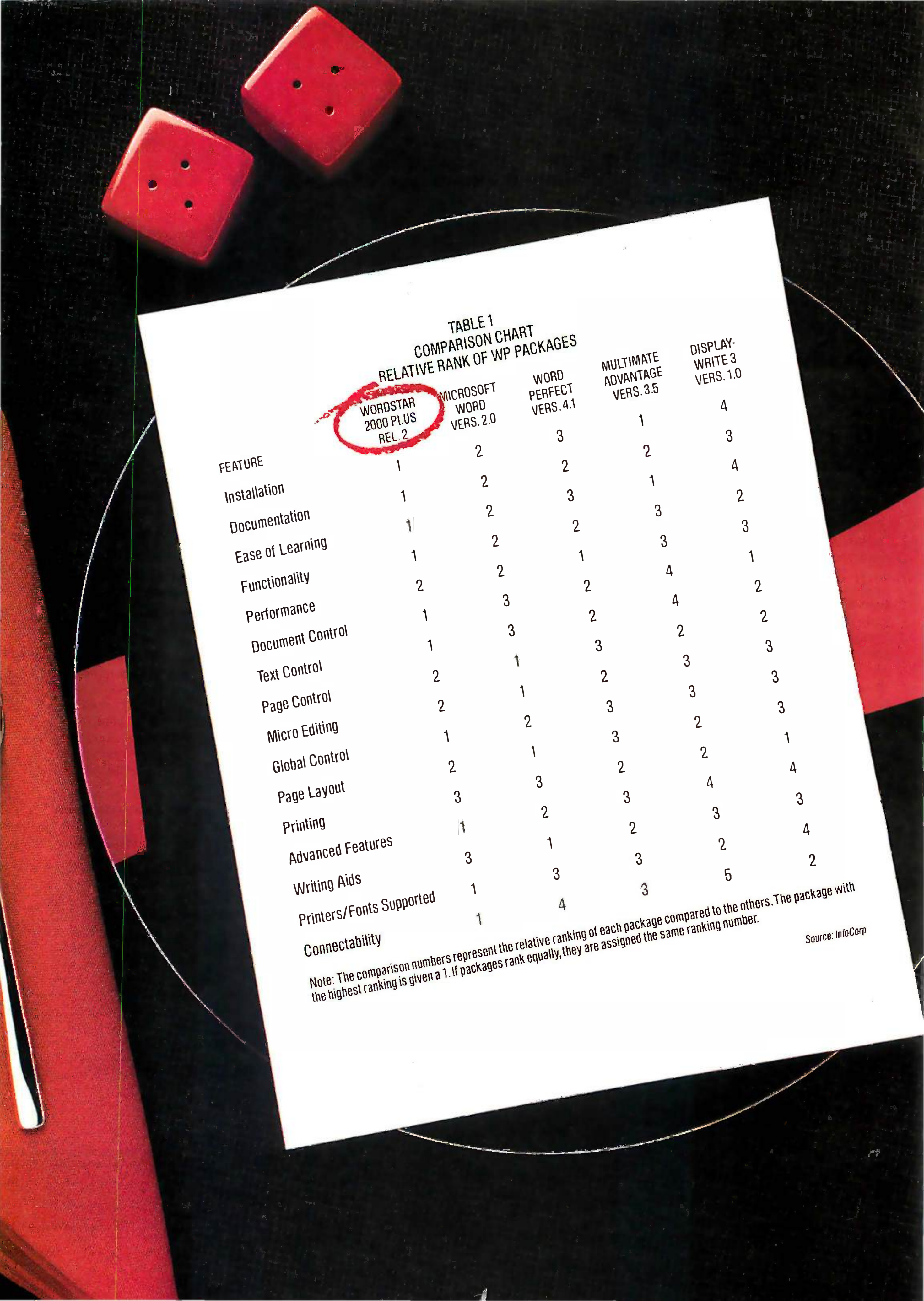

TABLE 1
COMPARISON CHART
RELATIVE RANK OF WP PACKAGES

| FEATURE | WORDSTAR 2000 PLUS REL. 2 | MICROSOFT WORD VERS. 2.0 | WORD PERFECT VERS. 4.1 | MULTIMATE ADVANTAGE VERS. 3.5 | DISPLAY-WRITE 3 VERS. 1.0 |
|---|---|---|---|---|---|
| Installation | 1 | 2 | 3 | 1 | 4 |
| Documentation | 1 | 2 | 2 | 2 | 3 |
| Ease of Learning | 1 | 2 | 3 | 1 | 4 |
| Functionality | 1 | 2 | 2 | 3 | 2 |
| Performance | 2 | 2 | 1 | 3 | 3 |
| Document Control | 1 | 3 | 2 | 4 | 1 |
| Text Control | 1 | 3 | 2 | 4 | 2 |
| Page Control | 2 | 1 | 3 | 2 | 2 |
| Micro Editing | 2 | 1 | 2 | 3 | 3 |
| Global Control | 1 | 2 | 3 | 3 | 3 |
| Page Layout | 2 | 1 | 3 | 2 | 3 |
| Printing | 3 | 3 | 2 | 2 | 1 |
| Advanced Features | 1 | 2 | 3 | 4 | 4 |
| Writing Aids | 3 | 1 | 2 | 3 | 3 |
| Printers/Fonts Supported | 1 | 3 | 3 | 2 | 4 |
| Connectability | 1 | 4 | 3 | 5 | 2 |

Note: The comparison numbers represent the relative ranking of each package compared to the others. The package with the highest ranking is given a 1. If packages rank equally, they are assigned the same ranking number.

*Source: InfoCorp*

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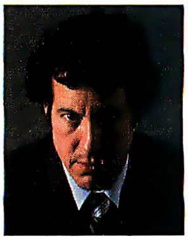
We could make all kinds of claims about our new WordStar 2000 Plus Release 2.

About its commonsense commands. Tutorials for easy training. Direct Lotus® file input. Extensive printer support. DCA connectivity. LANs and site licensing options.

That would be easy to do.

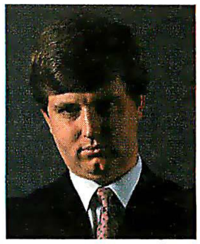
But we decided to let the experts do the talking.

In a comparative report—the report containing the chart to the left—Robert Lefkowits of InfoCorp said:



***"WS 2000+ emerges as a clear winner in overall applicability. InfoCorp believes WS 2000+ would appeal to the largest number and widest variety of users. Its layered functionality, ease of learning, and excellent communications features make it ideal for corporate users, ranging from secretaries to clerks to managers to executives."***

And, after reviewing WordStar 2000 Plus Release 2 alongside MultiMate™ Advantage™ and IBM®'s DisplayWrite® 3, International Data Corporation's Jim Chapman concluded:



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# THE DEFINICON 68020 COPROCESSOR

## *A plug-in board that provides 32-bit computing power and math processing for 16-bit machines*

Have you ever wished that your personal computer had the speed of a VAX or that the number 64K had never existed? Well, the Motorola 68020 32-bit microprocessor has the computing power to come close to fulfilling both those dreams. BYTE has arranged for Definicon Systems to design a special version of its 68020-based scientific microcomputer system that allows 68020 hardware and software development at a price all can afford. (See the text box "How to Get Your DSI-020 Coprocessor System" on page 122 for complete information.)

*Trevor Marshall, Christopher Jones, and Sigi Kluger are engineers with Definicon Systems Inc. They can be contacted at 31324 Via Colinas #108/9, Westlake Village, CA 91362.*

The DSI-020 is a coprocessor board (see photo 1) that uses the 12.5-megahertz versions of the 68020 CPU and the 68881 FPU (floating-point unit). Provision has been made for the addition of the 68851 PMMU (paged-memory-management unit) when it becomes available. The board has 1 megabyte of high-speed parity-checked dynamic RAM that requires only one CPU wait state to operate correctly. There are two high-speed (38,400 bps) serial ports (figure 1) and an interrupt-driven timer to ease the task of porting UNIX.

All the facilities of a host IBM PC or compatible are available to the coprocessor, including networking and access to any other peripherals connected to the PC's bus. System calls for full bit-mapped graphics are provided in the kernel. All BDOS and BIOS software interrupts in the PC are available to the 68020 programmer.

### OVERVIEW

The DSI-020 board is composed of a number of relatively independent functional blocks. The CPU cluster (figure 2) consists of the 68020, 68881, and 68851. The 32-bit bus address decoding circuitry is shown in figure 3 and includes the FPU20 and DEC20 PALs, the HOLD20 bus request arbiter PAL, the 32-bit bus DMA sequencer (74F161 and DPORT20 PAL), the DSACK20 PAL, and the BE20 byte enable PAL (figure 4). The DSACK20 PAL's main function is to provide signals to the 68020 to indicate that a memory access cycle is complete and whether the size of the transfer was 8, 16, or 32 bits.

A delay line and associated headers delay the CPU's address strobe (AS) signal long enough for all the decoding to have been completed before the $\overline{\text{RASIN}}$ signal is generated to initiate the DP8409 dynamic RAM controller's access cycle. The DP8409 (figure 5) directly drives the multiplexed address and $\overline{\text{RAS}}$ lines of the RAMs. The $\overline{\text{CAS}}$ signal is multiplexed with the Byte Enable signals before being applied to the RAM array, shown in figure 6. The refresh counter is driven from the CPU's clock oscillator, divided by 128. The DP8409 attempts to do a hidden refresh, but if this is not possible, a refresh request ($\overline{\text{RFIO}}$) will be sent to the HOLD20 PAL every 10.24 microseconds. When this is acknowledged (with $\overline{\text{RFSHACK}}$) the DP8409 will perform a $\overline{\text{RAS ONLY}}$ refresh cycle.

Hidden refreshes occur whenever any device other than the RAM itself is addressed. In particular, accesses to the 68881 will cause a hidden refresh to occur. This considerably reduces any overhead that might otherwise be incurred using this DMA refresh technique.

BY TREVOR MARSHALL, CHRISTOPHER JONES, AND SIGI KLUGER

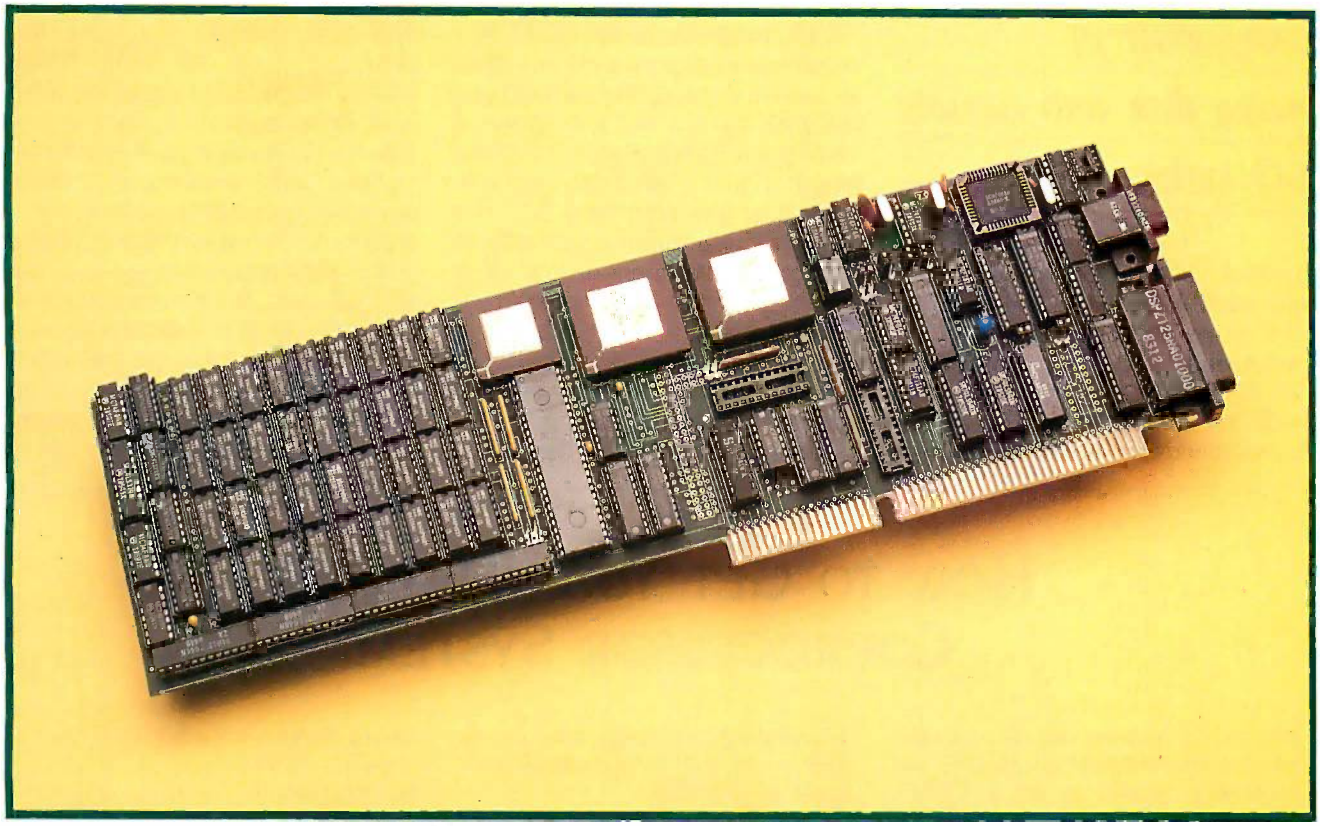

Photo 1: *The Definicon* DSI-020 *board with* 68020 CPU, 68881 FPU, *and* 1 *megabyte of memory.* A 68851 PMMU *is shown with this board although it is not commercially available at this time.*

The parity error signal generated as shown in figure 7 is latched and can be read by the host PC at bit 0 of the BFLAGS port (see table 1 and figure 4). Pulse the Refresh Inhibit line (RFSHINH) briefly to reset this latch.

### THE 68851 PMMU

The principal function of the PMMU is the translation of logical addresses from the software running in the CPU to physical addresses within the range of the available hardware facilities. This allows programs to run at addresses that are not available in physical memory. An operating system that swaps infrequently used memory blocks to disk and so enlarges the effective addressing range of programs is called a virtual memory system (VMS). Although Definicon has written a VMS for the DSI-32, the kernel for the DSI-020 does not yet implement virtual memory. The mapping from logical to physical addresses is stored in tables (in memory) that the PMMU can search. It has an internal cache so that the most recently used translation table entries are available without the necessity for an additional bus cycle. The PMMU implements a hierarchical protection mechanism with up to eight access levels. It also provides a breakpoint acknowledge facility to support the 68020 breakpoint instructions.

The 68851 internally decodes its own chip select function.

### THE 68881 COPROCESSOR

The 68881 is the first high-speed floating-point accelerator from Motorola. It is addressed when the 68020 places 111 on its status lines (FC0, FC1, and FC2), 0010 on lines A19 through A16, and 001 on lines A15 through A13 and performs a memory cycle. The special coding on the status lines indicates, however, that the cycle is actually for the coprocessor interface. Chip select for the 68881 is derived in the FPU20 PAL.

The major feature of the 68881 is that many frequently used mathematical functions have been microcoded into the silicon. This considerably enhances the performance of the 68020/68881 combination on engineering and scientific computations. It also accounts for its deceptively high performance on some function-sensitive benchmarks, such as the Savage benchmark (Dr. *Dobb's Journal*, March 1984, page 92).

### THE HOST PC BUS INTERFACE

The IBM PC XT bus was designed as a single master bus, so there is no

*(continued)*

PHOTOGRAPHED BY PAUL AVIS

*The 8088 is used to relieve the 68020 coprocessor of many disk and console I/O tasks.*

method for a slave coprocessor to take control of the bus, tell the 8088 CPU to go to sleep, and drive the peripherals directly. The XT relies on the 8088's DMA controller to take back control of the bus every 15 microseconds or so to perform a dynamic RAM refresh cycle. This forces a coprocessor system such as the DSI-020 either to replace the 8088 or to work in close cooperation with it.

With the design of the PC AT, provision was made for a slave processor to control the bus (via the DRQ and MASTER signals), but a limitation of 15 microseconds remains on the total length of time a slave can keep control before memory refresh fails! This limit obviously makes it very difficult to provide safe direct disk or other stream I/O tasks even using these newer capabilities. It is for these reasons that the DSI-020 is designed to transfer data 1 byte (or word) at a time to the host environment.

During the design of the DSI-32 (August 1985 BYTE, page 120) we found that the total replacement of the 8088 was relatively inefficient and that it is capable of relieving the coprocessor of many of the tedious disk and console I/O tasks. The DSI-020 follows the same design criteria. The MS-DOS system on either a PC AT or a PC XT is used to provide file I/O, networking, and other peripheral tasks, allowing the 68020 kernel to concentrate on the things it does best. The kernel provides the interface and translation between the UNIX-derived 68020 system software and the facilities provided by MS-DOS itself. We allowed the optional use of the 16-bit data transfer facility of the new AT bus. The majority of the improvement resulting from the use of

## How to Get Your DSI-020 Coprocessor System

Definicon Systems will provide the elements of the DSI-020 system at the following special prices for BYTE readers.

Note: These special prices have been provided by Definicon, reducing its margins to a bare minimum. In particular, no margin has been allowed for accounting overhead and so *no purchase orders* can be accepted for these special BYTE products.

Terms of payment are VISA/MasterCard/American Express only. There is a 30-day, no-questions-asked, money-back guarantee. Goods must be returned in "as new" condition in original packaging for full credit.

Software support available for all products is limited to a diagnosis and correction of your software problem. Under no circumstances will Definicon's technical support team attempt to teach you to program in any of these languages!

The DSI-020 has been tested in almost all the machines compatible with the IBM XT and AT. If it does not work in yours, Definicon reserves the right either to correct the problem (if it is with the DSI-020) or refund your money.

Although the DSI-020 will operate in a system with only floppy disks, a fixed disk is essential for meaningful program development.

**DSI-020 basic hardware:** $995
1 megabyte of RAM, 12.5-MHz 68020, and 12.5-MHz 68881
No parity chips or serial ports
MS-DOS interface software, simplified assembler, linker, and assembly-level debugger
The DSI-020 hardware is supplied fully assembled and tested.

**Optional hardware upgrade:** $99
Chips for the two serial ports, parity-detection circuitry, and the serial number EEPROM
Supplied fully tested if ordered at the same time as the basic hardware.

**SVS Library Manager:** $49
Forms object modules into libraries that can be searched by the linker rather than included as a whole.

**QUELO Macro Assembler and Utilities:** $155

**SVS BASIC PLUS:** $169
BASIC language interpreter similar to DEC's BASIC PLUS language

**Living Software BASIC to C Converter:** $299
Includes run-time package compiled for compatibility with either SVS C or LLL C.

**SVS C:** $349
Kernighan and Ritchie definition with most UNIX extensions

**LLL C:** $349
Kernighan and Ritchie definition with most UNIX extensions

**LLL PASCAL:** $399
ANSI level 1 PASCAL

**SVS PASCAL:** $399
ANSI level 0 PASCAL plus extensions

**SVS FORTRAN:** $459
ANSI FORTRAN-77 language with extensions

All the above items may be ordered only directly from
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31324 Via Colinas #108
Westlake Village, CA 91362
(818) 889-1646

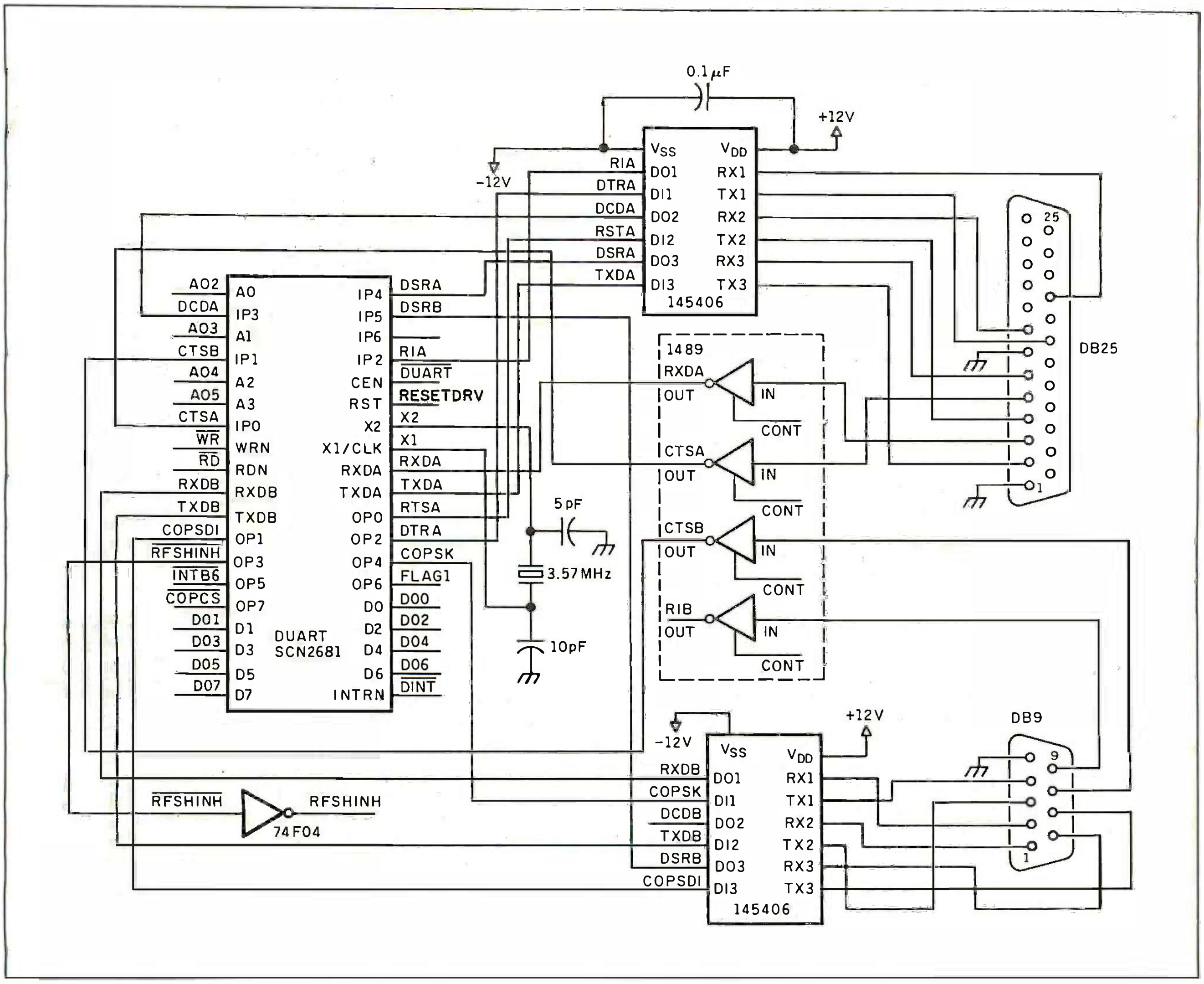



**Figure 1:** DUART *and* RS-232C *drivers.*

an AT host comes, however, from the faster disk subsystem and not from the wider bus.

The DSI-020 automatically senses whether a PC XT 8-bit bus or a PC AT 16-bit bus is available and adjusts to either 8- or 16-bit transfers as appropriate. When an XT is sensed, by the absence of a ground level on pin D18 of the interface (figure 8), the 74HCT245 buffer (figure 9) connects the top half of the 16-bit bus to the lower half of the bus so that the XT can see it. When an AT bus is present, the DSI-020 will assert MEMCS16 to the host whenever it is addressed at an even boundary. This conditions the AT for a possible 16-bit data transfer. If for some reason you are using an XT work-alike in which the 18-pin AT connector fingers are physically obstructed by components on the motherboard, it is possible to have the extra connector removed.

A jumper block has been provided to disable the AT sensing circuitry. This allows the use of the DSI-020 in an AT using the XT bus mode.

## The DMA Cycle

When the 68020 kernel wants the 8088/286 to perform a task, it asserts interrupt 2 (optionally INT 7). The 8088/286 addresses the card. The AT20 PAL (figure 4) generates a RAMSEL signal, which in turn generates an IOCHRDY signal to the host. This forces the 8088/286 to wait until the 68020's 32-bit bus becomes available. The DPORT20 also issues the HOLD86 request to the HOLD20 PAL. This PAL arbitrates the DMA request with refresh requests from the dynamic RAM controller and produces a BUS REQUEST (BR) to the 68020. On seeing this request the 68020 waits until it has completed the current 32-bit bus cycle and then releases its bus and asserts BUS GRANT (BG). The HOLD20 PAL then issues HLDA86, which releases the 74F161A DMA sequencer. The DPORT20 PAL then takes over the 32-bit bus and generates signals that simulate some of the control signals normally generated by the 68020. The dynamic RAM controller responds to these signals, placing the required byte (or word) of data on the 32-bit

*(continued)*

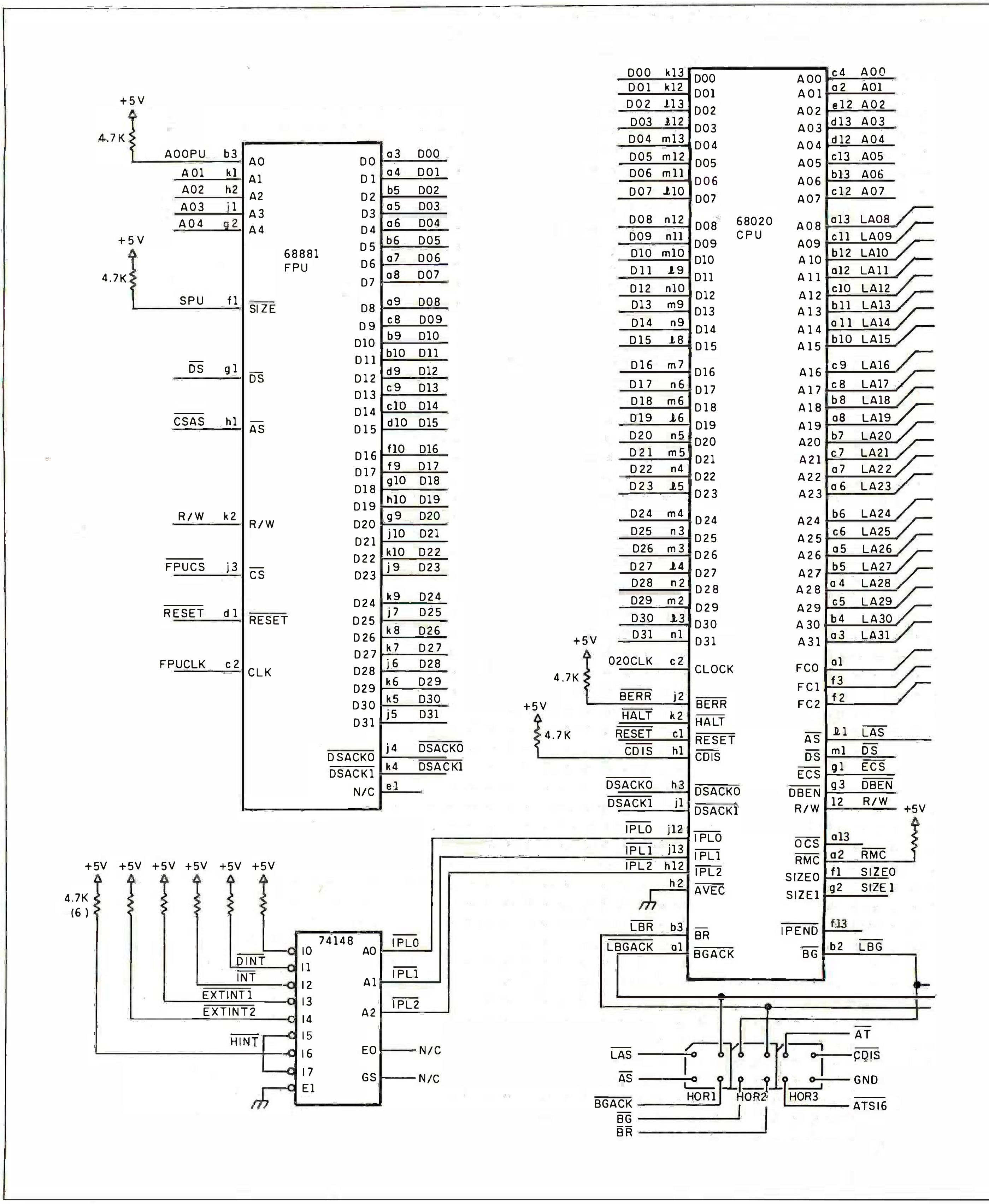
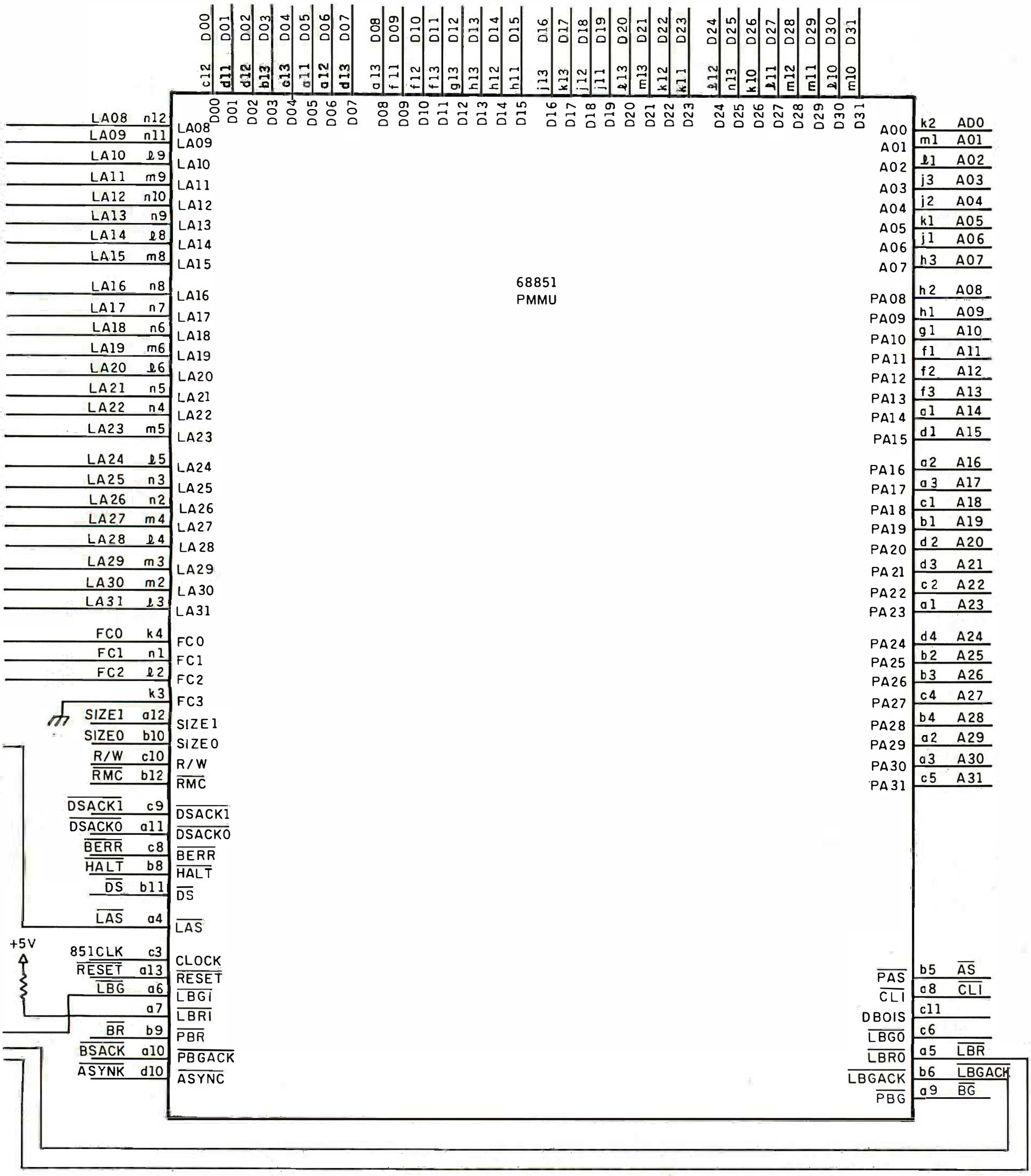



**Figure 2:** *The* CPU, *floating-point* (FPU), *and paged-memory-management* (PMMU) *processors.*


68851
PMMU
+5V

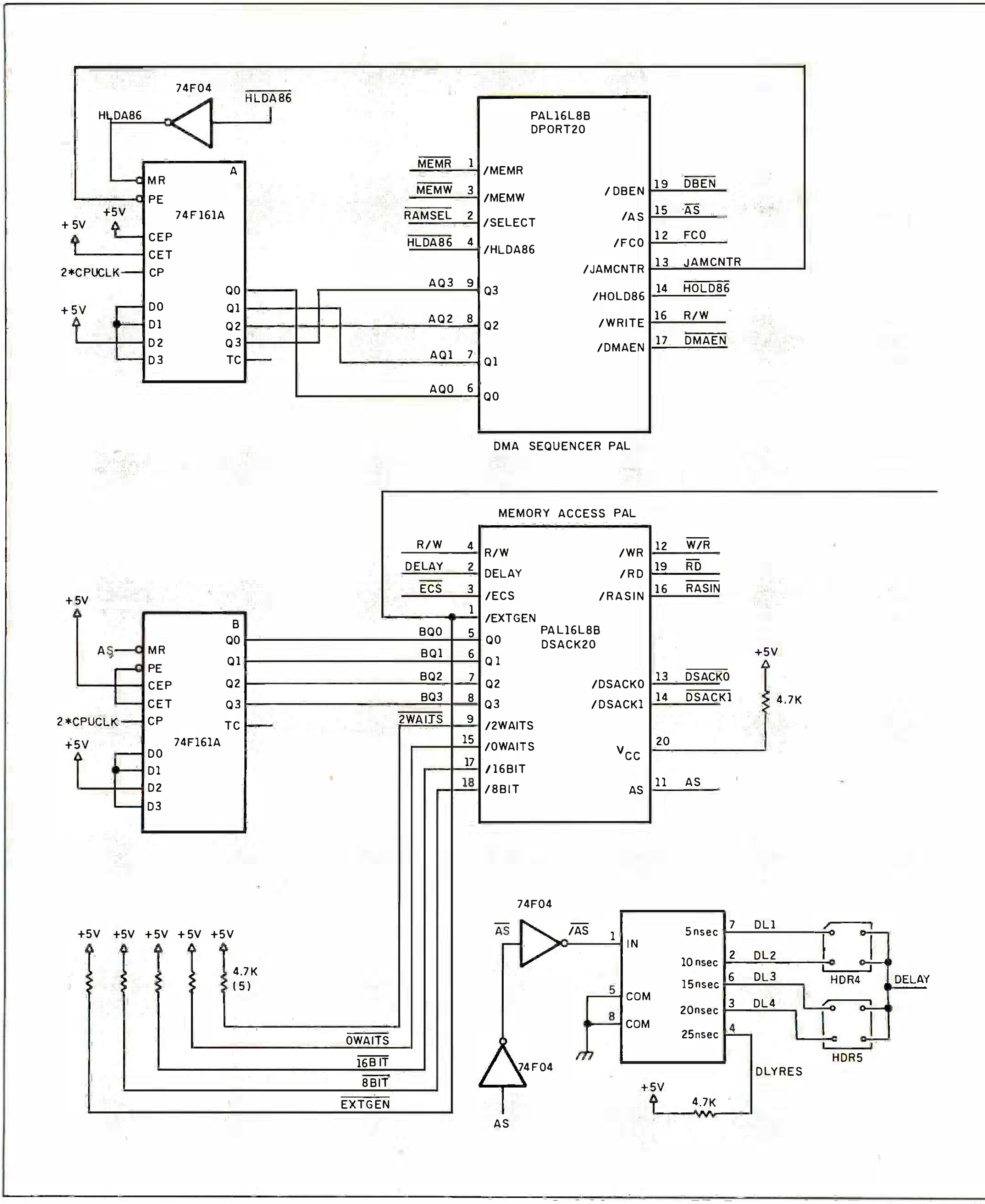
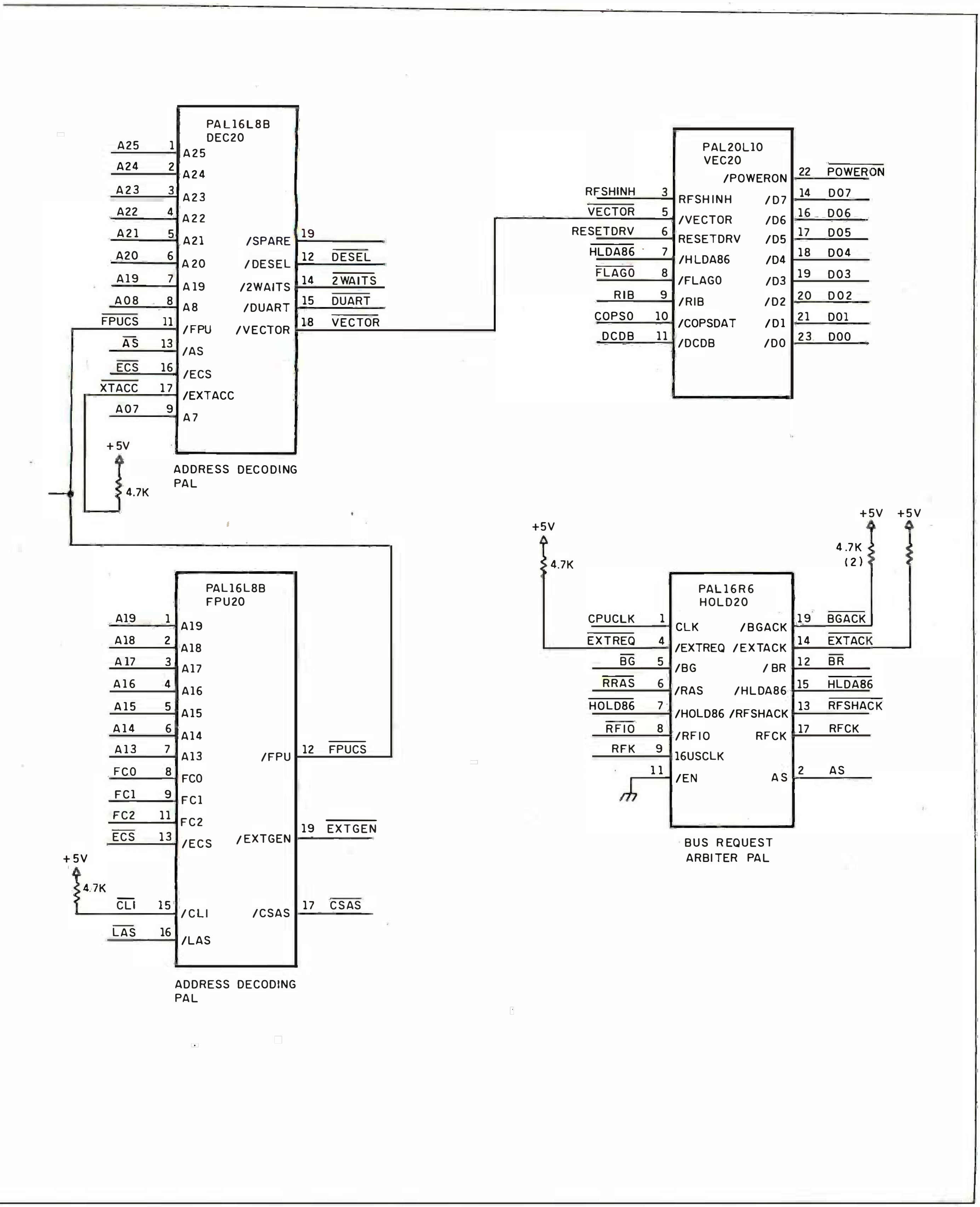



Figure 3: *Bus address decoding PALs.*


PAL16L8B
DEC20
A25 1 A25
A24 2 A24
A23 3 A23
A22 4 A22
A21 5 A21 /SPARE 19
A20 6 A20 /DESEL 12 DESEL
A19 7 A19 /2WAITS 14 2WAITS
A08 8 A8 /DUART 15 DUART
FPUCS 11 /FPU /VECTOR 18 VECTOR
AS 13 /AS
ECS 16 /ECS
XTACC 17 /EXTACC
A07 9 A7
+5V
4.7K
ADDRESS DECODING PAL
PAL20L10
VEC20
/POWERON 22 POWERON
RFSHINH 3 RFSHINH /D7 14 D07
VECTOR 5 /VECTOR /D6 16 D06
RESETDRV 6 RESETDRV /D5 17 D05
HLDA86 7 /HLDA86 /D4 18 D04
FLAGO 8 /FLAGO /D3 19 D03
RIB 9 /RIB /D2 20 D02
COPSO 10 /COPSDAT /D1 21 D01
DCDB 11 /DCDB /D0 23 D00
PAL16L8B
FPU20
A19 1 A19
A18 2 A18
A17 3 A17
A16 4 A16
A15 5 A15
A14 6 A14
A13 7 A13 /FPU 12 FPUCS
FC0 8 FC0
FC1 9 FC1
FC2 11 FC2
ECS 13 /ECS /EXTGEN 19 EXTGEN
+5V
4.7K
CLI 15 /CLI /CSAS 17 CSAS
LAS 16 /LAS
ADDRESS DECODING PAL
+5V
4.7K
+5V +5V
4.7K (2)
PAL16R6
HOLD20
CPUCLK 1 CLK /BGACK 19 BGACK
EXTREQ 4 /EXTREQ /EXTACK 14 EXTACK
BG 5 /BG /BR 12 BR
RRAS 6 /RAS /HLDA86 15 HLDA86
HOLD86 7 /HOLD86 /RFSHACK 13 RFSHACK
RFIO 8 /RFIO RFCK 17 RFCK
RFK 9 16USCLK
11 /EN AS 2 AS
BUS REQUEST ARBITER PAL

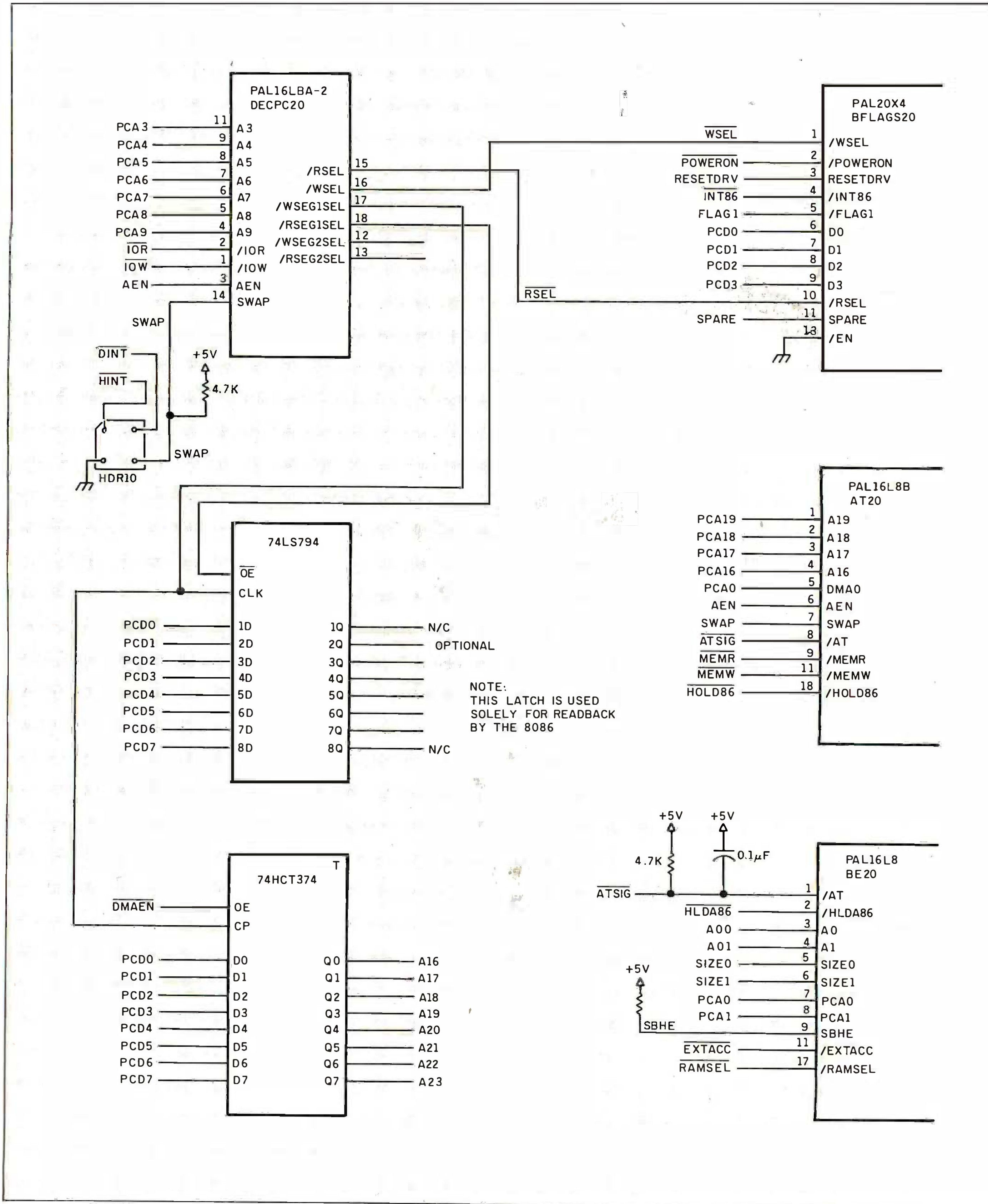
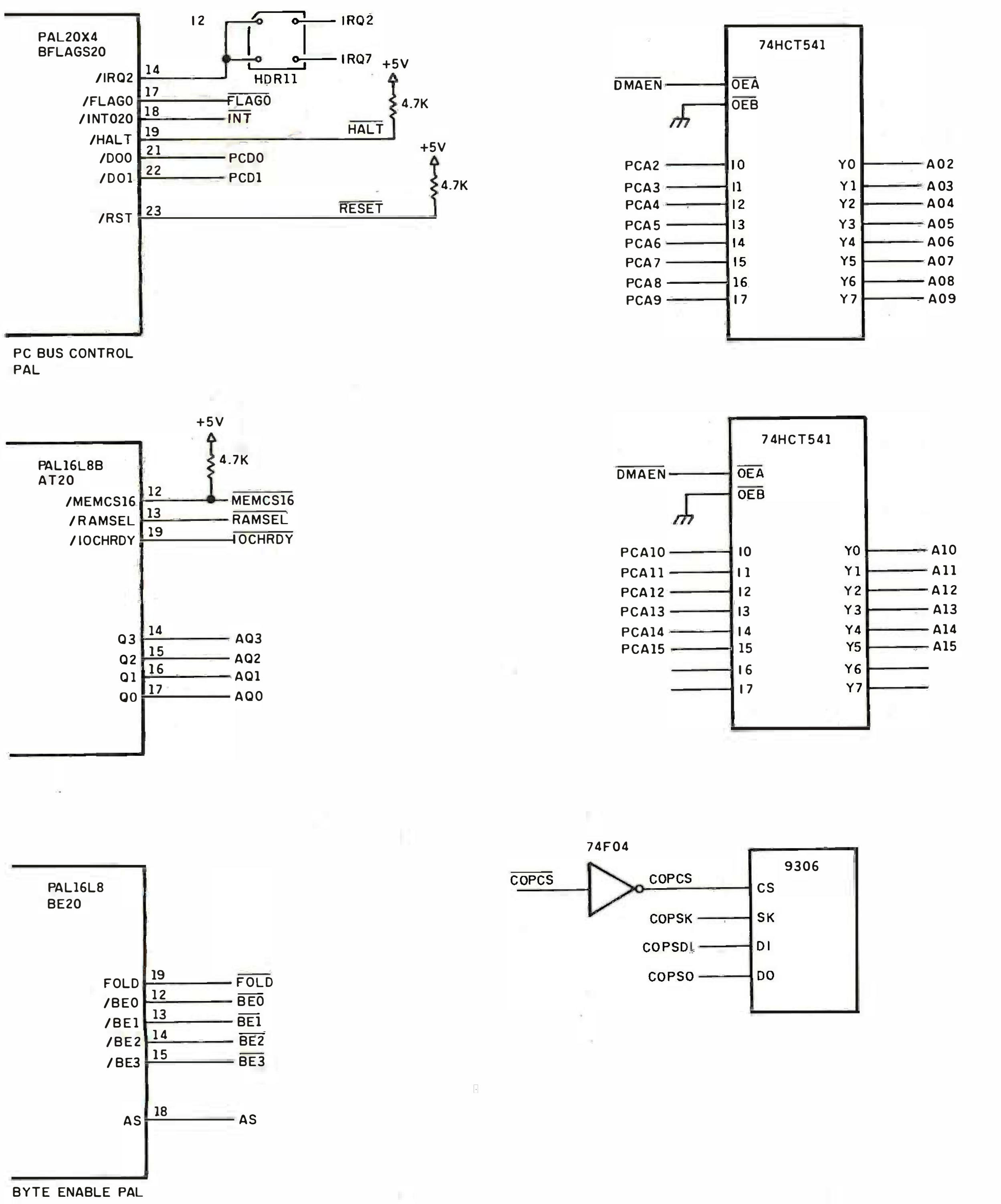



Figure 4: PC *interface circuitry and* PALs.


PAL20X4
BFLAGS20
/IRQ2
/FLAG0
/INT020
/HALT
/D00
/D01
/RST
14
17
18
19
21
22
23
12
IRQ2
IRQ7
HDR11
FLAG0
INT
HALT
PCD0
PCD1
RESET
+5V
4.7K
+5V
4.7K
PC BUS CONTROL PAL
74HCT541
DMAEN
OEA
OEB
PCA2
PCA3
PCA4
PCA5
PCA6
PCA7
PCA8
PCA9
A02
A03
A04
A05
A06
A07
A08
A09
PAL16L8B
AT20
/MEMCS16
/RAMSEL
/IOCHRDY
MEMCS16
RAMSEL
IOCHRDY
Q3
Q2
Q1
Q0
AQ3
AQ2
AQ1
AQ0
74HCT541
DMAEN
PCA10
PCA11
PCA12
PCA13
PCA14
PCA15
A10
A11
A12
A13
A14
A15
PAL16L8
BE20
FOLD
/BE0
/BE1
/BE2
/BE3
AS
FOLD
BE0
BE1
BE2
BE3
AS
BYTE ENABLE PAL
74F04
COPCS
COPCS
9306
CS
SK
DI
DO
COPSK
COPSDI
COPSO

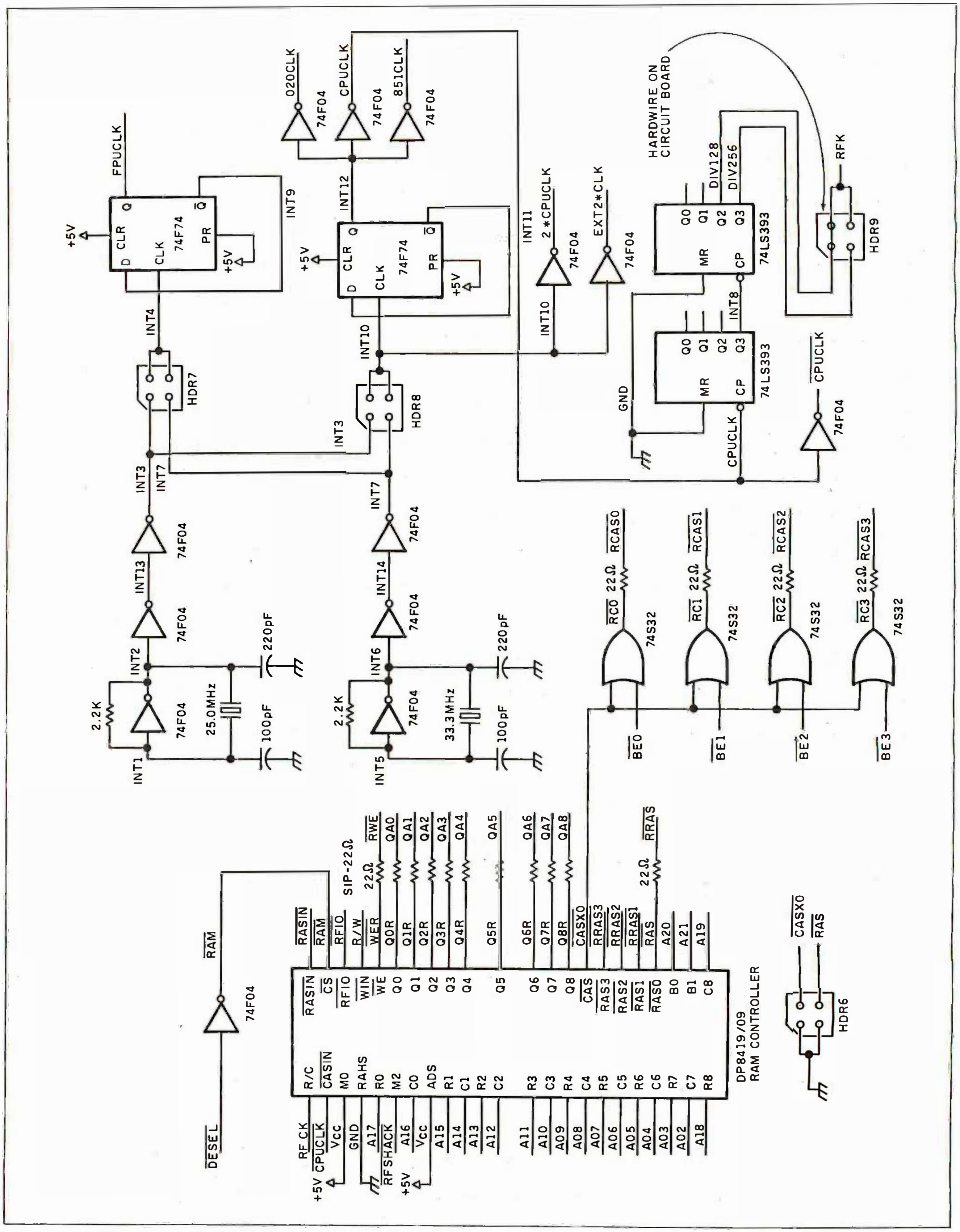



Figure 5: RAM *controller circuitry.*

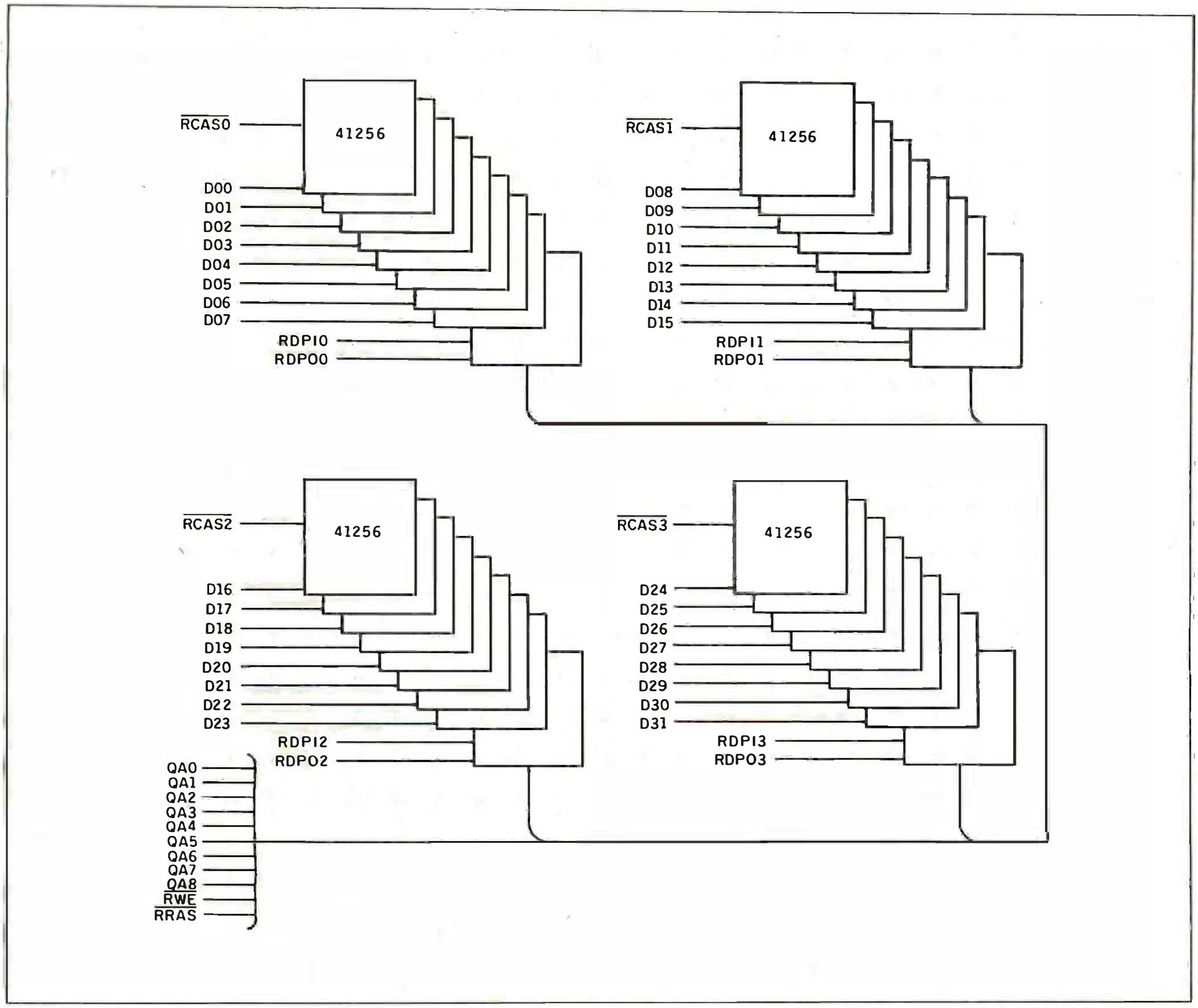



Figure 6: *Memory array.*

bus so that it can be read by the host computer's data bus.

Despite the number of discrete operations during a DMA transfer, the entire cycle is usually performed in less than a microsecond. Since the 68020 continues to process instructions within its cache, DMA transfers usually do not significantly affect execution speed. This allows a graphics application to continuously update the display adapter's screen without slowing the formation of the next image.

## Why Intel Doesn't Talk to Motorola

A major difficulty arises when interfacing an Intel-like processor (such as the 8088 or 80286) with any of the Motorola processors. The Intel architecture defines that, starting at the base address (usually 0) the first byte (at address offset 0) holds data bits 0–7 (see table 2), the second byte (at address offset 1) holds data bits 8–15, and the third and fourth bytes hold data bits 16–31.

Motorola, however, has defined that the first byte holds bits 24–31 and so on in exactly the reverse order. This has the advantage that when you examine a hexadecimal dump of Motorola memory the data is exactly as you read it, the most significant byte first, least significant last, and no mental reordering of bytes is necessary. The disadvantage is, of course, that the DSI-020 design had to provide for this byte reordering, so that data from the PC's screen or disk files would appear to the 68020 rearranged in the correct byte order.

This feature is provided within the hardware design, as software fixes proved far too slow for disk I/O. If you look carefully at figure 4, you will note that A0 and A1, the two least significant (LS) address lines, are not used directly but go to a PAL, the Byte Enable (BE20) PAL, before they interface with any of the memory or peripherals. In addition, PCA0 and PCA1, the LS address lines from the PC, also go to this PAL. Table 2 gives the design equations for this PAL. It can

(continued)

be seen that it takes the lower address lines, the $\overline{HLDA86}$ signal (to indicate if the cycle is a processor cycle or a DMA cycle), and the SIZE outputs from the processor and decodes them to four independent Byte Enable outputs (BE0–BE3). These are used to enable the appropriate data lines to the data bus. If a full 32-bit word is being fetched by the CPU, all four will be active; if only 8 bits, then only one will be active.

One incompatibility still exists, however. If a WORD WRITE is performed by an IBM PC XT into the DMA memory, the least significant and most significant bytes will be swapped. Consequently, you must be careful to use byte data transfers or remember to reverse the order of the bytes ob-

(continued)

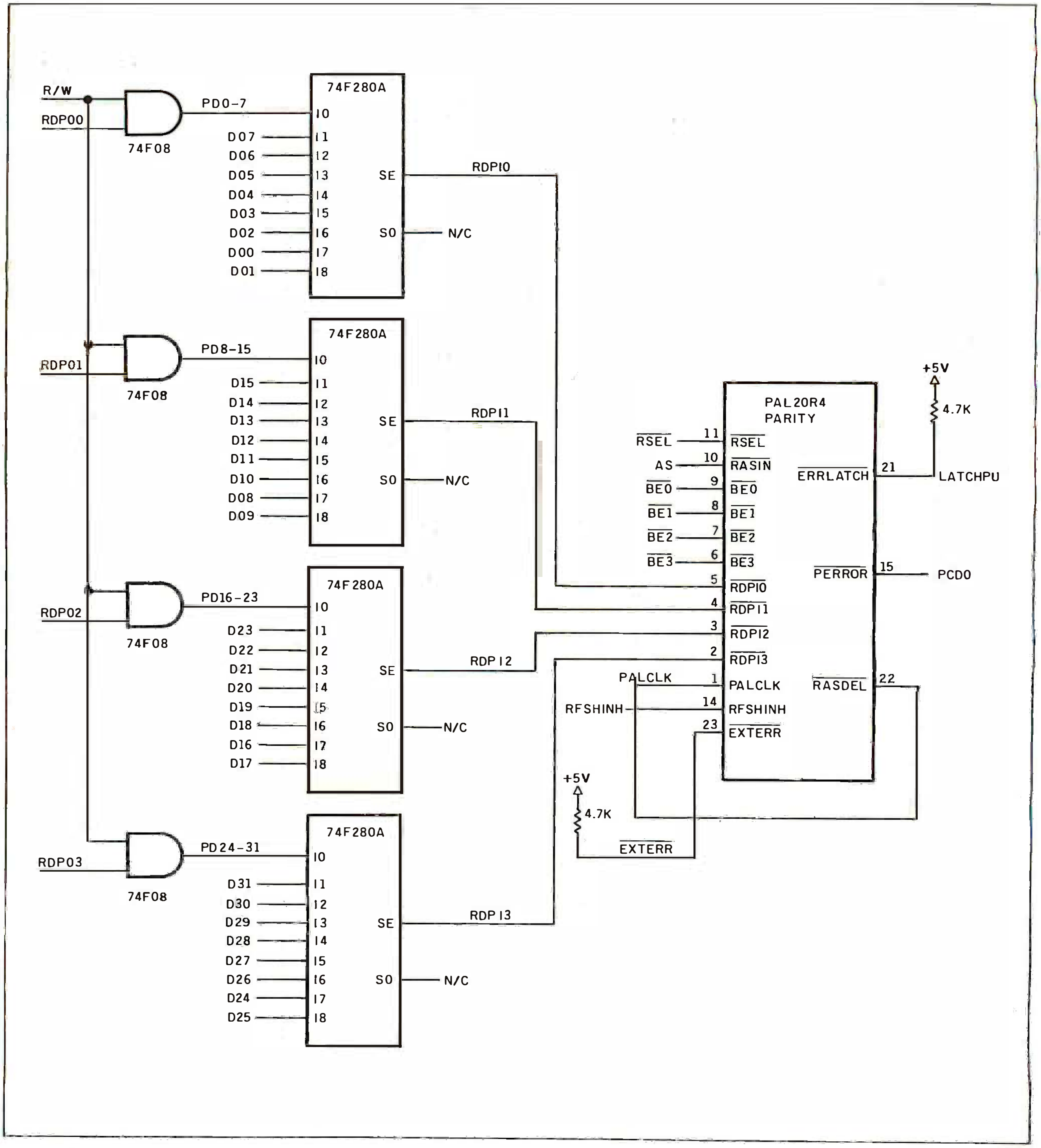



Figure 7: *Parity generation and detection circuits.*

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Table 1: DSI-020's *memory-addressing technique.*

The DSI-020's memory is all available to the host 8088/286. It appears as a 64K-byte "window" that can be steered through the 16-megabyte total address space by latching a "segment select" value at the segment port.

There are two distinct address spaces at which DSI-020 can be operated:

| HDR10 position | Memory Base | Segment Port | BFLAGS Port |
|---|---|---|---|
| Ground | E0000 Hex | 160 Hex | 150 Hex |
| $V_{cc}$ | D0000 Hex | 2B0 Hex | 2A0 Hex |

Use the ground position for XT clones only; the $V_{cc}$ position can be used with either XT or AT clones.

The BFLAGS control port is used for PC bus I/O control.
When READ by the PC:
Bit 0, if low, indicates that a parity error has occurred.
Bit 1 is a copy of the FLAG1 output of the DUART.
When WRITTEN by the PC (all outputs to the 68020 are latched)
Bit 0, when high, asserts HALT to the 68020.
Bit 1, when high, asserts INT020 to the 68020.
Bit 2, when high, resets the 68020.
Bit 3 is FLAG0, which may be read by the VEC20 PAL.

A number of status bits can be read from the VEC20 PAL:
Bit 0 is used by diagnostics to check the state of the Refresh Inhibit signal.
Bit 1 shows the state of the RS-232C RIB signal.
Bit 2 reads the data from the COPS EEPROM serial number chip.
Bit 3 shows the state of the RS-232C DCDB signal.
Bit 4 allows the 68020 to read the FLAG0 signal from the 8086.

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## System Builder™ $99.95 and Report Builder™ $75.00

### From the Designer Series™ by Royal American Technologies.

## Now, experience the magic of 5th generation software.

**It's a state-of-the-art program generator that automatically builds a relational database application for you in just seconds. You just paint your screen and datafile layouts.**

**SO EASY. . . ideal for entry level "coders" to produce relational database systems without coding. (Entry level guide with sample On-disk systems is provided.) SO POWERFUL . . . it provides programming professionals with more flexibility and horsepower than any development tool on the market (guide is provided.)**


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### REPORT BUILDER CYCLE:

Key in the report parameters on screen

Print your listings
- New report format for reference
- Report element layout

Press a key, wait 6 secs*

Key in the report data elements on screen

Report Builder automatically writes the program code and links it to your datafile

Print your listing
- Report program source code listings

Compile the report builder code using the Turbo Pascal™ compiler

Attach the new report module to your system menu

### SYSTEM BUILDER CYCLE:

Paint the menu screens

Paint the application screens

Define the datafile(s) on the screen

Press a key, wait 6 secs*

System Builder automatically writes the program code and combines the datafiles into a relational database

Print your listings
- Program source code listing
- Datafile layouts
- Self-documenting program (includes screen schematics)

Compile the System Builder code using Turbo Pascal™ compiler

Start using the completed system

*System Builder will generate 2,000 lines of program code in approximately 6 seconds.

### REPORT BUILDER FEATURES:

- Automatically generates Indented, Structured Source Code ready for compiling Turbo Pascal (no programming needed)
- Automatically interfaces to a maximum of 16 Datafiles created with System Builder
- Supports Global Parameters such as Headings, Footers, Lines Per Page, Print Size and Ad Hoc Sorting
- Produces reports containing an unlimited number of Sub-Headings, Sub-Totals and Totals
- Pagebreaks on Sub-Totals
- Report Builder will generate Report Programs which can contain Report Elements not just restricted to Data Elements. Reports can also include Text Strings, Variables or Computed expressions containing references from up to 16 Datafiles
- Use range input screens produced by System Builder to allow End Users to select portions of a report as needed (i.e. specific account ranges can be requested)
- Produces standalone Report Modules
- Easy-to-use Interface Program to access dBase Files

### SYSTEM BUILDER PERFORMANCE

(Typical 10 screen 8 file/index application)

| TASK | SYSTEM BUILDER | DBASE III™ |
|---|---|---|
| Planning and Design | 60 minutes | 60 minutes |
| Screen Painting | 15 minutes | 3 hours |
| Programming | 2 minutes | 10 hours |
| **Elapsed time to completed system** | **1 hour and 17 minutes** | **14 hours** |

### SYSTEM BUILDER FEATURES:

- Automatically generates Indented, Structured, Copy Book Source Code ready for compiling with Turbo Pascal (no programming needed)
- Paint Application and Menu screens using Keyboard or Microsoft Mouse™
- Finished Application screens all use System Builder's In-Line machine code for exceptional speed
- Use fully prompted Screen Guidance Templates™ to define up to 16 Datafiles per application, each record having an Unlimited Number of fields
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  —Center, copy, move, delete, insert or restore a line, Go straight from screen to screen with one keystroke
  —Cut and paste blocks of text screen to screen
  —Draw and erase boxes, Define colors and intensities
  —Access special graphic characters and character fill
- Supports an unlimited number of memory variables
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**30-Day Money-Back Guarantee.** Not copy protected. $10 restocking fee if envelope is opened.

System Requirements—System Builder/Report Builder: IBM PC/XT/AT[1], or similar, with minimum 256K RAM, dual floppy drives, or hard disk, color or monochrome monitor, MS[2] or PC DOS[1] version 2.0 or later, Turbo Pascal Version 2.0 or later (Normal, BCD or 8087 versions).

[1]Trademarks of International Business Machines Corp.
[2]Trademark of Microsoft Corp.
™TurboPascal is a registered trademark of Borland International.
™dBASE is a registered trademark of Ashton-Tate.

*The 68020 coprocessor runs UNIX software tools without a UNIX kernel.*

tained by a word transfer when writing PC interface software for the DSI-020.

### THE BIDIRECTIONAL LATCHES

The 68020 instruction cycles are very much faster than those of the 8088/286. This means that at the end of a bus cycle, after the 68020 has been released from the DMA task, the PC bus interface still requires the DMA data to be valid. Thus, on a PC bus READ cycle, the DMA data byte has to be latched while RAM data is valid so that it can be made available to the host asynchronously. This is the function of the 74HCT646 latches (see figure 9).

The RASIN (strobe) signal is activiated by the DPORT20 PAL at the end of the DMA cycle to latch the data. The RAM array is further stabilized by filter capacitors on the board (figure 10). When the PC writes to the DSI-020, the latches remain transparent for the total cycle, however.

### THE OPERATING SYSTEM

The basic operating system for programming or operating the DSI-020 is MS-DOS (or PC-DOS). Definicon has implemented an interface between the 8088/80286 and the 68020 that allows the 68020 to run UNIX-quality development tools without requiring either a UNIX kernel or a UNIX file system. The system calls are accessed via the 68020 TRAP #14 instruction. The text box "DSI-020 Kernel Functions" on page 142 provides a list of

*(continued)*

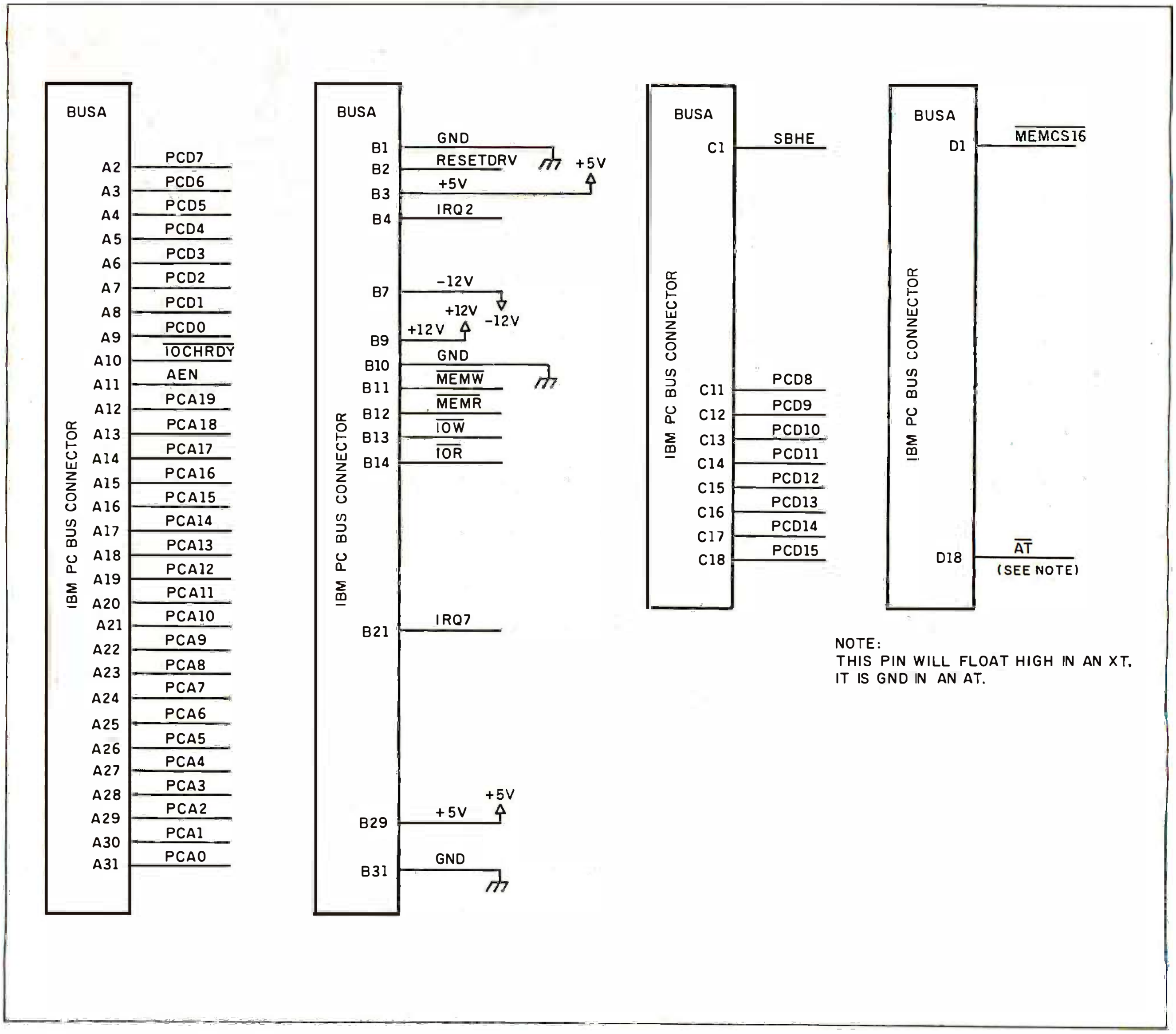



**Figure** 8: PC *bus connections.*

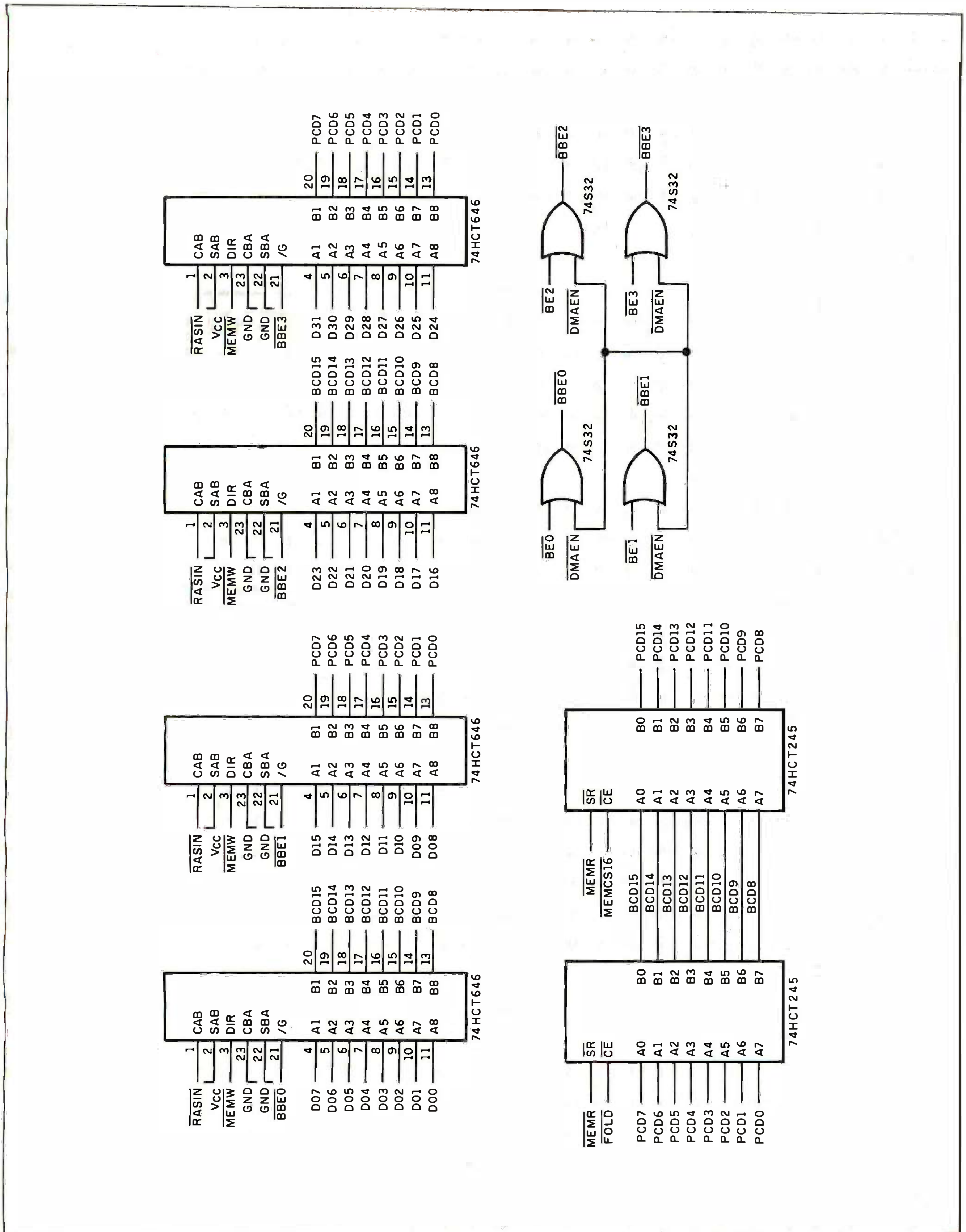



Figure 9: PC *bus interface latches.*

the available system calls. Note that functions 5 through 15 emulate the basic UNIX I/O system. Thus, STDIN (the keyboard) is treated as a FILE with a handle of 0, while STDOUT (the CRT) is addressed as a FILE with a handle of 1. These functions cannot interfere with the operation of the host PC, and it is recommended that you use them in preference to the enhanced interface calls (1,16–25). These enhanced calls, if invoked with faulty syntax, are sufficiently powerful to interfere with the operation of the MS-DOS system itself.

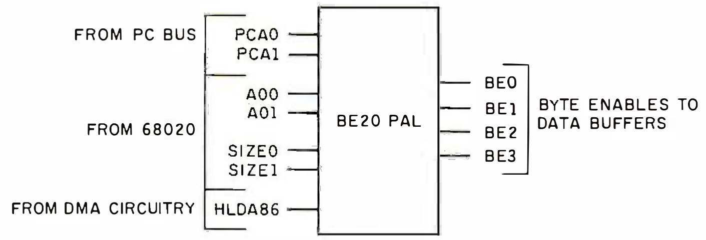
Note that any peripheral available to the host CPU is also available to the 68020. Bit-mapped graphics adapters are programmed directly using functions 16 through 19, networking is implicitly supported by the DOS file system, and specialized peripherals, such as A/D converters, can be accessed

*(continued)*

Table 2: *Comparison of Motorola and Intel memory arrangement and the hardware logic interface required for translating the data.*

| | ADDRESS 0<br>LSB . . MSB | ADDRESS 1<br>LSB . . MSB | ADDRESS 2<br>LSB . . MSB | ADDRESS 3<br>LSB . . MSB |
|---|---|---|---|---|
| INTEL DATA BITS | D0 . . . . . D7 | D8 . . . . D15 | D16 . . . D23 | D24 . . . D31 |
| MOTOROLA DATA BITS | D24 . . . D31 | D16 . . . D23 | D8 . . . . D15 | D0 . . . . . D7 |
| BYTE ENABLE | BE3 | BE2 | BE1 | BE0 |

| | ADDRESS 0<br>LSB.....MSB | ADDRESS 1<br>LSB.....MSB | ADDRESS 2<br>LSB.....MSB | ADDRESS 3<br>LSB.....MSB |
|---|---|---|---|---|
| INTEL DATA BITS | D0.........D7 | D8........D15 | D16.....D23 | D24.....D31 |
| MOTOROLA DATA BITS | D24......D31 | D16......D23 | D8.........D15 | D0.........D7 |
| BYTE ENABLE | BE3 | BE2 | BE1 | BE0 |




PAL EQUATIONS

$$\begin{aligned}\text{BE0} = &\ \text{HLDA86} \cdot \text{PCA0} \cdot \text{PCA1} \\ &+ \overline{\text{HLDA86}} \cdot \text{A00} \cdot \text{SIZE0} \cdot \text{SIZE1} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{SIZE0}} \cdot \overline{\text{SIZE1}} \\ &+ \overline{\text{HLDA86}} \cdot \text{A00} \cdot \text{A01} \\ &+ \overline{\text{HLDA86}} \cdot \text{A01} \cdot \text{SIZE1}\end{aligned}$$

:This is the PC bus decode term
:These next four implement the decode
:schematic from page 5-17 of the
:*Motorola MC68020 User's Manual.*

$$\begin{aligned}\text{BE1} = &\ \text{HLDA86} \cdot \text{PCA1} \cdot \overline{\text{PCA0}} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{A00}} \cdot \text{A01} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{A01}} \cdot \overline{\text{SIZE0}} \cdot \overline{\text{SIZE1}} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{A01}} \cdot \text{SIZE0} \cdot \text{SIZE1} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{SIZE0}} \cdot \text{A00} \cdot \overline{\text{A01}}\end{aligned}$$

:The remaining equations are
:constructed in a similar fashion.

$$\begin{aligned}\text{BE2} = &\ \text{HLDA86} \cdot \text{PCA0} \cdot \overline{\text{PCA1}} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{SIZE0}} \cdot \overline{\text{A01}} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{A01}} \cdot \text{A00} \\ &+ \overline{\text{HLDA86}} \cdot \text{SIZE1} \cdot \overline{\text{A01}}\end{aligned}$$

$$\begin{aligned}\text{BE3} = &\ \text{HLDA86} \cdot \overline{\text{PCA0}} \cdot \overline{\text{PCA1}} \\ &+ \overline{\text{HLDA86}} \cdot \overline{\text{A00}} \cdot \overline{\text{A01}}\end{aligned}$$

# AZTEC The C for Microcomputers

PC-DOS, MS-DOS, CP/M-86, Macintosh, Amiga, Apple II, CP/M-80, Radio Shack, Commodore, XENIX, ROM, and Cross Development systems

## MS-DOS, PC-DOS, CP/M-86, XENIX, 8086/80x86 ROM

### Manx Aztec C86

*"A compiler that has many strengths . . . quite valuable for serious work"*

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**Great Code:** Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

| | Execution Time | Code Size | Compile/ Link Time |
|---|---|---|---|
| Dhrystone Benchmark | | | |
| Manx Aztec C86 3.3 | 34 secs | 5,760 | 93 secs |
| Microsoft C 3.0 | 34 secs | 7,146 | 119 secs |
| Optimized C86 2.20J | 53 secs | 11,009 | 172 secs |
| Mark Williams 2.0 | 56 secs | 12,980 | 113 secs |
| Lattice 2.14 | 89 secs | 20,404 | 117 secs |

**Great Features:** Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

| | |
|---|---|
| Optimized C compiler | Symbolic Debugger |
| AS86 Macro Assembler | LN86 Overlay Linker |
| 80186/80286 Support | Librarian |
| 8087/80287 Sensing Lib | Profiler |
| Extensive UNIX Library | DOS, Screen, & Graphics Lib |
| Large Memory Model | Intel Object Option |
| Z (vi) Source Editor -c | CP/M-86 Library -c |
| ROM Support Package -c | INTEL HEX Utility -c |
| Library Source Code -c | Mixed memory models -c |
| MAKE, DIFF, and GREP -c | Source Debugger -c |
| One year of updates -c | CP/M-86 Library -c |

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

| | |
|---|---|
| **Aztec C86-c Commercial System** | **$499** |
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| **Aztec C86-p Personal System** | **$199** |
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**All systems are upgradable by paying the difference in price plus $10.**

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| | |
|---|---|
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| **PHACT $250** | **PC-lint $98** |
| **HALO $250** | **Amber Windows $59** |
| **PRE-C $395** | **Windows for C $195** |
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| **SunScreen $99** | **C Util Lib $185** |
| **PANEL $295** | **Plink-86 $395** |

## MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

### Manx Aztec C68k

*"Library handling is very flexible . . . documentation is excellent . . . the shell a pleasure to work in . . . blows away the competition for pure compile speed . . . an excellent effort."*

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

| | |
|---|---|
| Optimized C | Creates Clickable Applications |
| Macro Assembler | Mouse Enhanced SHELL |
| Overlay Linker | Easy Access to Mac Toolbox |
| Resource Compiler | UNIX Library Functions |
| Debuggers | Terminal Emulator (Source) |
| Librarian | Clear Detailed Documentation |
| Source Editor | C-Stuff Library |
| MacRam Disk -c | UniTools (vi,make,diff,grep) -c |
| Library Source -c | One Year of Updates -c |

Items marked -c are available only in the Manx Aztec C86-c system. Other features are in both the Aztec C86-d and Aztec C86-c systems.

| | |
|---|---|
| **Aztec C68k-c Commercial System** | **$499** |
| **Aztec C68d-d Developer's System** | **$299** |
| **Aztec C68k-p Personal System** | **$199** |
| **C-tree database (source)** | **$399** |
| **AMIGA, CP/M-68k, 68k UNIX** | **call** |

## Apple II, Commodore, 65xx, 65C02 ROM

### Manx Aztec C65

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NIBBLE review, July 1984

A vast amount of business, consumer, and educational software is implemented in Manx Aztec C65. The quality and comprehensiveness of this system is competitive with 16 bit C systems. The system includes a full optimized C compiler, 6502 assembler, linkage editor, UNIX library, screen and graphics libraries, shell, and much more. The Apple II version runs under DOS 3.3, and ProDOS, Cross versions are available.

The Aztec C65-c/128 Commodore system runs under the C128 CP/M environment and generates programs for the C64, C128, and CP/M environments. Call for prices and availability of Apprentice, Personal and Developer versions for the Commodore 64 and 128 machines.

| | |
|---|---|
| **Aztec C65-c ProDOS & DOS 3.3** | **$399** |
| **Aztec C65-d Apple DOS 3.3** | **$199** |
| **Aztec C65-p Apple Personal system** | **$99** |
| **Aztec C65-a for learning C** | **$49** |
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**Distribution of Manx Aztec C**

In the USA, Manx Software Systems is the sole and exclusive distributor of Aztec C. Any telephone or mail order sales other than through Manx are unauthorized.

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Cross developed programs are edited, compiled, assembled, and linked on one machine (the HOST) and transferred to another machine (the TARGET) for execution. This method is useful where the target machine is slower or more limited than the HOST, Manx cross compilers are used heavily to develop software for business, consumer, scientific, industrial, research, and educational applications.

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**TARGETS:** MS-DOS, CP/M-86, Macintosh, CP/M-68k, CP/M-80, TRS-80 3 & 4, Apple II, Commodore C64, 8086/80x86 ROM, 68xxx ROM, 8080/8085/Z80 ROM, 65xx ROM.

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using the I/O facilities (functions 20 and 21). In addition, any MS-DOS program that installs itself as an 8088/80286 interrupt process can be accessed via function 25. Most mice and many hardware drivers can be accessed in this way. COM1:, COM2:, and PRN: are accessed by opening files called COM1, COM2, or PRN.

Next month the DSI-020 software support will be discussed in detail.

## PERFORMANCE

While almost every reader took the trouble to look at the benchmarks published in the DSI-32 article, apparently only a handful actually believed we had not specifically made them up to favor the 32032! Consequently, the benchmark used to characterize the DSI-020 performance was not written by Definicon. This program is generally regarded as an "industry-standard" benchmark. This has the added advantage that you will be able to find a plethora of data tabulating the relative performance of other computers. Also, a special 16.7-MHz version of the DSI-020 was assem-

(continued)

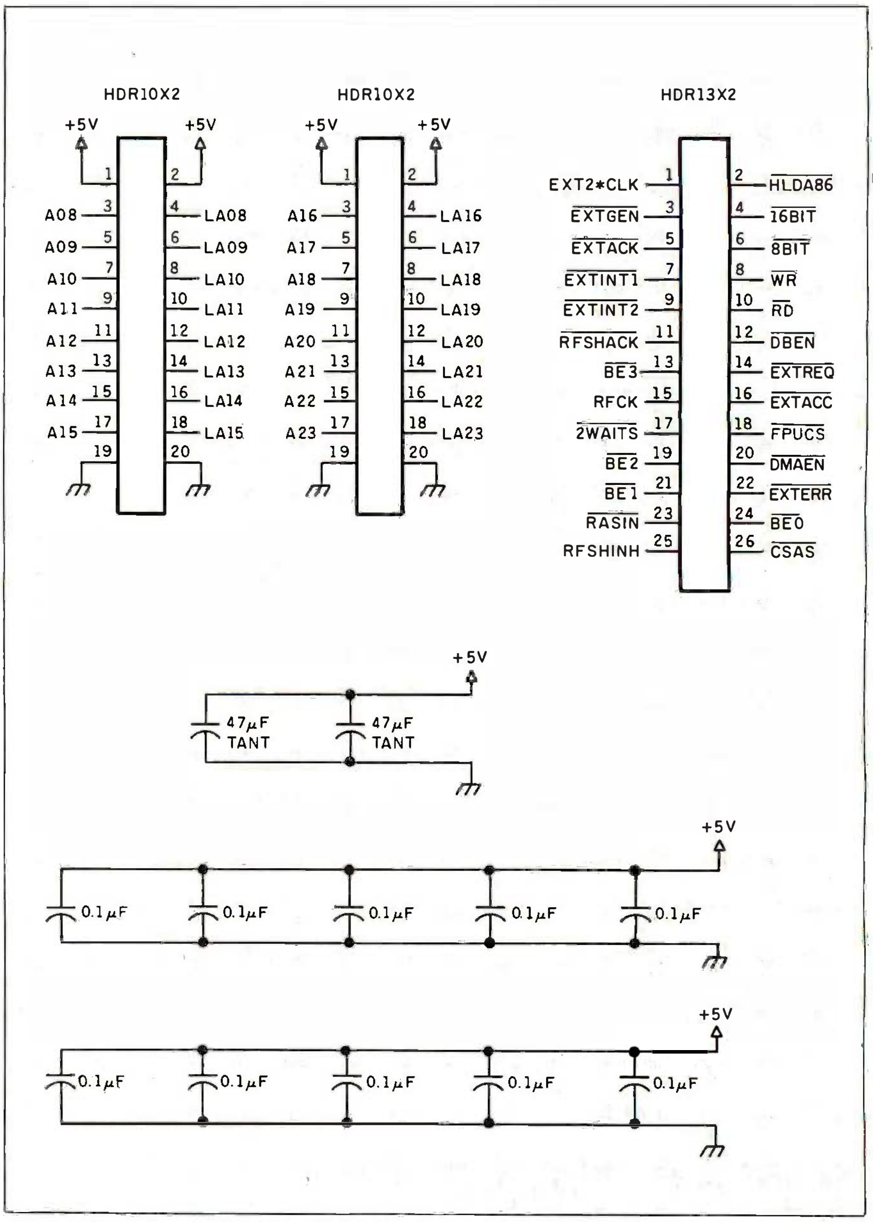



Figure 10: *Headers and filter capacitors for the* DSI-020.

# DSI-020 Kernel Functions

Register D0 is always used to communicate the function code to the kernel and will not be listed in the "entry parameters."

A suffix of .L, .W, or .B after a register shows the data size expected by the kernel.

The "no error" status code returned in D0 is 0000.

Address registers are always passed as 32-bit values.

### Function 1—BDOS Call

Used to communicate an MS-DOS system request (INT 21H) to the host. This function should be used only by experienced programmers.

| | | |
|---|---|---|
| Entry parameters: | A0 | DX argument |
| | D1.B | BDOS function code (AH argument) |
| Return parameter: | D0.B | AL return code, if any, else undefined |

This function was implemented for system software development. BDOS functions that allow multibyte I/O (such as string in/out and file I/O operations) will not work properly if crossing 64K page boundaries.

### Function 5—Open File

| | | |
|---|---|---|
| Entry parameters: | A0 | pointer to ASCIIZ filename with optional MS-DOS path specification |
| | D1.W | open mode, one of:<br>0 = read file<br>1 = write file<br>2 = read and write |
| Return parameters: | D0.W | file ID (handle), or FFFF = error and |
| | D1.W | error code |

### Function 6—Close File

| | | |
|---|---|---|
| Entry parameter: | D1.W | file handle |
| Return parameters: | D0.W | status. If error, |
| | D1.W | error code |

### Function 7—Create File

| | | |
|---|---|---|
| Entry parameter: | A0 | pointer to ASCIIZ filename |
| Return parameters: | D0.W | file handle, or FFFF = error and |
| | D1.W | error code |

### Function 8—Read File

| | | |
|---|---|---|
| Entry parameters: | D1.W | file handle |
| | A0 | disk transfer address (DTA) |
| | D2.L | number of bytes to read |
| Return parameters: | D0.L | actual number of bytes read, or 0000 = error and |
| | D1.W | error code |

### Function 9—Write File

| | | |
|---|---|---|
| Entry parameters: | D1.W | file handle |
| | A0 | DTA |
| | D2.L | number of bytes to write |
| Return parameters: | D0.L | actual number of bytes written, or 0000 = error and |
| | D1.L | error code |

### Function 10—Delete File (Unlink)

| | | |
|---|---|---|
| Entry parameter: | A0 | pointer to ASCIIZ filename |
| Return parameters: | D0.W | status (0000 = file deleted) or |
| | D1.W | error code |

### Function 11—Rename File

| | | |
|---|---|---|
| Entry parameters: | A0 | pointer to old ASCIIZ filename |
| | A1 | pointer to new ASCIIZ filename |
| Return parameters: | D0.W | status (0000 = file renamed) or |
| | D1.W | error code |

### Function 12—Seek to Byte in File

| | | |
|---|---|---|
| Entry parameters: | D1.W | file handle |
| | D2.L | byte to seek to |
| | D3.W | base, one of:<br>0 = from beginning of file<br>1 = from current location of FP<br>2 = from EOF |
| Return parameters: | D0.L | current position, or FFFFFFFF = error and |
| | D1.W | error code |

### Function 13—Determine Current Byte Offset

| | | |
|---|---|---|
| Entry parameter: | D1.W | file handle |
| Return parameters: | D0.L | current posistion from BOF, or FFFFFFFF = error and |
| | D1.W | error code |

### Function 14—Get Command Line Arguments

| | | |
|---|---|---|
| Entry parameter: | none | |
| Return parameters: | D0.W | number of commands |
| | A0.L | pointer to array of pointers to arguments |

### Function 15—Terminate

| | |
|---|---|
| Entry parameter: | none |
| Return parameter: | none (does not return) |

### Function 16—Move Memory Block from 8086

| | | |
|---|---|---|
| Entry parameters: | A0 | source address in 8086 space (20 significant bits) |

| | | |
|---|---|---|
| | A1 | destination address in 68020 space |
| | D1.L | word count |
| Return parameter: | none (memory is moved) | |

**FUNCTION 17—MOVE MEMORY BLOCK TO 8086**

| | | |
|---|---|---|
| Entry parameters: | A0 | source address in 68020 space |
| | A1 | destination address in 8086 space (20 significant bits) |
| | D1.L | word count |
| Return parameter: | none (memory is moved) | |

**FUNCTION 18—MOVE MEMORY FROM 8086 (BACKGROUND)**

Same as function 16, except that function call does not wait for completion before returning.

**FUNCTION 19—MOVE MEMORY TO 8086 (BACKGROUND)**

Same as function 17, except that function call does not wait for completion before returning.

**FUNCTION 20—READ 8086 PORT**

| | | |
|---|---|---|
| Entry parameter: | D1.W | 8086 port address |
| Return parameter: | D0.B | value read from port |

**FUNCTION 21—WRITE 8086 PORT**

| | | |
|---|---|---|
| Entry parameters: | D1.W | 8086 port address |
| | D2.B | byte to be output |
| Return parameter: | none | |

**FUNCTION 23—ALLOCATE 8086 MEMORY**

| | | |
|---|---|---|
| Entry parameter: | D1.L | number of bytes to allocate |
| Return value: | D0.L | pointer:<br>high word = DS<br>low word = OFFSET<br>00000000 if no memory available |

**FUNCTION 24—DEALLOCATE 8086 MEMORY**

| | | |
|---|---|---|
| Entry parameter: | D1.L | pointer (DS:OFFSET) to RAM |
| Return value: | none | |

**FUNCTION 25—EXECUTE 8086 INTERRUPT**

| | | |
|---|---|---|
| Entry parameters: | D1.B | interrupt vector number |
| | A0 | pointer to register structure Sequence: DX, CX, BX, AX |
| Return value: | Register structure filled with result | |

**FUNCTION 27—GET SYSTEM DATE**

| | | | |
|---|---|---|---|
| Entry parameter: | none | | |
| Return value: | D0.L | bits: | |
| | | 31..16 | year (1980 base) |
| | | 15..08 | month |
| | | 07..00 | day |

**FUNCTION 28—GET SYSTEM TIME**

| | | | |
|---|---|---|---|
| Entry parameter: | none | | |
| Return value: | D0.L | bits: | |
| | | 31..24 | hour |
| | | 23..16 | minute |
| | | 15..08 | second |
| | | 07..00 | 1/100 |

**FUNCTION 29—CHAIN TO PROGRAM (EXEC( ))**

| | | |
|---|---|---|
| Entry parameters: | A0 | pointer to full command line |
| | A1 | desired load address |
| Return value: | none — new program is loaded and executed if it is a valid .E20 file | |

**FUNCTION 30—GET/SET RS-232C CONTROLS**

This function is used to control the on-board DUART.

| | | |
|---|---|---|
| Entry parameters: | D1.B | 00=get controls, FF=set controls |
| | D2.B | 00=set stop bits<br>01=set parity<br>02=set character length<br>03=set baud rate |
| | D3.L | set value and port<br>bits 23..16 = logical port number<br>bits 07..00 = value |
| Return value: | D0.L | controls if get, error if set<br>bits 19..18 = number of stop bits<br>bits 17..16 = parity (0=N, 1=EVEN, 2=ODD)<br>bits 15..08 = character length<br>bits 07..00 = baud rate |

**FUNCTION 31—INPUT CHARACTER**

This function inputs a byte from the local DUART.

| | | |
|---|---|---|
| Entry parameter: | D1.B | logical port number |
| Return value: | D0.W | status word:<br>bit 15 set if no character available<br>bits 8..0 contain character if bit 15=0 |

**FUNCTION 32—OUTPUT CHARACTER**

This function outputs a character to the local DUART.

| | | |
|---|---|---|
| Entry parameter: | D1.B | character to be output |
| Return value: | none (character is output, waiting if necessary) | |

**FUNCTION 33—GET BOARD SERIAL NUMBER**

| | | |
|---|---|---|
| Entry parameter: | none | |
| Return value: | D0.L | board serial number |

All functions listed are subject to change due to improvements or bug fixes at any time without notice. Type the file IO-READ.ME on your distribution disk for the latest definitions.

Table 3: DSI-020 *Whetstone benchmarks.*

1. Single-Precision Whetstones
Performance is quoted as the number of Whetstones per second

| DSI-020 12.5 MHz | DSI-020 16.7 MHz | IBM PC RT | VAX-11/780 |
|---|---|---|---|
| 770K | 1028K | 200K | 1152K |

2. Double-Precision Whetstones
Performance is quoted as the number of Whetstones per second

| DSI-020 12.5 MHz | DSI-020 16.7 MHz | IBM PC RT | VAX-11/780 |
|---|---|---|---|
| 676K | 902K | 185K | 798K |

Note: All machines have floating-point hardware or coprocessors.

bled to show the peak performance currently available using the 68020 microcomputer family. Although the chip set made available by Motorola is a 12.5-MHz version, it is our experience that the careful hacker will note the additional crystal oscillator on the schematic and hone his system's performance to the limit. One tip: You will need to use 100-nanosecond RAM and carefully watch the FPU's operation at these faster speeds, however.

The Whetstone benchmark first appeared in ALGOL in *Computer Journal* (February 1976, pages 47–49). This version was translated to FORTRAN by D. Frank in 1979. Both single- and double-precision results are given. The Whetstone tests mathematical functions such as LOG and EXP in addition to linear arithmetic. Table 3 shows the results obtained with the DSI-020 at 12.5 MHz and 16.7 MHz, the IBM PC RT, and a VAX-11/780.

You can draw your own conclusion from the data presented in table 3, but one thing is clear: The days when a desktop microcomputer could be regarded as a development tool with limited capability are gone. The question that must be asked now is "how much further can technology go?" A VAX-11/780 dissipates about 6 kilowatts of electricity and requires a small army of technicians to service it. The DSI-020 dissipates 10 watts, and its peripherals and operating procedures (MS-DOS) can be comprehended and serviced by most all the population. Time alone will tell. ■





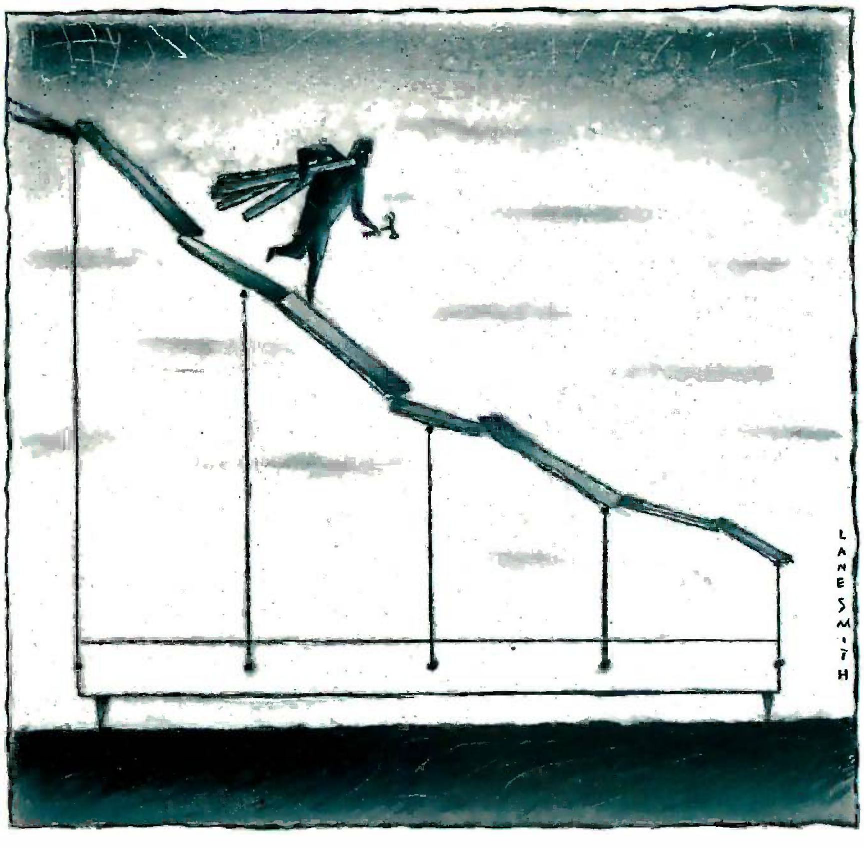
 Inquiry 312 Inquiry 101

BY CHRIS PEDICINI

# ENGINEERING ON A MICRO

## *A bridge-truss analysis program in* BASIC

Computer-aided engineering is not an application you would normally consider for the microcomputer. That's because most computer programs for analyzing stress, temperature, and so on, are based on matrix techniques such as the finite-element (FE) method. Typically, FE-method techniques require a lot of memory and high computational speed to be effective. Fortunately, the advent of 16- and 32-bit-based microcomputers has increased the operating speed and memory capability of home systems to the point that small FE-method packages are now practical for the home computer.




In this article I will discuss the basis for the method and give the source code for a BASIC program that effectively analyzes pin-jointed trusses. This program, called Truss2, can assist engineers in the design of truss-type structures, as well as provide an excellent basis for understanding the FE method. (See the text box "Finite-Element Analysis Primer" on page 148 for information on the finite-element method.) [*Editor's note: The source code listing for* TRUSS2.BAS *is available in a variety of formats. See pages 459–461 for details. It runs on an* IBM *Personal Computer with 128K bytes of memory, a graphics board, and* BASICA.]

Truss2 can solve some practical problems in the interpretive BASIC version presented here, and if it's compiled, it can solve larger problems. Table 1 shows maximum program limits. The program is completely menu-driven, with all node, element, and load data entered through self-contained spreadsheets. Finally, Truss2 includes plotting options for displaying the truss geometry in both its original and deflected shapes.

*(continued)*

*Chris Pedicini (1139 Highland Ave., Brunswick, OH 44212), a mechanical engineer, works at Union Carbide Corporation. He uses computers for design and analysis as well as personal enjoyment.*

The hardware requirements for this program are an IBM PC compatible with at least one floppy disk drive, an operating system with advanced BASIC (BASICA), a color graphics board, a printer, and 128K bytes of memory. Using the compiled version to improve the solution speed and truss size increases the minimum memory requirement to 192K bytes.

## USING THE TRUSS ANALYSIS PROGRAM

You use Truss2 in the same way that many FE analysis programs are used. First, define the structure that you wish to analyze, and then assign the node and element numbers. We will use the truss shown in figure B in the text box on page 148 in order to demonstrate the program.

Begin by entering the Data Editor menu and key in the node, element, and load data. I designed the editor to support the PgUp, PgDn, Home, End, and the arrow keys to simplify cursor positioning for large data fields. The procedure for changing an existing value or entering a new value is the same: Position the cursor over the item to be changed, enter a new value, and press Return. To delete an entry, position the cursor in the row you want to delete and press the F1 function key. The entire row will be deleted and the data display shifted. Note that you will not be able to position the cursor more than one row past the last element.

Photos 1a, 1b, and 1c contain screen images of the node, element, and load data editors as you would see them. Once the node, element, and load data have been satisfactorily entered, the control parameters that govern the problem are entered in the Control Cards menu. These parameters include title, date, and the elastic modulus and design strength of the material. I use a format that allows you to change one or all of the control parameters without having to go through the list sequentially. Position the cursor in the line of the item that you wish to change and enter the new value. Press the Return key to terminate the entry and log in the new value. Note that the elastic modulus and design strength are assigned default values of 30,000,000 and 30,000 pounds per square inch, respectively.

Before you analyze the problem, you should enter the Plot menu and check the geometry. Any node or element data that is in error should be apparent in the original geometry plot (see photo 2). Some of the features that you may want to explore are zoom, node numbering, and element numbering. Labeling the nodes in a plot is a good way to verify the points at which to apply the loads. If everything looks satisfactory, you solve for the displacements at each node and the stresses in the individual bars by returning to the main menu and selecting the analysis option.

The program results are shown in table 2, along with the theoretical results. You can see that the finite-element solution is exact in this case. This means that the element-stiffness matrix that we wrote for the truss element is in fact equal to the stiffness of the element. If we were to develop different elements for other two- or three-dimensional problems, this might not be true. Perhaps more interesting than the tabular results is the overall behavior of the structure. This is visualized by entering the Graphics menu and plotting out the distorted structure with an exaggeration ratio of 30, as shown in photo 3. We get more information by making a stress plot of the structure. The stress plot puts a solid rectangle through any element that has exceeded our design stress. This is an excellent method for checking the overall design strength against the actual stress in the structure.

The real advantage of the FE

Table 1: *Maximum program limits for the Truss2 analysis program in interpretive and compiled* BASIC.

| | Interpretive version | Compiled version |
|---|---|---|
| Number of nodes | 100 | 150 |
| Number of elements | 100 | 150 |
| Number of materials | 1 | 1 |
| Number of loads | 100 | 150 |
| Maximum bandwidth | 25 | 30 |


**Photo 1a:** *Data entry and modification is done through the node, element, and load screen editors. Pictured is a screen image of the node editor.*

method becomes evident when you begin to analyze the "what ifs" of an engineering situation. For instance, what if the loads are 10,000 pounds instead of 8000 pounds? To analyze this situation you need only go to the data editor, alter the loads, and instruct the computer to recalculate the deflections and stresses (see photo 4). This is much simpler than the classical analysis in which you would have to re-solve the entire truss.

## Program Description

Truss2 requires approximately 32K bytes of memory for the source code and about another 30K for variable storage. We add to this the 20K overhead from DOS 2.0 and get a 128K-

(continued)


Photo 1b: A *screen image of the element editor.*


Photo 1c: A *screen image of the load editor with data for the truss shown in figure B.*

# FINITE-ELEMENT ANALYSIS PRIMER

The finite-element (FE) method is a numerical technique for solving partial differential equations by converting them into a set of simultaneous linear equations and applying appropriate boundary conditions. The basic concept of the method is that any continuous quantity—such as temperature or displacement—can be approximated by a discrete model composed of a set of piecewise continuous functions (see figure A). These functions are defined using the values of the continuous quantity at a finite number of points in the domain called *nodes*.

The primary advantage of FE over other numerical methods is that once the programming is done for one category of problems, all problems of that class can be analyzed with no further programming. Thus, the technique is virtually independent of the particular geometry and load conditions. The FE method has the additional advantage that different classes of problems can be analyzed using very similar programs. Although I have covered only simple two-dimensional truss-type problems, this program could form the building block for a larger program capable of handling planar, axisymmetric, or three-dimensional structures.

FE-method terminology can be better understood using the example shown in figure B. Here we have a truss that has been subdivided into regions called *elements*. Points where the regions interconnect are called the *nodes*, and the displacements of these points are the unknowns for which we must solve. These elements, called *truss elements*, are defined by the two endpoints (nodes) and a cross section, which is constant within an element but can vary from element to element.

Once we have divided the structure into nodes and elements, we must determine the stiffness matrix for the element before the structure can be analyzed. This is more easily understood if each of the legs in the truss is envisioned to be a spring with varying stiffness. The truss element can be considered to be a very stiff spring governed by equation $F = kX$. In this equation, we see that the displacement ($X$) of the two node points is related to the force ($F$) necessary to produce this displacement by the element-stiffness matrix ($K$). The order of each of the matrices can be determined by the number of degrees of freedom (DOF) in the element. In this case, we have four DOF: $Xi$, $Yi$, $Xj$, $Yj$, and thus the force and displacement matrices are each 4 by 1 vectors. This means that the stiffness matrix that relates the corresponding force and displacement components must be a 4 by 4 matrix. There are several methods of obtaining the stiffness of this matrix, the simplest being to consider small *x* and

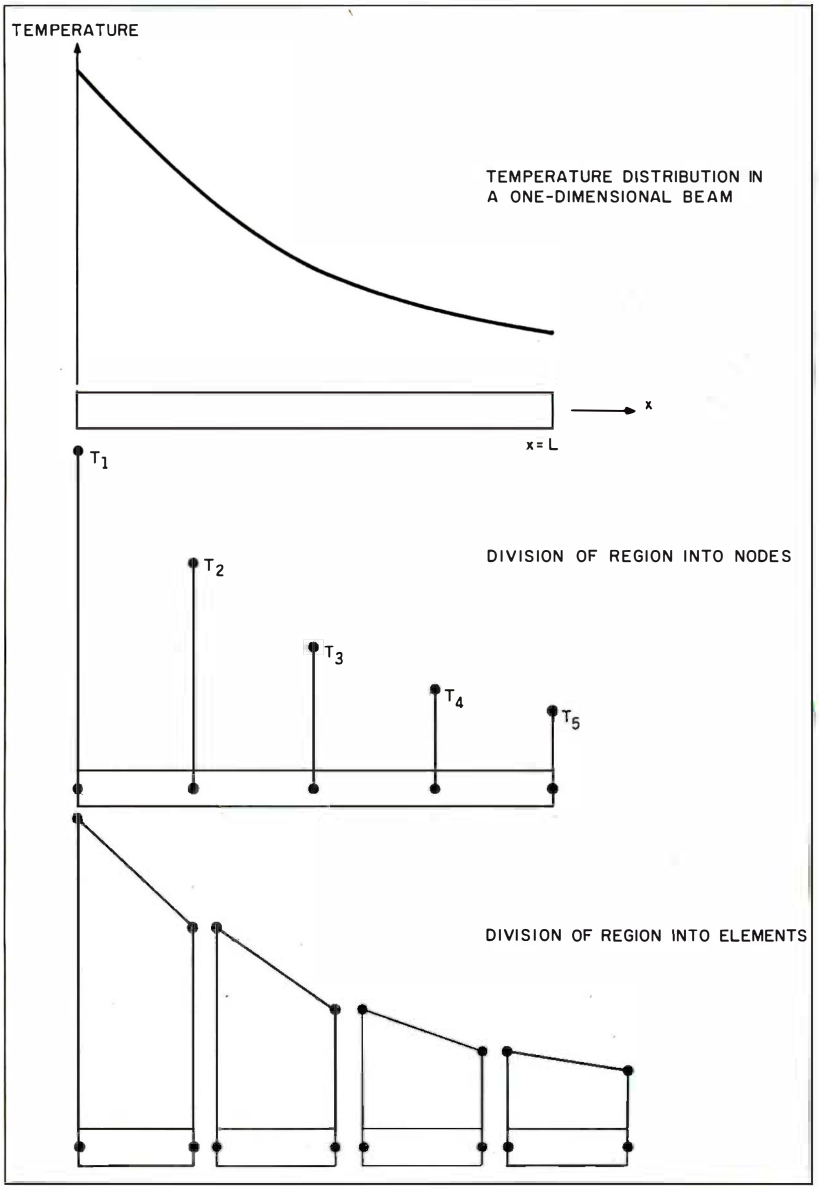



Figure A: *Heat distribution in a beam showing the true response and the finite-element approximation at the nodes.*

$y$ displacements at each node. This leads to internal forces in the element that must be balanced by the external forces as shown in figure B. By using the equation $F = kX$ and multiplying it by the rotation of the element and the displacement of each of the nodes, we equate this to the vector of external forces and solve for the stiffness matrix $K$. The rotation of the matrix must be considered because it controls the direction of the resulting force vector. Typically, this is built into the stiffness matrix: $K \times T \times U = F$, where $T$ = rotation matrix and $U$ = displacement matrix. And the equation

$$K = \frac{AE}{L}$$

where $A$ = member area, $E$ = elastic modulus, and $L$ = length, gives the element stiffness for an arbitrary truss element at any orientation.

The next step is to assemble this collection of element-stiffness matrices in an orderly fashion such that we have a mathematical model that represents the stiffness matrix of the complete structure. This is referred to as the global-stiffness matrix. (See figure C.) The key to developing the global-stiffness matrix is determining the location of the element stiffness inside the global stiffness. This is done by considering the DOF that the element affects. All that is necessary is to expand the element-stiffness matrix (using zeros) until it is the size of the global-stiffness matrix. This allows us to add the element-stiffness matrix to the global stiffness and thus build the complete global-stiffness matrix.

Two observations can be made about a correctly constructed global-stiffness matrix. First, it is symmetrical about the principal diagonal; second, a large portion of the matrix is filled with zeros. This is referred to as a banded symmetric matrix, and it is typical of the FE method. The banded matrix structure is a consequence of individual nodal displacements that are affected only by the elements that intersect at those nodes. To optimize the storage requirements of the global-stiffness matrix, we store the elements of the matrix in a rectangular array. This array will have a length equal to the number of degrees of freedom and a width equal to the *bandwidth*, or the number of nonzero columns in the array (see figure C). To further reduce the storage requirements of the global-stiffness matrix, we number the truss nodes to minimize the bandwidth. Generally, this consists of numbering the structure across its minimum dimension. For plane trusses, the bandwidth is given by two times the absolute value of the maximum node difference in an element plus 2.

To complete the definition of the problem, we must construct the force vector ($F$) from the load conditions. There are two types of loads that we impose on our structure: The first are simple forces in either the $x$ or $y$ directions, and the second are prescribed $x$ and/or $y$ displacements at certain nodes. The latter type of load fixes the displacements at the nodes to the desired value and is called a *fixity*. Fixities allow us to put supports in our structure without having to calculate their reactions. Therefore, we do not need to worry about the actual balance of external forces to prevent the entire structure from moving rigidly. Rigid body displacements allow for nonunique solutions to the structure displacements. Typically, we impose both forces and fixities on the structure.

In the case of force loadings, we can construct $F$ by adding the forces acting on a particular node to the corre-

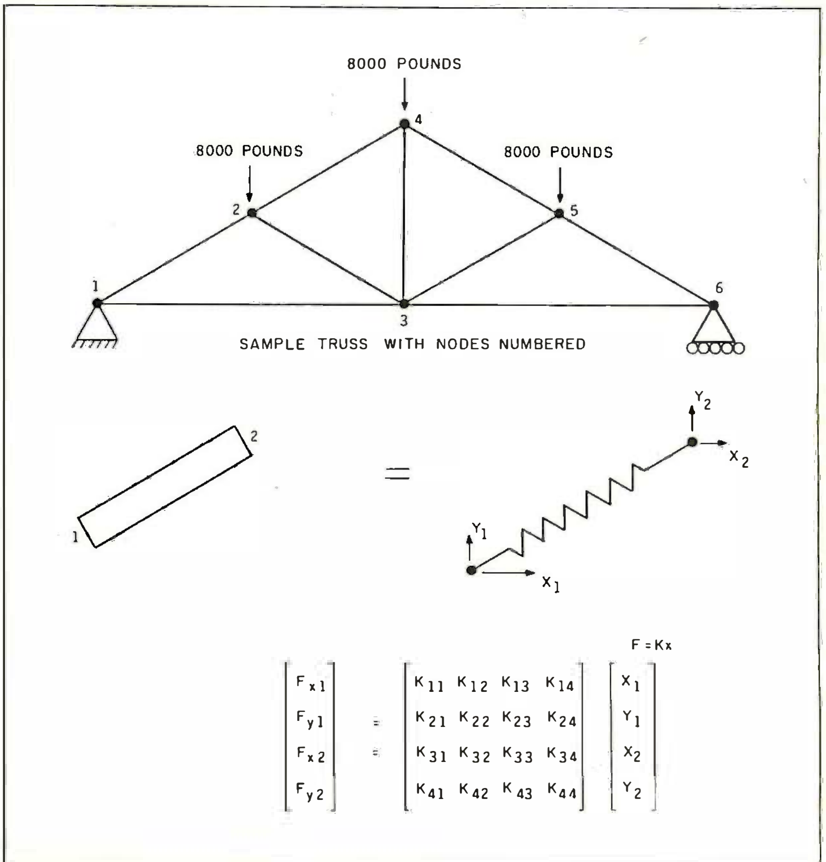



Figure B: *Example of a truss that has been subdivided into nodes and elements. The basic equivalence between a truss element and a stiff spring is shown.*

*(continued)*

sponding element in the force vector. For example, a force on node $i$ in the $x$ direction would correspond to location $2 \times (i-1)$ in the $F$ vector.

The next requirement is to force certain nodes to have specified displacements (e.g., if a member of a truss is attached to the ground, then we want a zero displacement). This is done by multiplying the diagonal associated with the node in the global-stiffness matrix by a number that is large in comparison to the other entries in the matrix. The corresponding element in $F$ must be multiplied by the same large number and the desired displacement. This forces the particular node to have the desired displacement value because all other entries in that row or equation are insignificant by comparison.

When we are finished assembling the matrix, we have a set of coupled algebraic equations in which the displacements of the nodal coordinates are the unknowns, the stiffness of the structure is given by a collection of element stiffnesses, and the loads are given by the force vector. This completes the assembly of the set of equations that govern the response of the structure to the load scheme. Once the global-stiffness matrix and the load matrix have been set up in this manner, they are solved using the Gaussian elimination technique. Because the global-stiffness matrix is stored in a rectangular (as opposed to square) array, the method must be modified. Detailed information on the application of Gaussian elimination to banded matrices can be found in references 1 and 2. Solving the matrix equation $F=KX$ for the displacements of the nodes and applying the following two definitions from strength of materials

$$\epsilon = \frac{dl}{L} \text{ (axial strain definition)}$$

$$\sigma = E \times \epsilon \text{ (Hooke's law)}$$

allows us to determine the strain and the stress in each element. The axial strain definition basically states that the strain in an element is equal to its change in length divided by its original length. Hooke's law is a relation that is valid for most materials if the yield stress is not exceeded. This completes our discussion of the fundamentals of finite-element analysis programming, but we need to touch on two additional themes to complete our story.

The first of these is called *preprocessing* and governs the method of getting the node and element data into the computer. It is easy to see how this could get out of hand for even medium-size problems of 500 nodes and 500 elements. Moreover, because of the tedium involved with typing in a data file of this size, it is one of the biggest sources for error in an analysis. The second area is called *postprocessing*, and it follows the FE-method analysis. Typically, FE-method analysis gives us results that are a localized description of the deflection and stresses in the structures, in other words, the stresses and displacements of the individual elements and nodes. Usually we are interested in the overall behavior of the structure, which can be difficult to interpret from the discrete behavior. Postprocessors have been written that graphically display the distorted structure on the screen. To clarify the results, the deflections can be magnified to exaggerate the structural response, or the plot can be enhanced through the use of color-coded stress fields.

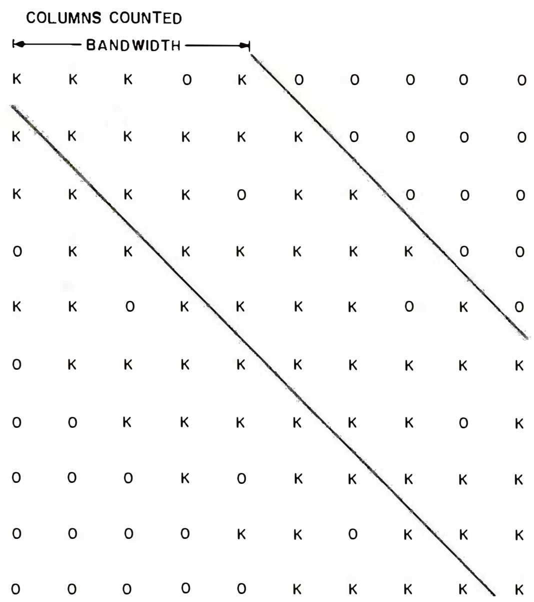



**Figure C:** *Global-stiffness matrix for a structure. Notice the symmetry around the main diagonal.*

## Conclusion

In summary, the five basic steps of any FE-method analysis program are

1. Divide the structure into elements and nodes.
2. Determine the stiffness of each element.
3. Assemble the element stiffnesses into a global-stiffness matrix that represents the stiffness of the entire structure.
4. Solve the resulting set of equations with the given load system for the displacements of each node.
5. Use the displacements to calculate the stresses in the members.

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At the start of this project, I wrote out the minimum specifications that the program should meet. These design criteria also helped define the basic program menus, which include

1. A method of entering and editing the nodes, elements, and loads with minimal difficulty.
2. A graphic representation of both the input data and the results to verify the input data and speed interpretation of the results.
3. A file management section to allow the storage and retrieval of the data and results (the Get/Save/Delete menu). This also allows the deletion of any file from within the program to make room on the disk.
4. An analysis of the truss and printing of the results.
5. A user-friendly design.
6. Structured programming throughout to increase program readability.

Truss2 has extensive comments that make it easier to follow. Unfortunately, using REM statements in interpretive BASIC chews up memory. While this is usually not important in small programs, it does affect us because Microsoft BASIC has a maximum address space of 64K bytes. For this reason, the variable definitions are broken out into table 3, instead of being included as comments in the source code.

Table 2: *Theoretical results compared to program output.*

| Element number | Theoretical stress | Stress by Truss2 |
|---|---|---|
| 1 | 24000 | 24000.0 |
| 2 | −22360 | −22361.0 |
| 3 | −22360 | −22361.0 |
| 4 | −22360 | −22361.0 |
| 5 | 26667 | 26667.0 |
| 6 | −22360 | −22361.0 |
| 7 | −22360 | −22361.0 |
| 8 | −22360 | −22361.0 |
| 9 | 24000 | 24000.0 |

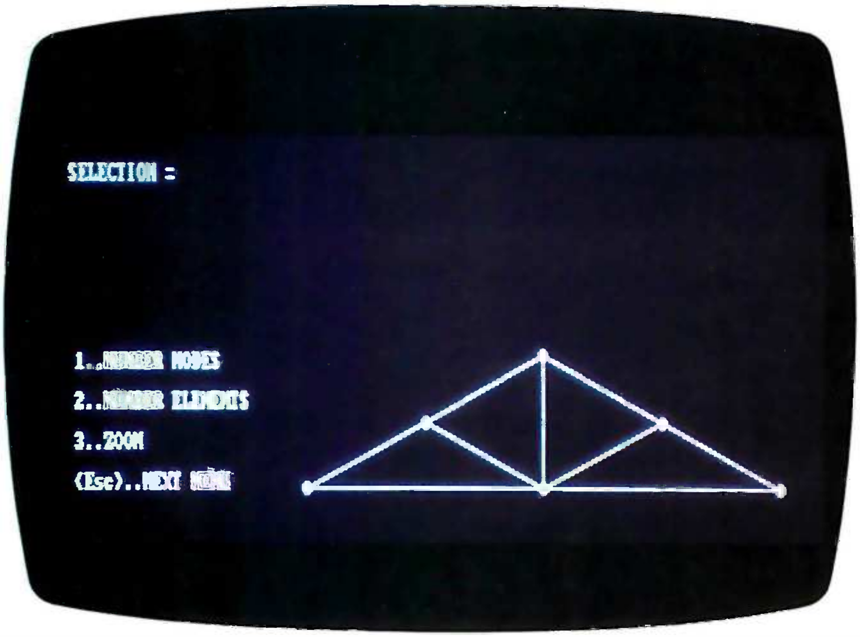


Photo 2: *Graphic display of the truss data, using the Plot menu.*

Lines 10–576 are devoted to initializing the variables and establishing the program limits. Lines 180–270 contain the graphic representations of the digits 0–9, respectively, for use in labeling nodes and elements in the graphics screen. The reason for this will become apparent later. Lines 370–400 include the information for the various menus in the program.

The first requirement was to write a user-friendly I/O section that would handle data that is being entered and edited. Because there are three separate data sets to handle with this routine, I wrote an interactive full-screen editor contained in lines 960–3050. It is controlled through the use of the array ID and the variables NCUR, NLMT, and K. The editor performs three basic functions: cursor positioning, data entry, and data deletion. The determination of which function to perform is made in lines 1070–1130. Cursor positioning is accounted for in lines 1140–1280. The method for scrolling the current information on the screen is worth mentioning. If the new position requires moving the existing information up or down one line on the screen, you directly access the screen buffer through the use of the PEEK and POKE commands (see lines 2390–2630). This is done instead of simply printing the data for speed. In the interpretive version presented here, it makes no difference. However, the compiled program updates the screen more quickly (two to three times as fast) using PEEK and POKE as opposed to printing the data. Deleting data is done in lines 1870–2120 by removing an element in the appropriate array. Once the element has been deleted, the current page of data is reprinted, and control is returned to lines 1080–1130. Data editing and entry is done in lines 1330–1560. The screen is updated once data has been entered via lines 2650–2790, and control is once again transferred to lines 1080–1130.

The next requirement involved writing a graphic display routine for drawing both the original and distorted

(continued)

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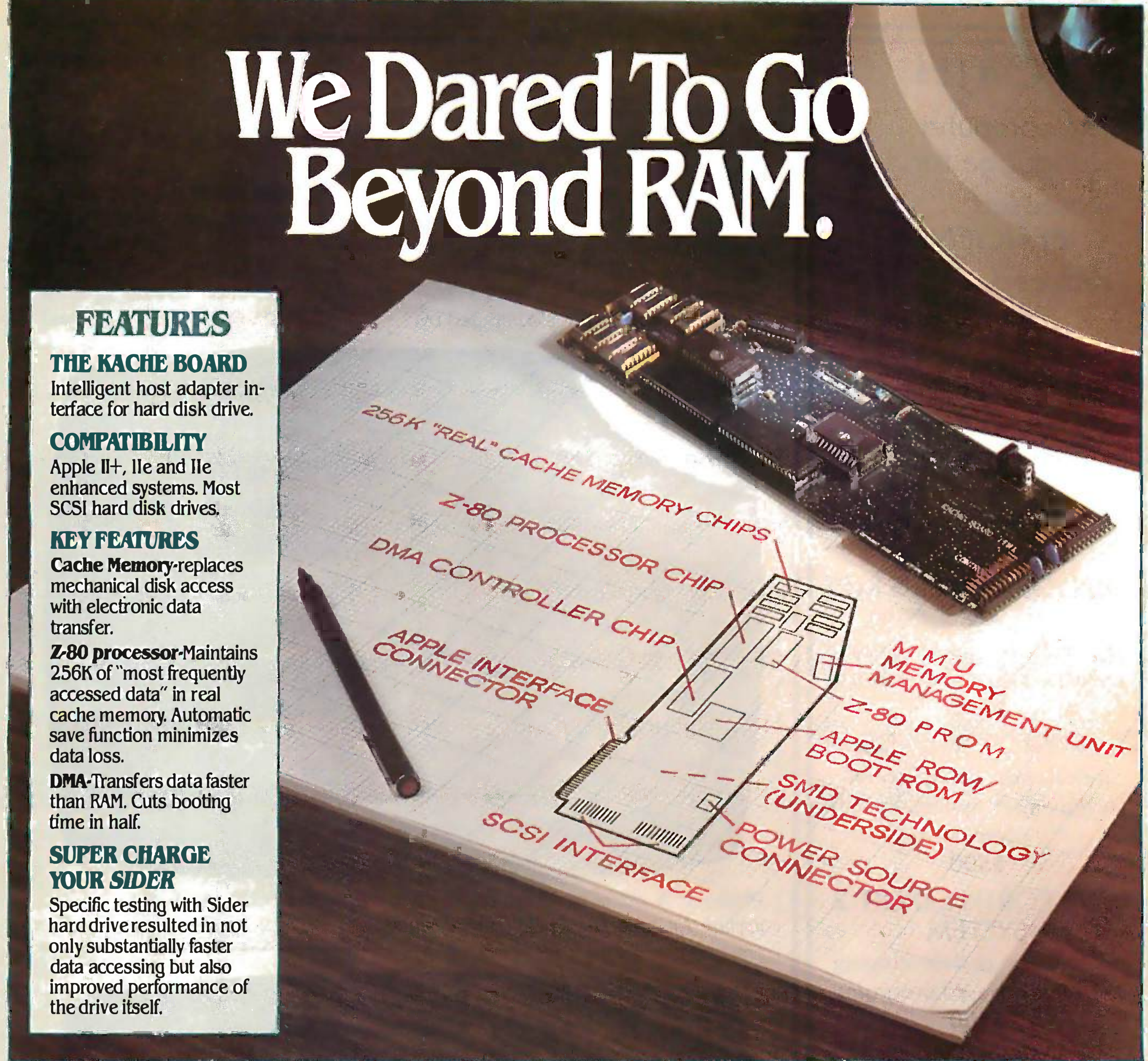


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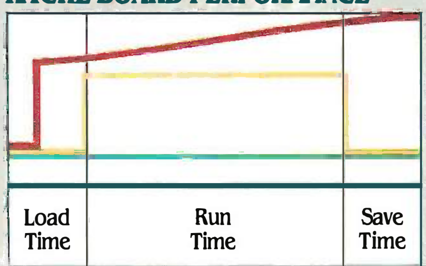


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structure (see lines 3460–4710). Graphically displaying the data not only simplifies data verification and interpretation, but it also makes the program easier to use. In any graphic display, the scaling factors need to be determined as shown in lines 3580–3677. The scale factor is computed by finding the minimum and maximum values for both the $x$ and $y$ axes and mapping those values onto the screen limits. In our case, the mapping takes place in the rectangle delimited by coordinates (200,10)–(620,190) on the IBM high-resolution screen. To keep

*(continued)*

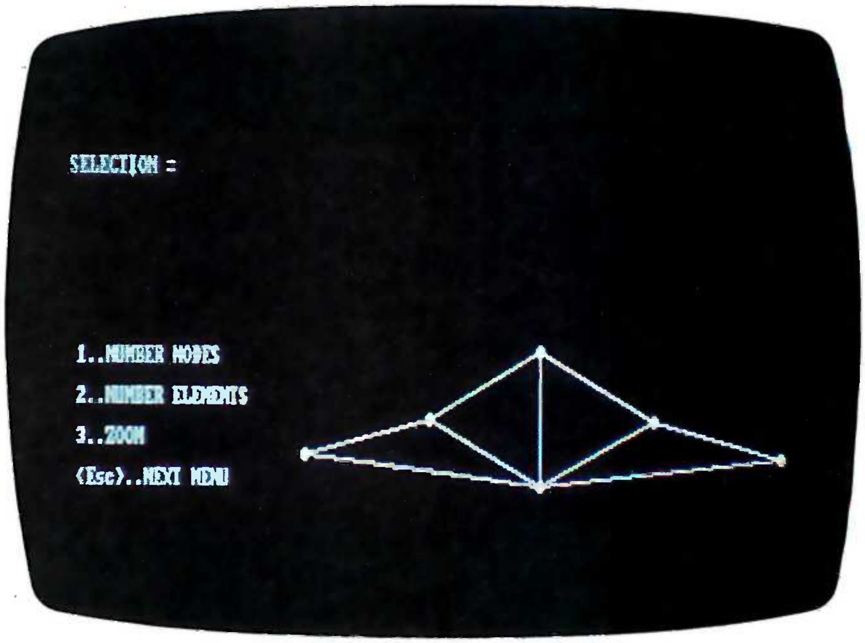


Photo 3: *A plot of the overall behavior of the truss with 8000-pound loads applied. An exaggeration ratio of 30 was used.*

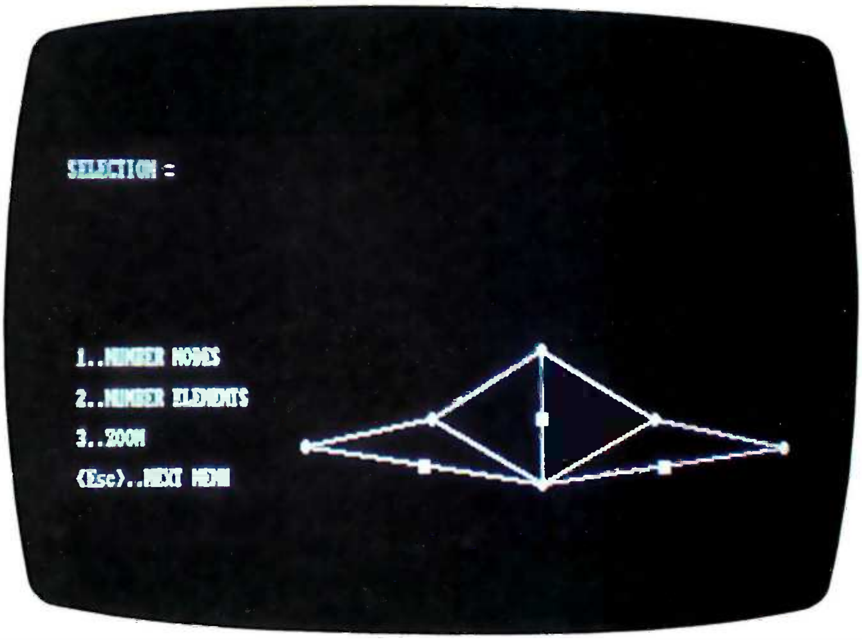


Photo 4: *The same truss plotted with 10,000-pound loads and an exaggeration ratio of 30. Rectangles have been placed by the program through members that exceed the design stress.*

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the $x$ and $y$ axes in scale, the smallest of the scale factors computed from

XSCALE = 210/(XMAX – XMIN)
YSCALE = 180/(YMAX – YMIN)

should be used. WINDOW or VIEW statements were not used because they are not supported by the BASIC compiler.

The routine for labeling the nodes and elements (see lines 3960–4370) uses the PUT and GET commands coupled with the array NUM(I,J). This allows us to put the node and element numbers beginning at any pixel on the IBM graphics screen and thus avoid the 80-column by 25-row limitation for printing data. A zoom routine is included that allows you to box in a particular area on the screen and then remap it to the physical screen limits. This is accomplished by taking the two entered cursor locations and using them to define the minimum and maximum values for the scale determination.

Printing or listing the data is covered in lines 31000–32280. This routine allows us to list the data on the line printer or the screen. This was done by opening the line printer or the screen as a file and printing the data to it. I chose to monitor the keyboard for an entry rather than trap a key as a way of stopping the printout. This allows you to optimize the compiled code in regard to both execution speed and size. Physically trapping keys in the compiled mode forces the compiler to put an extra 2 bytes of code for each line in the program. These 2 bytes cause the IBM PC to check for an interrupt before each line of code, thus slowing down execution speed. I felt that the additional programming required by taking this route was offset by its advantages.

The last menu in our program governs disk I/O functions (lines 5600–6170). These allow us to save, retrieve, and delete files from within Truss2. All disk I/O is done in ASCII files, allowing you to export or import compati-

*(continued)*

Table 3: *Definitions for the commonly used variables.*

| Variable | Definition |
|---|---|
| MBW | Maximum bandwidth |
| MAXEL | Maximum number of elements |
| MAXNP | Maximum number of nodes |
| MAXLD | Maximum number of loads |
| BW | Problem bandwidth |
| NUMNP | Number of node points in the problem |
| NUMEL | Number of elements in the problem |
| NLOAD | Number of loads in the problem |
| MENU$(5,7) | Character array of menu entries. Five menus with a maximum of seven entries per menu. The first one is the title. |
| NCON(*,1) | Node number 1 for element * |
| NCON(*,2) | Node number 2 for element * |
| AR(*) | Section area for element * |
| XNOD(*) | $x$ coordinate of node * |
| YNOD(*) | $y$ coordinate of node * |
| ILOAD(*,1) | Node number for load number * |
| ILOAD(*,2) | Code value of load number * |
| RLOAD(*) | Load exerted for load number * |
| EKEY(1) | Elastic modulus of material |
| EKEY(2) | Design strength of material |
| A(200,30) | Global-stiffness matrix |
| B(200) | Force matrix also stores displacements at the end of an analysis. |
| STR(*) | Stress in element * |
| BK(4,4) | Element-stiffness matrix |
| NCUR | Current number of entries in editor |
| NLMT | Maximum number of entries in editor |
| ID(K,*) | Editor control variables |

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ble files from other programs. In order to obtain a "neat" directory listing, I use the third screen on the IBM PC to accept the regular directory listing and export it to the first screen.

The heart of the program that does the calculation is contained in lines 10000–10980. Lines 10700–10980 form the element stiffness for a beam element. Lines 10220–10290 impose the loads and fixities, and the actual solution of the banded matrix takes place in lines 10300–10560. The stresses are then calculated in lines 10580–10690.

Lines 20000–30000 contain a number of general-purpose routines that can be merged into any program. A brief list of these routines and their functions follows:

20000–20180 Reset the screen, turn off the function keys, and print copyright notice.
21000–21230 String input and conversion module.
22000–22230 Trap and print run-time errors for disk and printer.
23000–23380 Determine the directory for path name and list on screen.
24000–24100 Exit the program and return to DOS.
25000–25270 Print out menu options and accept entry.
26000–26090 Print an error message contained in MSG$ onto the screen.
26100–26520 Routine to permit changing the drive or directory.



## ADVANCED FEATURES

The program is purposely limited to demonstrate the principles of the method and provide something that could run under IBM interpretive BASIC. The following suggestions are offered in case you want to expand or tailor the program to a specific application:

1. Check the truss elements for buckling in the event that they are long and slender.
2. Look at the effect of temperature changes in the truss on the stresses and displacements.
3. Expand the program to handle different types of elements such as plane elements, three-dimensional elements, or plates.
4. Display the resulting stresses in color fields using the medium-resolution color graphics mode. ■

[*Editor's note: The author has copies of both the source and compiled code available on disk to interested readers. The price is* $30. *Please respond to Chris Pedicini,* 1139 *Highland Ave., Brunswick,* OH 44212.]

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2. Segerlind, Larry J. *Applied Finite Element Analysis.* New York: John Wiley & Sons, 1976.

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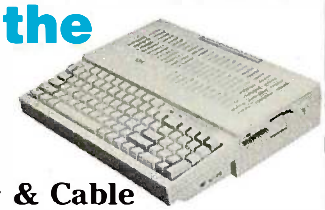

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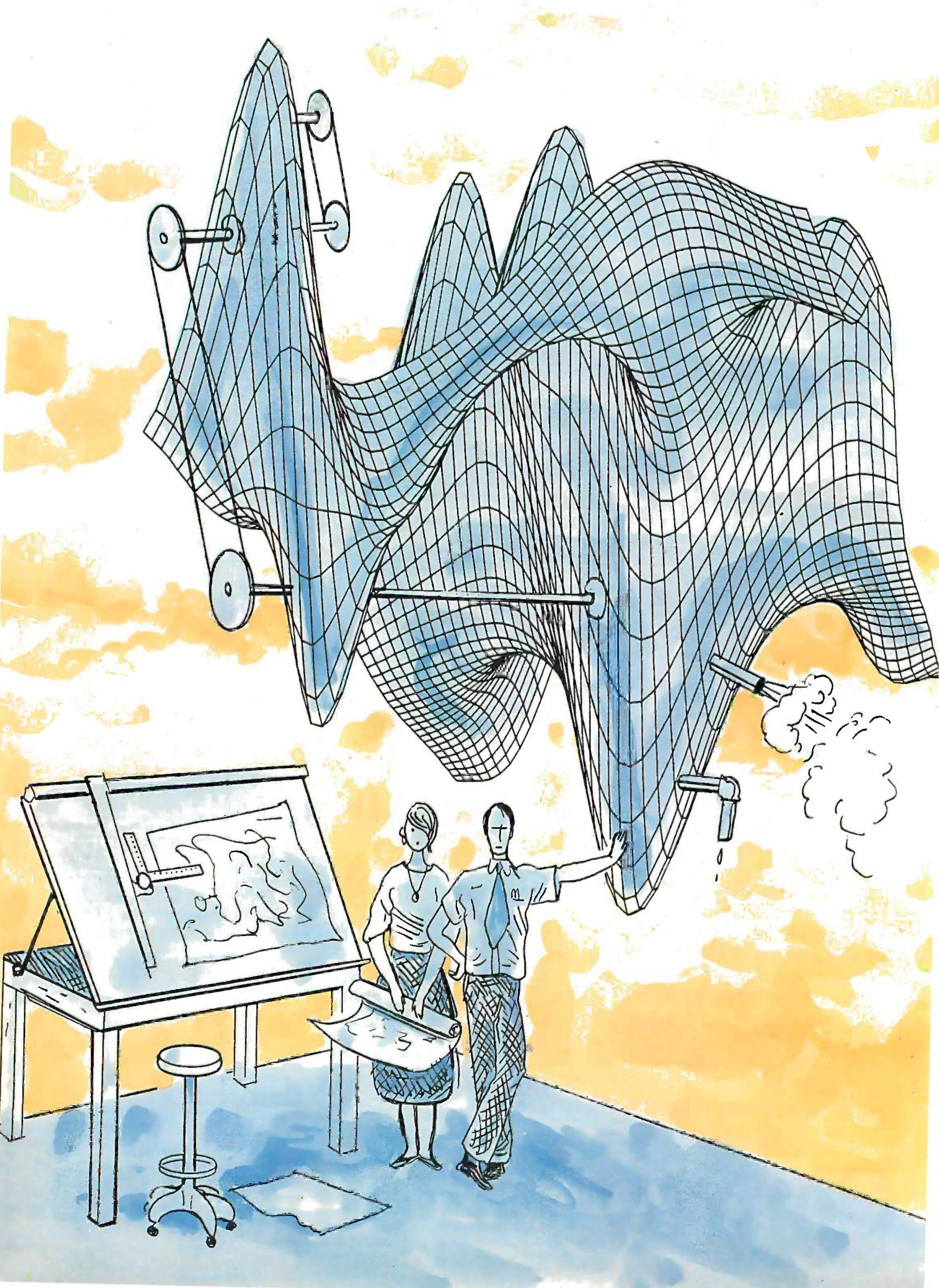


# Engineer's Toolbox



ONE OF THE REASONS that engineering and science advance exponentially is the availability of new tools that shorten the time required to accomplish fundamental tasks. Improved tools allow engineers to build many new technologies, including more advanced tools!

Our theme articles this month give a peek inside the toolbox of a mythical mega-engineer—a person building a microprocessor-controlled drawbridge that uses the latest in strong but lightweight materials. Our "meganeer" needs to analyze analog circuits to design the motor controls for the drawbridge; emulate an 8031 controller to design the controller board for sensing approaching vessels and activating the bridge; perform structural and stress tests on the bridge superstructure design; determine the critical properties of the space-age materials to be used in this bridge; and, finally, select the most cost-effective materials for constructing the finished design.

Our fictitious meganeer has plenty of help in his toolbox in the form of microcomputer software to perform many of these tasks. This software has been placed into the public domain and is available in a variety of formats (see pages 459–461).

The modeling and simulation of analog circuits has been possible on mainframe computers for some time with a program called SPICE. David McNeill has reproduced the functionality of SPICE in a program that runs on a Commodore 64. McNeill's article follows a lucid explanation of the theory of circuit-modeling programs by Wolfram Blume.

Next, George Dinwiddie explains a monitor board that permits in-circuit emulation of an Intel 8031 microcontroller. Using Dinwiddie's hardware and software, engineers can substantially cut the time it takes to debug an 8031 application.

Our thematic engineer is building only an imaginary bridge—but he still wants to know under what conditions it might collapse. Robert W. Johnson and Fernando G. Loygorri offer some help with an IBM PC structural analysis program that employs the finite-element method.

Our meganeer does not want to stop with structural analysis, so D. Lee Petersen and Steven L. Crouch offer an article and program on stress analysis using a boundary-element/finite-difference method, a technique that should prove useful to any physical scientist who needs to find numerical solutions to problems approaching infinity.

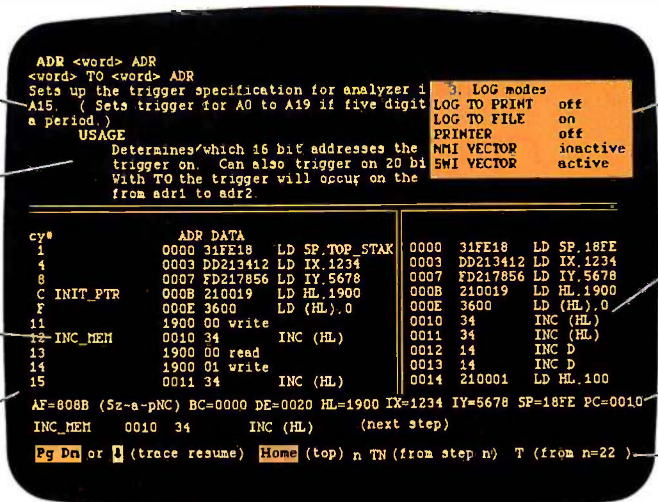
To select the best (and cheapest) materials to build the imaginary bridge, our engineer can use the sophisticated material selection program by Brother Tom Sawyer and Michael Pecht. Finally, J. Neil Stone provides help for our dauntless bridge designer with programs to determine the critical properties of unusual or new substances.

Armed with this megabyte of software, BYTE's intrepid, nonexistent engineer can now more easily solve a multitude of engineering problems. We've purposefully not given him much computer-aided design/engineering help—reserving a look into that burgeoning realm for an upcoming theme.

We hope *you* will also find these tools useful.

*—G. Michael Vose, Senior Technical Editor/Themes*

# Microprocessor Development Dreams Come True!

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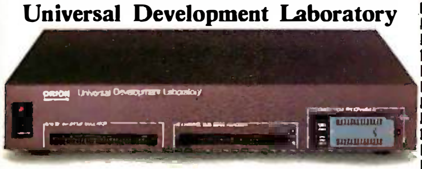


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# SIMULATING CIRCUITS

Circuit modeling programs have replaced "breadboards" as the building blocks of circuit design and development. With these programs, engineers can simulate a circuit, substitute components, vary parameters such as voltage and current in discrete time increments, and observe the changes at every point in the circuit. This capability represents an enormous savings in development time and effort.

The articles that follow present two approaches to the modeling of electrical circuits. The first, "Computer Circuit Simulation" by Wolfram Blume, is an introduction to the problems inherent in circuit modeling, such as linearizing nonlinear elements like diodes and transistors and solving the large simultaneous equations involved in circuit computations. The second article, "Analog Circuit Analysis" by David McNeill, describes the author's efforts in developing a set of circuit simulation programs for the Commodore 64, based on algorithms used in the SPICE simulation program of Dr. Laurence Nagel of the University of California.

*—Charles Weston*
*Technical Editor*

# COMPUTER CIRCUIT SIMULATION

## *Circuit modeling programs make breadboards obsolete*

BY WOLFRAM BLUME

COMPUTER SIMULATION is an important tool for circuit design engineers. The means for testing out ideas and checking a design has traditionally been the "breadboard" (a test circuit built on the workbench).

Computer simulation does the same job. It lets designers check out ideas while designing the circuit. Simulation programs also check the final design before it is released for production.

*Wolfram Blume is president of* MicroSim *Corporation, which manufactures and markets the* PSPICE *analog simulation program. He can be contacted at* MicroSim Corp., 23175 La Cadena Dr., Laguna Hills, CA 92653.

### ANALOG CIRCUITS

The goal of a simulation program is to calculate the voltage at each node and the current through each device of the circuit. We will first want to calculate these values at the circuit's steady state (bias point). Using the steady-state data, we are then able to calculate the circuit voltages and currents as functions of time and frequency.

Most analog circuit simulators in use today are based on the program SPICE (Simulation Program for Integrated Circuit Engineering), which was developed at the University of California at Berkeley in the early 1970s. SPICE included several advances over earlier simulators, such as a "sparse matrix" data structure.

### DATA STRUCTURE

Suppose we want to analyze the circuit shown in figure 1. Including ground, it has three nodes: 0, 1, and 2. The goal is to find the voltage at each node and the current through each device. For now, we will try to find the steady-state, or bias point, solution.

To analyze this circuit using a program we need a somewhat different approach than we would take in

*(continued)*

*As a rule, any nonlinear circuit has a linear equivalent, but only for one set of node voltages.*

analyzing it by hand. Our approach is known as the nodal analysis method. We will set up a vector that lists the total current being pumped into each node by current sources. For all nodes that are not attached to a current source (such as node 2) this sum will be 0 (since electrical charge cannot be created or destroyed). For node 1 this will be −0.1, since the current source $I_1$ is driving 0.1 amp into node 1.

For node 0 this will be +0.1, since $I_1$ is pulling 0.1 amp out of node 0. This vector, I in figure 2, describes the input to the circuit. The current sources are the stimuli that drive the circuit. Note that the vector I has the same number of elements as the number of nodes in the circuit.

Next we need a vector that describes the response of the circuit to I. This vector, V in figure 2, is a list of the voltages at each node. V is the vector we want to find.

Finally, we need a description of how V relates to I. This is provided by the conductance matrix, G (figure 2). G describes how current flows in elements that are not current sources. In our example, the currents through resistors R1 and R2 are proportional to the voltages across them. The term of G at row i and column j specifies how much current will flow away from node i if the voltage at node j were increased by 1 volt and the voltages at all the other nodes were held constant. This may seem like a peculiar way of thinking about the circuit, but it has the great advantage that

$$I = G \times V$$

Note that each term in G is the sum of the contributions of the relevant circuit elements. So, knowing which devices in the circuit are connected to which nodes, our program can build G in a straightforward way. G has the same number of rows and the same number of columns as there are nodes in the circuit. Now that I is known and G is known, we can solve for V and get the set of node voltages we are after.

Even in this small example, it is obvious that most of the terms of G will be 0. This becomes even more true as the circuit gets larger. In typical circuits of 30 or 40 transistors, over 90 percent of the terms in G will be 0. G is therefore referred to as a "sparse matrix."

Circuits of this size also typically have 100 to 150 nodes. Since the number of elements in G is $n^2$ ($n$ = number of nodes) it becomes clear that we must take advantage of all those 0 terms in G or its size will get out of hand. We do this by storing only the nonzero terms of G and a list of pointers to those terms. This process complicates the algorithms, but it is necessary in order to simulate realistic circuits.

## Solving the Circuit Equations

Now that we have established a data structure, we can proceed to analyze the circuit. There are three levels of analysis:

1. Solving a linear circuit by Gaussian elimination or LU factorization.
2. Solving a nonlinear circuit by repeatedly linearizing the circuit and using (1).
3. Solving a time-varying circuit by repeatedly converting the circuit to a nonlinear, non-time-varying circuit and using (2).

Calculating the circuit's response with respect to frequency is a special case of (1).

## Solving a Linear Circuit

Our example circuit (figure 1) is linear and does not vary with time. A linear circuit is composed of linear elements (those elements whose currents are proportional to the voltages within the circuit). For example, resistors are linear because the current through them is proportional to the voltage across their terminals. Ideal amplifiers are also linear because their output is proportional to their input.

Since our system is described by the matrix equation $I = G \times V$, we can use the standard methods for solving systems of linear equations. The two most common methods are Gaussian elimination and LU factorization. Both methods take about the same amount of computer time given one G and one I, but LU factorization has the advantage of being much faster given one G and several different I's. SPICE uses LU factorization.

Here is a brief overview of LU factorization: The idea is to split G into two matrices, L and U, which multiplied will give G.

$$G = L \times U$$

Therefore,

$$I = L \times U \times V$$

*(continued)*

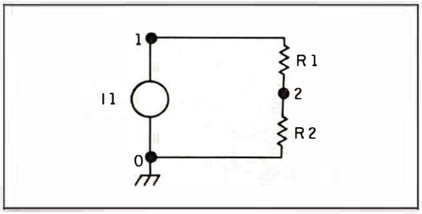


Figure 1: *A simple three-node circuit consisting of two resistors and a current source.*

$$\begin{pmatrix} -I_1 \\ +I_1 \\ 0 \end{pmatrix} = \begin{pmatrix} \frac{1}{R2} & -\frac{1}{R2} & 0 \\ \frac{1}{R2} & \frac{1}{R2} + \frac{1}{R1} & -\frac{1}{R1} \\ 0 & -\frac{1}{R1} & \frac{1}{R1} \end{pmatrix} \begin{pmatrix} V_0 \\ V_1 \\ V_2 \end{pmatrix}$$

Figure 2: *The conductance matrix for the circuit shown in figure 1.*

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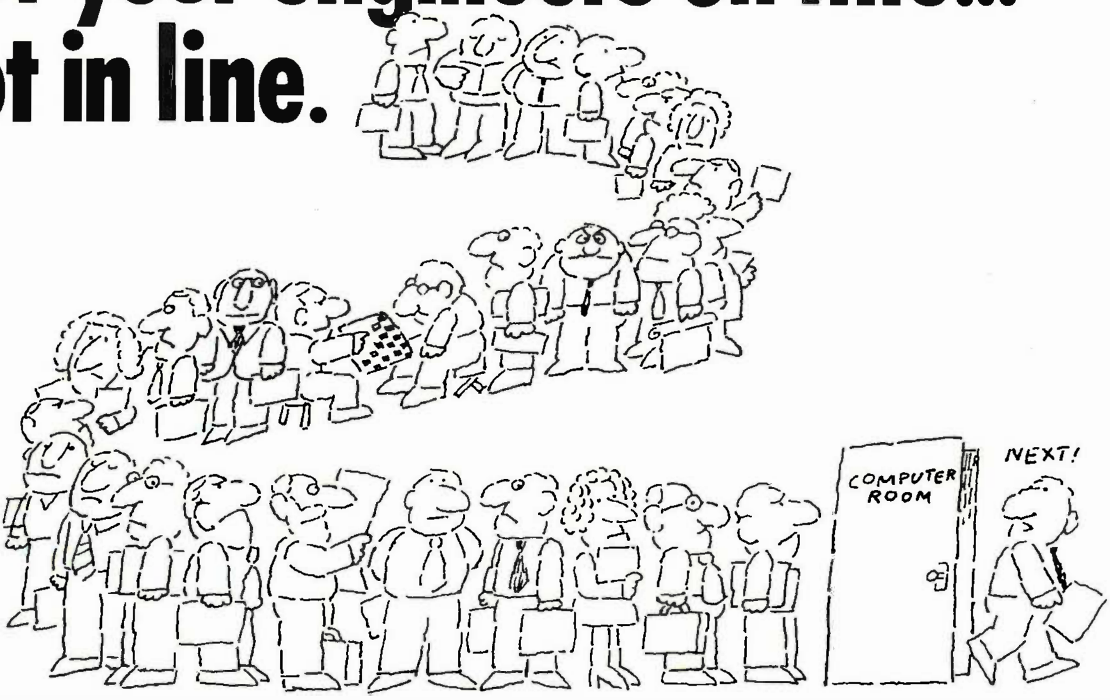


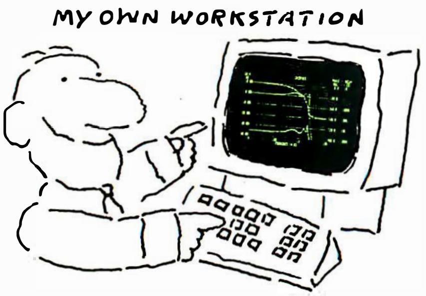


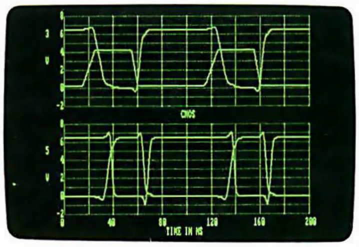
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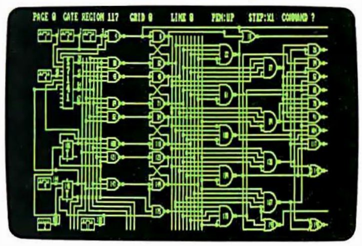
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Regarding MICROCAP . . . "A highly recommended analog design program" (PC Tech Journal 3/84). "A valuable tool for circuit designers" (Personal Software Magazine 11/83).

Regarding MICROLOGIC . . . "An efficient design system that does what it is supposed to do at a reasonable price" (Byte 4/84).

MICROCAP and MICROLOGIC are available for the Apple II (64k), IBM PC (128k), and HP-150 computers and priced at $475 and $450 respectively. Demo versions are available for $75.

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L is lower triangular and U is upper triangular, as shown in figure 3.

An important feature of LU factorization is that for any G there is only one pair of L and U that have this structure. It is also true that the process of splitting G into L and U uses the major part of the computation time in this method.

Once L and U are found, their triangular structure (all 0s above or below the diagonal) allows the program to quickly calculate V from I. Since most of the time is spent finding L and U, we can find the solutions for several I's almost as quickly as for one.

## Solving a Nonlinear Circuit

Now that we have a method to solve linear circuits, we can use it to find the solution for nonlinear circuits. The idea here is to use our last guess at V to linearize the circuit. Then, using our method for solving linear circuits, we can calculate a new guess for V. Hopefully, after a few iterations, successive guesses of V will converge to the correct answer.

How can we convert a nonlinear circuit into a linear one? By converting each nonlinear element into its linear equivalent. For instance, we can replace the diode in the circuit shown in figure 4 with a current source and a conductor.

The current through a diode is given by

$$I_d = I_s \times (e^{V/VT} - 1)$$

At a given voltage V across the diode we can replace the diode with a current source whose current is

$$I_{eq} = I_d - V \times G_{eq}$$

in parallel with a conductor whose conductance is

$$d(I_d)/dV = I_s/V_t$$

Note that the equivalent current and conductance change with the voltage V across the diode. This is true of diodes and of nonlinear elements in general. As a rule, any nonlinear circuit has a linear equivalent, but only for one set of node voltages. As soon as the node voltages change, we must "linearize" the circuit again.

Our algorithm for solving nonlinear circuits now looks like this:

1. Pick an initial guess for the node voltages V. Set $V_{old}$ = V.
2. Using the node voltages V, calculate the linear equivalent circuit and fill in the terms for the circuit matrix G and the current vector I.
3. Using the LU method, solve the circuit for a new set of node voltages V.
4. If V is close enough to $V_{old}$:
4a. Stop. We are done.
    Else:
4b. Set $V_{old}$ = V.
    Go gack to step 2.

## Solving Time-Varying Circuits

So far the circuits we have considered have not varied with time. That is, neither the sources nor the other elements change with time. Capacitors have been treated as open circuits, and inductors have been treated as short circuits. This means that the solution, V, does not vary with time either. So far, we have been solving for the steady-state, or bias point, solution.

To accommodate time, we need to add time-varying sources and we need to handle capacitors and inductors. The first objective is easily done. We just allow the value of a source to be a function of time, such as a sine wave, pulse, square wave, etc.

The second objective is done in a way similar to the technique for solving a nonlinear circuit using the method for solving a linear one. We will replace each capacitor and inductor by equivalent circuit elements. Our algorithm for simulating the circuit now looks like this:

1. Use the nonlinear circuit method above to calculate the bias point of the circuit.
2. Set Time = 0. Set TimeStep to a small positive number.
3. Set all sources to their values at time = Time + TimeStep.
4. Using TimeStep and the past values of V, replace each capacitor and inductor by its equivalent circuit.
5. Use the nonlinear circuit method above to calculate V for time = Time + TimeStep. Use V from time = Time as the initial guess for time = Time + TimeStep.
6. Set Time = Time + TimeStep. Update TimeStep based on error-estimation formulas.
7. If Time => final time requested for simulation:

```
           1  0  0  0  0 . . .
           x  1  0  0  0 . . .
           x  x  1  0  0 . . .
   L =     x  x  x  1  0 . . .
           .
           .
           .
and
           x  x  x  x  x . . .
           0  x  x  x  x . . .
           0  0  x  x  x . . .
   U =     0  0  0  x  x . . .
           .
           .
           .
```

Figure 3: *A typical LU-factorization matrix. Note that L has 1s on the diagonal and 0s above the diagonal, and U has 0s below the diagonal.*

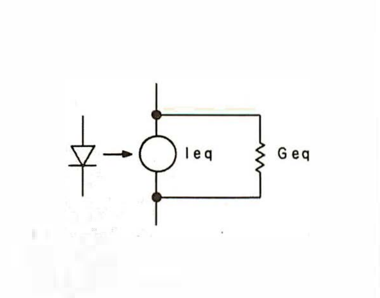


Figure 4: *A diode and its linear equivalent circuit, a current source and a conductor.*

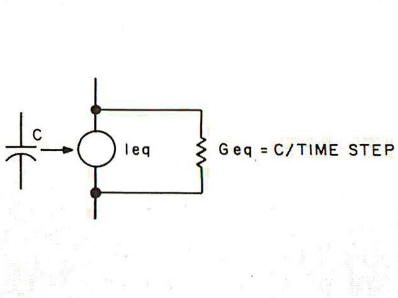


Figure 5: *A capacitor and its linear equivalent circuit, a conductance and a current source in parallel. The size of the time step is varied as simulation proceeds.*

7a. Stop. We are done.
Else:
7b. Go to step 3.

Replacing the capacitors and inductors by equivalent circuit elements is possible because we know the size of the time step and the past values of each element's charge or current. For example, a capacitor is converted into a current source with a conductance in parallel as shown in figure 5.

The size of the time step is changed as the simulation proceeds. We could use a fixed time step, but this would waste computer time. We need to use a step small enough to accurately calculate those areas where things are changing rapidly (such small steps would be wasted during times when nothing was changing). By changing the step size based on the activity of the circuit, we can use a fine step size where it is needed and a coarser step size otherwise.

### CALCULATING FREQUENCY RESPONSE

The response of the circuit to different frequencies is calculated in a way very similar to solving a linear circuit. The difference is that the voltages, currents, and conductances now have real and imaginary parts instead of just real parts. The circuit algorithm now looks like this:

1. Use the nonlinear circuit method previously mentioned to calculate the bias point.
2. Set Frequency = beginning frequency.
3. Linearize the circuit using V calculated in step 1. Fill in terms, both real and imaginary parts, for I and G. Fill in the terms for capacitors and inductors as well. These are implemented as conductances, with imaginary values dependent upon Frequency.
4. Using the LU method, solve for V. V will have real and imaginary parts.
5. Set Frequency to the next frequency. If Frequency > ending frequency:
5a. Stop. We are done.
Else:
5b. Go to step 3.

### DISPLAYING RESULTS

Personal computers are well suited for displaying results. Because they are interactive and have graphics widely available, they are a natural for conveniently displaying the results of a simulation. Although SPICE does not provide for an interactive display of the results, this can easily be added.

The approach I followed is to store all the node voltages and all the device currents at each step of the simulation (e.g., at each time or frequency). These are stored in a binary data file. The display software is a separate program that implements a virtual-memory scheme to allow the data file to be larger than the computer's RAM.

Besides drawing voltages and currents it is very convenient also to be able to draw expressions. For example, by multiplying a voltage and a

(continued)

current we can display instantaneous power.

**COMMENTS**

Analog circuit simulation makes heavy use of floating-point arithmetic. For accurate results, double-precision (64-bit) numbers must be used for the V, I, and G terms. As a result, it is necessary to have a floating-point coprocessor, such as the Intel 8087, in the computer. It improves run time by a factor of 15 in a typical circuit. In other words, without a floating-point coprocessor the simulation will be too slow to be useful.

Another requirement is RAM. Typical analog simulations are of circuits with 30 to 40 transistors. This requires about 100K bytes of RAM. Paging to and from disk would make the simulation intolerably slow. The program code itself takes up several hundred kilobytes of space, depending on how sophisticated the transistor models are and how many kinds of analyses are implemented. Therefore, to run a reasonable simulation, a machine with 512K bytes or more of RAM is needed.

Both these requirements are readily met by an IBM PC XT with 640K bytes and the 8087 coprocessor, which can simulate circuits of up to about 120 transistors. Calculating the time-varying response of a 30-transistor circuit takes about 12 minutes. Once the simulation is done, waveforms can be displayed almost instantly. ■

*Editor's note: If you are interested in the concepts and algorithms of circuit simulation, the author strongly recommends that you read* "SPICE: A *Computer Program to Simulate Semiconductor Circuits*" *by* Laurence W. Nagel.

*You can obtain a copy of this document* (Memorandum No. ERL-M520) *by sending a check for* $20 *made out to:* Regents of the University of California. *Send check to* Ms. Deborah Dunster, EECS Industrial Liaison Program, 457 Cory Hall, University of California, Berkeley, CA 94720.

*The document is* Dr. Nagel's Ph.D. *thesis and contains an excellent discussion of the various algorithms in* SPICE. *He covers the material in this article in more detail and also provides discussions of alternative algorithms and the reasons for selecting those that finally went into* SPICE.

# ANALOG CIRCUIT ANALYSIS

## *An analog circuit modeling and simulation program for the Commodore 64*

BY DAVID MCNEILL

OF THE THREE GOALS that I wanted to accomplish with this project, the main one was to produce a program like the circuit analysis program SPICE for my Commodore 64. My second goal was to better understand how transistor models worked and how to incorporate these models into the nonlinear algorithms used by SPICE to solve electronic circuits. My third goal was to fit the program into the memory space of the Commodore 64 and make it run at a reasonable speed.

My circuit analysis package is composed of three programs: a preprocessor and editor program, the AC analysis program, and the DC analysis program. To perform a circuit analysis, you first load the preprocessor and editor program used for entering the circuit description. Then, using a chaining technique, you can jump between all three programs to run the different analyses.

You can model 12 devices with the programs: resistors, inductors, capacitors, independent voltage sources, independent current sources, voltage-controlled current sources, diodes, bipolar transistors (*npn* and *pnp*), field-effect transistors (*n*-channel and *p*-channel), and operational amplifiers.

The programs allow you to sweep various parameters and print voltages, currents, impedances, or gains as the output variables. For example, in the model for the bipolar transistor, you can specify forward and reverse beta, Early voltage, reverse saturation current, junction capacitances, and transit times as parameters.

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**PROGRAM DESIGN PHILOSOPHY**

When I developed these programs, I decided to have as many model parameters as possible to better describe the device and produce more accurate data. Although this increased the complexity of the programs and tended to reduce the size of circuits that could be analyzed, I preferred to have programs that could better model actual transistors rather than analyze larger circuits with less accuracy. I felt that the limitation on running large circuits would be the speed of analysis rather than the amount of memory available.

The heart of the analysis programs is a routine that solves a set of linear equations. These equations arise from performing Kirchhoff's current equation at every node in the circuit. (Kirchhoff's current law states that the sum of all the instantaneous currents flowing toward a given node is equal to the sum of all the instantaneous currents flowing away from that node.)

For simple circuit elements such as resistors, voltage sources, and current sources, the formulation of the set of

*(continued)*

equations is straightforward, and since the equations in the set are all linear, they can be solved using standard numerical techniques such as Gaussian elimination or LU decomposition. The solution to this set of equations gives the voltage at each node in the circuit.

An element such as a diode, however, is not as easy to model because the relationship between the current through and the voltage across the diode is not linear but exponential. Because of this, we cannot directly assemble and solve a set of equations and arrive at the correct answer.

### MODELING NONLINEAR ELEMENTS

To solve this problem, two things must be done. One is to somehow modify the diode to make it appear linear. If it were linear, then we could formulate a set of equations that could be solved directly.

The second thing that must be done is to create an iterative process where we progressively change the linear diode that we created so that it will come closer and closer to the actual diode that exists in the circuit. As our model of the diode becomes better, the solutions to the set of equations will also get closer and closer to the actual answer. This second process is the program algorithm that controls the whole sequence of solving the set of equations, updating the linear diode, checking for convergence to a correct answer, and then repeating the procedure.

There are several crucial parts to this algorithm that can mean either success or total disaster. Due to the exponential nature of the diode equation, it is very easy to cause an overflow on the computer. Because of this, a good algorithm for clamping and limiting the exponential function was needed.

Figure 1 shows a simple resistor/diode circuit with a graph showing the load line for each element. The solution to this circuit is the point where the two lines intersect, which is at this time unknown. To start the analysis, we first make a guess at the voltage across the diode and pick this point on the diode curve. We can then linearize the diode by drawing a straight line through this point that is tangent to the diode curve, as shown in figure 2.

Notice that we now have two straight lines that intersect close to the actual intersection of the resistor and diode line. The point where the two straight lines intersect is found by the solution of two simultaneous equations. This solution then becomes an approximation of the actual answer. Although I've shown this graphically, the mathematical approach would be to perform a Taylor's series expansion on the diode equation (see figure 3).

Notice that in the resulting equation, shown in figure 3, we can identify two elements: a constant current source and a conductance. This equation is simply the equation of the straight line that was drawn through the point that we first guessed at on the diode curve.

The important point here is that we have been able to model the diode with two simple linear elements: a resistor and a current source. We now have a circuit that is composed entirely of linear elements. We can use the Gaussian elimination technique to calculate the point of intersection of the two straight lines. At this point we have an answer that is an approximation of the actual answer.

In the next phase we repeat the process and gradually improve the model of the diode so that the answers that are computed each time become closer and closer to the actual answer.

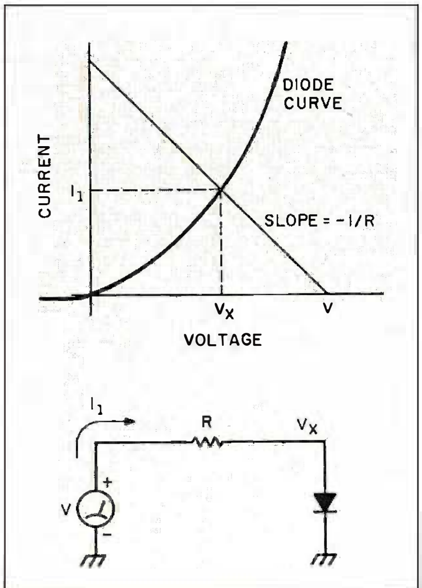


Figure 1: *This graph shows the load lines for the resistor and diode in the inset circuit.*

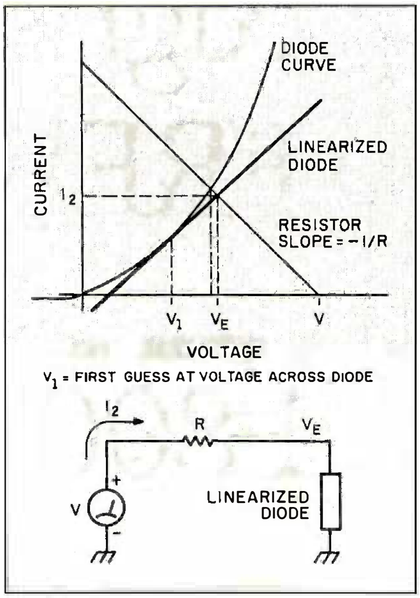


Figure 2: *This graph shows the resistor load line, the diode curve, and the linearized diode load line.*

### THE LINEARIZATION ALGORITHM

Figure 4a is a flow diagram of the algorithm used to perform this iterative process for the diode. Figure 4b is a graphic description of the iterative process of the linearization algorithm. The first step is to check to see if the program has changed the temperature (such as in a temperature sweep analysis). If the temperature has been changed, the value of the reverse saturation current $I_s$ must be recomputed, since it is temperature-dependent. Next, the program calculates and stores the value of the voltage across the diode that resulted from the last iteration.

The program then checks to make sure that if this value of voltage is used, the exponential function will not overflow. If overflow is possible, the program then clamps the voltage appropriately. Next, the program checks to see if this is the first iteration, and if so, guesses at a starting point for

(continued)

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By performing a Taylor's series expansion on the diode equation about an operating point, $V_O$, you are able to estimate the current in the diode for any voltage, $V$.

Diode equation: $I_{D_O} = I_S\,(e^{V_O/V_T} - 1)$

Taylor's series expansion equation: $f(x) = f(a) + f'(a)\,(x-a)$
(first two terms)

First compute the derivative:

$$f'(a) \rightarrow f'(V_O) = \frac{\partial I_{D_O}}{\partial V_O} = \frac{\partial}{\partial V_O}\left(I_S\,(e^{V_O/V_T} - 1)\right) = \frac{I_S}{V_T}\,e^{V_O/V_T}$$

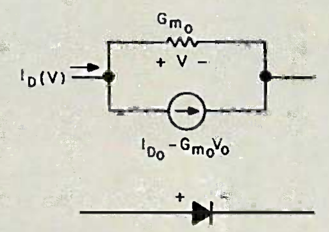
Since this is a conductance, let $\frac{I_S}{V_T}\,e^{V_O/V_T} = G_{M_O}$

Plugging into the expansion equation:

$$I_D(V) = I_S\,(e^{V_O/V_T} - 1) + G_{M_O}(V - V_O)$$

$$I_D(V) = I_{D_O} + G_{M_O}V - G_{M_O}V_O$$

This equation represents a current source and a conductance:




This model then becomes the approximation for the diode:

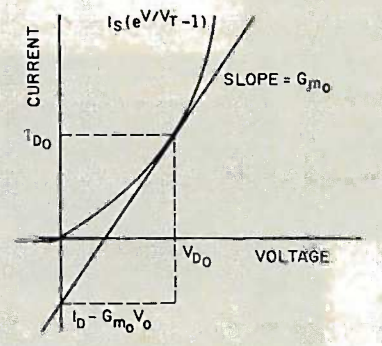



**Figure 3:** *A Taylor's series expansion of the diode equation. The graph now represents the diode as a constant current source and a conductance.*

the voltage across the diode. (The value used is the point on the exponential curve that has the minimum radius of curvature.) This point is called the critical voltage.

The next section is very important. Here the program tries to estimate the next voltage to use to linearize the diode. The goal here is to progressively move closer to the actual voltage that is across the diode. The process of determining the next voltage must be done carefully because it is easy to pick a voltage that will make this process diverge so that it can't converge to an answer.

In this algorithm there are two ways of selecting the next voltage to use. When we solve a set of equations with the Gaussian elimination routine, we have calculated a voltage value that is an estimate of the actual voltage across the diode. We can now use this calculated voltage as the starting point for the next guess. This first method of estimating the voltage is called "iterating on the voltage."

Another way of determining the starting point for the next iteration is to determine the value of current flowing in the diode at the point that the Gaussian routine indicated as the solution. Then, with this value of current, the corresponding voltage across the diode is calculated using the diode equation, and this voltage is then used as the starting point for the next guess. This method is called "iterating on the current."

This method of alternating between voltage and current is illustrated in figure 4b. The algorithm says that if the last voltage computed across the diode is greater than the critical voltage, iterate on the current; if the voltage across the diode is less than the critical voltage, then iterate on the voltage.

I found that using this algorithm helped tremendously in reducing the number of iterations it took to converge to the correct answer. It also helped prevent the iteration process from diverging, especially when I had a circuit where a transistor was in the off region of operation or was saturated.

At this point, I have determined a voltage across the diode either through assigning a value to it or by calculating a new value by iterating on the voltage or current. I now take this voltage and insert it into the equations for linearizing the diode and calculate the values for the conductance and current source for the diode model.

Now I use Kirchhoff's current law to create a set of linear, simultaneous equations based on these new values. The Gaussian elimination program is again used to solve the equations, and, based on the results, the entire process is repeated to converge on the correct answer.

### MODELING TRANSISTORS

The algorithm described above is the procedure I used to convert a diode into linear components so that I could solve a circuit as if it contained only linear elements. Since diodes are integral parts of the bipolar and junction FET (field-effect transistor) models, I used this same algorithm for modeling both of these devices.

For the bipolar transistor, I started with the nonlinear hybrid-pi model as shown in figure 5. I chose this model because it simulates all four regions of transistor operation. Using this model, I performed the same steps that I did to linearize the diode. However, because the defining equations have dependent values and are functions of two variables, the linearization process is a little more difficult.

Figure 6 shows the linearized hybrid-pi model. This model results from performing a Taylor's series expansion on the equations defining each element of the nonlinear hybrid-pi model. The resulting expansion equation was then arranged so that its parts represented a controlled current source, a constant current source, and/or a conductance.

Next, the nonlinear components in the hybrid-pi model were replaced with these linear components. The iteration process is the same as with the diode. Once the terminal voltages are determined (from the last iteration), those voltages are inserted into the equations in figure 6, and the resulting values are used to compute (using Kirchhoff's current law) the

*(continued)*

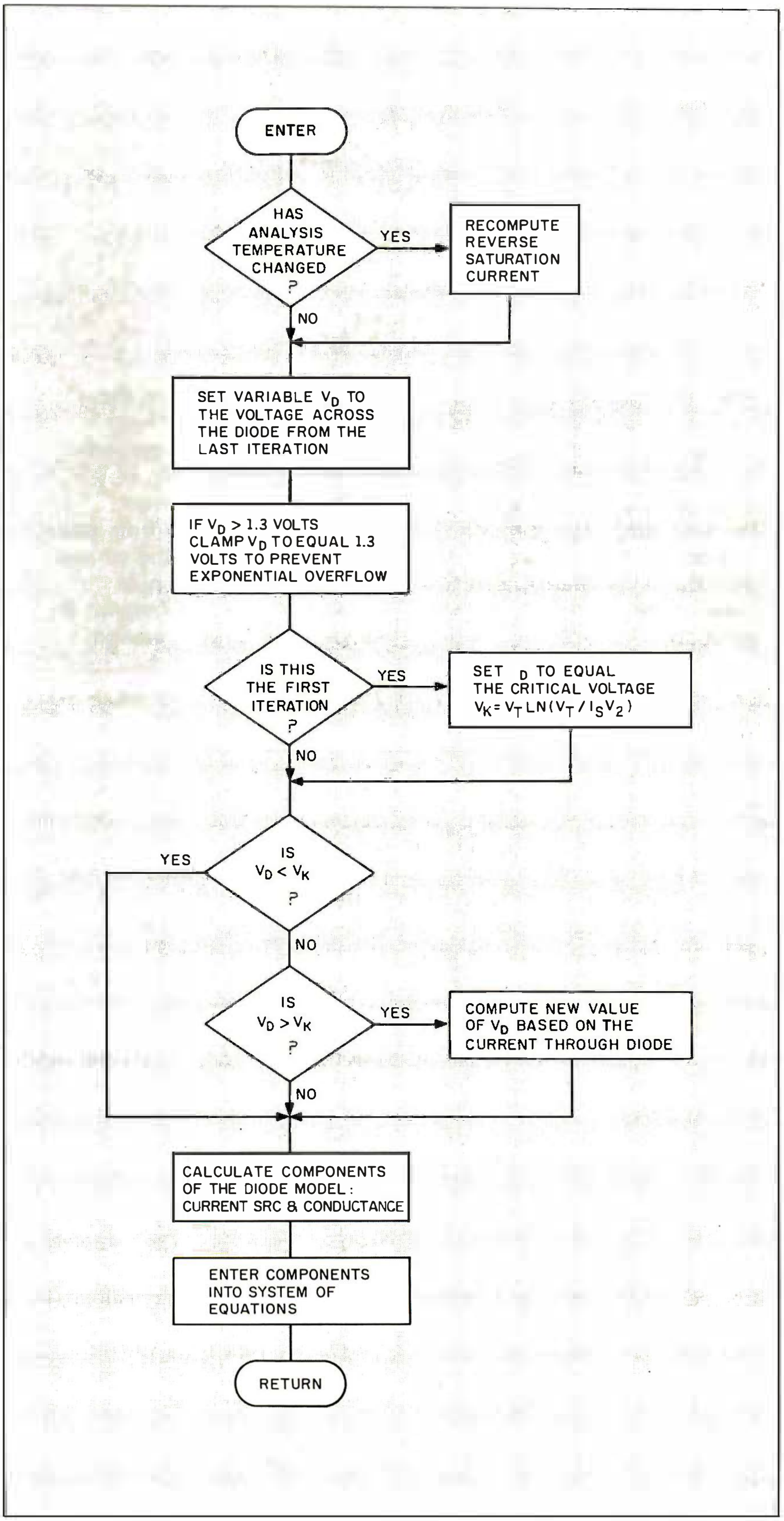
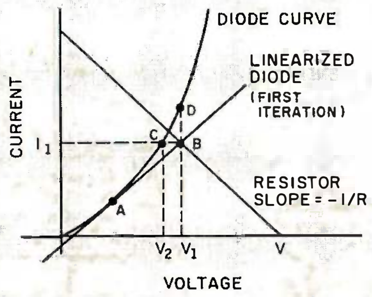



**Figure 4a:** *The flow chart of the algorithm used to find the diode operating point.*




After the first iteration, point B is the solution given from the simultaneous equation solution routine. To compute the next voltage to use for the next iteration, use either of two methods:

| I. Iterate on the Voltage | II. Iterate on the Current |
|---|---|
| Proceed vertically from point B to point D. This voltage, $V_1$, is then the point that is used to linearize the diode for the next iteration. | Proceed horizontally from point B to point C. From the current at this point, $I_1$, compute voltage $V_2$, used to linearize the diode for the next iteration. |

**Figure 4b:** *This graph shows the process of iterating alternately on the voltage and current values from previous iterations.*

solution for this circuit.

When I was troubleshooting my algorithms, I found that the number of iterations it takes to converge on a circuit with a turned-off transistor could be drastically reduced if, on the first iteration, that transistor was analyzed as if it were out of the circuit. Then, on the second iteration, the transistor is analyzed as usual. Of course, this requires that you know the transistor is off, but usually that information is already known.

The SPICE program does this in a different way. SPICE removes the turned-off transistor from the circuit and computes an operating point. Then the transistor is put back in the circuit and another operating point is computed for the final answer. My technique of turning off the transistor for only the first iteration seemed to work fine and saved many iterations.

Trying to get all of this to work together on the Commodore 64 was the real challenge. When the Commodore 64 is powered up, only 38,911 bytes of memory are available to hold the program and variables. It was important to keep the size of the programs small to leave memory available to hold circuit descriptions and arrays for solving the circuit.

Each circuit requires an approximate square matrix equal to the number of nodes in the circuit plus the number of independent voltage sources. This array is by far the largest consumer of memory.

## IMPLEMENTING THE ALGORITHMS

I decided it was best to have three separate programs to handle the AC analysis, DC analysis, and editing functions. I felt that even though this would be less convenient than having one larger program, I could make up for it by being able to analyze reasonable-size circuits.

Each program has a chaining feature that allows you to automatically load and run any of the other two programs. Each program can create a disk file that can be read and used by the other programs. For example, the preprocessor program will create a disk file that contains all the information about a circuit in a form that the AC and DC analysis routines can use.

One method I used to allow analyzing larger circuits was to dynamically allocate memory according to the size of the circuit. After loading one of the analysis programs, a fixed amount of memory remains to hold a circuit description and the array used to solve the circuit. If this memory were divided into two areas, one to hold the circuit description and the other to hold the main array, it is possible to have a circuit that would need more memory than allocated in one area but would use up only half of the other memory area.

In this case, there would be physically enough memory to work, but it is arranged such that it won't work. To prevent this, I dynamically allocate the memory for the circuit description and arrays as it is being loaded by the analysis program. A disadvantage to this is that I don't know the exact size of a circuit that can be analyzed, since it depends on the size of the circuit description. However, an advantage is that a wider variety of circuits can be analyzed, and available memory is used more efficiently.

Another technique that I used to help conserve memory was to use a utility program that went through the BASIC program and removed all remarks and would crunch up to 255 BASIC tokens on a single line. This made the program incapable of being edited, but it saved an average of 3.3K bytes of memory for each program and made a slight improvement in the speed of operation.

Despite all these attempts, the program still ran too slow. Analyzing the 741 op-amp circuit (26 nodes and 23 transistors) with the DC analysis program was taking about an hour and 20 minutes to compute the operating point. After doing some investigation, I found that the two bottlenecks were the Gaussian elimination routine and the routine used to clear the contents of the main array used by the Gaussian elimination routine. So my next major project was to write these routines in machine language.

Since I had the locations of the floating-point routines used by the operating system available, I fortunately did not have to create those routines myself. Within the Gaussian elimination routine, the subroutine that performed partial pivoting was the big bottleneck. The partial-pivoting routine is used during the elimination procedure to place, on the diagonal of the matrix, the largest number for a particular column. This ensures maximum accuracy during the elimination process. Placing the largest number on the diagonal involved checking the values on the column below the diagonal and then interchanging the elements of two rows when a number was found.

This interchanging procedure can take a long time. I tried using a permutation vector to act as an index for each row. Then, instead of interchanging every element, only the indexes to the rows are interchanged. This is a good idea, but when implemented in BASIC there was not a very significant improvement in speed for the size of arrays that I was using. However, when I wrote the whole routine in machine language, I did use a permutation vector since it was simple to implement.

I think one of the major improvements I was able to make in the performance of the Gaussian elimination routine was in the speed of accessing the elements of the array. The Commodore 64 operating system stores arrays in column-major form. So to access, for instance, the element in column 6 and row 3, the formula used to calculate the address of that element would be

ADDRESS = STARTING ADDRESS + (COLUMN# * (TOTAL # ROWS) + ROW#) * 5

The number 5 comes from the fact that each floating-point number uses 5 bytes. This formula indicates that every time you want to access any element of an array, you have to perform two multiplications and two additions. To get around this, I decided to set up two tables to assist in accessing elements. The first table consists of the addresses of the zeroth element of each column. The second table is a list of constants that are multiples of 5, starting with 0.

Then, to access the element at column 6 and row 3, I would index into the sixth entry of the first table to get the address of the zeroth element of column 6. Next, I would index into the third element of the second table and obtain 15. This would be added to the number I obtained from the first table to yield the final address of the element that I was searching for. The advantage of this method is that the indexing operation can be done by using the indirect-indexing commands of the 6502 instruction set, and beyond that only a simple 16-bit addition operation is required.

Of course to set up the first table requires a loop of multiplications to be performed. To get around this, I made the following improvement. The first time an array is solved using the Gaussian elimination routine, I find the starting address for the array and save its value. Then, the first table described above is created and the actual elimination process begins.

*By rewriting the whole BASIC indexing routine in machine language I was able to increase its speed by a factor of 50.*

The next time the array is to be solved (as on the second iteration), I find the starting address of the array and compare it with the previous starting address. If they are the same, I skip the construction of the first table and proceed directly with the elimination process.

The routine that replaces the contents of the main array with 0s in preparation for the next iteration can

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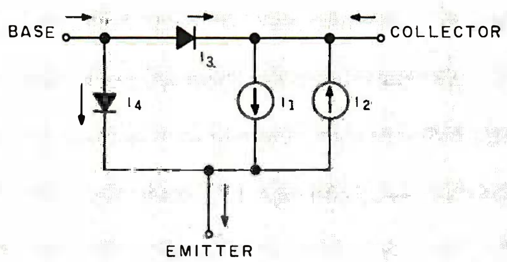
Nonlinear Hybrid-Pi Model with Early Voltage Effect




$$I_1 = I_S\,(e^{qV_{BE}/KT} - 1)\,(1 - \frac{V_{BC}}{V_A})$$

$$I_2 = I_S\,(e^{qV_{BC}/KT} - 1)\,(1 - \frac{V_{BC}}{V_A})$$

$$I_3 = I_S\,(e^{qV_{BC}/KT} - 1)\,(1/B_R)$$

$$I_4 = I_S\,(e^{qV_{BE}/KT} - 1)\,(1/B_F)$$

where:

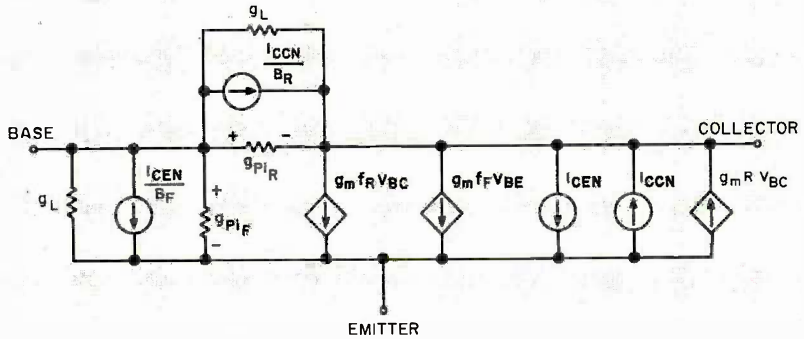
$B_R$ = reverse beta

$B_F$ = forward beta

$V_A$ = Early voltage

**Figure 5:** *The nonlinear hybrid-pi model of the transistor.*

### Linearized Hybrid-Pi Model




$$I_{CEN}/B_F = \frac{I_S\,(e^{V_{BE}\lambda} - 1) - \lambda I_S\, e^{V_{BE}\lambda} V_{BE}}{B_F}$$

$$g_{pi_F} = \frac{\lambda I_S\, e^{V_{BE}\lambda}}{B_F} \qquad g_{pi_R} = \frac{\lambda I_S\, e^{V_{BC}\lambda}}{B_R}$$

$$I_{CCN}/B_R = \frac{I_S\,(e^{V_{BC}\lambda} - 1) - \lambda I_S\, e^{V_{BC}\lambda} V_{BC}}{B_R}$$

Let $\gamma = \frac{1}{V_A}$, $\lambda = \frac{1}{V_T}$, $g_L = IE-12$

$$g_m f_R = I_S\,(e^{V_{BE}\lambda} - 1)\,\gamma$$

$$g_m f_F = \lambda I_S\, e^{V_{BE}\lambda}\,(1 - \gamma V_{BC})$$

$$g_m R = I_S\,[\lambda e^{V_{BC}\lambda}\,(1 - \gamma V_{BC}) - \gamma\,(e^{V_{BC}\lambda} - 1)]$$

Figure 6: *The linearized hybrid-pi model of the transistor resulting from performing a Taylor's series expansion on the nonlinear hybrid-pi model shown in figure 5.*

be very time-consuming since each element of the array is being addressed in BASIC. The equivalent routine written in machine language proved to be well worth the effort, as it was about 50 times faster than the BASIC routine.

Early in the project I became concerned with accuracy and whether or not the single-precision BASIC that I was using would do the job. In the Gaussian elimination routine, the roundoff error could reduce the number of significant digits by $1 + 2 \times \log N$, where $N$ is the number of equations. However, in practice, I found on the many circuits I tested that the answers were well within the accuracy I needed.

On one circuit, however, the transconductance value calculated for a particular transistor was way off. This was because the computation for the transconductance of the transistor involved subtracting two numbers, and since that transistor was saturated, those two numbers happened to be very close in value to each other. The 31-bit mantissas of the floating-point variables did not provide enough accuracy for this case. I did not consider this a problem since the transconductance of a saturated transistor is not a very useful quantity anyway.

One benchmark test that I used was to perform a DC operating point analysis of the internal circuitry of a 741 operational amplifier with 26 nodes and 23 transistors. My program was able to perform this analysis in about 12 minutes and give results to within 1 percent of the results given by SPICE.

Although major simulation needs obviously cannot be met with a program like this, I find that, for small circuits, it has been very useful in providing analysis information without unduly compromising accuracy or computing-time requirements. ■

*Editor's note: David McNeill's Commodore 64 program library "Circuits" is available in a variety of formats. See pages 459–461 for full details. You can obtain a copy of "Electronic Circuit Analysis," the 80-page user's manual for these programs, by sending $18 to the author.*

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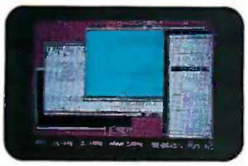
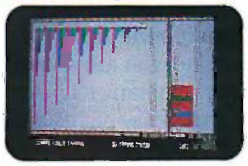
- Twenty-four hour Hotline Support (optional)



Multiple windows allow quick movement between tasks.



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# AN 8031 IN-CIRCUIT EMULATOR

BY GEORGE DINWIDDIE

*Build this emulator and avoid debugging headaches*

DEBUGGING A microprocessor-based program in assembly language can be difficult for a home engineer. The equipment to aid such a task—logic analyzers and emulators—is usually incredibly expensive. Even a large company might not be able to afford the thousands of dollars needed for an emulator because of the processor-specific nature of the tool. Such was the case when I was developing firmware for an embedded processor controlling a commercial product. The processor in use was an Intel 8031, and at that time, only Intel had an emulator for it. Obviously, Intel wanted a lot of money for the emulator. Worse, it needed a new microprocessor development system to host it.

My alternative was to edit, assemble, burn EPROMs, trace the execution using a logic analyzer, and deduce where the code was going wrong. Once I found a bug, I usually had to start over at the edit step before I could hunt for the next one. This was a slow process.

## A BETTER WAY

It didn't take me long to become frustrated with this method. There *had* to be a better way. At the suggestion of a microprocessor guru, I decided to build a monitor. Because the product hardware was mostly developed, I designed the monitor board so that it could function as an emulator—plugging into the processor socket of the application hardware.

The primary benefit of my monitor is that it gives you the ability to patch errors without repeating the edit, assemble, burn EPROM cycle. Sometimes a patch alters only a byte or two, but more often than not it involves a jump to an unused section of RAM where a hand-assembled routine is inserted.

Another handy debugging tool is the monitor's breakpoint capability. While the breakpoint in my monitor is extremely limited and simple, it does provide a way to verify which path of a conditional jump was taken without having to resort to the logic analyzer. Furthermore, you can check the actual values in variables and internal registers instead of deducing them from external behavior.

Another technique I found helpful was to insert temporary test patches that displayed the value of some variable each time through a loop. This was accomplished by calling monitor subroutines via a convenient jump table provided at the start of the monitor. This technique was at the expense of real-time operation, but it provided insights into the dynamics of the software that were unobtainable by any other means.

I also included some basic but necessary functions that let you initialize memory, copy a block of memory, compare two blocks of memory, and perform a hexadecimal dump on a block of memory. Of course, I had to provide commands to edit the contents of memory and to execute instructions starting at any arbitrary location. Finally, I added some convenience commands to display the command syntax and the locations in the jump table and to perform hexadecimal arithmetic.

## THE PROCESSOR

The Intel 8031 single-chip microcomputer is the ROM-less version of the

*(continued)*

*George Dinwiddie (13808 Wayside Dr., Clarksville, MD 21029) is a software engineer for Mitron Systems Corp. He is currently working on his M.S. degree in computer science.*

Listing 1: *The code for performing ASCII-hexadecimal to binary conversion.*

```
06EB 9430             SUBB    A,#'0'
06ED 4017             JC      BAD             ; ACC < '0'
06EF 940A             SUBB    A,#10
06F1 5005             JNC     $+7             ; ACC > '9'
06F3 240A             ADD     A,#10   ;RESTORE
06F5 020704           LJMP    GOOD            ; '0' <= ACC <= '9'

06F8 2403             ADD     A,#('0'+10-'A'+10)      ;CORRECT FOR (-'0'-10)
                                                      & MAP 'A' INTO 10
06FA 20E709           JB      ACC.7,BAD       ; '9' < ACC < 'A'
06FD C3               CLR     C
06FE 9410             SUBB    A,#16
0700 5004             JNC     BAD             ; ACC > 'F'
0702 2410             ADD     A,#16
0704 C3       GOOD:   CLR     C
0705 22               RET
0706 D3       BAD:    SETB    C
0707 22               RET
```

8051, the high end of Intel's 8-bit microcontrollers. It has five interrupts—two external inputs, two hardware timers, and one hardware asynchronous serial port (UART). It sports a 16-bit external address bus and 16 bidirectional I/O lines. The processor has three separate memory spaces—a 64K-byte program memory space, a 64K-byte external data memory space, and 128 bytes of internal RAM. The 8031 even features a hardware multiply and divide.

While this processor has a lot of speed and power, it has its share of problems, too. The architecture is accumulator-based. This means a lot of processing time and bytes of code are used to load and store the accumulator. The instruction set is highly irregular. For example, the only compare instruction is a compare-and-jump-if-not-equal. To do a compare-and-jump-if-equal requires an exclusive-or, a subtract, or a jump-around-a-jump. A jump-less-than or a jump-greater-than also involves extra work. You can see some of the problems this causes in the ASCII-hexadecimal to binary conversion in listing 1. The instruction set also has few instructions that are capable of accessing the two large external memory spaces.

## THE EMULATOR BOARD HARDWARE

The hardware design of the emulator board is straightforward. Figures 1a and 1b show the schematic diagram. It features 4K bytes of monitor EPROM, 8K bytes of application EPROM space, and 8K bytes of emulation RAM. With the current prices for larger memories it would make more sense to use 8K by 8 monitor and application EPROM

*(continued)*

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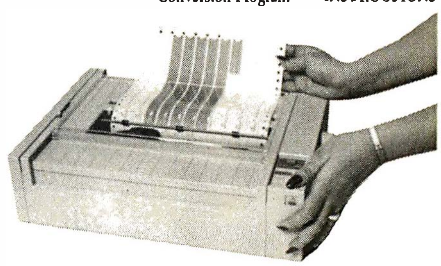

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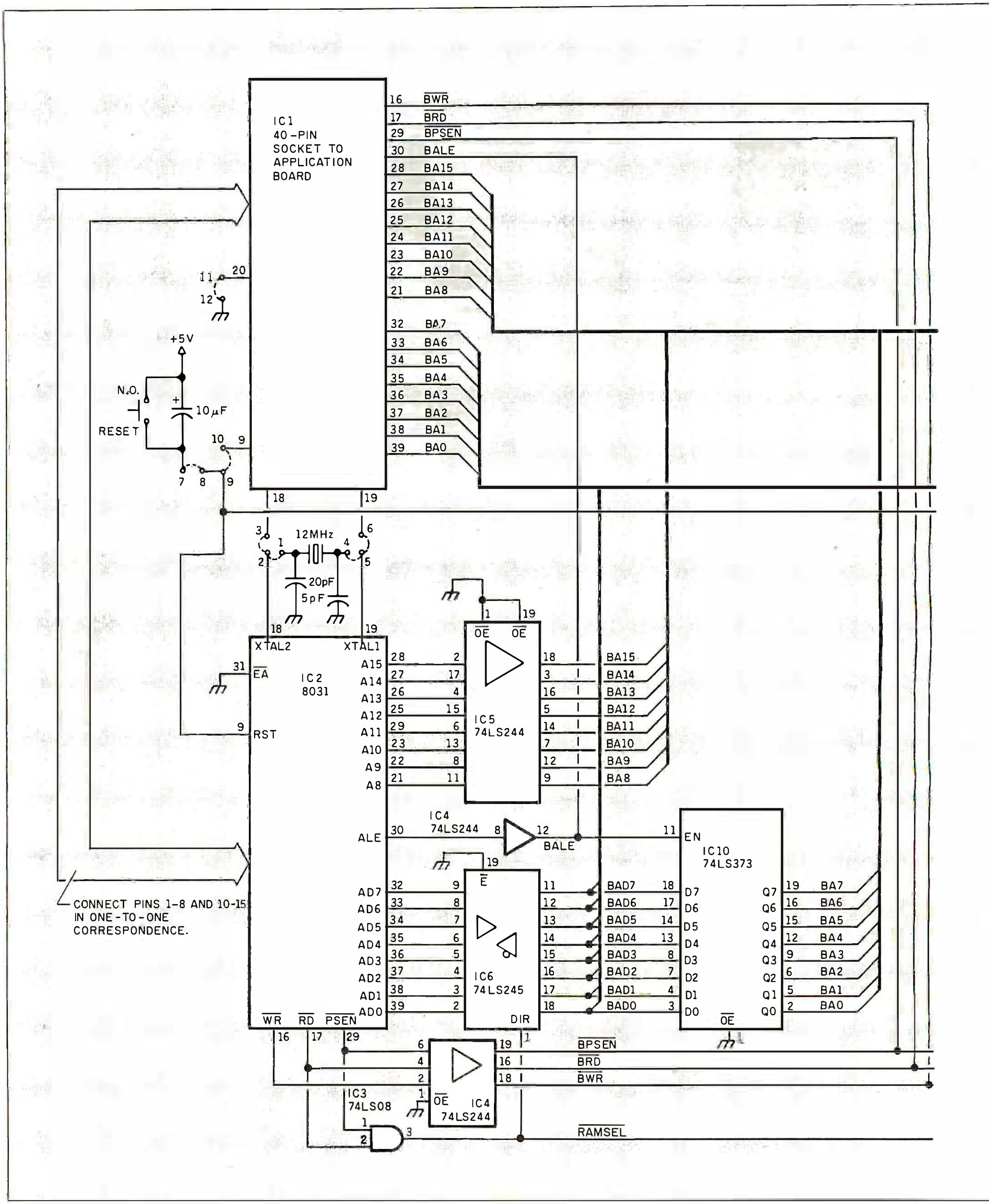
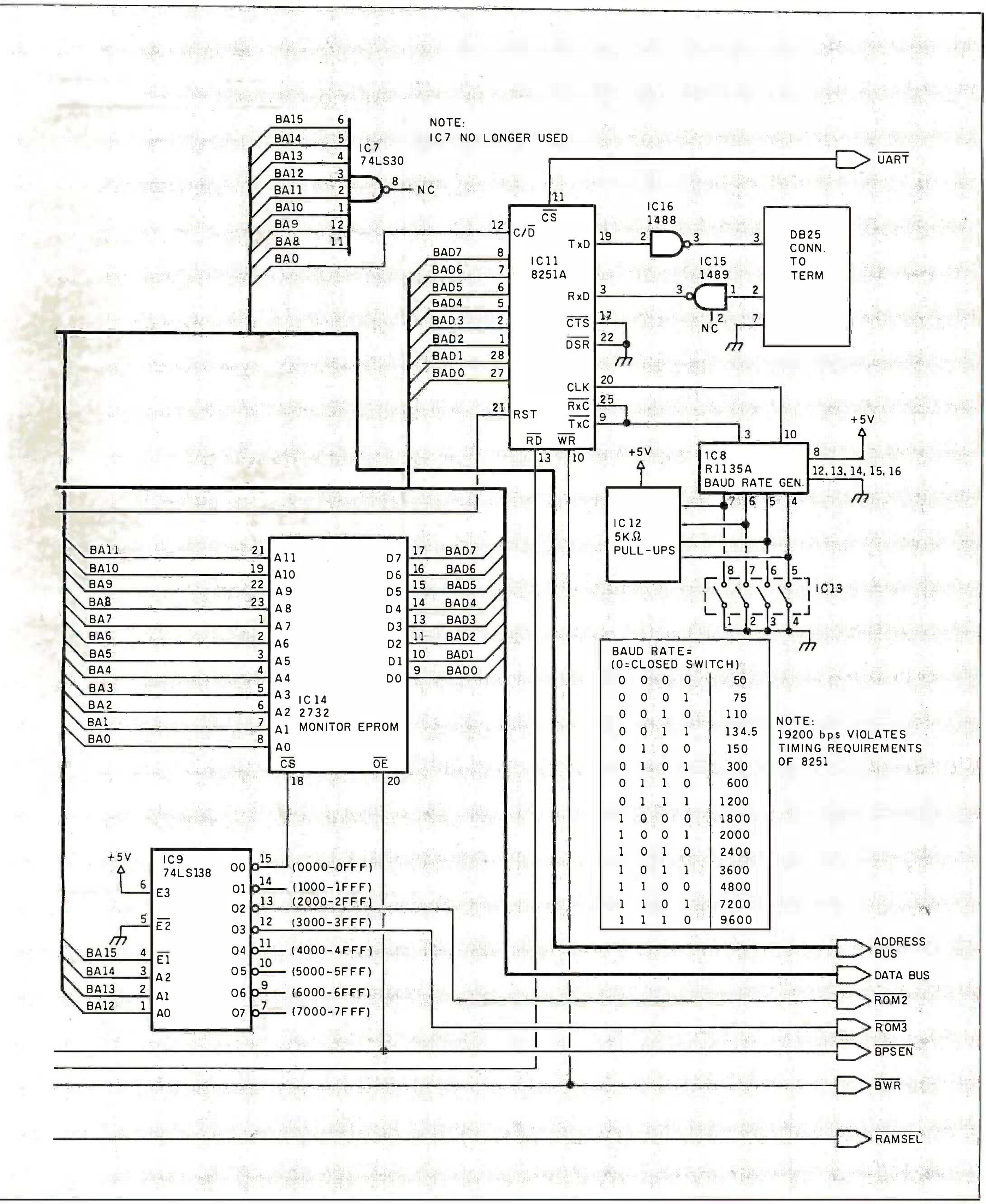



**Figure 1a:** *Schematic of the 8031 emulator board, showing the central processor, UART, and address-decoding circuitry.*


NOTE:
IC7 NO LONGER USED
IC7
74LS30
NC
UART
IC11
8251A
C/D
CS
TxD
RxD
CTS
DSR
CLK
RxC
TxC
RST
RD
WR
IC16
1488
IC15
1489
DB25
CONN.
TO
TERM
+5V
IC8
R1135A
BAUD RATE GEN.
12, 13, 14, 15, 16
IC12
5KΩ
PULL-UPS
IC13
BAUD RATE=
(0=CLOSED SWITCH)
0 0 0 0 50
0 0 0 1 75
0 0 1 0 110
0 0 1 1 134.5
0 1 0 0 150
0 1 0 1 300
0 1 1 0 600
0 1 1 1 1200
1 0 0 0 1800
1 0 0 1 2000
1 0 1 0 2400
1 0 1 1 3600
1 1 0 0 4800
1 1 0 1 7200
1 1 1 0 9600
NOTE:
19200 bps VIOLATES
TIMING REQUIREMENTS
OF 8251
IC14
2732
MONITOR EPROM
IC9
74LS138
(0000-0FFF)
(1000-1FFF)
(2000-2FFF)
(3000-3FFF)
(4000-4FFF)
(5000-5FFF)
(6000-6FFF)
(7000-7FFF)
ADDRESS
BUS
DATA BUS
ROM2
ROM3
BPSEN
BWR
RAMSEL

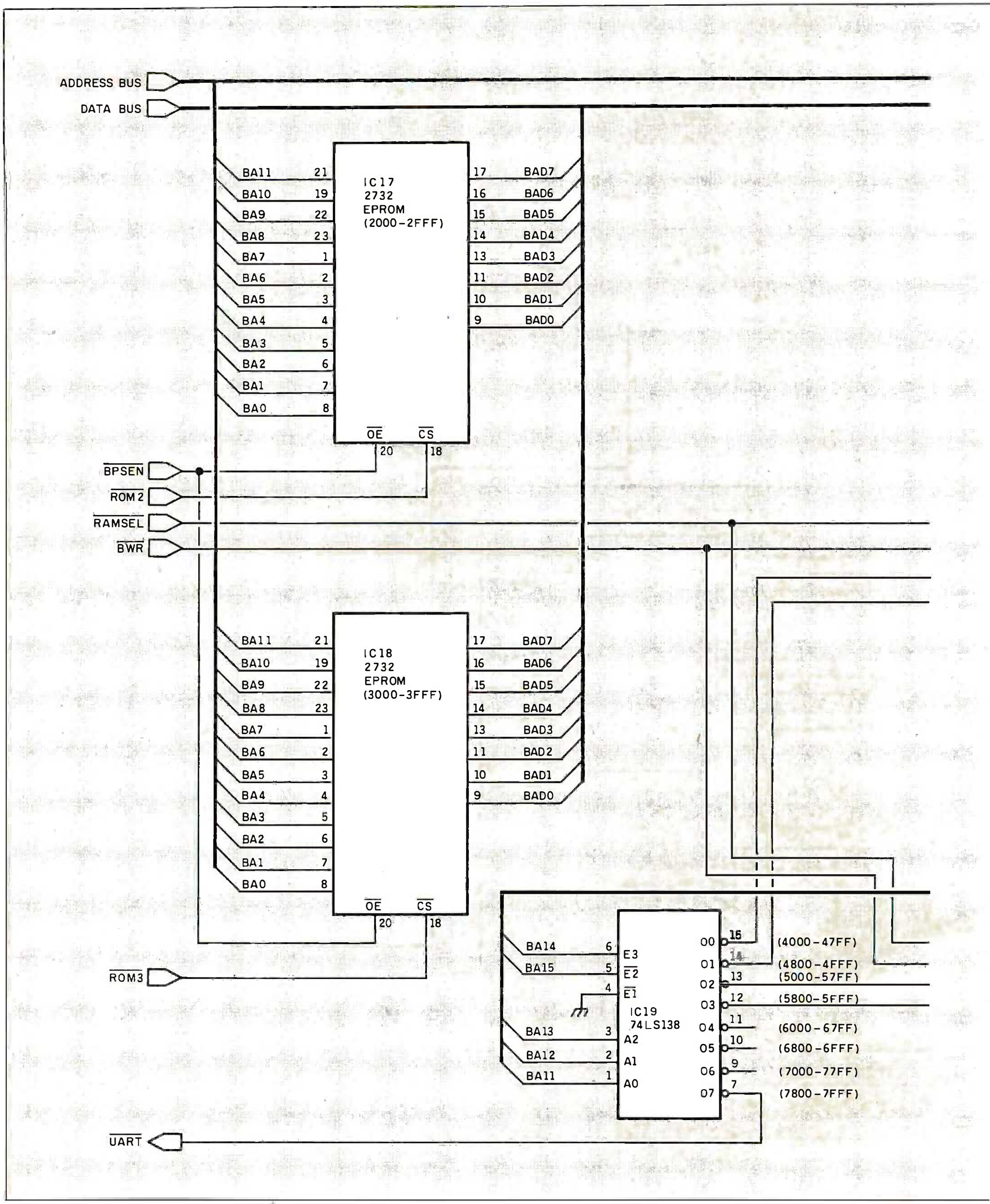
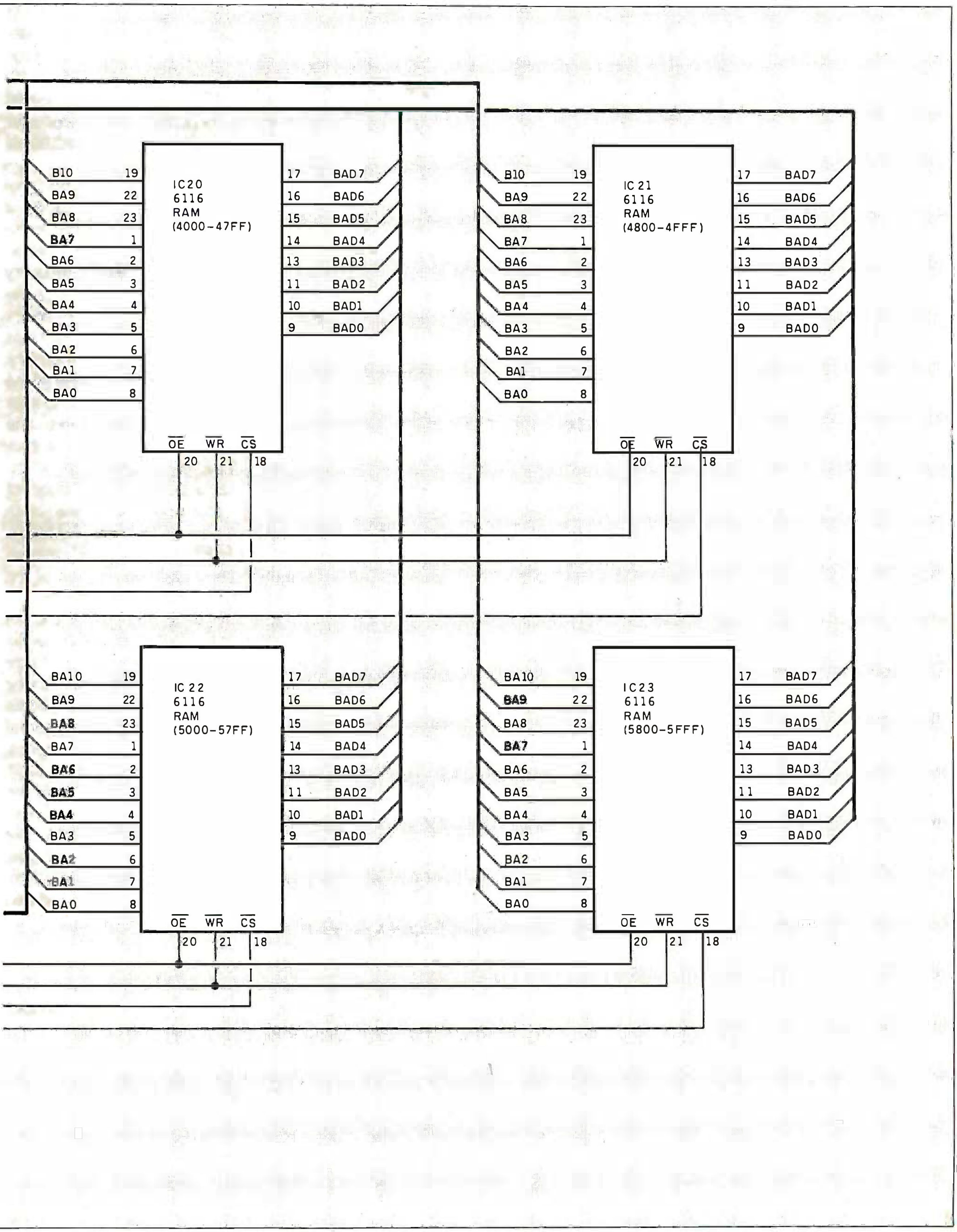



Figure 1b: *Schematic of the 8031's ROM and RAM circuitry.*


IC20
6116
RAM
(4000-47FF)
IC21
6116
RAM
(4800-4FFF)
IC22
6116
RAM
(5000-57FF)
IC23
6116
RAM
(5800-5FFF)
B10
BA10
BA9
BA8
BA7
BA6
BA5
BA4
BA3
BA2
BA1
BA0
BAD7
BAD6
BAD5
BAD4
BAD3
BAD2
BAD1
BAD0
OE
WR
CS

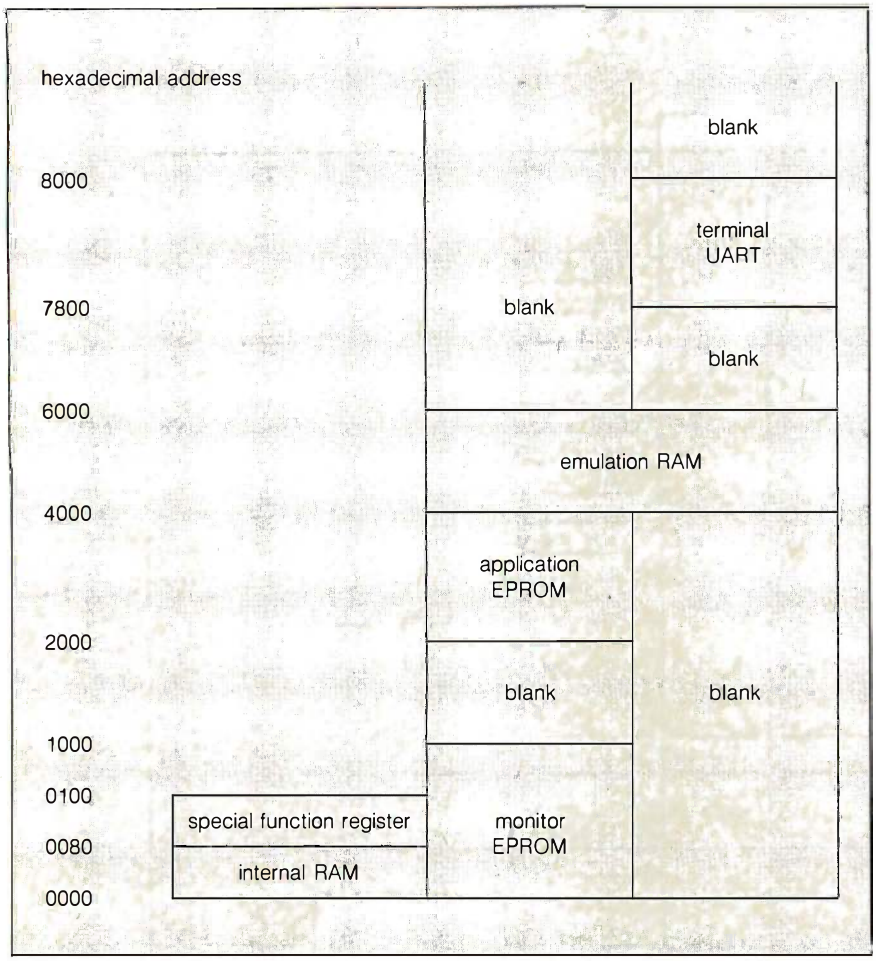



Figure 2: *The emulator board's memory map.*

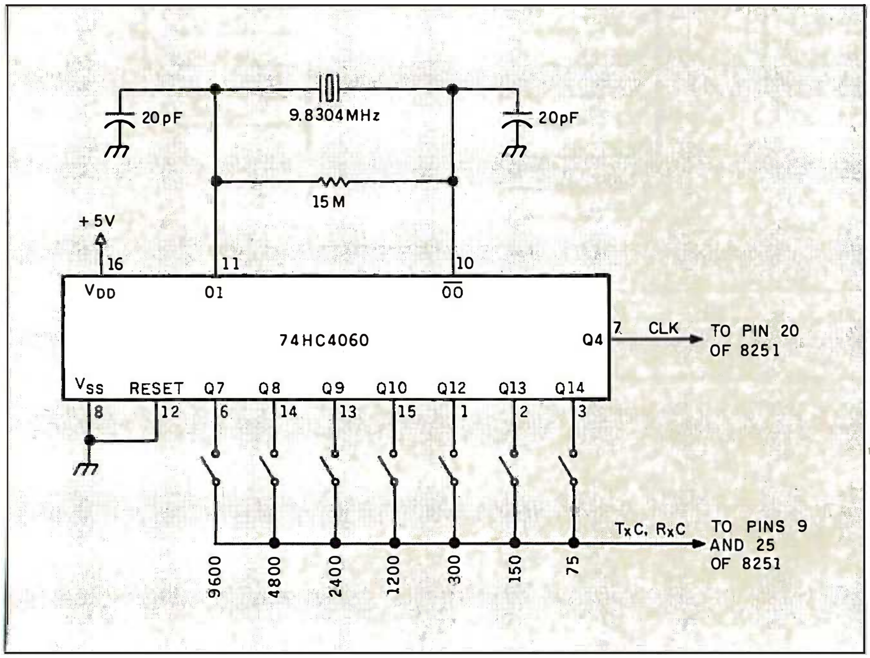



Figure 3: *Alternate circuit for generating baud-rate clock signal.*

chips and an 8K by 8 emulation RAM chip. When this circuit was first designed, however, an 8K by 8 static RAM chip cost approximately $50. Using the larger memory chip could save one 74LS138 address-decoder chip, not to mention the additional sockets and wiring.

The 8031's separate external program and data memories pose a problem in the design of the emulator. The monitor and application EPROMS are in the program memory —that's easy enough. The RAM, however, must be in the data memory because the 8031 has no instructions for writing to the program memory. On the other hand, the purpose of the emulation RAM is to allow you to alter the executed code. Therefore, the RAM must also be part of the program memory so that instruction fetches may access it. The solution, of course, is to map the RAM into both memory spaces. The signal $\overline{RAMSEL}$ is true if $\overline{PSEN}$ is true or if $\overline{RD}$ is true. Figure 2 shows a memory map of the emulator board.

I tried to tie up as few of the resources of the processor as possible. The exception to this is the large amount of external memory space used. The project that prompted this monitor used very little external memory, but it did use the internal UART. Therefore, I included an 8251 USART for communicating with the terminal rather than the internal UART of the 8031. Clocks for the 8251 are provided by a Motorola K1135A dual baud-rate generator. The K1135A contains both a crystal oscillator and two divider chains in one 18-pin dual inline package. If you are unable to find a K1135A, you can substitute the alternate circuit, shown in figure 3, that uses a 74HC4060 oscillator/divider chip.

The address, data, and control signals are buffered to allow for the extra loads placed on them by circuitry on the monitor board. If these signals are also buffered on the target board, it may cause excessive propagation delays. If necessary, replace one set of buffers with jumpers. Jumpers are also provided to choose either the onboard crystal or an external clock

*(continued)*

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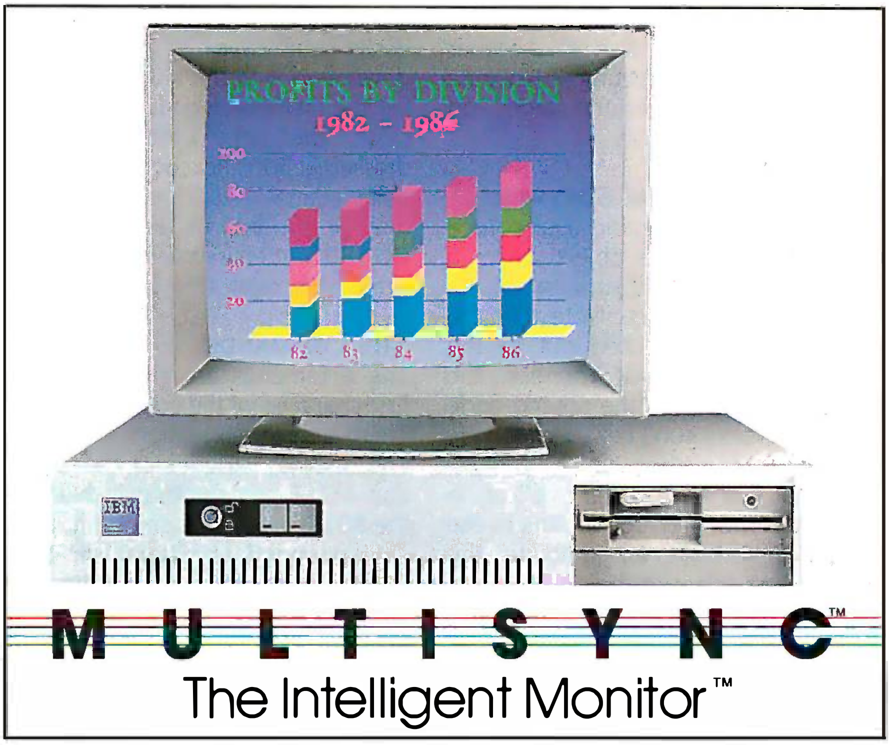


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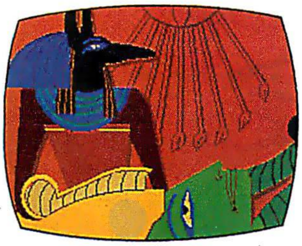

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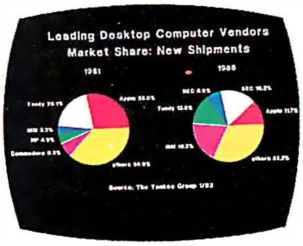


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from whatever application board you are using the emulator with. Similarly, there is a jumper selection enabling the on-board reset button, the application board reset, or both. Another jumper allows connecting or isolating the grounds between the target and emulator boards.

### OPERATION OF THE SOFTWARE

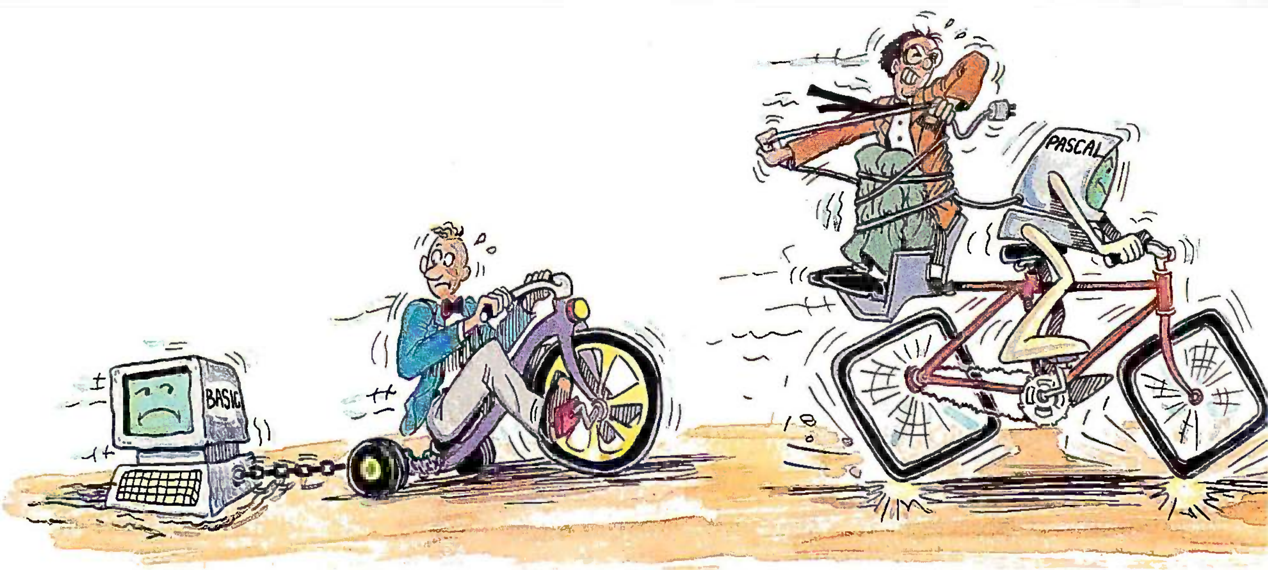
First, edit and assemble your source code. Program the object code in EPROMs and plug them into the application code space. Note that the code will be executed out of the emulator board's RAM. Therefore, the origin statement in the source code should specify 4000 hexadecimal, the start of RAM, rather than 2000 hexadecimal, the start of the application EPROM. The interrupt vectors in the monitor EPROM all jump to the equivalent offset in the RAM space, allowing use of all the interrupts with only a slight additional latency. The reset vector, however, jumps to the monitor initialization code. This scheme allows the application EPROMs, burned for development purposes, to be used in the final project in some cases. In the products I developed with the aid of this monitor, the memory decoding was incomplete. The same EPROM was addressed at 4000 hexadecimal and 000 hexadecimal. [*Editor's note: The source code for the author's monitor program,* UGHBUG.ASM, *is available in a variety of formats. See pages* 459–461 *for details.*]

### THE COMMANDS

The commands are invoked by the first character of the command name. There are a few exceptions to this rule. The internal varieties of the DUMP and ALTER commands (which access the 8031's internal memory) have an "I" appended to distinguish them from their external equivalents. The HEXMATH command is invoked with a number sign (#). All numeric values are expressed in hexadecimal. If you mistype an address or a data value, just keep typing. The monitor accepts the last four digits entered for address values and the last two for data values. You need not type leading zeros unless you're covering up a mistake. To cancel a command that you've started to type, just type any illegal character. To abort a command that outputs to the screen, merely type any character. These rules are consistent for all the commands.

The first command needed in any debugging session is the COPY command. Copy the application code from the EPROM to the RAM. Be sure not to overwrite the last 9 bytes of RAM; these are used by the breakpoint routine.

Next, use the VERIFY command to make sure the transfer was successful. VERIFY indicates agreement between two blocks of memory by doing nothing. Any differences are displayed. (I never got around to adding a memory test. With only four RAM chips it



didn't seem worth the effort. Usually, corrupted memory was the result of stack overflow or some other errant code.) Always VERIFY the damages after your code goes into the weeds.

Run your code using the GO command. If you do not specify an address, execution will restart at the breakpoint. (I'll talk more about breakpoints later.) Although the most likely starting place is 4000 hexadecimal—the reset vector of the application code—you can GO to any address in the program memory.

I had to resort to some tricks in my monitor's code. The 8031 does have an indexed jump instruction, JMP @A + DPTR. Unfortunately, the data pointer is only easily loaded by a constant—a variable must be loaded a byte at a time—and the accumulator is only 8 bits. Besides that, I wanted to be able to restore the data pointer and the accumulator when resuming after a breakpoint. The simple solution, shown in listing 2, is to push the address onto the stack and execute a return-from-subroutine instruction.

Before running your code you may want to set a breakpoint. The BREAK routine requires a little explanation. Many processors have a single-byte software-interrupt instruction that can be used for breaking back to the monitor. This single byte may be substituted for the first byte of any instruction. When the software interrupt is executed, it transfers control to a breakpoint routine. The 8031 lacks such an instruction; you have to use a long jump instruction, which is 3 bytes long. The break address must be aligned with the first byte of an instruction so that it will be executed and not treated as data.

First you want to save the original instructions. Because an 8031 instructon may be 1, 2, or 3 bytes long, inserting the 3-byte jump instruction at a given point in the code may clobber a sequence of 3, 4, or 5 bytes of code. The number of bytes affected is the optional final parameter of the break command; 3 is the most convenient value and is the default. This parameter is stored at the location BYTENUM, and the bytes of code are stored in the following 5 bytes (padded with NOP instructions if necessary). Following this, the next 3 bytes of RAM are filled with a jump instruction to the location following the code that was copied, that is, BYTENUM bytes after the break address. After all this is done, a jump-to-the-breakpoint-routine instruction is written at the break address. When execution reaches the break address, control passes to the breakpoint routine. The breakpoint routine saves the registers that are treated as volatile memory and displays the values that they contained.

A GO command without a starting address resumes from the break address. First it restores the saved registers and executes the saved code,

*(continued)*

and then it jumps back to the application code following the break address. If you execute the breakpoint routine, you should reset the board before attempting to initiate a GO command to a starting address. This will recover the 5 bytes of stack space used to store the volatile registers.

The code saved at location BYTENUM+1 is restored to its original location when a new break address is entered or if the BREAK command is invoked without a new address. You should do this before a reset because the initialization code clears BYTENUM and the following locations.

The DUMP command comes in two flavors, internal and external. The external version does a memory dump of the program memory in hexadecimal, showing the ASCII translation to the right (see figure 4). If no ending address is specified, 0FFFFH is assumed. A DUMP may be interrupted, as can any command that writes to the screen, by typing any key.

The internal DUMP command is similar but dumps the internal RAM and the special function registers. No ASCII translation is shown since it is unlikely to find ASCII strings in internal memory. The special function registers are indicated symbolically in addition to their addresses. This is shown in figure 5.

The ALTER command also comes in two flavors. The external version displays the current byte from program memory followed by a dash. If you enter a hexadecimal value, that value will be inserted at that location in external data memory. A space or a carriage return leaves the location unchanged and displays the next byte (carriage return puts you on a new line, space leaves you on the current line). A period or a backspace backs up the displayed byte by one location. Any other nonhexadecimal character cancels the command. Remember that the RAM on the monitor board is mapped to both the program memory and the data memory. The ALTER command writes to data memory because there is no way to write to program memory. It is frequently convenient to use the ALTER command to check code, hitting carriage return after each instruction for readability.

The internal form of the ALTER command accesses the 8031's internal RAM. As in the DUMP command, when you reach the special function registers (locations above 7F hexadecimal) the name of the register is displayed.

*(continued)*

Listing 2: *The author's solution to the 8031's lack of an indexed jump instruction.*

```
060F             GXXXX:
060F C049                 PUSH    LOBYTE
0611 C048                 PUSH    HIBYTE
0613 22                   RET
```

```
UGH:d 23 00b1
      0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F
0020           02 40 23 02 00  F5 02 00 F8 02 06 B3 02        .@#.. ........
0030  06 C6 02 06 F0 02 07 20  02 07 48 02 07 C9 02 06  ........ ..H.....
0040  D7 02 06 CD 02 07 6C 02  07 69 02 07 A7 02 07 A1  ......l. .i......
0050  02 08 16 02 07 70 02 06  AD 02 07 BD 02 07 AF 02  .....p.. ........
0060  07 EA 02 05 91 0D 0A 55  67 68 62 75 67 20 4D 43  .......U ghbug MC
0070  53 2D 35 31 20 6D 6F 6E  69 74 6F 72 2C 20 76 65  S-51 mon itor, ve
0080  72 73 69 6F 6E 20 31 2E  30 30 0D 0A 63 6F 70 79  rsion 1. 00..copy
0090  72 69 67 68 74 20 31 39  38 36 20 62 79 20 47 65  right 19 86 by Ge
00A0  6F 72 67 65 20 44 69 6E  77 69 64 64 69 65 2E 0A  orge Din widdie..
00B0  04 75                                              .u
UGH:
```

Figure 4: *Sample output of the external version of the DUMP command.*

```
UGH:di 69

      0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F
60                                9E AC C9 1C CE CC E4
70    88 90 80 30 02 20 88 A2  DF 9B EC E4 BB 46 E6 E4

80=P0  :55  81=SP  :52  82=DPL :69  83=DPH :08  87=PCON:7F  88=TCON:00
89=TMOD:00  8A=TL0 :00  8B=TL1 :00  8C=TH0 :00  8D=TH1 :00  90=P1  :FF
98=SCON:00  99=SBUF:00  A0=P2  :08  A8=IE  :60  B0=P3  :FF  B8=IP  :E0
D0=PSW :29  E0=ACC :01  F0=B   :0D
UGH:
```

Figure 5: *Sample output of the internal version of the DUMP command.*

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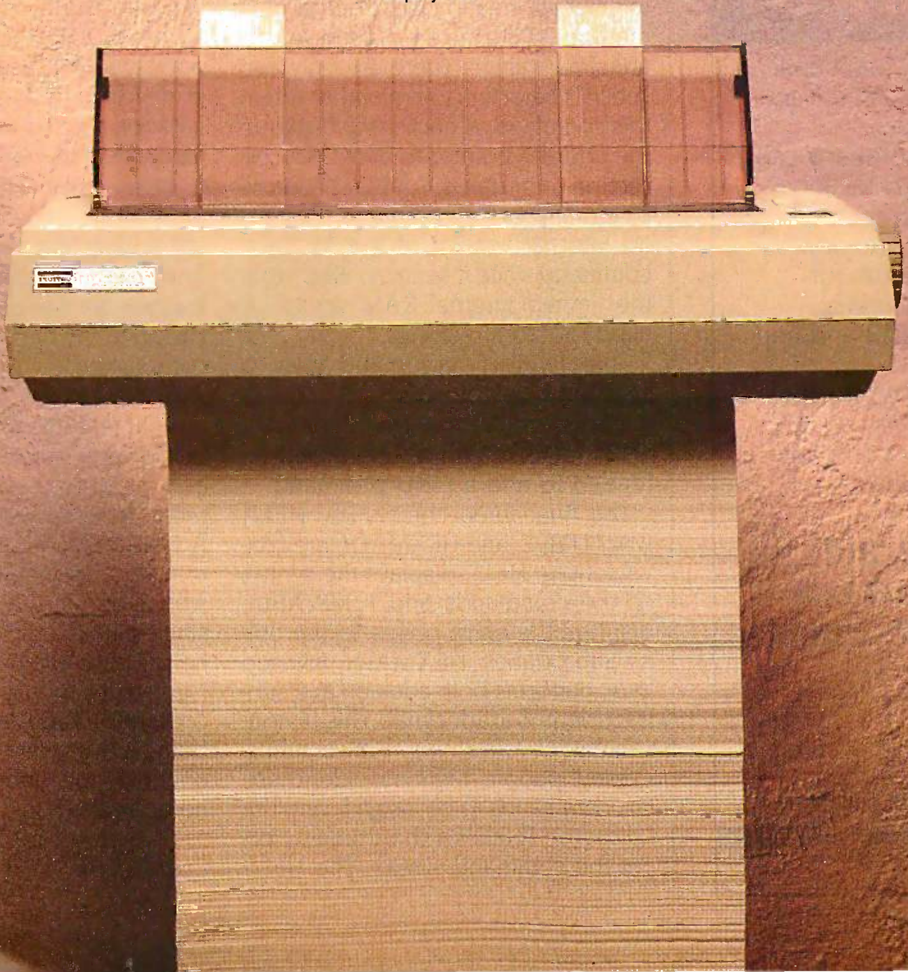

Both the DUMP and ALTER commands use the SFR table (special function registers table—it can be found near the end of the monitor's source code listing) to access these registers. The special function registers cannot be accessed indirectly, and the memory space they occupy is sparsely populated. The SFR table provides a solution to both of these problems. Each table entry is 11 bytes long. The first 5 bytes give the symbolic name of the register. At an offset of five is a subroutine to read the register. Within this subroutine, at an offset of six, is the hexadecimal address of the register. Eight bytes from the start of each entry is a subroutine to alter the contents of the register. Some registers, such as the stack pointer, would crash the system if they were altered, so these entries return an error flag instead. Some registers, such as the accumulator, are treated as volatile by the monitor. You can alter them, but the monitor makes no attempt to preserve the contents of these registers.

The MODIFY command allows you to enter information into external data memory as characters instead of hexadecimal values. There are only two special characters to remember within this command. A backspace backs up the address pointer to allow the correction of mistakes. An EOT (Control-D) terminates the command. There is no internal version of the MODIFY command since it seems unlikely that the limited internal RAM would be used for storing strings.

The INSERT command fills a selected block of external RAM with a single hexadecimal byte. I used INSERT rather than FILL because I intended to add a FIND command.

The final three commands, HELP, JUMPTABLE, and HEXMATH, are conveniences. HELP displays the syntax of the commands and JUMPTABLE displays the entry points to the utility subroutines. HEXMATH, invoked by #, performs both addition and subtraction in hexadecimal. This is convenient for calculating relative jumps.

Some people might consider these last commands to be insignificant, but I disagree. It takes a short time to forget the command syntax. The HELP command also makes this tool easily available to others. The JUMPTABLE command allowed me to create test patches easily. Before I added this command I was constantly searching for the monitor program listing to look up the jump-table addresses. The HEXMATH is a cheap convenience—convenient to include when compared with the trouble caused by missing a jump target by 1 byte. Even simple software such as this should attempt to be as helpful as possible—there are better ways to spend time.

## CONCLUSION

In this article, I have focused on one particular implementation of a debug monitor. If you are using a different processor it is well worth the effort to create your own. In addition to the debugging help, writing a monitor is a good exercise. It helps you to become familiar with a new instruction set.

Build your monitor one function at a time. First start with displaying a sign-on message. Then accept input and echo it back to the screen. Once you have the terminal interface working, add the more basic commands such as DUMP and ALTER. At this point you will have tools to aid you in developing the rest of the code.

It took me two weeks to develop the hardware and enough of the software to start using my new tool to develop application code. A year later I was still adding features and refining functions. Every minute I spent working on the monitor was quickly repaid in time saved. In the first week I used it, I accomplished six weeks of debugging measured by my previous standards.

What features would I like to add to this or any other monitor? A LOAD command to download a hexfile directly to RAM would be first choice. A FIND or SEARCH command to pick out variable-length byte sequences would be nice. A disassembler and single-line assembler would be a great help. These two are big jobs, though. I got to be pretty good at patching code with hand assembly, but I was doing it every day. The list of features could go on and on. A monitor is never finished until you quit using it. ■

*Special thanks to Jim Gaudreault.*

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# STRUCTURAL ANALYSIS

BY ROBERT W. JOHNSON AND FERNANDO G. LOYGORRI

## *This finite-element method works on an* IBM PC

THE FINITE-ELEMENT method is one of many attempts by scientists to reduce the complexity of some real-life problems to manageable proportions in order to analyze them. The ultimate goal of the different numerical procedures developed over the years is to find the solution to a complicated problem by solving a simpler one that closely represents the actual problem.

For example, you may replace the elusive task of geometrically computing the length of an irregular figure's perimeter by calculating the perimeter of a polygon with a large number of sides (see figure 1). As you increase the number of the polygon's sides, its perimeter's approximation of that of the irregular figure improves until, with infinite sides, the perimeter of the polygon becomes equal to that of the original figure.

### SIMPLIFY, SIMPLIFY

The simplifications used in this attempt fall into two separate categories, physical and mathematical. The finite-difference method and the least-squares approximation represent the group of mathematical simplifications used to reduce the complexity of equations. The finite-difference method replaces the derivatives in differential equations and boundary conditions with difference equations. If you carry this method far enough, you get surprisingly good results.

The finite-*element* method is an example of a physical simplification. The equations are left alone, but you reduce the complexity of the part by replacing it with a model made up of a finite number of discrete pieces called elements—similar to the sides of the polygon in figure 1. These elements are interconnected at a number of points called nodes. The behavior of the elements approximates that of the continuous subject.

Finite-element-analysis procedures that require extensive mathematical calculations have been around a long time. Prior to the availability of sophisticated computers, these procedures were impractical and not widely used. Finite-element analysis enjoyed successful, if limited, use on mainframe computers, but it became a practical everyday tool within the reach of the average engineer with the explosion of microcomputer availability.

Of course, there is a catch: You can reduce the complexity of analyzing some phenomena, but the solution loses precision in the process. If you study a simplified approximation of the real problem, the solution will also be an approximation.

In structural analysis, this is not a costly trade-off. After all, prior to the finite-element methods, the solutions for complex structures were limited to approximations that, even with very sophisticated mathematics, seldom matched the actual structure. Engineers used conservative assumptions to account for this lack of analysis capability.

### THE FINITE-ELEMENT METHOD

Although finite-element analysis started as a tool for engineers who

*(continued)*

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*Fernando G. Loygorri is also a structural engineer at Boeing. A native of Spain, he has an M.S. in aerospace engineering from the University of Madrid. Both authors can be contacted at Microstress Corp., 10950 Forest Ave. S, Seattle, WA 98178.*

perform aircraft structural analysis, it has been widely applied to solving other types of engineering problems such as fluid dynamics, heat transfer, and soil mechanics. Other less common applications include the biological sciences, where finite elements have been used to determine stresses in the eyeballs and bones, to study the lubrication of natural joints, and to study the motion of blood cells in capillary blood vessels.

The nature of the finite-element method makes it useful to engineers and scientists faced with three different types of problems:

1. equilibrium analyses, like the static solution of the loads and deformation of a structure;
2. eigenvalue analyses, like those you would use in determining the natural frequencies of a structure; and
3. transient analyses, like those found in structural dynamics.

The finite-element solution doesn't consider the effect that deflections have on a structure's ability to carry loads. For example, a thin flat plate under pressure loading with the edges fixed would show large deflections due to plate bending. These deflections, in reality, would result in the "membrane" characteristics of the plate being loaded. The finite-element method considers only the initial shape of the model. Therefore, no membrane loads are calculated in the plate; this results in no tensile stresses in the model plate elements.

In spite of this obvious limitation, the finite-element stiffness solution is the most common method of stress analysis for complex structures in use today. Most structures do not have large deflections that alter the stiffness characteristics of their elements.

You can account for the effect of the loads on the deflected geometry—if deflections are large—if you solve the problem for a fraction of the total load. Then you add the resulting structure deformation to the geometry of the previous solution to calculate the next increment of loading. The solution is built up by adding the incremental-solution deflections, stresses, and internal loads until you have accounted for the total applied load. The resulting stresses and loads represent the large-deflection solution to the problem you modeled. You must take care in unique cases like the pressurized flat-plate model to keep the load increments small enough to prevent an excessive build-up of error.

The finite-element solution of a statically loaded structure is reasonably complete in that all internal forces (loads and stresses) are solved as well as all deflections. The deflections are most useful as a way to visualize the structure's performance.

The degree of refinement of the finite-element grid—the element size—is a function of the level of detail required in the solution results. For example, the method can analyze a pin-jointed bar element. In this case, the only possible deformation is the extension or contraction of the bar length. It is a natural assumption that the length increases or decreases linearly along the bar. If the area of the bar is constant, or no analysis of the bar will be done from the element's internal data, then this idealization is adequate for the rest of the model. If stresses along a bar that varies in area are required, then you must model the bar with a number of elements.

Elements interact with each other only through a limited set of points called nodes. The multiple node interactions are mathematically represented by a system of simultaneous equations. In the case of structural analysis, this system expresses the relationships between applied loads and restraints on one side of the equation and the deformed state of the structure on the other side. You can represent the system of simultaneous equations in matrix form as $\{F\} = \{K\} \{u\}$, where $\{F\}$ is a vector representing the applied forces and reactions, $\{K\}$ is the matrix of coefficients, called the stiffness matrix, of the model, and $\{u\}$ is a vector representing the displacements of all the nodes in the system.

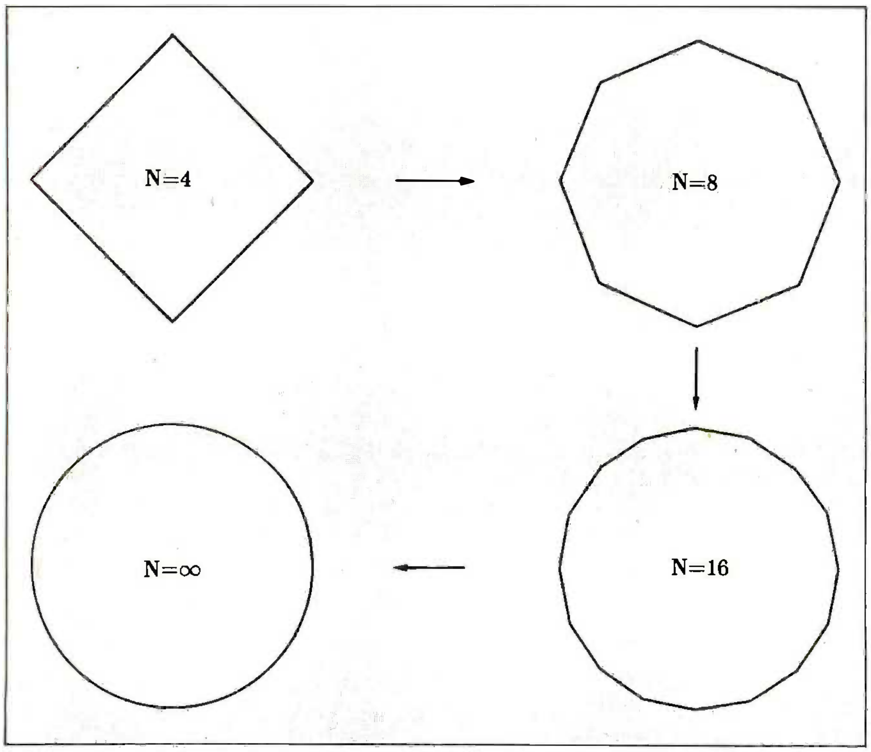
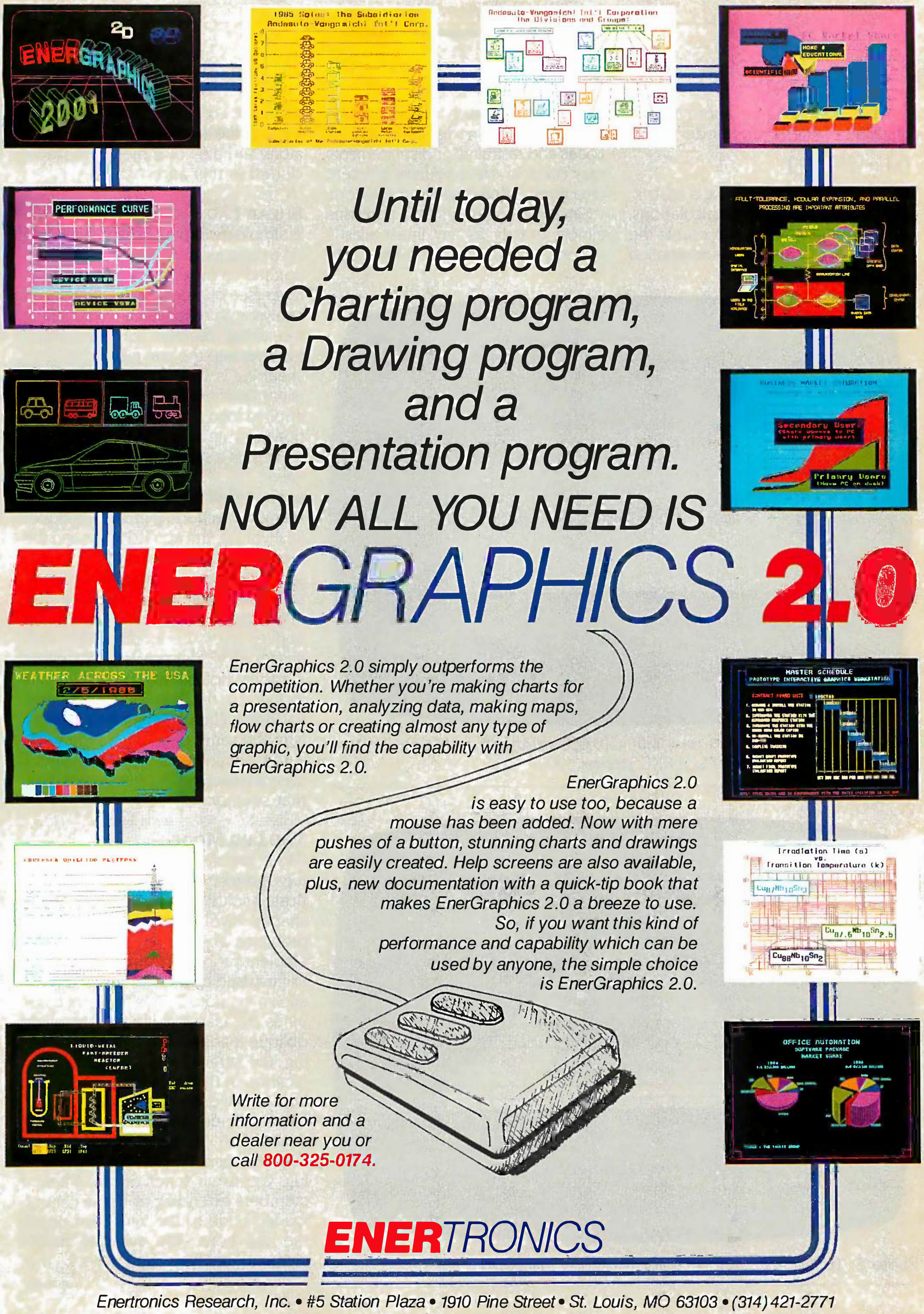


Figure 1: *A polygon approximation of the circumference of a circle where* N *is equal to the number of sides the polygon has.*

## THE STIFFNESS MATRIX

The values of the stiffness matrix depend only on the geometry of the problem and the basic assumptions made about the behavior of the ele-

*(continued)*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ments. The goal is to determine the deformed state of the model $\{u\}$:

$$\{u\} = \{K\}^{-1}\{F\}$$

Determining the inverse of a matrix, $\{K\}^{-1}$, requires a lot of calculations.

The stiffness matrix represents the effects that loads or restraints applied to the model at each individual node have over all the nodes in the model. Loads and restraints or displacements may occur at every node in different directions, called degrees of freedom.

Since the finite element performs almost exactly as any linear elastic material would, complex effects such as "shear lag" (changes in load distribution due to structural deflections along the axis of a member) are included in this approach.

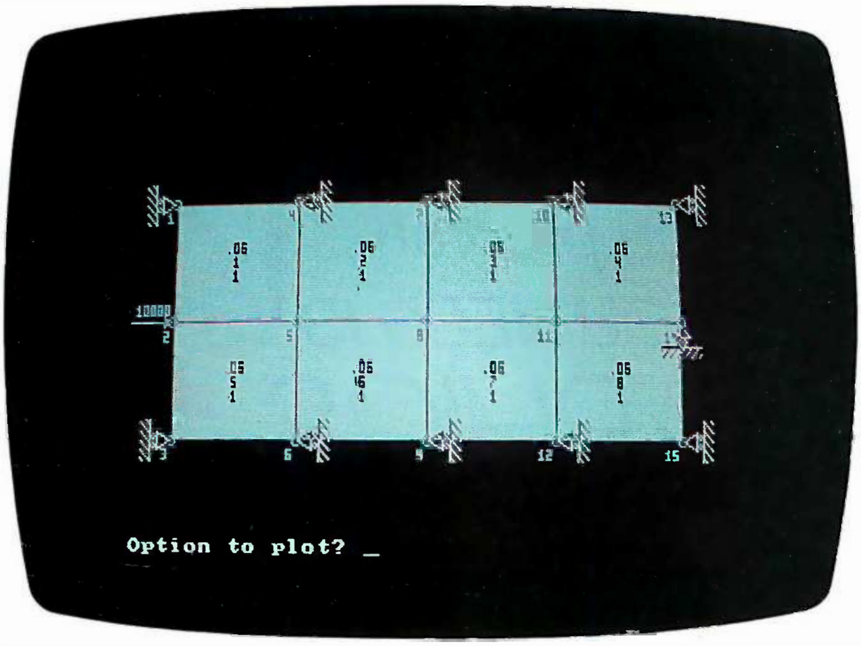


Photo 1: *Plot of the stiffened panel with a 10,000-pound load on the central stiffener, drawn by the* SAFEPLOT.EXE *program.*

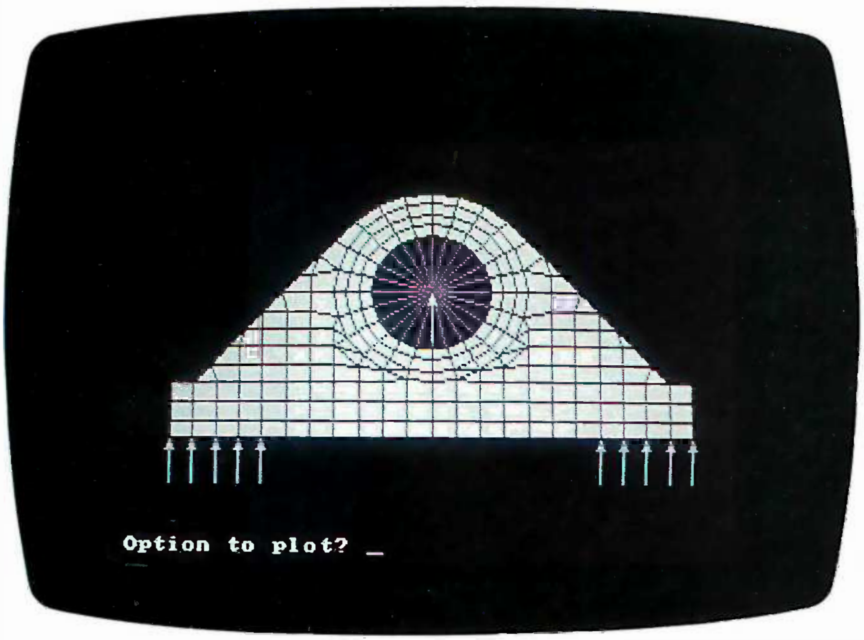


Photo 2: *The lug model with the plates, beams, and loads shown.*

## Shear Lag

A simple example of shear lag would be a stiffened panel with a large load applied on the end of the central stiffener (see photo 1). An inexperienced analyst may have difficulty estimating the shear reaction of the central member into the skin plates. The term shear lag is used to explain why the shear flows are much higher near the applied load than a linear shear reaction over its length.

There is a significant difference between the shear-lag deflections that are included and the flat-plate membrane deflections that are excluded. In shear lag, the applied loads and the element-stiffness values are in the same direction, where the membrane stiffnesses for the flat plate are oriented at 90 degrees, relative to the applied pressure loading. The stiffnesses at 90 degrees to the applied loads are not a load path and are not included in the finite-element-method solutions. The plate-bending stiffness is in the same direction as the pressure loading and is the only stiffness used to react to the pressure loads in that solution.

## The Lug Model

Other problems such as fittings, or lugs, have stumped the most sophisticated solutions due to the complex shapes involved in most practical problems. The two-dimensional finite-element problem is most dramatically illustrated by the solution of the lug shown in photo 2. This problem combines the classical lug solution with oblique loading and structural bending, the latter of which is due to the location of the attachment-bolt reactions at the ends of the fitting and the bearing-loads distribution from the central bolt on the lug itself.

To represent the bolt bearing on the lug, you use a series of radial beam members extending from the central loaded node to the inner surface of the lug bore. You run the finite-element analysis and check the

(continued)

resulting loads in these beam members for tension values. The bolt can transmit only bearing loads—beam-compression values—to the lug material since the lug and bolt are separate parts. Then you divide the area values of those beam members in tension by 10,000 to reduce the tension values to an insignificant magnitude and rerun the solution. This procedure is convenient on personal computers since solution turnaround is fast and full-screen editors let you review the significant model data without waiting for a printout.

Figure 2 shows the location and value of the maximum stress in the lug as a function of load-application angle. We obtained these results by changing the applied load and the orientation of the reduced beam areas in the central-bolt idealization and rerunning the solution. We made these changes to the lug model with an editor, saved the resulting models for each loading on the computer's hard disk, and then ran the series of jobs in batch mode.

This example illustrates the real value of the finite-element solution as a tool for understanding how structures perform. Since the complete solution—stresses and deflections—is available, you can derive a "picture" of the part's stress distribution from the solution data, much as you would use a photostress model to visualize the stress distribution in real parts.

## PROBLEMS

The main problem with a finite-element-analysis program for microcomputers is the efficient use of the memory that is available on the machine. Memory usage is such an important issue because even modest-size finite-element models require relatively large amounts of storage space.

The analysis of a model involves solving a system of simultaneous equations. All the coefficients must be stored adequately in the computer memory while the solution is in progress. The matrix solutions require a very large storage volume. There is one equation for each independent displacement in the model, which is referred to as a degree of freedom. In a two-dimensional model with in-plane loads, there are three degrees of freedom per node, because each node may independently translate in two orthogonal directions in the plane of the model, and it may also rotate within the plane. In a three-dimensional model, there are six degrees of freedom per node, three translations, and three rotations.

A moderate-size model may contain around 100 nodes, for example. Therefore, the system of simultaneous equations to be solved will contain $3 \times 100 = 300$ equations for a two-dimensional model, or $6 \times 100 = 600$ equations for a three-dimensional model. Obviously, this method would be totally impractical if computers were not available.

The storage problem comes up when you realize that the matrix $\{K\}$ in the 100-node two-dimensional example contains $300 \times 300 = 90,000$ terms, or in the 100-node three-dimensional example contains $600 \times 600 = 360,000$ terms. Obviously, it is impossible to store that many numbers in the main memory of an IBM PC.

To get around such a seemingly unsolvable problem, you must take advantage of the particular characteristics of the system that you need to solve. The theory shows that the matrix $\{K\}$ is always symmetric; that is, all the matrix terms above the principal diagonal (top left to bottom right) are just a mirror image of the matrix terms located below that diagonal. By not storing the redun-

(continued)

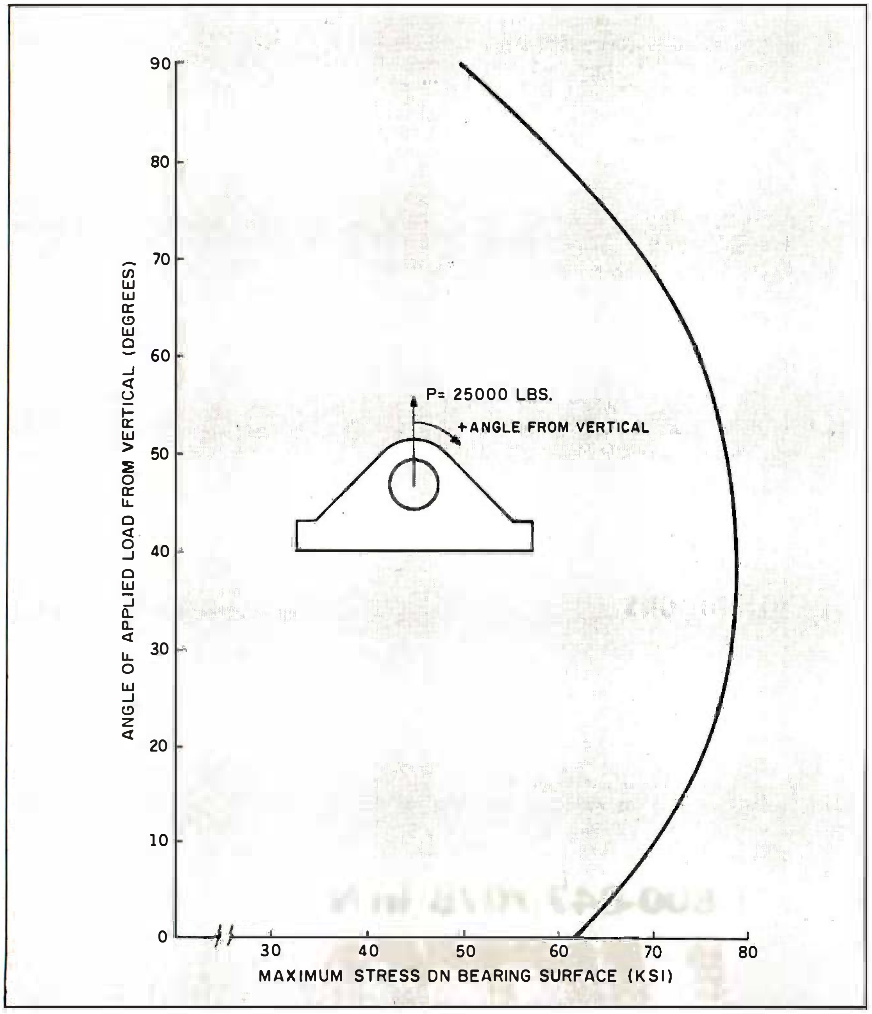


Figure 2: *A plot of the variation of the location of maximum stress in the lug against the angle of applied load.*

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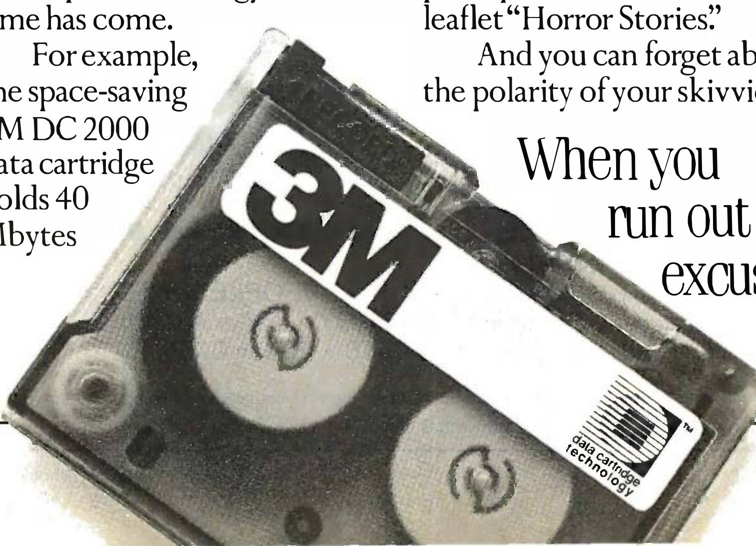


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*To store a complete triangular submatrix would be inefficient because the matrix is usually heavily banded.*

dant terms, the storage needs are reduced by almost half.

Still, to store a complete triangular submatrix would be very inefficient because the matrix is usually very heavily banded. In other words, the nonzero terms are clustered in a band located along the principal diagonal. Outside the band, all the terms are zero; if you know this, you don't need to store them.

### Banding

The matrix is banded because each node is connected to a relatively small number of other nodes through the model elements. The terms corresponding to the nodal connections that are *not* made have a value of zero so the matrix is sparsely filled. If all nodes are numbered so that the connections are made between nodes with close numeric identifiers, the nonzero terms in $\{K\}$ will form a narrow band.

In a well-ordered model the bandwidth is easily as low as 25 to 30 percent of the total number of degrees of freedom, reducing the storage needs significantly. For example, the stiffness matrix of a 100-node three-dimensional model with a half bandwidth of 16 nodes contains approximately 57,000 nonzero and nonredundant terms, down 84 percent from the total original value of 360,000.

Once the stiffness matrix has been shrunk as much as possible, we need to find the best way to keep it in the computer's memory. Because the bandwidth of the model is variable, we use a single-dimension array (vector). This is done by appending each line to the end of the previous one.

*(continued)*


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# MICROSAFE 2-D AND 3-D

The Microsafe series of finite-element-analysis programs are best suited to the analysis of static structures using linearly elastic materials. Microsafe performs the type of solution that resolves equilibrium problems, like the static solution of the loads and deformation of a structure.

## SOLVING A MODEL

To solve a structural model with Microsafe, you need to create a file with all the information you need to define the model. You can use any text editor or word processor capable of creating an ASCII character file with no special control characters. You write the parameters of the model (node coordinates, beam areas, plate thicknesses, loads, etc.) in the file, separated by blanks. To save future relearning time, we have included the ability to write notes to ourselves on any line in the file or after the data on the line. Many models are made by editing previous ones such as beam, fitting, or frame models to create those for similar structures. Also, if very unique modeling characteristics are used, a note may be included for future reference. Listing A shows a portion of an actual file including optional English notes.

Once you have created the file, you should verify it by running it through the graphics module. The program will read the model file and perform an exhaustive validity check. If it finds an error, the program reports all the information available: location, type of error, and reason why that information cannot be accepted. For example, if you incorrectly define the thickness of a plate, the program indicates that the thickness specified doesn't fall within acceptable bounds; it states what those bounds are; and arrows point to the incorrect entry, so you don't have to search the whole line to find the error. Other errors are handled similarly (see photo A).

You may graphically review the entire model, including all the properties, to make sure it matches the intended model. The system does not require any special graphics hardware, only the standard IBM Color Graphics Adapter and a graphics monitor. A zoom feature was added to overcome the rather obvious resolution problems with small details in these monitors. For execution speed, all the graphics routines were written in assembly language.

The solution module also checks the model so you don't necessarily need the graphics module. When solving big models, the computer seems to be "dead" for long periods of time, so we added progression bars to keep track of its progress. Thus, the program indicates how far the task is away from completion. The solution module reports the displacements, element-corner forces, internal-node and element stresses, and the reactions at the restrained nodes.

We have also included a table not usually found in finite-element programs—residual loads at free nodes. In a balanced model the force contributions of all the elements connected to a given free node should cancel out, and the residual load should be zero. But we found that if the model is poorly designed (with sudden large changes in properties instead of realistically gradual changes, for example), the residual loads quickly become nonzero in the ill-conditioned area. To identify this situation—if it occurs—we included the residual-loads table as a post-processing aid.

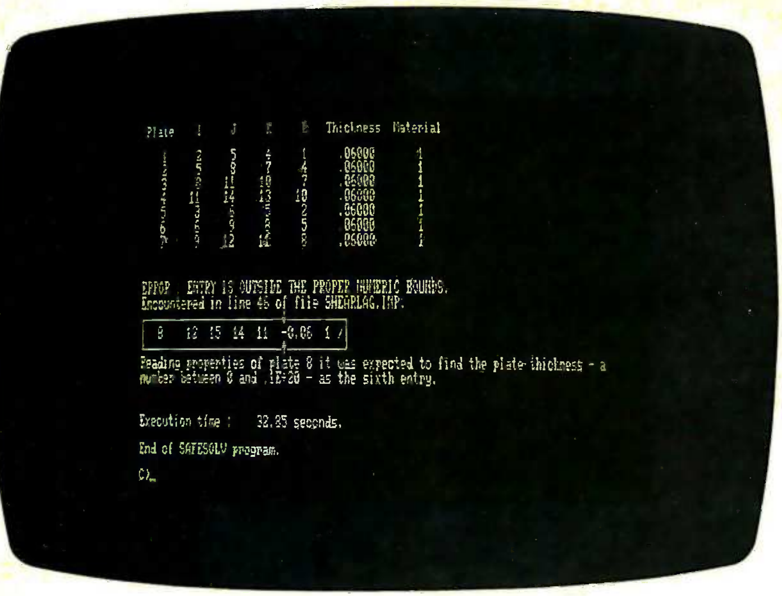



Photo A: *Microsafe error-diagnostics format.*

## IN TWO DIMENSIONS

The two-dimensional Microsafe program allows models with up to 400 nodes, 500 plates, 600 beams, and 60 fasteners and allows plotting of all elements and properties (data values). All solutions are run in memory and require a minimum of 448K available bytes. The 8087 is used if available. Because the stiffness matrix is stored in banded form, models with a high bandwidth require extra memory; up to 704K may be used if available.

The examples shown requiring two-dimensional solutions correspond to the Microsafe 2-D solution program. There is also a plotting program that is used to check out the model data prior to the solution. Use of this program before the solution program will ensure correct results with fewer solution iterations.

## IN THREE DIMENSIONS

The example shown in figure A is representative of the type of problem solved by the three-dimensional program. This problem represents the outboard-wing panel of an aircraft with six ribs, a rear spar, a main box spar, and both upper and lower surface skins.

The three-dimensional stiffness matrix is much bigger than the stiffness

Listing A: PUNCH.INP, *sample input file for Microsafe 2-D program with examples of optional notes and comments to explain data.*

```
This file demonstrates the mixture of text (notes) and input data
allowed in the Microsafe Program Series. The data for the program is
contained on the lines that contain a slash character. All lines
without a slash and any characters following the slash are ignored by
the program.
15 / # of nodes
1 /  # of materials
4 / # of beams
8 / # of plates
0 / # of fasteners
1 / # of loaded nodes
11 / # of imposed restraints
 1  0.0   10.0 / node-#  x-coordinate  y-coordinate
 2  0.0    0.0 /
 3  0.0  -10.0 /
 4  10.0  10.0 /
 5  10.0   0.0 /
 6  10.0 -10.0 /
 7  20.0  10.0 /
 8  20.0   0.0 /
 9  20.0 -10.0 /
10  30.0  10.0 /
11  30.0   0.0 /
12  30.0 -10.0 /
13  40.0  10.0 /
14  40.0   0.0 /
15  40.0 -10.0 /
1 10.3E6 0.33 / material-#  Young's-modulus  Poisson's-ratio
1 2 5 0.5 0.1 1 0.0 0.0 /beam# node1 node2 area inertia material# Q1 Q2
2 5 8 0.5 0.1 1 0.0 0.0 /
3 8 11 0.5 0.1 1 0.0 0.0 /
4 11 14 0.5 0.1 1 0.0 0.0 /
1  2  5  4  1 .06 1 /plate# node1 node2 node3 node4 thickness material#
2  5  8  7  4 0.06 1 /
3  8 11 10  7 0.06 1 /
4 11 14 13 10 0.06 1 /
5  3  6  5  2 0.06 1 /
6  6  9  8  5 0.06 1 /
7  9 12 11  8 0.06 1 /
8 12 15 14 11 0.06 1 /
2 10000. 0.0 0.0 / node #  load-x  load-y  moment
 1 1 0.0 / node-#  restrained-freedon-#  imposed-deflection
 3 1 0.0 /
 4 1 0.0 /
 6 1 0.0 /
 7 1 0.0 /            1 -> restrain x-direction
 9 1 0.0 /            2 -> restrain y-direction
10 1 0.0 /            3 -> restrain rotation
12 1 0.0 /
13 1 0.0 /
14 2 0.0 /never remove this node-used to eliminate freebody translation
15 1 0.0 /
```

matrix for plane models, typically by a factor of four. Thus, Microsafe 3-D uses as much memory as is available up to 704K bytes before it starts to off-load data to a spill file. This program makes the faster hard disks really attractive. Microsafe 3-D uses disk drives like virtual memory, that is, as slow emulators for RAM. (We are in the process of extending the Microsafe 2-D program to include this feature as well.)

The plotting portion of the three-dimensional analysis program is under development. The rest of the three-dimensional analysis program and all other programs in this article are complete and have undergone extensive testing and use.

## AVAILABILITY

[*Editor's note: Microsafe 2-D is available as* SAFE2SOL.FOR *and* SAFE2SUB.FOR *in a variety of formats (see pages 459—461 for details), for use with the Microsoft* FORTRAN *Compiler version 3.2. A library,* SAFE2D.LIB, *is included that contains the assembled machine language routines. These routines allow character handling and other facilities not included in* MS-FORTRAN *and must be used with the compiled .OBJ files at link time. The libraries required for linking are* SAFE2D.LIB *plus the Microsoft* FORTRAN

*(continued)*

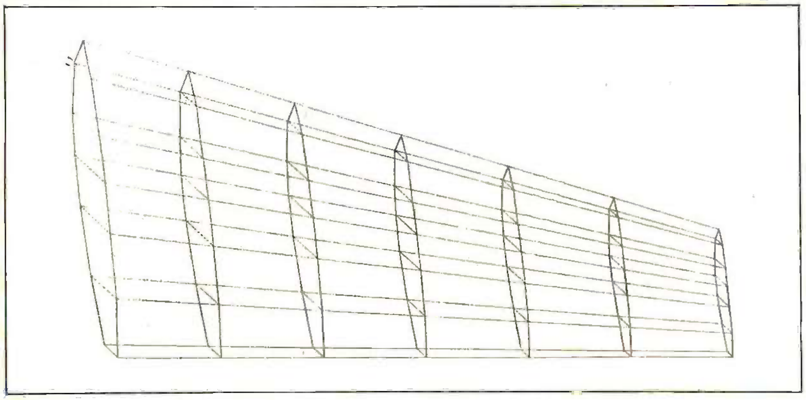


Figure A: *Plot of wing model using printer-graphics routine.*

*libraries* MATH.LIB, FORTRAN.LIB, *and* DOS2FOR.LIB. *Instructions for running Microsafe 2-D can be found in* BROCHURE.DOC. *Two input files are available*: LUG.INP *and* PUNCH.INP. *And the assembly language routines are available in source code also*: ASCSTR.ASM, CHKDUP.ASM, CHOPWR.ASM, CONFRM.ASM, CONSTR.ASM, DATE.ASM, DEFDRV.ASM, DELFIL.ASM, DSKFRE.ASM, DSKSPC.ASM, ENDSTR.ASM, EXPSTR.ASM, FILSTR.ASM, INTSGN.ASM, LENSTR.ASM, LOCSTR.ASM, LOGPSL.ASM, LWCSTR.ASM, MEMAVA.ASM, MODSTR.ASM, MOVSTR.ASM, PACER.ASM, PAKSTR.ASM, RESSTR.ASM, SETSTR.ASM, SIZFIL.ASM, SIZSTR.ASM, TIME.ASM, *and* UPCSTR.ASM.]

Microsafe 2-D and 3-D are shareware products. If you don't know anyone you can get an evaluation copy from, you can obtain executable versions of either of the programs from Microstress Corp. (10950 Forest Ave. S, Seattle, WA 98178) for $10 to cover the cost of the disks and postage. The disks include an abbreviated manual and numerous examples.

You may evaluate the programs at length, trying them on problems that represent the type of designs that you will actually use them for. Only after you determine that the program serves your particular needs do you purchase either program for $75. In return you will receive the complete typeset manuals, including the latest program release and notification of future updates.

To determine the location $i$ corresponding to row $r$ and column $c$, you need a simple computation: $i = (r-1) \times b + c$, where $b$ is the bandwidth of the model.

### FOOLING THE SYSTEM

A dilemma arises when selecting the size of the vector because our programs are written in Microsoft FORTRAN (see the text box, "Microsafe 2-D and 3-D" on page 208), and the language forces you to fix the dimensions of each array in the program. If the value you select is too high, the program will not run on machines with a small amount of memory because these machines have no virtual-memory facilities with which to swap portions of the array to disk storage. On the other hand, if the number you pick is low enough to accommodate everybody, then the programs will not use all the memory available in computers that have plenty of it—a very sloppy approach.

We decided to play tricks on the operating system. At run time an MS-FORTRAN program has the code loaded in low memory and the data areas loaded immediately on top of it. The last data blocks to be loaded are the common blocks and, for some reason, the named common blocks are sorted in reverse alphabetical order. Free memory is located after the last common block, starting at segment HIMEM as reported by the linker (see listing 1).

The last common block is the only one that you can expand, without clobbering something of value, to the top of the memory physically present in the machine and known to the operating system. By putting the $\{K\}$ array in a common block named, for example, AAAAAA, you can dynamically allocate memory to it at run time.

You can determine the location of "top of memory" with a simple routine that examines the data area. The number of elements that will fit in memory is determined by subtracting the address of the first element of the array from top of memory (see listing 2). If you dimension the array at compile time with 8200 elements, it will span more than one segment, so that MS-FORTRAN will generate the proper code when calculating the array indexes.

You can successfully apply this method to most programs that require some degree of dynamic runtime allocation of memory. Unfortunately, it works only for one single array and does nothing to solve the problem of not having enough RAM. Also, it prevents using the program in a multitasking environment.

When the different methods of reducing storage needs still leave a stiffness matrix too big to fit in RAM, it is time to think about extending the amount of memory available to the program. One way of doing it is to use the disk drives as a (slow) emulator for RAM in a mechanism, sometimes called "virtual memory," that is the reverse image of the popular RAM disk, which uses RAM to emulate a disk drive.

The first step in setting up the virtual-memory mechanism is to determine how much space you need on the disk and create a random access file of the proper size. After that, every time an element of the stiffness matrix needs to be accessed (read or written), the program will have to check whether it resides in RAM or in the disk file and act accordingly.

Because disk access is slow compared with memory access, you should minimize the number of disk accesses you use throughout the program. Careful examination of the way the stiffness equations are solved pays off in solution-time savings.

The solution of the system is pro-

(continued)

Listing 1: *The linker listing showing the location of free memory that starts at segment* HIMEM, *after the last common block.*

```
 Start  Stop   Length Name                            Class
 00000H 072C9H 072CAH SAFES_                          CODE         ---
 072CAH 0B3B2H 040E9H PARSF_                          CODE          |
 0B3C0H 0B914H 00555H CSLOGD                          CODE          |
 0B920H 0B947H 00028H CSDSKS                          CODE          |
 0B950H 0B977H 00028H CSUPCS                          CODE          |
 0B980H 0B9D3H 00054H CSCONS                          CODE          |
 0B9E0H 0BA00H 00021H CSSETS                          CODE          |
 0BA10H 0BA42H 00033H CSMEMA                          CODE          |     Program
 0BA50H 0BA75H 00026H CSEXPS                          CODE          |      code
                        .                                           |      area
                        .                                           |
                        .                                           |
                        .                                           |
                        .                                           |
 14AADH 15498H 009ECH MATHCODE                        CODE          |
 154A0H 154D3H 00034H INTRQ7                          CODE          |
 154E0H 15677H 00198H OEMR87                          CODE          |
 15680H 15864H 001E5H INTRQ7                          CODE         ---
 15870H 15870H 00000H HEAP                            MEMORY       ---
 15870H 15870H 00000H MEMORY                          MEMORY        |
 15870H 15A6FH 00200H STACK                           STACK         |      Data
 15A70H 232C7H 0D858H DATA                            DATA          |     segment
 232C8H 232D0H 00009H EINQQQ                          DATA          |      area
 232E0H 2331FH 00040H COMADS                          COMADS        |
 23320H 24993H 01674H CONST                           CONST         |
 24994H 249C3H 00030H TRANS                           CONST        ---
 249D0H 249DFH 00010H SIZEBW$A                        $SIZEBW      ---
 249E0H 2BF4FH 07570H PLATES$A                        $PLATES       |
 2BF50H 2BF7FH 00030H GLOBAL$A                        $GLOBAL       |
 2BF80H 2E4FFH 02580H FORCES$A                        $FORCES       |     Common
 2E500H 2E59FH 000A0H FILENM$A                        $FILENM       |     blocks
 2E5A0H 2E5AFH 00010H DSKROM$A                        $DSKROM       |
 2E5B0H 2F23FH 00C90H COORDI$A                        $COORDI       |
 2F240H 3F23FH 10000H AAAAAA$A                        $AAAAAA       |
 3F240H 3F27FH 00040H AAAAAA$B                        $AAAAAA      ---
 3F280H 3F280H 00000H HIMEM                           HIMEM        ---    High memory:
                                                                    |      expandable
 Origin   Group                                                     |     dynamically
 0E15:0   CGROUP                                                   \|/
 149D:0   DGROUP                                                    "

Program entry point at 0E2D:0029
```

Listing 2: MEMAVA.ASM, *a routine that determines the number of elements that will fit in the remaining memory.*

```
TITLE MEMAVA - FUNCTION TO DETERMINE HOW MUCH MEMORY CAN BE ADDED
PAGE ,132

; (C) Copyright by Microstress Corporation 1985, 1986
; Written by Fernando Garcia-Loygorri

COMMENT *
        MEMAVA is a routine designed to be called from FORTRAN as a function
        to determine how much memory is available to the last common block as
        dynamic memory.

        Mode of use:
                            size = MEMAVA (var)
        where
                var = variable name of the last array in the last common block.
                size = name of the 4-byte integer variable receiving the return
                       value.
```

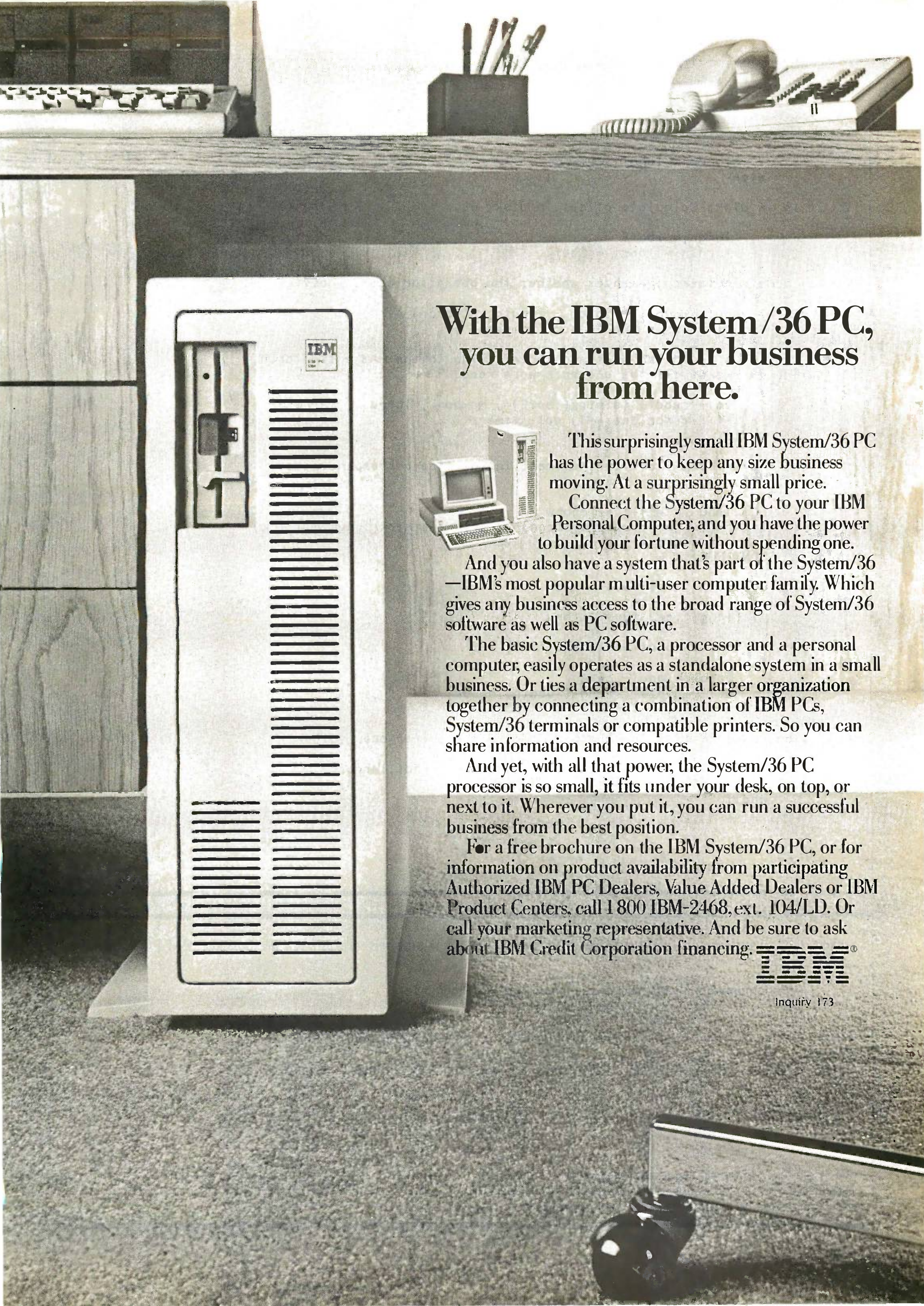
(continued)

```
        *

SUBTTL FORMAL DECLARATIONS
PAGE

csmema  SEGMENT 'CODE'
        ASSUME  CS:csmema

SUBTTL MEMAVA - EXECUTABLE CODE
PAGE

PUBLIC  MEMAVA
memava  PROC   FAR

        PUSH BP                         ; Save registers.
        MOV BP,SP
        PUSH DS
; Get total amount of room in machine.
        mov ax,40h                      ; Point to the location in memory where
        mov ds,ax                       ; DOS keeps the total amount of memory:
        mov bx,13h                      ; Segment 40h, offset 13h-14h.
        mov ax,[bx]                     ; Get number of K in AX.
        mov cl,6                        ; Multiply by 64 to get total number
        shl ax,cl                       ; of paragraphs (groups of 16 bits).
; Get address of parameter from program.
        LDS BX,DWORD PTR [BP+6]         ; Address of the parameter.
        mov dx,ds                       ; Store the segment to add later.
        mov cl,4                        ; Divide by 16 to get the number of
        shr bx,cl                       ; paragraphs in the offset.
        inc bx                          ; Increment for the one partially used.
        add dx,bx                       ; Add it to the segment.
        sub ax,dx                       ; Substract it from the total.
; Convert to words in DX:AX because that is where FORTRAN expects the return of
; a 4-byte integer.
        push ax                         ; Save it for later.
        mov cl,13                       ; Set to isolate top 3 bits.
        shr ax,cl                       ; Isolate them by shifting.
        mov dx,ax                       ; Move them to DX.
        pop ax                          ; Recover it.
        mov cl,3                        ; Multiply by 8 (words/paragraph) by
        shl ax,cl                       ; shifting 3 places.
; Everything done except housekeeping.
        POP DS                          ; Recover the registers saved.
        MOV SP,BP
        POP BP
        RET 4                           ; Discard the input parameter.

memava  ENDP
csmema  ENDS

END
```

Listing 3: *An example of the method used to read elements from the disk one matrix line at a time, process all the terms in that line, and return the values to the disk file in one loop of code.*

```
                                   .
                                   .
                                   .
                                   .
                                   .
C
C  Check if the degree of freedom "I" is in RAM or in disk.
C
         longl = maxban * j  +  longi
         if (longl .lt. ibuf1) then
C
C  It is in RAM: Copy pointer only.
C
```

*(continued)*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```
               longn = longl
            else
C
C  It is in disk: Calculate offset in disk, ...
C
               longn = ibuf2
               locatn = longl - ibuf1
C
C  ... update pointer and check whether the operation was successful ...
C
               call movpfl (ihandl , locatn , ierror)
               if (ierror .ne. 0) call vmmerr
C
C  ... and move an entire stiffness matrix line to the RAM buffer area,
C  making sure that all the elements were read.
C
               call readfl (stmtrx(ibuf2) , maxban , ihandl , ierror)
               if (ierror .ne. -1) call vmmerr
            endif
C
C  Operate over each individual element in the line corresponding to
C  d.o.f. "I".
C
            DO  1130  k = j+1 , lenhbw
            stmtrx(longn) = stmtrx(longn) - ratio * stmtrx(longm - 1 + k)
            longn = longn + 1
 1130       CONTINUE
C
C  If the d.o.f. "I" resides in disk...
C
            if (longl .ge. ibuf1) then
C
C  ... point to its location in the file, ...
C
               locatn=longl-ibuf1
               call movpfl (ihandl,locatn,ierror)
               if (ierror .ne. 0) call vmmerr
C
C  ... and save to file the changes made to the buffer area values.
C
               call writfl (stmtrx(ibuf2),maxban,ihandl,ierror)
               if (ierror .ne. 0) call vmmerr
            endif
                              .
                              .
                              .
                              .
                              .
```

Table 1: *Comparison of execution times for Microsafe 2-D and 3-D programs. (Times given are from the IBM PC's internal clock.)*

Performance of Microstress Finite-Element-Analysis Programs
on IBM PC Machines

| Finite-Element Model | # Nodes | # Beams | # Plates | # Fasteners | Solution Type | Solution Times in Sec. PC | PC XT 8087 | PC AT 80287 |
|---|---|---|---|---|---|---|---|---|
| Splice | 30 | 0 | 16 | 3 | 2D-Double | 96 | 47 | 16 |
| Apframe | 98 | 159 | 50 | 0 | 2D-Double | 479 | 256 | 83 |
| Lug | 247 | 24 | 222 | 0 | 2D-Single | 2500 | 792 | 320 |
| Wing | 91 | 36 | 132 | 0 | 3D | 12278 | 2429 | 1090 |

2D-Single refers to the single-precision version of Microsafe 2-D.
2D-Double refers to the double-precision version of Microsafe 2-D.
3D-Double refers to the three-dimensional Microsafe 3-D.

*Time savings also result due to the simplicity of the finite-element model.*

grammed by executing a series of nested loops that sweep through the lines and columns of the stiffness matrix. That is, the elements of a line are needed sequentially, and thus it saves time to read them from disk one entire line of the matrix at a time, process all the terms in that line, and then return all the values to the disk file in a single code loop. Listing 3 shows an actual example of this method.

### TIME AND TIME AGAIN

The time savings involved are significant, because instead of making $2 \times b$ disk accesses per line (where $b$ is the bandwidth of the stiffness matrix), the program makes only two. The efficiency of the method increases dramatically in models with a large bandwidth, which happen to be the ones most in need of a virtual-memory mechanism, nicely proving their mutual support.

The use of microcomputers produces significant time savings. While sophisticated mainframe computers can solve problems more quickly than microcomputers can, you must usually wait for the results to be available in printouts or plots while the job goes through batch processing. The actual results may not be available to the engineer for hours or days. IBM PCs run the solutions for two-dimensional problems, like the one in this article, in a few minutes, and the results are available immediately. Of course, an 8087 coprocessor or an IBM PC AT with an 80287 coprocessor would cut execution times by a factor of from 3 to 11 (see table 1).

Time savings also result due to the simplicity of the finite-element model. It is straightforward to construct and once it is complete, you can calculate many load conditions with very little additional work. ■


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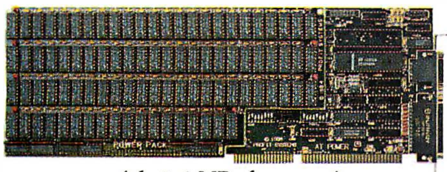

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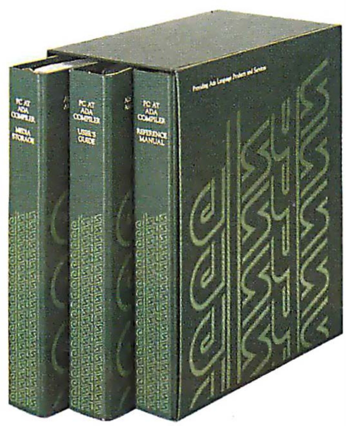


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# STRESS ANALYSIS

BY D. LEE PETERSEN AND STEVEN L. CROUCH

## *A coupled boundary-element/finite-difference method*

OUR TECHNIQUE for stress analysis of underground mine layouts uses two different methods for solving the governing differential equations. The boundary-element method is used to determine the far-field stresses and displacements, and the finite-difference method is used to determine the near-field stresses and displacements. Although our specific area of discussion is stress analysis, this technique should be of interest to anyone working in the physical sciences who must obtain numerical solutions to problems in infinite or semi-infinite regions.

Within the field of mining engineering, you must design an underground mine to ensure safe and stable conditions for extracting the valuable ores. The geometry of a typical coal mine is illustrated in figure 1. The coal seam in our example is located some distance below the earth's surface (500 feet is typical) and has a thickness adequate for excavation equipment (7 feet, for example). A regular pattern of tunnels is excavated in the seam, and the excavated coal is transported to the surface for processing and use.

Prior to excavation, the full weight of the overburden rocks rests on the coal seam. At a depth of 500 feet, the vertical stress resulting from the overburden rocks would be approximately 500 pounds per square inch. Upon excavation of the tunnels, the coal remaining in the seam must support the overburden. The average vertical stress acting on the remaining seam increases in direct proportion to the amount of coal excavated. For example, if 50 percent of the seam were excavated, the average vertical stress would increase to 1000 psi. Stress concentrations in the coal seam and nearby rocks cause localized stresses to be higher than the average stress in some areas and lower in others. Clearly, you must limit the proportion of coal that is excavated to prevent unsafe conditions. Stress-analysis techniques allow the design engineer to determine the stress concentrations resulting from different extraction percentages. For further discussion of mine design techniques, see reference 1.

### METHODOLOGY

In designing an underground coal mine, the mining engineer must select the dimensions of the mine layout (e.g., pillar width, pillar height, tunnel width) and any man-made support or reinforcement required. In a wider context, design of any engineered structure involves the assessment of two factors—the forces acting on the structure and the ability of the structure to carry those forces. In the simplest case, the forces on a structure may be known and fixed, while in more complex situations, the forces depend on the response of the structure. The action of the forces is to deform the structure and yield a new distribution of stress and displacement within it. The stresses and displacements must be controlled within specific limits that are based on experience with the material that makes up the structure.

*(continued)*

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*Steven L. Crouch (Department of Civil and Mineral Engineering, University of Minnesota, Minneapolis, MN 55455) is a professor in geo-engineering at the University of Minnesota and a consultant in rock mechanics. He has a Ph.D. in mineral engineering.*

The analysis of stresses and displacements must consider applied forces, the geometry of the structure, and the mechanical properties of the material. In the terminology of differential equations, it is a *boundary-value* problem. That is, we know the values of forces, or displacements, on the boundaries, and we would like to determine the internal stresses and displacements that result.

A variety of differential equations must be solved for specific boundary-value problems. There are three common techniques to do this—direct solution by mathematical analysis, experimental methods such as photoelasticity, and approximate solutions obtained by numerical methods. With the widespread use of computers, numerical techniques have become increasingly popular, with many stress-analysis computer programs now being available for microcomputers. In general, numerical techniques allow stress analysis of complex geometries and material response that is beyond the scope of the analytical and experimental methods. (Reference 2 is a good source of information on numerical techniques applied to problems in the geosciences.)

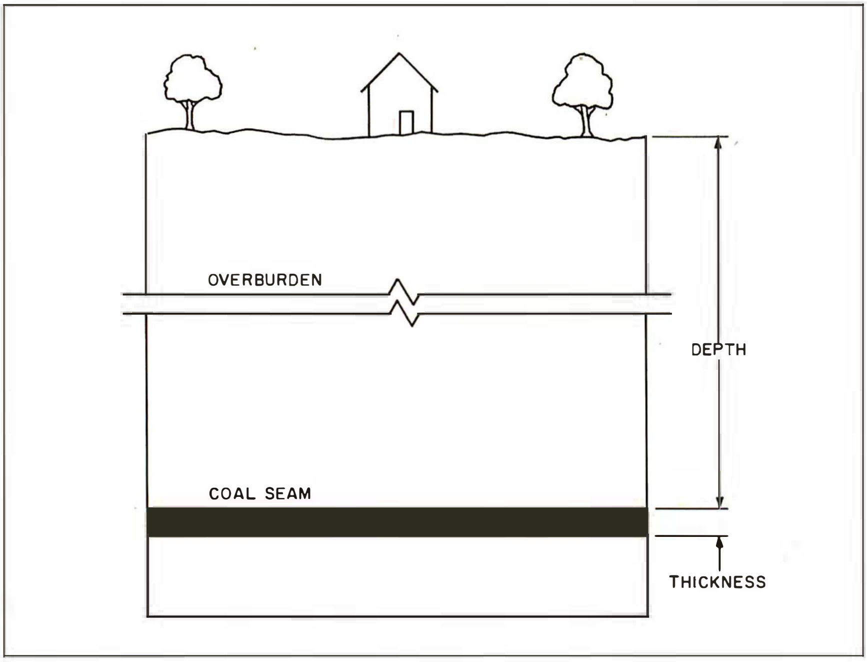


Figure 1: *The geometry of a typical coal mine.*

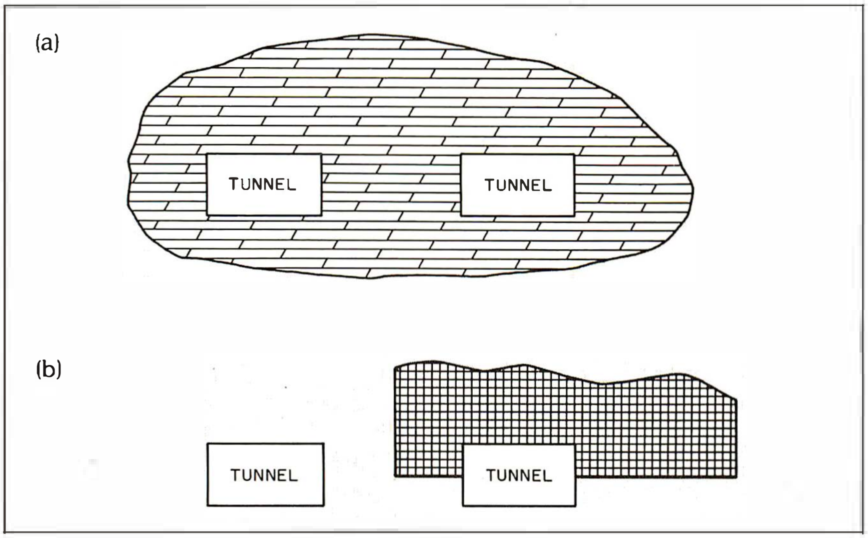


Figure 2: *An illustration of either* FE *or* FD *methods for a single coal-mine geometry; (a) shows a simple two-tunnel one-pillar problem; (b) displays the* FE *or* FD *mesh that subdivides the coal pillar and adjacent roof and floor rocks into elements.*

## Rationale for a Hybrid Model

The coal-mine stress-analysis problem in our example requires a numerical technique to achieve adequate results. Having selected numerical techniques in general, you must now select a specific numerical model. You can choose from distinct categories of continuum models: differential methods such as the finite-element (FE) or finite-difference (FD) methods; integral methods such as the direct-boundary integral-equation method (BIEM); or one of the indirect methods, fictitious-stress (FS) or displacement-discontinuity (DD) (see reference 3). Each method has specific advantages and disadvantages; the best choice depends on the characteristics of the physical problem to be modeled.

With the differential methods, you subdivide the region to be modeled into elements, or zones, the fineness of the mesh depending on the scale of the problem and the local accuracy required. In contrast, the integral methods require that only the boundaries of the region be subdivided.

You can apply all five of the methods mentioned above to the coal-mine geometry in our example. Figure 2 illustrates the use of either the FE or FD methods for a simple two-tunnel geometry (figure 2a). In figure 2b, the coal pillar and adjacent roof and floor rocks have been subdivided into elements. One vertical and one horizontal line of symmetry have been used in preparing the mesh. The FE and FD methods have been widely applied to mining geometries such as this because these methods can deal with different rock materials within the region, including

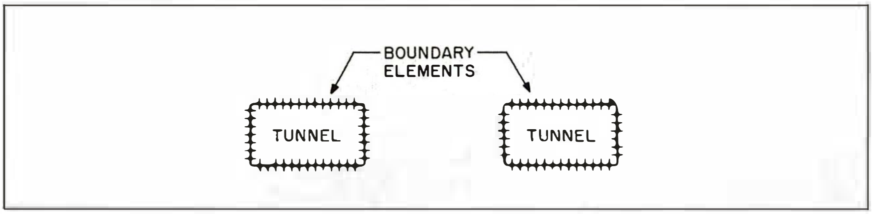


**Figure 3:** A BIEM *representation of the two-tunnel geometry.*

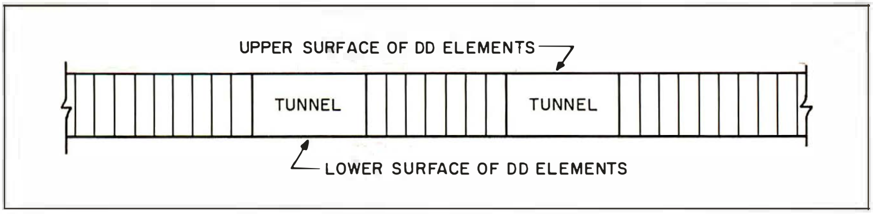


Figure 4: A DD *representation in seam-element mode. A single* DD *element is used for both the upper and lower surfaces of the coal seam.*

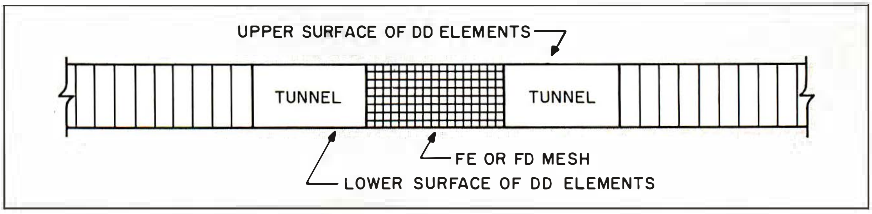


**Figure 5:** A *representation of the hybrid* DD/FD *model.*

nonlinear or inelastic rock behavior. However, there is commonly a practical limitation on the number of elements allowed by a specific program, so you must set an arbitrary limit on the size of the modeled region. The differential methods are most appropriate for the stress analysis of a single tunnel or an extensive array of tunnels.

Figure 3 illustrates application of the BIEM method to the two-tunnel geometry. The boundary of each excavated tunnel is subdivided into elements, the number of which depends on the computer program and the local accuracy required. Figure 3 shows a typical element size for this problem. The lines of symmetry used in developing the FE or FD mesh could have been used to reduce the number of boundary elements.

The BIEM and FS methods have been used to model coal-mine problems as well, although not as extensively as the FE or FD methods. Both techniques have the advantage of representing an infinite region automatically; you don't have to place arbitrary limits on the region modeled. However, the BIEM and FS methods are normally limited to homogeneous, elastic materials.

You can use the DD method in two different modes for the stress analysis of a coal-mine layout. First, you can use it, as the BIEM and FS methods were used, to outline each excavation with elements. This approach, however, offers no advantage over the BIEM or FS methods. Second, you can use the DD method in the "seam-element" mode. In this mode, you use a single DD element to represent both the upper and lower surfaces of the coal seam (see figure 4). Such an approach loses detail within the seam pillars because it ignores their height, but it allows you to model a large-scale mine geometry economically. The seam-element mode of DD modeling is not appropriate if you need detailed knowledge of the stresses and displacements within pillars. For problems on a larger scale, where the relative displacements between the upper and lower seam surfaces control the stress distribution away from the excavation, you can use the seam-element mode and ignore the thickness of the seam.

Development of the hybrid model arose due to the limitation of the seam-element DD approach. Seam elements use a rough approximation for mine pillars that yields little more than the average vertical stress acting on the seam. To overcome this limitation, the DD method, which economically represents the rock materials away from the seam, was coupled with one of the differential methods used to represent the pillars (see figure 5). The coal pillars are subdivided in the same manner as in figure 3, and single DD elements are used to represent both seam surfaces along the entire portion of the seam. (The portion of the physical problem represented by the FE or FD method is not limited to the coal pillar; the FD mesh may extend into the roof and floor rocks as desired.) With the hybrid model, the extent of the region represented by the differential method is smaller for a given problem, and the correct boundary conditions are achieved over the height of the pillars. The relative economy of the DD seam method is maintained, but you can determine detailed pillar-stress distributions and incorporate inhomogeneous and nonlinear material behavior into the FE/FD region where such behavior is most important and most likely to occur.

The FD method was selected for coupling with DD seam elements to create the hybrid model. This choice, while somewhat arbitrary, was primarily based on the relatively simple input and small memory needs of the FD method. And, although both the FE and FD methods can model nonlinear material behavior, modifications to the FD method to accommodate such behavior are relatively simple.

## THE HYBRID COMPUTER MODEL

The DD and FD methods are based on the same three governing equations common to all boundary-value

*(continued)*

problems in solid mechanics: the differential equations of motion (based on Newton's second law), a constitutive law that relates strains to stresses, and a kinematics law that defines strains in terms of displacements. In this article we will discuss only two-dimensional plane strain problems of isotropic, linear elasticity. As a result, the governing equations are simplified, and a specific constitutive law—Hooke's law—is used (see the text box "The Governing Equations" on page 230). Our model of the mining problem is called quasi-static: Although the physical problem changes with time, those changes are sufficiently slow that you can neglect inertial effects. Nevertheless, for reasons that will become apparent, we will use the equations of motion (rather than the equations of equilibrium) to formulate the FD method. The DD method, on the other hand, uses the equations of equilibrium. At this point, therefore, the formulations of the DD and FD methods diverge.

## FORMULATION OF THE DD MODEL

Development of the DD model involves considerable mathematical analysis. This analysis yields equations for the three stresses and two displacements at any point in an elastic body due to the influence of a DD element located at the origin of the coordinate system (see reference 3, page 81). Figure 6 illustrates such an element; you can think of it as a line crack existing in the body. If you consider the displacements on the top and bottom surfaces of the element, you will find that the displacements "jump," or are discontinuous, across the crack. The values by which they jump are called the displacement discontinuities and are given the symbols $D_x$ and $D_y$.

The equations for the stresses and displacements resulting from a DD element with components $D_x$ and $D_y$ are a powerful stress-analysis tool. To illustrate, let's develop a simple computer program (based on only one of the stress equations) that provides a numerical solution to the problem of a pressurized crack in an elastic body. From a physical viewpoint, you expect that a crack will expand or open if it is pressurized; the numerical model allows you to calculate the shape of the crack as a function of the pressure, the crack length, and the elastic properties of the host material. The problem of a pressurized crack is numerically similar to the coal-seam stress-analysis problem, and you can easily extend the computer program to solve simple seam problems.

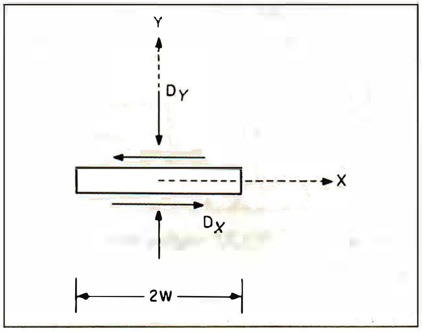


Figure 6: A *single* DD *element of length* 2*W*, *such as a line crack in the body.*

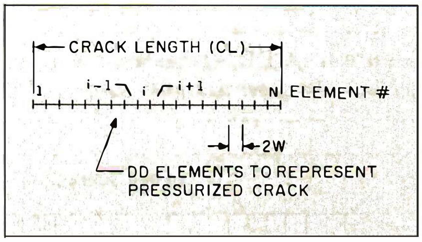


Figure 7: A DD *representation of a pressurized crack divided into N boundary elements of uniform length* 2*W*.

You divide the pressurized crack into $N$ boundary elements of uniform length $2W$ (see figure 7), each of which has constant, but at this point unknown, $D_x$ and $D_y$ values. From the symmetry of the crack in the $y$ direction you can conclude that all $D_x$ components are zero. You specify an internal pressure $P$ for the crack that must be met at the midpoint of each boundary element.

To complete the computer model, you select the DD-element stress equation that calculates the vertical normal stress ($\sigma_{yy}$) at a point as a function of the $D_y$ component of the element (see reference 3). You can simplify the original equation because you require all elements to lie in a straight line and have the same length. If the elements are numbered 1 through $N$ from left to right, then the stress at the $i$th element as a function of the $D_y$ component at the $j$th element is

$$\overset{i}{\sigma}_{yy} = \frac{-G}{\pi w(1-\nu)} \; \frac{1}{4(j-i)^2-1} \; \overset{j}{D}_y$$

where G and $\nu$ are the shear modulus and Poisson's ratio of the elastic body. You must add the influence of all $N$ elements to determine the total stress at element $i$, which you require to be $P$:

$$\overset{i}{\sigma}_{yy} = P = \sum_{j=1}^{N} \overset{ij}{A} \, \overset{j}{D}_y$$

where:

$$\overset{ij}{A} = \frac{-G}{\pi w(1-\nu)} \; \frac{1}{4(j-i)^2-1}$$

The second of these three equations defines a system of $N$ linear algebraic equations, where $P$ and the $\overset{ij}{A}$ coefficients are known and the $D_y$ components are unknown.

Listing 1 contains PCRACK.BAS, a Microsoft BASIC program that uses the above formulation to solve the pressurized-crack problem. [*Editor's note*: PCRACK.BAS *is available in source code in a variety of formats. See pages 459–461 for details.*] The input data is the crack length and pressure, element size, and material properties of the elastic body. Lines 1000 to 1210 give usage notes, define array sizes, read model-definition data, and initialize constants. Lines 1220 to 1270 set up the DY(I) and A(I,J) arrays; line 1250 evaluates the third equation above. Note that we have not used an array for the crack pressure, P. In the pressurized-crack problem, all elements have the same pressure P, so you don't need an array. In the coupled DD/FD model, however, each element will have a different P and therefore must be stored in an array.

Lines 1290 to 1470 solve the system of equations using the Gauss-Seidel method with overrelaxation (see reference 4). The Gauss-Seidel method is an iterative technique for solving systems of equations in which successively better estimates for the

*(continued)*

Listing 1: PCRACK.BAS, *a* Microsoft BASIC *program using the* DD *method to solve the pressurized-crack problem.*

```
1000 REM -----------------------------------
1010 REM          PROGRAM PCRACK
1020 REM -----------------------------------
1030 REM       PROGRAM USAGE NOTES
1040 REM       (1) USE CONSISTENT PHYSICAL UNITS
1050 REM       (2) NUMBER OF ELEMENTS <= 30
1060 REM -----------------------------------
1070 DEFINT I-N
1080 OPTION BASE 1
1090 DIM A(30,30),DY(30)
1100 REM ---------------------------------- READ BASIC MODEL PARAMETERS
1110 INPUT "CRACK PRESSURE, CRACK LENGTH, NUMBER OF ELEMENTS";P,CL,N
1120 W=CL/(2!*N)
1130 INPUT "MATERIAL PROPERTIES - G,PR";G,PR
1140 REM ------------------------------------------------ SET CONSTANTS
1150 PI=3.14159
1160 CON=-G/(PI*W*(1!-PR))
1170 REM --------------------------- GAUSS-SEIDEL ITERATION PARAMETERS
1180 TOL= .00001
1190 ITMAX=2*N
1200 OMEGA=1.3
1210 REM -------------------------- INITIALIZE DY AND COMPUTE A MATRIX
1220 FOR I=1 TO N
1230      DY(I)=0!
1240           FOR J=1 TO N
1250                A(I,J)=CON/(4!*(J-I)^2 - 1!)
1260          NEXT J
1270 NEXT I
1280 REM ------------------ SOLVE EQUATIONS BY GAUSS-SEIDEL ITERATION
1290 FOR NUM = 1 TO ITMAX
1300      ERRMAX=0!
1310           FOR I=1 TO N
1320                TEMP=0!
1330                     FOR J=1 TO N
1340                          TEMP=TEMP+A(I,J)*DY(J)
1350                     NEXT J
1360                TEMP=(P-TEMP)/A(I,I)
1370                DY(I)=DY(I)+OMEGA*TEMP
1380                ERRI=ABS(TEMP)
1390                IF ERRI > ERRMAX THEN ERRMAX=ERRI
1400           NEXT I
1410      IF ERRMAX <= TOL THEN GOTO 1460
1420      PRINT USING"ITERATION, MAXIMUM ITERATE ## #.######";NUM;ERRMAX
1430 NEXT NUM
1440 PRINT "ITERATION PROCESS DID NOT CONVERGE AFTER";ITMAX;" ITERATIONS!"
1450 STOP
1460 REM --------------------------------------------------- PRINT RESULTS
1470 PRINT "ELEM CRACK OPENING CRACK OPENING COMPUTED STRESS"
1480 PRINT "      (NUMERICAL)    (ANALYTICAL)"
1490 DELB=CL/N
1500 X=-(CL+DELB)/2!
1510 B=CL/2
1520 CON=2!*(1!-PR)*P*B/G
1530 FOR I = 1 TO N
1540      SIGYY=0!
1550           FOR J = 1 TO N
1560                SIGYY=SIGYY+A(I,J)*DY(J)
1570           NEXT J
1580      X=X+DELB
1590      DD=CON*SQR(1!-(X^2/B^2))
1600 PRINT USING" ##     ##.####       ##.####   ######.#";I;DY(I);DD;SIGYY
1610 NEXT I
1620 END
```

unknowns are calculated. In the pressurized-crack problem, we could have used a direct method of solution, such as Gaussian elimination. However, the iterative Gauss-Seidel procedure is important to the coupled DD/FD model, and we have chosen it here to illustrate its use. The boundary condition P is applied in line 1360, and the new DY(I) estimate is calculated in line 1370.

In the coupled model, the P values for each element may change from step to step. With a direct method of solution such as Gaussian elimination, you would have to solve the equations from scratch each time a P value changed. However, the Gauss-Seidel method allows the P value for each element to change (see line 1360). The DY(I) values from the previous solution are good estimates for the new solution if the changes in P are small, so you need relatively few iterations to achieve a new solution.

Lines 1480 through 1620 print, for each element, the computed value of DY, the analytic solution for the displacement discontinuity (obtained from a well-known formula), and the stress computed from the second equation. (The last quantity provides a check on the accuracy of the numerical solution, because the stress at each element should be equal to P.) We recommend that you run the program for different numbers of elements to determine when you achieve adequate agreement with the analytic solution.

### FORMULATION OF THE FD MODEL

The FD model, in this case, has closer ties to the physical problem and the governing equations than does the DD model. You apply the equations, with little modification, directly to a mesh of zones and grid points established in the body to be modeled. An explicit, or "time-marching," solution scheme is used, although the time variable has no relevance in the final solution to the problem.

Figure 8a illustrates a portion of a typical FD mesh that consists of arbitrary quadrilaterals (zones) with a grid point at each zone corner. Stresses are associated with the centroids of zones, while displacements, velocities, and accelerations are associated with grid points. The elastic properties of the body are assigned to zones, but the mass of the body is assumed to be concentrated at the grid points.

Both the differential equations of motion and the definitions of strains in terms of displacements contain partial derivatives. Although there are no functions to differentiate, there are function values (stresses, strains, and displacements) at the zone centroids and grid points. You can estimate a partial derivative by summing, for each side of a polygon, the average function value times geometric properties of the polygon side. Using this approximation, all partial derivatives in the governing equations are re-

(continued)


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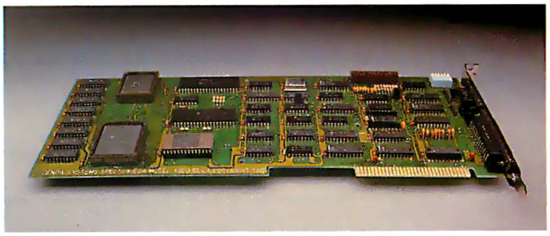

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placed by sums of stress or displacement values times the geometric properties of the FD mesh.

The calculation sequence consists of repeatedly applying the governing equations while updating the stress and displacement components of the mesh after each calculation. Each iteration begins by applying the equation of motion. The sequence assumes that you will use sufficiently small time steps so that the stresses remain constant during this portion of the calculation. For each grid point, stresses from adjacent zones are summed to determine the out-of-balance forces, which cause the grid point to accelerate according to its mass (Newton's second law). The acceleration is integrated twice in time to achieve first, the new grid-point velocity (by multiplying by the time step), and then, the new displacement. Next, you assume that all velocities and displacements are constant, and, using the definition of strain in terms of displacement, calculate new strains for each zone. Finally, the strains are used, via the constitutive law, to calculate new stresses. The entire calculation process then repeats, starting with the equations of motion.

Figure 8b illustrates this FD calculation sequence. Due to the nature of the algorithm, the equations-of-motion calculations for the grid points are entirely independent of the strain-and-constitutive-law calculations for the zones. Boundary conditions are applied either during the equations-of-motion calculation (if displacement conditions are specified) or during the constitutive-law calculation (if stress conditions are specified). This independence of the two phases of the FD calculation is important to the FD-to-DD linkage.

Other calculations also occur during each cycle. The grid-point velocities must be damped to remove mechanical energy from the system so that a quasi-static solution is achieved. And the mesh geometry must be periodically updated if the grid-point displacements are sufficiently large to cause significant changes in the geometric properties of the mesh.

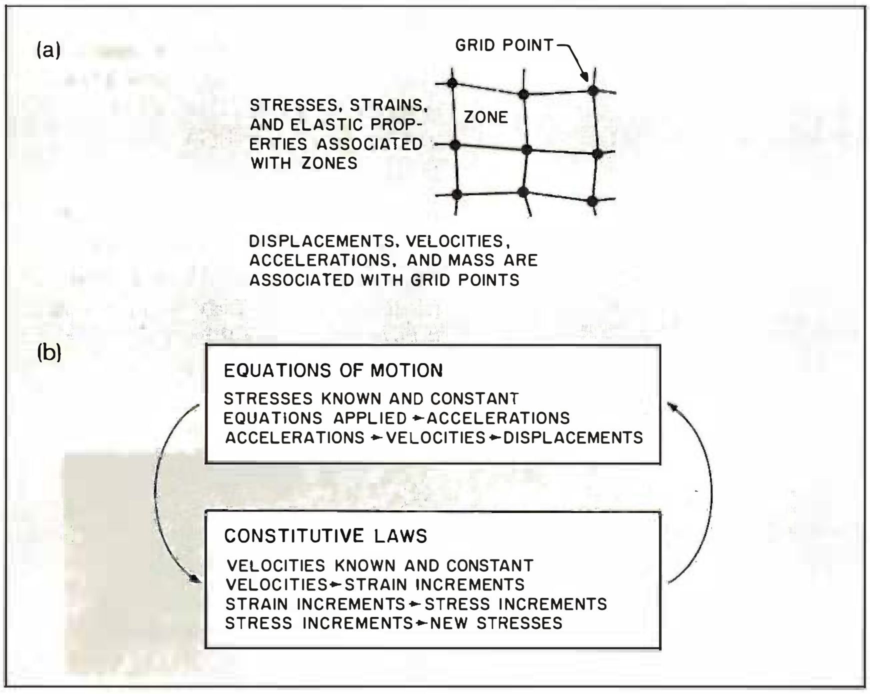


**Figure** 8: *Details of the FD method; (a) shows a portion of a typical FD mesh consisting of arbitrary zones with a grid point at each corner; (b) illustrates the FD calculation sequence.*

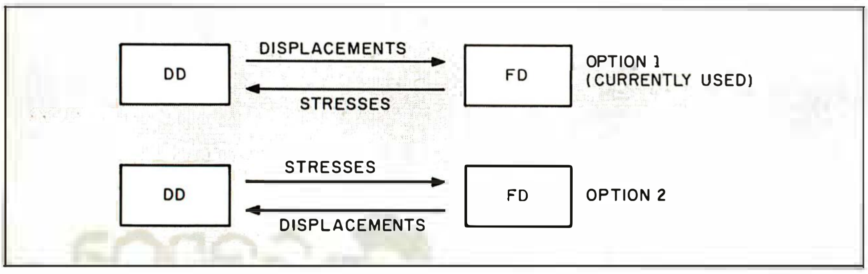


**Figure** 9: *Coupling options for the hybrid DD/FD model.*

## Coupling the Models

As shown in figure 5, the hybrid DD/FD model is achieved by linking an FD model of a pillar region between the surfaces of a seam modeled by DD elements. At the contacts between the two regions, you must ensure that the stresses and displacements are continuous, as they are in the physical problem. This continuity requirement provides boundary conditions for both constituent parts of the hybrid model.

Because both the DD and the FD models use iterative methods of solution, it is relatively easy to couple them. You use the results from an iteration of the DD model as boundary conditions for the FD model. Iteration of the FD model then provides boundary conditions for the DD model, and so on. There are two alternatives for the linking procedure, both illustrated in figure 9.

With the first option, the DD model cycles through one or more iterations of the Gauss-Seidel solution procedure yielding new displacement-discontinuity components for each element. These DD components are converted to displacements and applied as boundary conditions to the FD model grid points that are linked to DD elements. The FD calculation procedure executes one or more cycles causing deformation of the mesh and new stresses in each of the

*(continued)*

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zones. The stresses in the zones adjacent to the DD seam surfaces are converted to the form needed by the DD model and used as new boundary conditions—new P values in analogy to the pressurized-crack program. The DD model then cycles through one or more Gauss-Seidel iterations to start the overall procedure again. With this approach, the DD model provides displacement boundary conditions to the FD model, which in turn provides stress boundary conditions to the DD model.

With the second option, you need a different formulation of the DD model, one in which the displacement-discontinuity components are the known quantities, and the stress conditions at each element are the unknowns. Each iteration of the Gauss-Seidel procedure yields new estimates of each element's stress components, which are applied to the DD seam surfaces. Again, one or more cycles through the FD solution procedure are performed causing deformation of the mesh and new displacements at each of the grid points. The displacements at grid points linked to DD elements are used as boundary conditions for the DD model, and one or more Gauss-Seidel iterations are performed again. With this approach option, the DD model provides stress boundary conditions to the FD model, which in turn provides displacement boundary conditions to the DD model.

We have chosen the first option, with the DD model providing displacement boundary conditions, and the FD model returning stress boundary conditions because it uses the common "seam-element" formulation of the DD model. However, applying displacement boundary conditions to the FD model (as we have formulated it) leads to numerical problems in some instances. It is possible to subtract out the errors by performing correction calculations every several cycles through the FD sequence.

## A Hybrid Model Example

Let's return to the coal-mine-seam example and apply the hybrid DD/FD model to a real problem. We will model the simple two-tunnel, one-pillar geometry of figure 2a, with the pillar represented by an FD mesh. Figure 5 illustrates how the seam surfaces and pillar were subdivided into DD elements and FD zones. There were 72 DD elements placed along the seam surfaces, and the pillar was divided into a 6 by 12 FD grid. Although the problem is symmetric about the vertical centerline of the pillar, the full problem was modeled. Note that the seam elements are extended past the tunnels on each side; enough elements must be provided so that the last element on each side has nearly zero closure (relative movement between the top and bottom of the seam) in the final solution. Standard DD seam elements have been used to represent the unmined portions of the seam outside the tunnels.

Figure 10 shows the results of the DD/FD calculation, a plot of the DD/FD mesh showing the deformed shape of the pillar and seam. The deformations have been enlarged to accentuate the deformed shape. The greatest deformation occurs in the tunnels, where the seam surfaces have undergone significant closure. Note also that the pillar has compressed vertically and, due to the Poisson effect, expanded laterally.

The results shown in figure 10 indicate that the coupled DD/FD model gives detailed information within the pillar, as desired, while automatically incorporating the elastic response of the surrounding rock mass. The model exploits the advantages of both the DD and FD methods, without the drawbacks of either.

## Summary

The stress analysis of the geometries found in underground mining engineering is a relatively narrow application, but the nature of the problem that led us to develop the hybrid computer model is common to other disciplines in the physical sciences. Hybrid boundary-element/finite-element programs are reported in the technical literature of mechanical engineering, rock mechanics, soil mechanics, and groundwater mechanics.

Our technique is unique in that it uses one of the indirect boundary-element methods coupled with an explicit differential method. This approach offers particular advantages in some phases of this problem, particularly the seam-element representation of the DD method.

The coupled DD/FD computer program is relatively small and quick to run, if you restrict problems to a single, planar seam divided into elements of uniform size. One version of the coupled program, written in FORTRAN and incorporating all the features described in this article, fits easily into the 95K bytes of available RAM on a 128K-byte CP/M-86 system. This microcomputer version of the program allows 200 DD elements and 200 FD zones. Problems such as the example above run in under an hour on this system with no 8087 chip. Significantly larger problems run much faster on the newer microcomputers.

The real payoff of the coupled model occurs in problems more complex than our example, specifically two- and three-dimensional problems in which rock failure occurs. Solving two-dimensional, nonlinear problems using FE techniques alone typically

*(continued)*

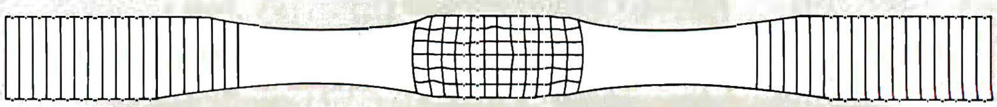

Figure 10: *A plot of the results of the hybrid DD/FD model.*

# THE GOVERNING EQUATIONS

The governing equations for two-dimensional isotropic plane-strain problems in linear elasticity fall into three groups: equations of motion based on Newton's second law, definition of the strain components in terms of displacements, and Hooke's law. The following sets of equations adopt the solid-mechanics sign convention with tensile stresses taken as positive.

Equations of motion:

$$\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{xy}}{\partial y} + \beta_x = m\ddot{u}_x$$

$$\frac{\partial \sigma_{xy}}{\partial x} + \frac{\partial \sigma_{yy}}{\partial y} + \beta_y = m\ddot{u}_y$$

Strain components:

$$e_{xx} = \frac{\partial u_x}{\partial x}$$

$$e_{yy} = \frac{\partial u_y}{\partial y}$$

$$e_{xy} = \frac{1}{2}\left(\frac{\partial u_x}{\partial y} + \frac{\partial u_y}{\partial x}\right)$$

Hooke's law:

$$\sigma_{xx} = 2G\left[e_{xx} + \frac{\nu}{1-2\nu}(e_{xx} + e_{yy})\right]$$

$$\sigma_{yy} = 2G\left[e_{yy} + \frac{\nu}{1-2\nu}(e_{xx} + e_{yy})\right]$$

$$\sigma_{zz} = \frac{2G\,\nu}{1-2\nu}(e_{xx} + e_{yy})$$

$$\sigma_{xy} = 2G\, e_{xy}$$

Notation:

| | | |
|---|---|---|
| $\sigma_{xx}, \sigma_{yy}, \sigma_{zz}, \sigma_{xy}$ | = | stress components |
| $\beta_x, \beta_y$ | = | body-force components (gravity) |
| m | = | mass |
| $u_x, u_y$ | = | displacements |
| $e_{xx}, e_{yy}, e_{xy}$ | = | strain components |
| G, $\nu$ | = | elastic constants: shear modulus, Poisson's ratio |
| $\ddot{u}_x, \ddot{u}_y$ | = | accelerations |
| $\frac{\partial}{\partial y}, \frac{\partial}{\partial x}$ | = | mathematical notation indicating partial derivatives |

requires much greater computer resources than problems in which the rock remains elastic, because you need a more extensive mesh, you must follow the excavation sequence closely, and the calculation sequence is more complex. In contrast, our hybrid model solves such two-dimensional problems with only slightly more computer run time than the elastic version. Work is currently under way to expand the model to three dimensions and to include non-linear material response in the FD region. ■

ACKNOWLEDGMENT
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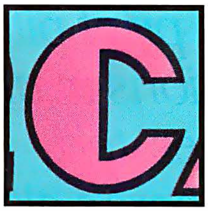

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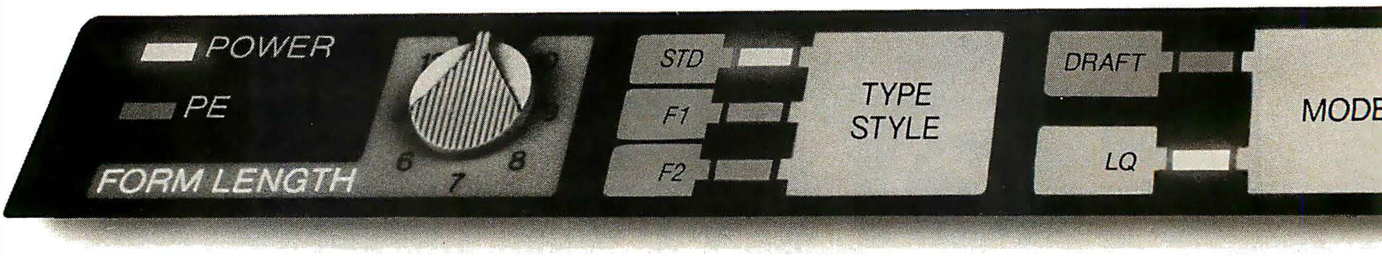


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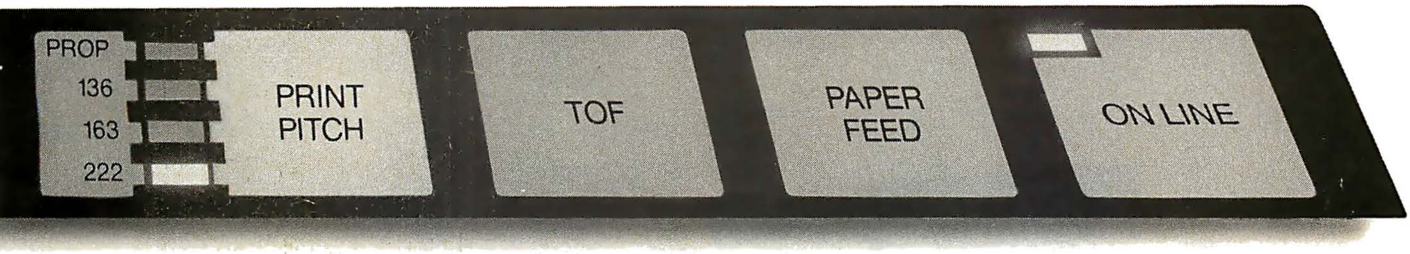


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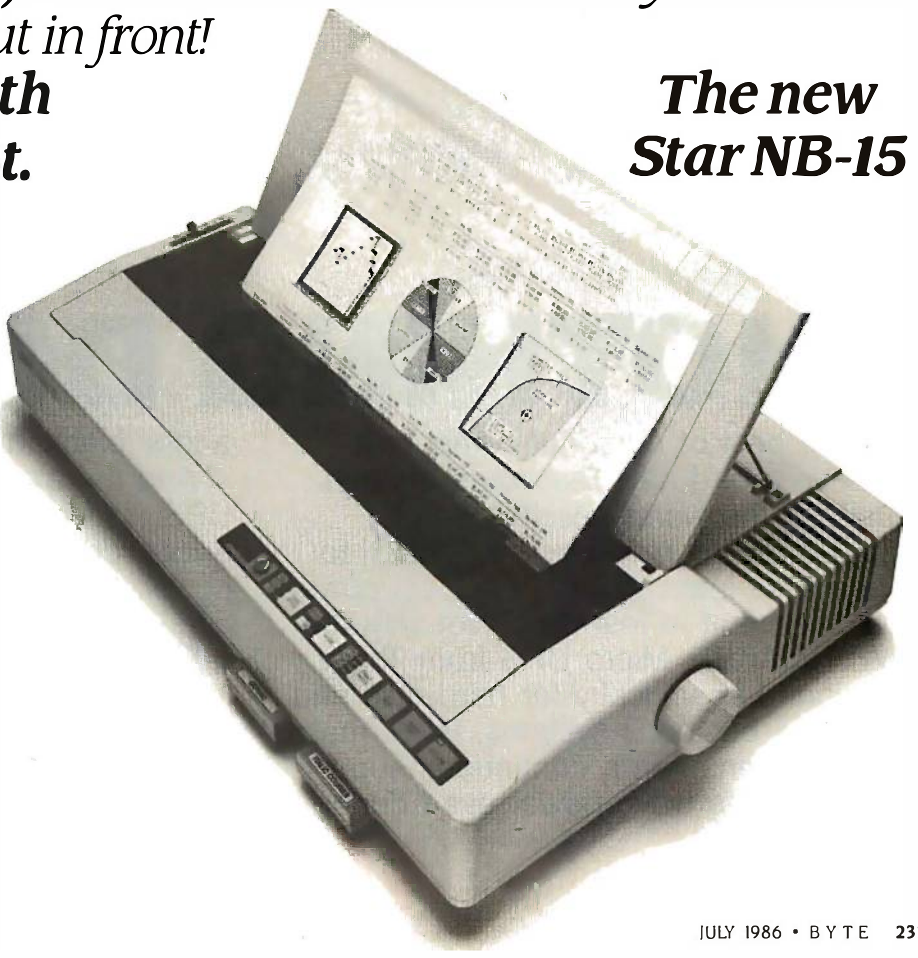

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# A MATERIAL SELECTION PROGRAM

BY BROTHER TOM SAWYER AND MICHAEL PECHT

*You can weight options and do "what if" searches*

MSP IS A microcomputer-based, public domain, material selection program that aids an engineer in designing a product by providing an easy method of finding the proper materials for its construction. MSP searches a database and produces a ranked list of materials based on weighted search criteria. [*Editors note*: MSP.PAS, SRCHFOR.PAS, *and* WTRANK.PAS *are available in Turbo Pascal source code in a variety of formats. See pages* 459–461 *for full details.*]

### A DIFFICULT DECISION

The choice of materials to be used in the construction of an engineering product generally depends on four broad material categories: function, appearance, manufacture, and cost. Each of these can be divided into subcategories, or attributes. The function of a product places certain constraints on the materials that compose it. They must withstand its stresses, deformations, environmental conditions, and possible misuses. In addition, reliability and safety conditions must be satisfied. The appearance or quality of the product relates not only to its polishability, paintability, and texture, but also to its corrosion resistance, fading properties, and smell. Manufacturing methods determine how the product material will be formed into the desired shape (e.g., molding, extrusion, machining) while meeting the tolerances imposed by the designer. Cost includes the price of the raw material, the cost of forming the material into the product, and other costs, such as welding or hardening, which are directly related to the material's characteristics.

Material selection is usually a difficult decision task for three primary reasons. First, you must examine a large amount of data. For metals alone, more than 100,000 materials with over 80 attributes (fundamental properties) can be identified. The addition of plastics, ceramics, and composites increases this list considerably. Second, data originates from a diversity of disciplines, including electrical, chemical, mechanical, and civil engineering, as well as the human-factors and economics areas. A complete spectrum of attribute data for a particular material rarely resides in a single reference book, and some data may not exist at all. Third, every material possesses a combination of often conflicting attributes. For example, a high-strength material is typically more difficult to machine and more costly than one of lesser strength. Finding a material that satisfies a variety of such requirements is a very time-consuming task.

Often an engineer will choose a proven material because there isn't time to consider alternatives. The computer can help to overcome this difficulty because it can search a data-

(continued)

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*Michael Pecht is an assistant professor in the Mechanical Engineering Department (University of Maryland, College Park, MD 20742). He has an M.S. in electrical and computer engineering and a Ph.D. in engineering mechanics from the University of Wisconsin at Madison.*

base and compare properties more quickly than we can. This is especially true if the list of materials is large or if you want a material that meets a number of criteria at the same time (e.g., hardness, weldability, tensile strength, machinability, and availability).

## THE PROGRAMMING MODEL

MSP looks through a data table for materials that meet certain criteria. First it looks for materials that are within a desired range of values. For example, if the material must have good machinability, all of the "good, very good, and best" materials are selected from the list. For numerical data, typically only the one or two most significant digits are examined to select a group of likely candidates. You then examine that group of materials for other desired properties (in any order) and generate a new list. This process continues until a few materials emerge. Finally, you can establish varying degrees of importance for the desired properties. For example, if cost is critical, you should give it more weight in the selection process than other properties.

MSP has the following characteristics:

- You can search for discrete values or values in a given range.
- You can assign a relative importance to each desired attribute.
- It handles descriptive as well as numerical data.
- Selected materials are ranked according to the search criteria.
- It works with multiple, dissimilar databases.
- It does not require the use of special languages or codes.
- It records the search criteria you impose.
- It runs on a microcomputer with a single floppy disk.

MSP was developed jointly by a programmer and an engineer. Both Turbo and UCSD versions of Pascal met our requirements, but we finally chose Turbo because it compiles into native code and thus requires no system files in order to run.

The most immediate programming problem encountered was the variety of data types used for engineering materials. There are numerical types like strength and hardness, descriptive types like weldability and machinability, and discrete types such as whether the material class is aluminum, steel, or cobalt. Pascal's RECORD type allows you to put these into a single structure but requires that you declare the structure beforehand. The use of a strongly typed language like Pascal led us to store the data descriptors and categories as strings of characters to serve only as menu labels. The actual value of a given descriptor comes from its position in the qualifier list; that is, data is stored apart from the descriptors as a scalar, or ordinal, type.

For example, assume that a material has a hardness of 142 on the Brinell scale and you want to put that data in its data record. The Hardness menu categories are character strings that are displayed as in table 1. You enter the letter C, which is then translated into a scalar matching that letter's position in the menu. The program then places the scalar into the material's data record. During a search, you select all materials with a hardness in the range 120 through 179 by pressing the letter C. The actual value 142 is not in the database because the program "sees" only scalar values that correspond to the string descriptors in the menu.

The decision to reduce numerical data to ranges of values is consistent with our intent to reduce the number of acceptable materials to a manageable size. It is a trade-off that produces some desirable results. The first is a compact database. An array of 32 scalars (one for each attribute), each able to differentiate 16 categories, occupies only 32 bytes of storage. Compact data files mean faster search times, especially when accessing a floppy disk drive. Second, you can create any type of data category, providing a truly customized database. Third, data entry and searching are accomplished by entering single letters. You don't need to learn any special codes or procedural languages. The loss of numerical values and thus the inability of the program to calculate derived categories was outweighed by the advantages of compact data, fast searching, and ease of use.

Table 1: *Typical menus showing the different types of data that can be entered into MSP. Column a shows the Hardness menu, column b the Machinability menu, and column c the Metal's Class menu.*

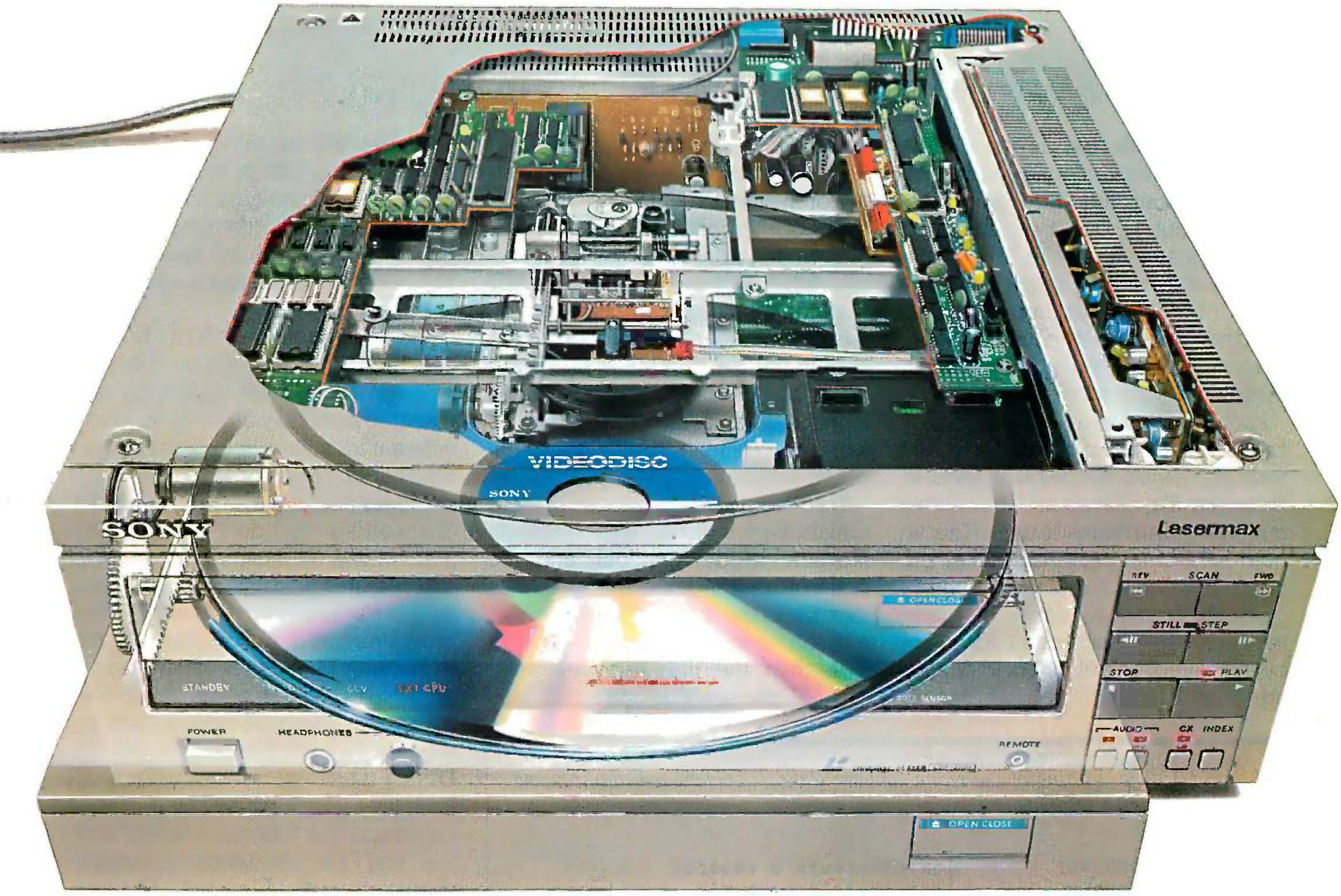
| (a) Hardness (Brinell) (numerical continuum) | (b) Machinability (descriptive continuum) | (c) Metal's Class (discrete values) |
|---|---|---|
| A: 0 – 59 | A: poor | A: alloy |
| B: 60 – 119 | B: fair | B: aluminum |
| C: 120 – 179 | C: good | C: carbon |
| D: 180 – 239 | D: very good | D: cast iron |
| E: 240 – 299 | E: best | E: cobalt |
| F: 300 – 359 | | F: copper |
| G: 360 – 419 | | G: nickel |
| H: 420 – 479 | | H: stainless |
| I: 480 – 539 | | I: misc. |
| J: 540 – 600 | | |

## DATA STRUCTURES

**Attributes and Qualifiers.** Attributes are the properties such as hardness, tensile strength, cost, and machinability that differentiate materials. Qualifiers are the subdivisions of a particular attribute. For example, you can subdivide the cost attribute into the qualifiers very low, low, average, high, and very high. A qualifier for hardness could be 120 through 179 or above 600.

The descriptors for each attribute and its corresponding qualifiers are stored in a record that has the structure shown in listing 1. The numbers of attributes [0..31] and qualifiers

*(continued)*

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[0..10] were selected as reasonable limits. The qualifier range could be [0..15] without requiring additional memory, but we didn't see the need for that many categories. The string lengths of 20 and 10 were chosen for the attribute and qualifier names, respectively, because the lengths seem reasonable and they fit evenly on an 80-column screen or printer.

Each database has a file that may contain up to 32 attribute records that form its menus. Record 0 is used to store the file's name and the actual number of attributes it uses. The atnum field of record 0 is used as the upper limit for some of the program's FOR..DO loops. A zero in that field indicates that the menus have not been created. The qlnum field of each attribute contains the number of menu items, or qualifiers, for that item. A zero indicates no data. The array of attribute records occupies 4K bytes of memory.

**Data Records.** The data for a particular material resides in a RECORD that contains a character index (fid), a record number (inum) to locate the item in the file, and the name of the material (iname). The character index is included to allow the program to work with items from different databases simultaneously.

The record also contains an array of scalars. Each index corresponds to an attribute of the material, and the scalar at that index is the qualifier's location in the menu. If a material has a hardness in the range 120 through 179, then the fifth array element, idata[5], the one that corresponds to hardness, will contain the value D2, the third qualifier in the menu. The value NUL represents no data, and D0 through D9 correspond to menu positions 1 through 10, respectively. The declarations relating to data items are shown in listing 2.

The scalar identifiers (NUL, D0, D1, etc.) can be expressed as the subrange [0..10] because scalars are represented internally as integers. Using different identifiers helps in range and type checking. Record 0 contains the database name and the total number of records in the data file. The program stores data records in an array that requires 5.5K bytes for each 100 items. Rankitemrec is used by the program's search option. It is a slightly larger array (5.6K bytes per 100 items) because of the additional field (rank) that is the cumulative rank of the item.

Listing 1: *The structure of the record containing the descriptors and corresponding qualifiers for each attribute.*

```
attrrec = RECORD              {an attribute's record}
  atnum : 0..31;              {attribute's number}
  atname: STRING[20];         {name of the particular attribute}
  qlnum : 0..10;              {index of the last qualifier}
  quals : ARRAY[0..10] of STRING[10]
                              {label for each qualifier}
END;
```

Listing 2: *The declarations for the various data items.*

```
TYPE
  attrdata = (NUL,D0,D1,D2,D3,D4,D5,D6,D7,D8,D9);
      {scalar marks position of a qualifier in a given menu}

  itemrec = RECORD          {record for a particular data item}
    fid : CHAR;             {database identifier}
    inum : INTEGER;         {the record number of the item}
    iname : STRING[20];     {name of the item}
    idata : ARRAY[0..30] of attrdata
  END;

  rankitemrec = RECORD  {used in the ranking segment}
    rank : INTEGER;
    irec : itemrec
  END;
```

Listing 3: *The declaration for the* FINAMES.DTA *file's records.*

```
Finamrec = RECORD
  id : CHAR;              {letter identifier for the database}
  rtnam : STRING[6];      {the rootname of the database}
  name : STRING[20]       {database name, as seen by you}
END;
```

## DISK FILES

Each time you create a database, MSP constructs the rootname, a string of the first six (or fewer) nonspace characters of the filename. (The program requires nonspace characters since Turbo Pascal removes spaces from filenames.) You use the rootname to check for duplicate files and to create names for the attribute and item files associated with a given database. The attribute file is given the name *rootname*AT.DTA, and the item file is called *rootname*IM.DTA. After the program verifies that the database's rootname is unique, it creates the attribute and item files and initializes each with an empty record. The rootnames and actual names you see are stored in a file called FINAMES.DTA. The declaration for this file's records is shown in listing 3.

The character field id serves as the menu option for file selection and as the identifier for items in the database. When you select an option that requires opening files, the program reads FINAMES.DTA and creates a menu using the character ID with the actual filename listed next to it. After you select a letter from the menu, the program passes the rootname to a procedure that opens the appropriate files. The procedure also checks the status of the database before allow-

*(continued)*


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ing its files to be used. For example, if you want to search for a material, the program will check to make sure that the attribute file contains menus and that the item file contains data. This method of selecting a database (file) is consistent with the user interface in the rest of the program, and it avoids prompts such as "type in the filename."

After each selection, the record Trackrec is created and stored in the file TEMPFILE.DTA. The contents of this file are output as a heading for each ranked list so you see not only a list of materials but also the criteria that were used to produce that list. You could use TEMPFILE.DTA to return to previous ranked lists, but this is not a part of MSP's present version.

Listing 4: *The declaration for* Trackrec.

```
Trackrec = RECORD
  nofitems : INTEGER;      {number of items found in search}
  atnum : attrnum;         {number of the attribute selected}
  atrbute : attrdata;      {scalar value of attr. qualifier}
  selection : CHAR;        {code for selection range <=,+,>=}
  atname : attrlab;        {name of the attribute selected}
  qualname : quallab       {name of the qualifier selected}
END;
```

Table 2: *Summary of file types used in* MSP *and the disk space each requires.*

| Diskfile Name | Program Identifier | Type | Size |
|---|---|---|---|
| FINAMES.DTA | Nfile | FILE OF finamrec | 29 bytes/record |
| *rootname*AT.DTA | Afile | FILE OF attrrec | 4K bytes |
| *rootname*IM.DTA | Ifile | FILE OF itemrec | 6K /100 records |
| TEMPFILE.DTA | Tfile | FILE OF trackrec | 32 bytes/record |


Photo 1: MSP's *main menu. The choices are written to reflect the user's point of view and do not use words like "files" and "records."*

The file is active only during the selection process. It is erased when you exit that section of the program. The declaration for Trackrec is shown in listing 4.

MSP's disk and memory requirements are minimal. Three databases of 1000 items each and the program will fit on a 360K-byte floppy disk with some room to spare. The program is 28K bytes long plus a 10K-byte library segment added by the Turbo compiler to produce a .COM file. Program data storage is a constant 5K bytes plus about 6K bytes for each 100 materials. You can control file buffer memory if you open only one file at a time and close it after you put the data into an array. TEMPFILE.DTA is, however, kept open during the selection segment. In Turbo Pascal a declared, unopened file requires only 48 bytes of memory. Table 2 contains a summary of MSP's file types and their sizes.

## PROGRAM OPERATION

The main menu for MSP (see photo 1) shows the five operations it performs. The "remove a data base" option deletes the attribute and item files and removes the database name from FINAMES.DTA. You must enter the word "Yes" before the option is carried out in order to prevent accidental loss of a database. The "system overview" option defines the terms attribute, qualifier, pivot, and relative importance as they are used in the program. MSP comes with a working database of 288 metals. It is a good idea to use the program with the accompanying data before trying to build a database of your own.

**Create a new data base.** This option allows you to build a customized database shell; that is, you can create all of the menus that drive the program. You need to plan ahead in order to get the most out of the database you are creating. You must decide on the best way to arrange the materials' attributes, and you must look through the data to determine the range of possible values the program might encounter.

We have identified in table 1 three types of data descriptors that you

*(continued)*


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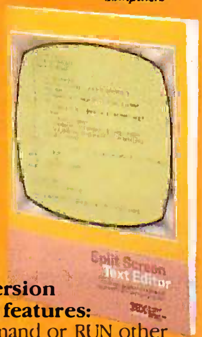


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B

might encounter in a metals database: numerical continuum, descriptive continuum, and discrete values. You can list data that lies on a continuum in either increasing or decreasing order since the search function has the option of going either way. Note that the program "sees" only character strings. You can subdivide the data range in any way you wish since MSP gives no numerical significance to qualifiers. For example, assume that the tensile strengths of the materials to be put in the database are in the range 0 to 300 KSI (kilograms per square inch), but the ones of most interest have values between 90 and 200. Rather than divide the attribute into 10 equal qualifiers, each with a range of 30 KSI, you could use an arrangement like the one shown in table 3 to focus on the "interesting" materials.

Table 3: *Sample menu showing how an attribute can be subdivided into unequal ranges in order to focus on materials that are of interest to the user.*

| Tensile Strength KSI |
|---|
| A: below 85 |
| B: 85 – 99 |
| C: 100 – 114 |
| D: 115 – 129 |
| E: 130 – 159 |
| F: 160 – 174 |
| G: 175 – 189 |
| H: 190 – 204 |
| I: 205 – 249 |
| J: 250+ |

You have ample opportunity to edit the qualifier string inputs. However, once you have saved them to the disk, you cannot edit them further because the program stores the data values for each material as a position in a given menu. If you altered the menu, the data might no longer fit the descriptor. When you complete this database-creation section of the program, you have a customized database shell. The attribute and qualifier descriptors now become the menus that the next two parts of the program will use.

Add data to an existing data base. The task of data entry, or building the database, is now simply entering data from a table. The only string input for an item is its name. Once you type this in and verify it, you will see the menus created earlier, and you simply press the letter of the qualifier that best suits the item. The following example shows how the data-input section of the program operates. The descriptors used to create the shell are shown as menus, one for each attribute. The Machinability menu is shown in table 1. If you press the letter C on this menu, the program assigns the scalar value D2 to the eighth element in the attribute array (itemrec.idata[8]), the one that corresponds to machinability. If there is no data for a particular attribute, you press the letter X to assign the scalar NUL to the array element. The menu, letter choice process continues until you have entered all the attributes. You are then shown the list of attributes with the qualifier descriptors that were selected for the material, and you may change any or all of them using single-letter input. MSP gives a null response to choices that are outside the legal range. A null response means that rather than giving you irritating beeps or error messages, invalid input is simply ignored. In the few instances that require a warning or explanation, it is given with a minimum of fanfare.

The default mode for Turbo Pascal keyboard input is buffered, which means that whatever you type is not processed until the Return character is received. Since most of MSP uses only single-letter input, having to press the Enter key after each letter would interfere with the flow of the program. Therefore, we used the {$B–} compiler option to suppress input buffering. The keyboard is ignored until the program encounters a READ statement. However, the buf-

*(continued)*

## WHAT'S NEXT?

A new version of MSP is in the works. It includes some new data types and some additional procedures. It will look the same to the user but will allow more flexibility in representing data.

One feature the new MSP will have is multiple qualifiers for a single attribute. This will be implemented as an array of sets rather than scalars. By using the IN operator, or intersection, the presence of one or more qualifiers can be tested. However, unlike scalars, sets are not ordered. To maintain the ability to test ranges of values, it will be necessary to manipulate the bits in the set's memory location. Turbo Pascal allows direct memory access of variables as well as the inclusion of assembly language code in the Pascal source code. Thus, a comparison set for a range of values can be formed by setting the appropriate bits in memory, and an ordinal value can be produced by testing the location of a bit within the set.

Another new feature will be the ability to record and manipulate numerical data. You will be able to type in a numerical value for a qualifier, and the program will store that value in a file as well as record its location in the present relative scale. This will require number-to-string conversion as well as an additional reference pointer from the MSP item file to the numerical-value file. The presence of numerical data will permit you to calculate other values not in the database. We also plan to have the program adjust the qualifier ranges as more numerical data is added. The program will look at the range of values, divide it into categories, and store these in the item file as members of a set. You will be able to override this self-adjusting-database feature if unequal ranges of values are desired.

The new version of MSP will address the problem of unifying numerical and descriptive categories, both of which are common and important in engineering specifications for material selection. The range-search feature of the present MSP will remain; however, a numerical element will be integrated into it.

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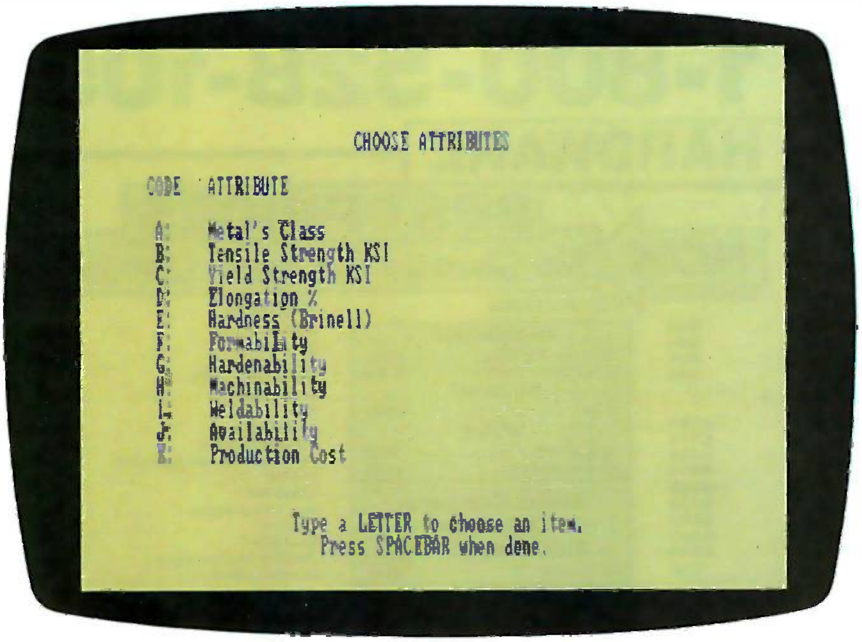


Photo 2: *Attribute menu for the metals database that accompanies the* MSP *program.*

Listing 5: *Procedures to search the data array in the program for values that match the user's specifications.*

```
PROCEDURE Searchfor(VAR It:ranktable; atn:attrnum;
          atr:attrdata; fnam:stri; selcode:CHAR;
          VAR Zflag:flag);
{Get data from file or from ranktable.}
{It[0] used to pass values to output.}
VAR
  memsrch : BOOLEAN;
  J,cnt,last : INTEGER;
  itrec : itemrec;
  tempatr : attrdata;
  itfile:Ifile;

  PROCEDURE Checkrec(VAR cnt:INTEGER);
  {look for data in It or on disk}
  {changes It and uses selcode,tempatr,atr,memsrch, and j}
  VAR
    match : BOOLEAN;
  BEGIN
    match := FALSE;
    CASE selcode OF
      'A' : IF tempatr <= atr THEN match := TRUE;
      'B' : IF tempatr =  atr THEN match := TRUE;
      'C' : IF tempatr >= atr THEN match := TRUE
    END; {case}
    IF (memsrch) AND (tempatr = NUL) THEN
      match := TRUE;            {Include no-data items}
    IF match THEN
    BEGIN
      cnt := cnt + 1;
      IF memsrch THEN         {data is in It}
        It[cnt] := It[J]
      ELSE                    {data is on disk}
      BEGIN
```

*(continued)*

fer is useful for string input since it allows you to use the Backspace character. Thus, MSP uses the statement READLN(con,*input string*) to get attribute and qualifier names. The console specification provides buffered input.

When you exit the add-data section, the program appends the new data to the existing item file and updates record 0 so that it contains the total number of items in the file. It is advisable to protect your data by exiting this section every once in a while so that the program will write the data to the disk.

Search for selected items. Material selection is the central function of MSP. You select an attribute and then choose its relative importance, minimum acceptable value (pivot), and finally the range of desired values. For example, the menu choices in photo 2 are used to produce a ranked list of materials based on weighted options. First, you choose an attribute to be the basis of the selection—normally the most desired attribute. Assume that you press the letter H for Machinability. Next, you select the relative importance of the attribute. We included this feature because all attributes may not be equally important in selecting a material. You may want a high-strength material with good machinability but wish to give more weight to the latter. The program converts the choice of relative importance ("least" to "greatest") into a weighting factor (10 to 50) that is used in the ranking formula. That is, if you select B or "high" importance, the weighting factor will be 40.

The third step is to specify the minimum acceptable value, or pivot, for the search. For example, if the machinability must be at least "good," the C qualifier becomes the pivot. Last, you select the range of acceptable values. The pivot value may be "good," but values of "very good" and "best" are also acceptable; thus, you would choose the range option that includes qualifiers from "good" to "best" (also C). For discrete qualifiers like the metal's class, you ordinarily choose the qualifier equal to the pivot. The range-selection menu shows the importance of the pivot in the search. It also shows how you can include continuous values whether they are listed in increasing or decreasing order. The program converts the range selection into a character and passes it to the search procedure (see listing 5) as selcode. In our example, the program looks for all metals that have a machinability value of greater than or equal to D2. The first time through, the program does a sequential search of the file *rootname*IM.DTA on the disk. On subsequent passes, the program performs the search on the data in the array ranktable.

The scalars NUL through D9 are ordinal, meaning that each has an integer value based on its position in the declaration. The ORD function converts a scalar to an integer and thus allows you to use the difference in position in a numerical expression. Listing 6 shows the entire weighting and ranking procedure. In our example, the pivot value is D2, which makes the base value equal to 3 (baseval := ORD(D2)). A material with a machinability value of D4 produces an attribute value of 5 (atrval := ORD(D4)). A "high" relative importance translates to a weighting factor (wt) of 40. Qualifier lists are not all the same length so the difference in two values is made proportional by dividing it by the list size (qln). We made the weighting factors multiples of 10 in order to convert the ratio to whole numbers. In our example, the formula becomes

It[J].rating := It[J].rating +
ROUND(40*ABS(3 – 5)/5)

Note that if a qualifier equals the pivot value, the rating is 0. This is reasonable since the pivot is the minimum acceptable value. The formula shows that the greater the weighting factor, the larger the final rating. It is also clear that the farther a value is from the pivot, the greater the rating it receives. That's why only those values greater than zero (NUL) are ranked; otherwise, a NUL would produce the greatest difference and therefore a higher rank.

The value of the Boolean wtit is

(continued)

```
          It[cnt].rating := 0;     {initialize rating}
          It[cnt].Item := itrec
        END
      END  {if match}
    END; {Checkrec}

BEGIN   {Searchfor}
  cnt := 0;
  Zflag := 0;                   {assume no data is present}
  last := It[0].item.Inum;
  IF last = 0 THEN              {search disk file}
  BEGIN
    memsrch := FALSE;
    ASSIGN(itfile,fnam);
    RESET(itfile);
    READ(itfile,itrec);
    It[0].item.iname := itrec.iname;   {data base name}
    WHILE NOT EOF(itfile) DO
    BEGIN
      READ(itfile,itrec);
      tempatr := itrec.idata[atn];
      Checkrec(cnt);
    END;
    CLOSE(itfile);
    IF cnt = 0 THEN Zflag := -1 {No items found in database}
  END  {last=0}
  ELSE                  {search array It}
  BEGIN
    memsrch := TRUE;
    FOR J := 1 TO last DO
    BEGIN
      tempatr := IT[J].item.idata[atn];
      Checkrec(cnt)
    END;
    IF cnt = 0 THEN
      Zflag := 1  {No items in It fit the new constraint}
  END; {else}
  It[0].item.idata[0] := atr;   {desired qualifier value}
  IF Zflag <> 1 THEN  {change item count. New list or no}
                      {items in data base}
    IT[0].item.Inum := cnt
END; {Searchfor}
```

Listing 6: *The procedures that weight and rank the data items.*

```
PROCEDURE Wtandrank(VAR It:Ranktable; atn:attrnum;
      atr:attrdata; qln:qualnum ;wt:INTEGER; wtit:BOOLEAN);
VAR
  J,last,baseval,atrval : INTEGER;

  PROCEDURE Ranklist(VAR It:Ranktable; last:INTEGER);
  VAR             {selection sort by decreasing rating}
    J,K,hdx : INTEGER;
    switch : BOOLEAN;
    high : rankitemrec;
  BEGIN
    FOR J := 1 TO last-1 DO
    BEGIN
      switch := FALSE;
      high := It[J]; hdx := J;
      FOR K := J + 1 TO last DO
        IF It[K].rating > high.rating THEN
        BEGIN
          switch := TRUE;
          high := It[K];
          hdx := K
```

(continued)

```
        END; {if}
      IF switch THEN {must switch places}
      BEGIN
        It[hdx] := It[J];
        It[J] := high
      END
    END {for J}
  END; {Ranklist}

BEGIN  {Wtandrank}
  baseval := ORD(atr);
  last := It[0].item.inum;   {# of items in array}
  FOR J := 1 TO last DO
  BEGIN
    atrval := ORD(It[J].item.idata[atn]);
    IF (wtit) AND (atrval > 0) THEN
      It[J].rating := It[J].rating +
        ROUND(wt*ABS(baseval-atrval)/qln)
  END;
  IF wtit THEN
    Ranklist(It,last)
END; {Wtandrank}
```

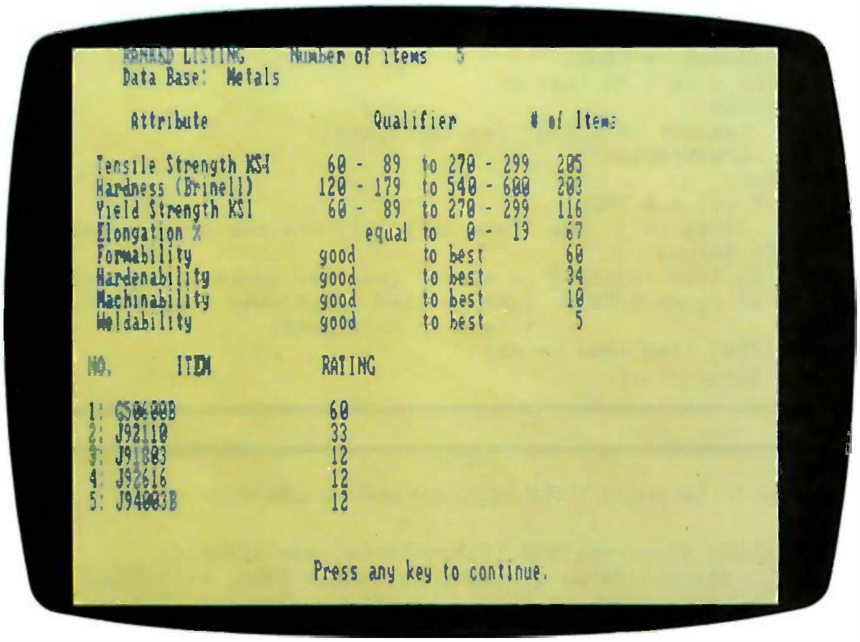


Photo 3: *Sample of a ranked listing produced by* MSP.

passed from another procedure and is true unless you have selected an attribute for the second time. It ensures that an attribute is weighted only once during a search even though it may be selected more than once, perhaps to narrow down a large list. Once the program calculates the rating, it sorts the array on this number. This is a selection, or push-down, sort. It was chosen because the list may already be in the desired order (a worst case for Quicksort), and if so, less movement of variables is required. The Boolean switch was included to prevent switching a value that is already in place. The procedure Wtandrank takes about a second for 280 items. Since this is a tolerable pause, a more code-intensive sort like Quicksort was unnecessary.

We decided to exclude items with no data on the first pass unless you select those values less than or equal to the pivot. This includes the NUL value since it is the lowest in rank. Since your first choice is generally the attribute that is most critical, we assumed that items with no data on that attribute should not be included unless you ask for them to be. On subsequent searches, no-data items are accepted because a material may contain other desirable properties. NUL items are not rated, so they will migrate to the bottom of the list unless they rank high in some other property.

After each search, the program tells you the number of items found and gives you the option of getting a ranked list on the screen or printer. If you don't want a list, the program shows you the attribute menu so you can make any further choices. If the ranked list is output (see photo 3), you can then get a listing of the data values for those materials. The selection, relative importance, pivot, and range options are repeated as often as you wish. Once you generate a new list, the former one is lost unless the new selection produces no items (zflag = 1). In that case, the former list is preserved. The search time for 280 records is about 6 seconds on a floppy disk and 1 or 2 seconds on a hard disk. Once the data is in memory, the search time is reduced to a second or less.

## Other Program Characteristics

MSP uses parameter passing extensively. This reduces memory requirements and has helped in revisions because the parameter declarations show which variables are affected by each procedure. Comments are added to note exceptions. Global variables have been kept to a minimum (32 bytes). In many cases, parameter values are passed in element 0 of the table arrays. Since these parameters are invisible, comments are made to indicate which values are in which fields of the record arrays.

To further reduce memory requirements, you can declare each of the four major procedures as OVERLAY PROCEDURE. This allows all four to use an amount of memory equal to

*(continued)*

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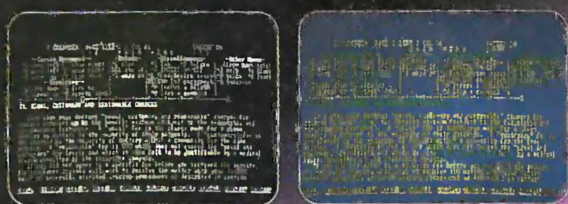

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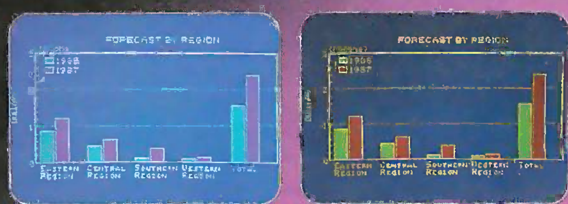


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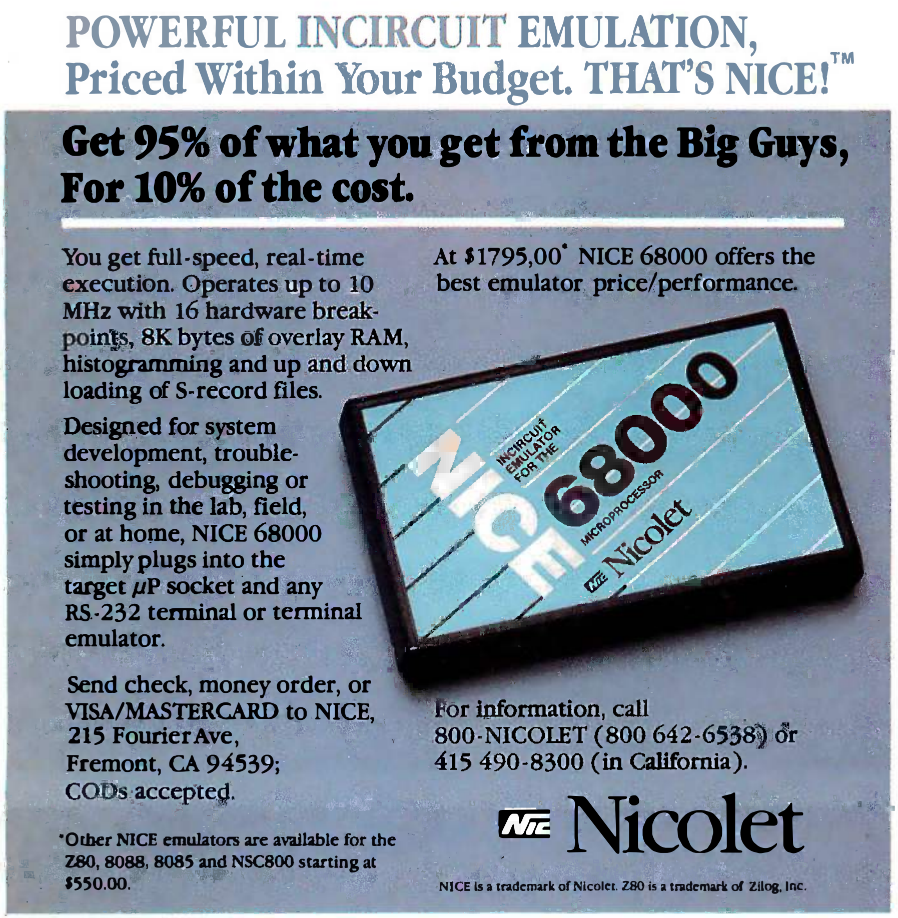


the size of the largest one since only one procedure is resident in memory at a time. The program is structured so that overlays can be used without frequent disk-to-memory swapping. The first few procedures, labeled as utilities, should not be declared as overlays because they are called frequently, and this swapping would cause unnecessary delays. Using overlays reduces the memory that the program occupies by about half.

## IN THE FINAL ANALYSIS

The decision to treat attribute descriptors as character strings led to a program that can be tailored to meet your specific needs. The menus are familiar to you because you created them to fit your data and your needs. Further, you can put any kind of data into the database, and you can specify any kind of attribute.

MSP works best as a means to reduce the search list to a manageable size using any number of constraints. It allows you to weight options and is very useful if you want to do a "what if" search. The current version of the program also has limitations: Attribute and qualifier labels cannot be changed once they are stored; data items cannot be deleted and may have only one qualifier; and finally, no derived qualifiers can be calculated from the data. (See the text box "What's Next?" on page 242.) Still, MSP allows you to create a custom database, and with a little practice it is not difficult to construct one from a table of values in a handbook. ■

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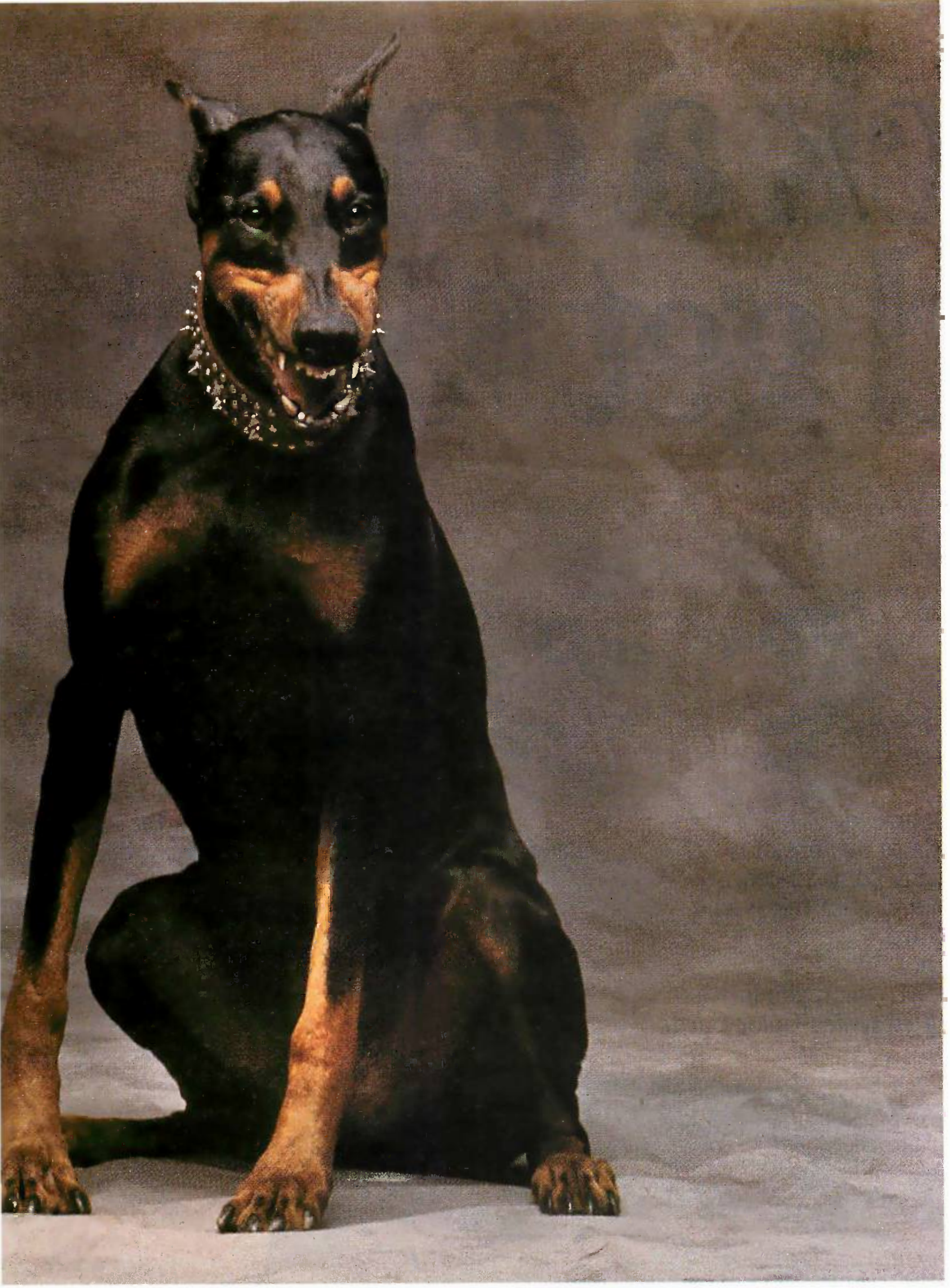

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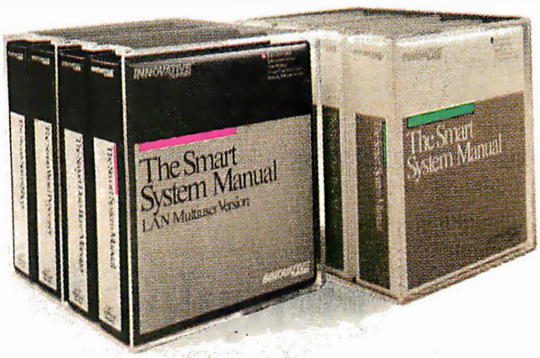


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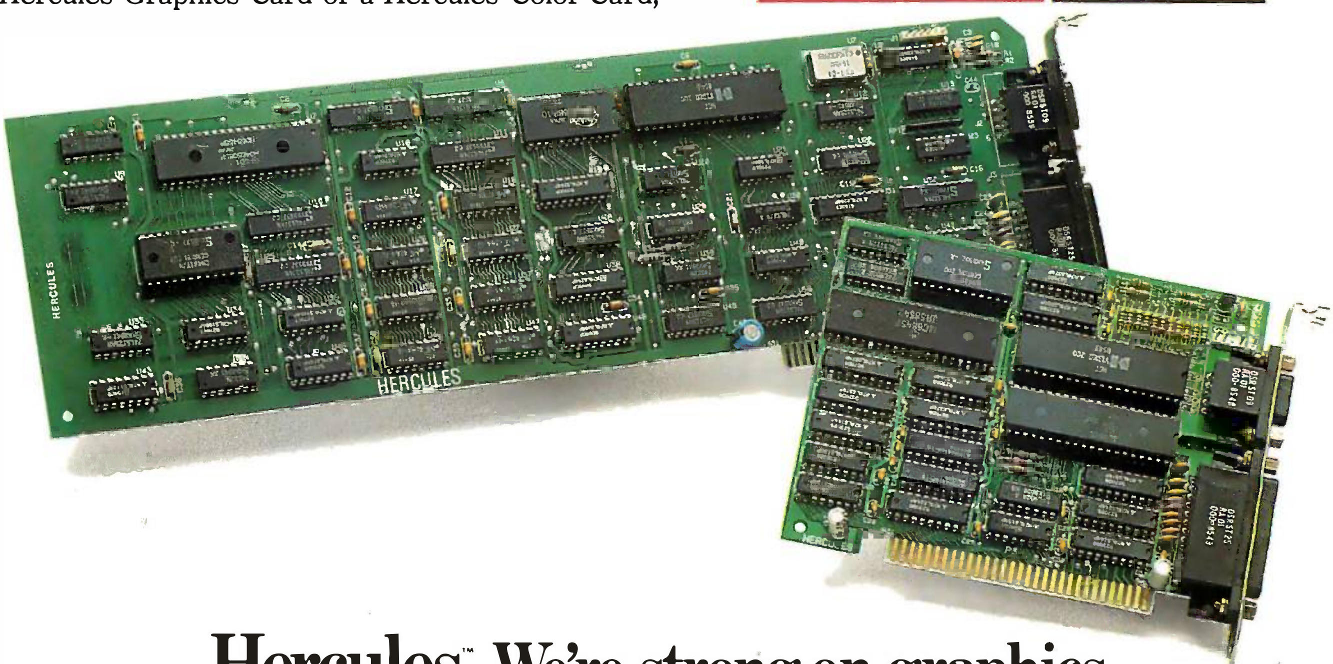


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# SMALL-SCALE ENGINEERING APPLICATIONS

BY J. NEIL STONE

*Estimate critical properties and liquid viscosities, and build a database for physical property estimation*

ALMOST ALL chemical engineering design calculations require a knowledge of the physical properties of substances you handle. Pressure-drop calculations require the density and viscosity; heat-transfer estimates need thermal conductivity and specific heat; absorbers and distillation designs use diffusivity, surface tension, and vapor pressure.

Such physical properties for most pure substances are available in reference books, but it often happens that the substance you're interested in is the one missing from the books on your shelf. Moreover, few chemical engineering designs relate only to pure substances—most involve mixtures, of which there are an almost unlimited number whose properties are not tabulated anywhere.

For these reasons, chemical engineers need to estimate the physical properties of pure substances and mixtures, preferably from a minimum amount of data. For each property, numerous estimating methods have been proposed. Many of these methods are based on the theory of corresponding states, which requires a knowledge of the critical temperature, critical pressure, critical volume, and acentric factor—collectively known as the critical properties—of the substance. The critical properties of many common substances have been experimentally determined and are readily available, but measuring the critical properties for unusual or new substances is not simple.

I've written two programs, CRITICAL/BAS and VISC/BAS, in TRS-80 BASIC for estimating all physical properties. [*Editor's note: The* TRS-80 BASIC *programs* CRITICAL/BAS *and* VISC/BAS *and* BASICA *programs* CRITIBM.BAS *and* VISCIBM.BAS *are available in a variety of formats. See page* 459–461 *for full details.*] CRITICAL/BAS estimates the critical properties of pure substances, and VISC/BAS estimates the viscosities of pure liquids and mixtures. Although the programs work independently, it is my intention eventually to make the various property routines accessible through one central program, as shown in figure 1. To some extent, in fact, the two programs are already linked via a database of critical and fundamental properties that is established and accessible by each of the program modules.

A great deal of research effort has been expended over the years in developing and improving various techniques for property estimation. For example, the well-known text *The Properties of Gases and Liquids* by R. C. Reid and T. K. Sherwood is a compendium of these methods, and it is quite common to find as many as five or more different methods for estimating any one property. To simplify the use of the programs, I've selected one or two methods that provide reasonable accuracy for a wide range of classes of substances and require only readily available data.

For example, the critical property estimation method I use is that of Rummens and Rajan. This method requires knowledge of the material's molecular weight, density, normal

*(continued)*

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boiling point, and one other vapor pressure value. This information is usually readily available or can be measured.

## PROGRAM PHILOSOPHY

Before I wrote the programs, however, I had to consider the philosophy of engineering programs. Many commercial engineering programs and trade publications that cover the subject tend to concentrate on the so-called big applications—multicomponent distillations, flow networks, and heat exchanger design. Such a narrow focus is natural, as these types of applications have an obvious payoff, which justifies the often high price of the software. In practice, though, most engineers more often do small, one-shot calculations and therefore need small, one-shot applications programs.

The advantages are easy to count. Most obviously, these programs take only a few seconds to do calculations that would take a much longer time if done manually. In addition to reducing drudgery, the programs improve accuracy, because once the program is proven, the chances of a calculation error are minimal. Such programs also eliminate transcription of intermediate data and results—a fruitful source of mistakes. And they can easily print out the input data and results. Most important, though, they provide a standard method of calculation, ready to use, without the need to research the literature.

But engineering work is by nature varied, and a particular calculation may only be required at infrequent intervals. So the potential problem of a one-shot application program that you might use, say, only once every three months is that you might spend more time reading the software manual than using the program.

When I'm in the middle of an engineering job, the last thing I want to do is to read a software manual, learn obscure commands, or program the application. What I do want is to load the program and use it, get the results printed out, and carry on with the job at hand. I may also want to perform several calculations using similar input data to determine the effect of different parameters on the design or to get results for a range of parameters.

As a result, I expect several features in a specific-purpose engineering program. An opening screen display, for example, should give the source of the method, its range of applicability, and input data required. Data entry should be screen-oriented with easy modification of data items, and I expect the ability to enter data in any commonly used system of units. Printouts should be dated and properly identified with associated input data. Also important is the ability to easily return to the input screen and edit the original input data for a new run. Finally, the program should save the input data and results to a disk file for use in other programs.

The bottom line is that programs must respond to the usage pattern of the engineer. There is nothing more frustrating than being in mid-calculation and thinking, "If only I could . . ."

But program features alone aren't enough. Equally important to an engineer is the technical documentation that is specific to the application (not the hardware or software). While it is fairly easy to check that a word processor or spreadsheet program is working correctly by running a test case, the same cannot be said of engineering calculation programs.

There are usually several accepted methods of calculating any given parameter, each of which gives similar but not identical results. Thus, the only way you can evaluate a new program is by reviewing the method used to determine if it is appropriate to your design conditions. To allow this, the program writer must document the source of the method used, the

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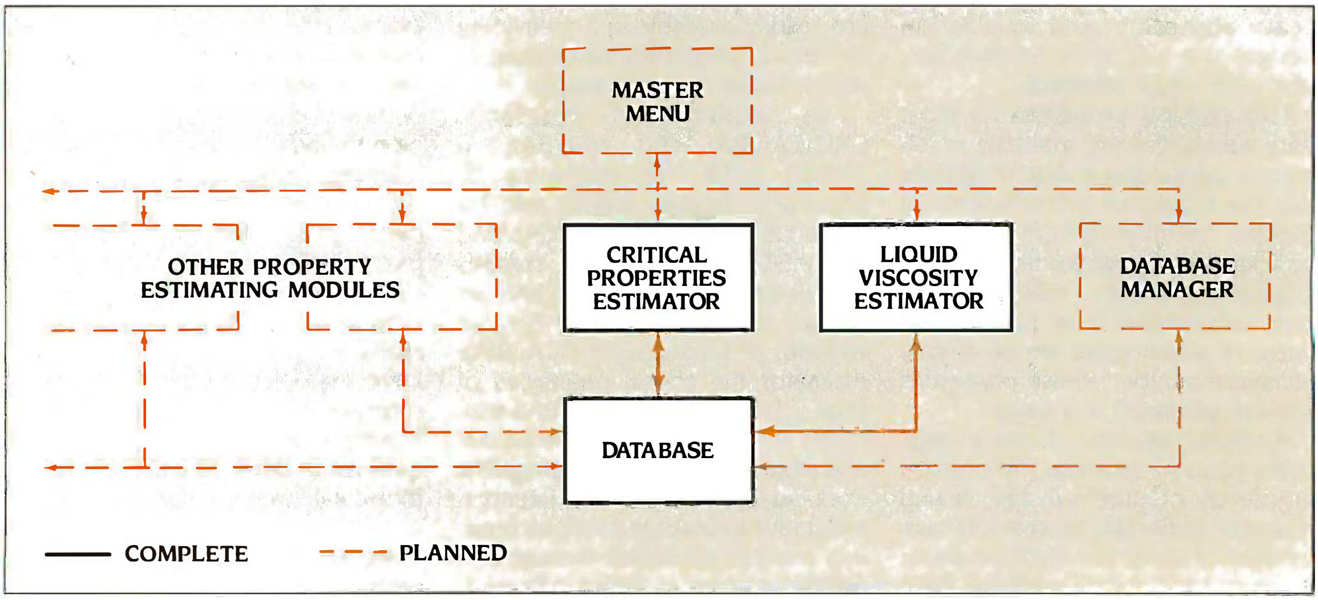


Figure 1: *The programs that estimate critical properties and liquid viscosities generate and use a shared database that can also be accessed by future program modules. A database manager module could be added to make maintaining the database easy.*

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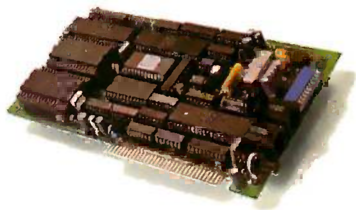

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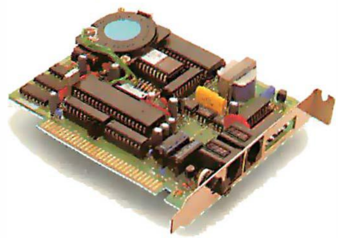

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procedure followed, and any assumptions the programmer made.

That documentation is not easily included in the program itself, as the information is often difficult to display and takes up disk space. Moreover, a printed manual lets you refer to the information at any time while the program is running. Therefore, separate, hard-copy, detailed technical documentation is essential for engineering programs.

### WHAT MY PROGRAMS DO

The first program, CRITICAL/BAS, is a very simple, single-purpose linear program. After the introductory text, you enter the project title, date, and substance name, and then the program displays a data-entry screen. Once the data is entered, the program calculates the critical properties—this takes a few seconds because the method involves estimating the critical temperature, then iterating until the calculated and estimated values agree. After the calculation, the results are displayed for review, and you can choose to print the results, save the data to disk, or do a new calculation.

The second program, VISC/BAS, is somewhat more complex, involving three separate but interlinked branches. The main menu offers two pure-component viscosity estimating methods and one method for mixtures. The two pure-component methods—one for nonassociating compounds and the other for associating compounds—operate alike. After you enter the name of the substance, the program checks the database for the critical and fundamental properties and displays a data-entry screen that includes the data found in the database. You may then edit that data and add any necessary data that's not already in the database.

The program calculates the basic parameters for estimating viscosity and then prompts for the temperature—either a single temperature or a range and interval, in which case the viscosity for the range will be tabulated. In either case, the results are displayed, and you can then print them, calculate the same substance at another temperature or range, or calculate for a different substance using the same procedure.

In the case of mixture viscosity, a multicolumn data-entry format is provided for the viscosity, percent composition, and molecular weight of up to 10 components. The viscosity data for some or all of the components may be omitted, in which case the program will call the estimating routine to determine these values. After you have entered the data, the viscosity of the mixture is calculated and displayed on the screen, and you can choose to print the results, calculate a mixture made of the same materials, or calculate a different mixture.

To make data entry easy, both programs use a full-screen data input format based on a concept originally published and placed in the public domain by L. E. Sparks. I have refined the method and added features to suit my way of working and programming, and I think it is the best data-entry format for engineering programs.

The screen is divided into three areas—a single line of title at the top, up to 11 lines of data entry in the center, and two lines of prompt at the bottom. The layout I use is designed to fit the 16-line display of my TRS-80 Model III—with a 24-line display up to 19 lines of data can be accommodated. Data is entered opposite descriptive text for each entry, and the routine lets you modify or correct an entry as necessary. Having all the input data on the screen at once makes it easy to check for inconsistencies and detect incorrect values.

Both programs have the same structure, and that allows me to keep a set of all the utility subroutines to use as a starting point for each new application I write. This not only speeds up the programming, but also maintains a standard operator interface and variable names. Thus, each program responds in a similar way, and there is no need to puzzle over the expected response when running an unfamiliar or little-used program. And because the variables are standard, I can easily integrate my programs.

Only slightly over 10 percent of the

(continued)

*There is no point in cluttering the database by saving estimated properties, as they are usually temperature- or pressure-dependent.*

program lines are involved in the actual manipulation of numbers. Thus there is little need for clever algorithms and mathematical techniques, and. in fact. the essential math of these programs consists of evaluating a sequence of mathematical expressions. While the math is what makes the program so much faster than manual calculations, it's the I/O that makes the program convenient to use. And that's why I chose to write the programs in BASIC.

If I can reduce an hour of manual calculations to 5 seconds, there is little incentive to use a more difficult or more complex programming language to complete the calculations in 0.5 seconds. Also, tidy screen formatting for data entry and hard-copy output are major factors in making an engineering program useful. None of the other popular languages has anywhere near the ease of handling these matters that BASIC has. In fact, most other languages are either still in the dark ages of batch input (not much use for an interactive program), or they provide minimal I/O facilities. Of course, routines can be written in languages to provide screen and printer formatting, but that's just additional complication and work. Besides, BASIC's math capabilities provide the accuracy needed in most routine engineering calculations and convenient error-trapping procedures.

## GENERATING THE DATABASE

The database that links the two programs contains critical and certain fundamental properties for various substances. Table 1 shows the structure of each record. The fundamental properties in the record were chosen because they are used in predicting others. A spare field of 60 bytes is provided in each record of the database, so you can add other fundamental properties you frequently use. However, there is no point in cluttering up the database by saving estimated properties, as they are usually temperature-dependent or pressure-dependent, and it is unlikely that the same result at the same conditions will be required in the future.

Both programs let you generate your own database that contains the specific substances you most often use. (Listing 1 shows the database generation and retrieval subroutine in VISC/BAS.) Random access files are most suitable for saving this type of information, so that new program modules can be created to rewrite specific records without rewriting the whole file. However, there's no need for any tricky pointers or sorting since most chemical engineers are interested in only 50 to 100 substances. To save search time, though, I use alphabetic subfiles, in which all substances with names starting with *H*, for example, are saved in the file HCRIT/DAT, and those starting with *S* in *SCRIT/*DAT. In this way, each file has only a few entries, and data retrieval is fast. The field lengths are chosen to give a record length of 128 bytes, so as to pack two records to a sector on a TRS-80-formatted disk.

The database generation and retrieval routine checks if a specified substance is already in the database and, if it is, loads the data into the program. First, the subroutine at line 8780 is called to generate an uppercase version (YH)—to avoid problems with mixed cases—of the substance name (YB), and then the appropriate subfile is opened (line 8670) and searched for the substance name (line 8720).

If the substance is found, the data is retrieved (lines 8590–8620); otherwise, the record counter (line 8750) stops at the end of the file so that a subroutine can save the new data (line 8850). In the case of VISC/BAS, the substance's freezing point is saved for future use, but the boiling point is not used, so a blank has to be saved in this field. Since reading empty fields and attempting to convert those fields into numeric variables results in a small garbage value, the program purges them (line 8630). Also, each module can update existing files with data generated by that module. In this way, each module of the program contributes a share to the database that's used by all modules.

## CONVERTING TO BASICA

The programs are written in TRS-80 Model III BASIC. Since we have MS-DOS machines in my company, I

(continued)

Table 1: *The database is made up of 128-byte records containing the fundamental and critical properties that are used in predicting other properties. The 60-byte spare field allows you to add other fundamental properties as needed without rebuilding the database.*

| Item | Type | Field length (in bytes) |
|---|---|---|
| Substance name | string | 32 |
| Molecular weight | single-precision | 4 |
| Boiling point, °C | single-precision | 4 |
| Critical temperature, K | single-precision | 4 |
| Critical press, atm | single-precision | 4 |
| Critical volume, cc/g.mol | single-precision | 4 |
| Acentric factor | single-precision | 4 |
| Density, g cc | single-precision | 4 |
| Temperature of density measure, °C | single-precision | 4 |
| Freezing point, °C | single-precision | 4 |
| Spare field | | 60 |
| | Total record | 128 |

usually do a conversion to BASICA. The BASICA versions of CRITICAL/BAS and VISC/BAS are CRITIBM.BAS and VISCIBM.BAS, respectively, and are also available via BYTEnet Listings and in other formats.

Listing 1: *Both the critical properties estimator and the liquid viscosities estimator programs include similar database generation and retrieval routines. This listing is the routine from the* TRS-80 *program* VISC/BAS.

```
8540 REM Read data from file
8550 CLS
8560 PRINT"Checking disk for data..."
8570 GOSUB 8780:GOSUB 8670:GOSUB 8720
8580 IF N>LOF(1)/LF THEN 8650
8590 A(2,KS)=CVS(MF$):A(2,KS+1)=CVS(TF$)
8600 A(2,KS+2)=CVS(PF$):A(2,KS+3)=CVS(VF$)
8610 A(2,KS+4)=CVS(WF$):A(2,KS+5)=CVS(DF$)
8620 A(2,KS+6)=CVS(SF$):A(2,KS+7)=CVS(FF$)
8630 FOR J=1 TO 7:IF ABS(A(2,KS+J))<C3 THEN A(2,KS+J)=0
8640 NEXT
8650 RETURN
8660 REM Open file for crit data
8670 Y=LEFT$(YH,1)+"CRIT/DAT"
8680 OPEN"R",1,Y,128
8690 FIELD 1,32 AS NF$,4 AS MF$,4 AS BF$,4 AS TF$,4 AS PF$,
 4 AS VF$,4 AS WF$,4 AS DF$,4 AS SF$,4 AS FF$,60 AS XF$
8700 RETURN
8710 REM Find if name in record
8720 N=1
8730 GET 1,N
8740 J=LEN(YH):K=LEN(NF$):IF LEFT$(NF$,J)=YH THEN IF
 RIGHT$(NF$,K-J)=STRING$(K-J," ") THEN 8760
8750 N=N+1:IF N<=LOF(1)/LF THEN 8730
8760 RETURN
8770 REM Convert name to caps
8780 YH=YB
8790 FOR J=1 TO LEN(YB)
8800 K=ASC(MID$(YB,J))
8810 IF K>96 AND K<123 THEN YL=CHR$(K-32):MID$(YH,J)=YL
8820 NEXT
8830 RETURN
8840 REM Write data to disk
8850 IF N<=LOF(1)/LF THEN LSET FF$=MKS$(A(2,KS+7)):
 GOTO 8920
8860 LSET NF$=YH
8870 LSET MF$=MKS$(A(2,KS)):LSET TF$=MKS$(A(2,KS+1))
8880 LSET PF$=MKS$(A(2,KS+2)):LSET VF$=MKS$(A(2,KS+3))
8890 LSET WF$=MKS$(A(2,KS+4)):LSET DF$=MKS$(A(2,KS+5))
8900 LSET SF$=MKS$(A(2,KS+6)):LSET FF$=MKS$(A(2,KS+7))
8910 LSET BF$="      "
8920 PUT 1,N
8930 CLOSE 1
8940 RETURN
```

Listing 2: *To make conversion between* BASICA *and* TRS-80 BASIC *easy, the programs include the lines below that define the parameters of the two different displays and a function that converts values in* BASICA LOCATE *statements to acceptable values for* TRS-80 BASIC PRINT@ *statements.*

```
200 NS=64:NR=16:LF=1   'screen parameters for TRS80
210 'NS=80:NR=24:LF=128 'screen parameters for 80x24 (IBM)
220 DEF FN LC(J,K)=(J-1)*NS+K-1
```

To make conversion easier, I incorporated a few additional items into the TRS-80 program, as shown in listing 2. These lines define three parameters that differ between various computers—the number of columns on the video (NS), the number of rows on the video (NR), and the conversion factor from LOF to record number (LF)—on the TRS-80 the LOF is returned in records, in BASICA it is returned in bytes. In addition, a function is defined that takes a row and column number, as in the BASICA LOCATE statement, and converts it to a value for a TRS-80 BASIC PRINT@ statement.

Most screen displays in the program are set up in terms of these variables and function so that, when converting to BASICA, all you do is replace the PRINT@ statements with LOCATE(..): PRINT using the same parameters. Other changes needed for the conversion besides the PRINT statements include a more complex statement to decode the cursor arrow input for the IBM PC.

But whether you use a TRS-80 or an IBM PC, I hope you will find my programs helpful in creating your small-scale engineering applications. From an engineering standpoint, the value of these and similar programs comes not from complex math routines or innovative algorithms used in the calculations, but from relatively simple but tedious math in a flexible and convenient package that an engineer can pick up after a period of disuse and put to work immediately. ■

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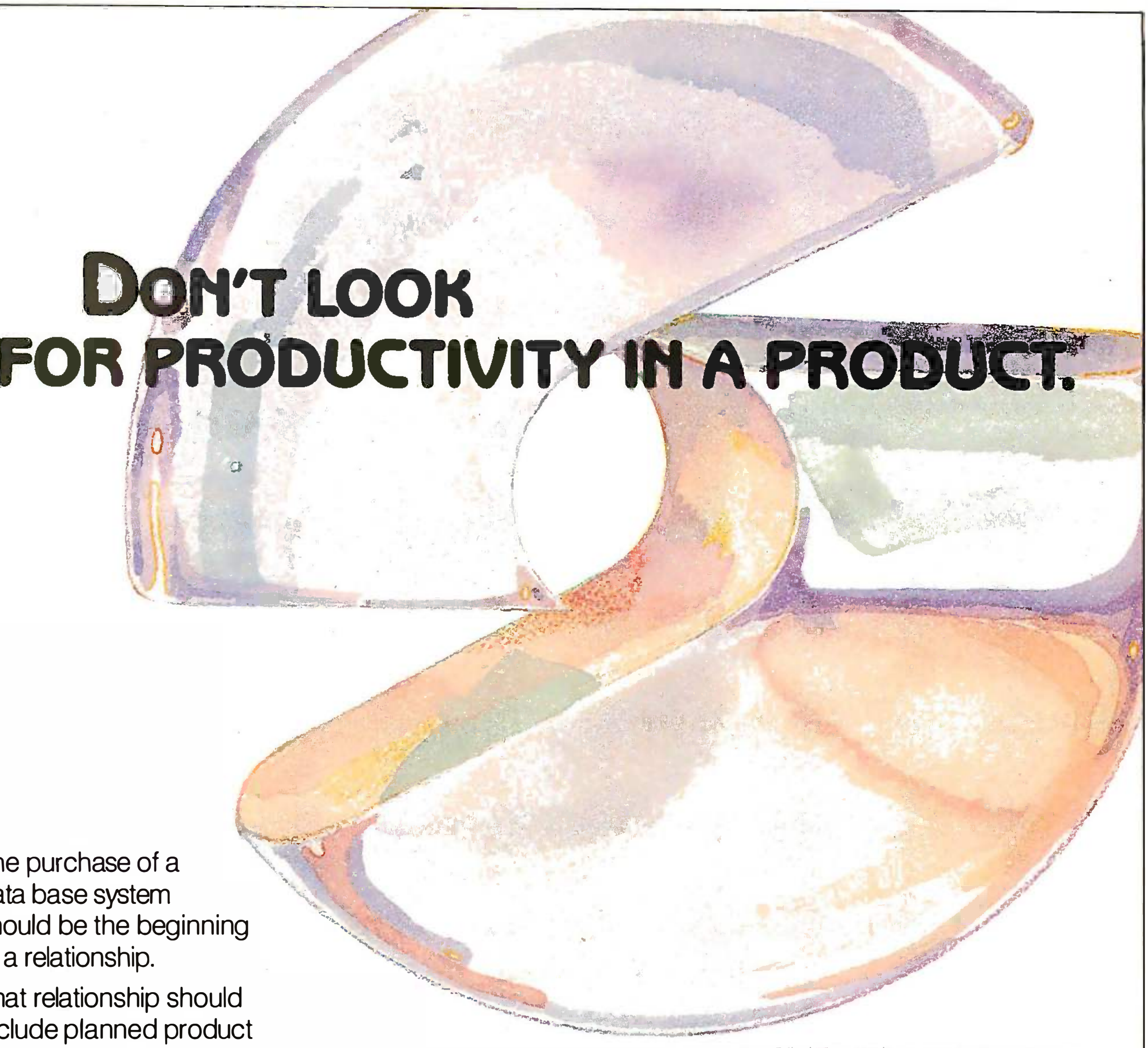

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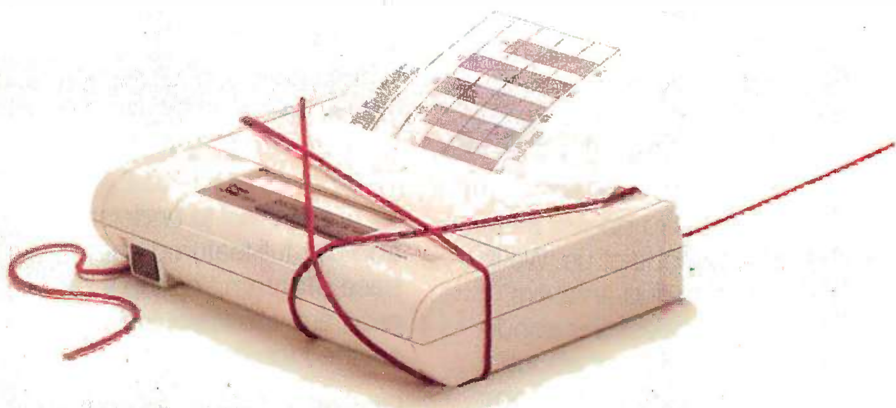


# Reviews



THE COMMODORE 128 is three computers in one. It has a Z80 for CP/M, a Commodore 64 mode, and a C-128 mode that provides 80-column RGB text output and uses an 8502 processor, switchable between 1 and 2 MHz. William Wiese Jr. reports that the C-64 mode ran all his C-64 software, although it cannot access the improved features available in the C-128 mode. The system appears to be a good value and an interesting path of expansion for C-64 owners.

John D. Unger was impressed with the ITT XTRA XP. It is an IBM PC AT clone, but it is more compatible with the IBM PC and PC XT than the AT is. The benchmarks prove that the system is fast, especially when you use the disk-caching software provided with the unit. John believes that the combination of zero-wait-state RAM and disk caching put the XP ahead of the AT in most categories.

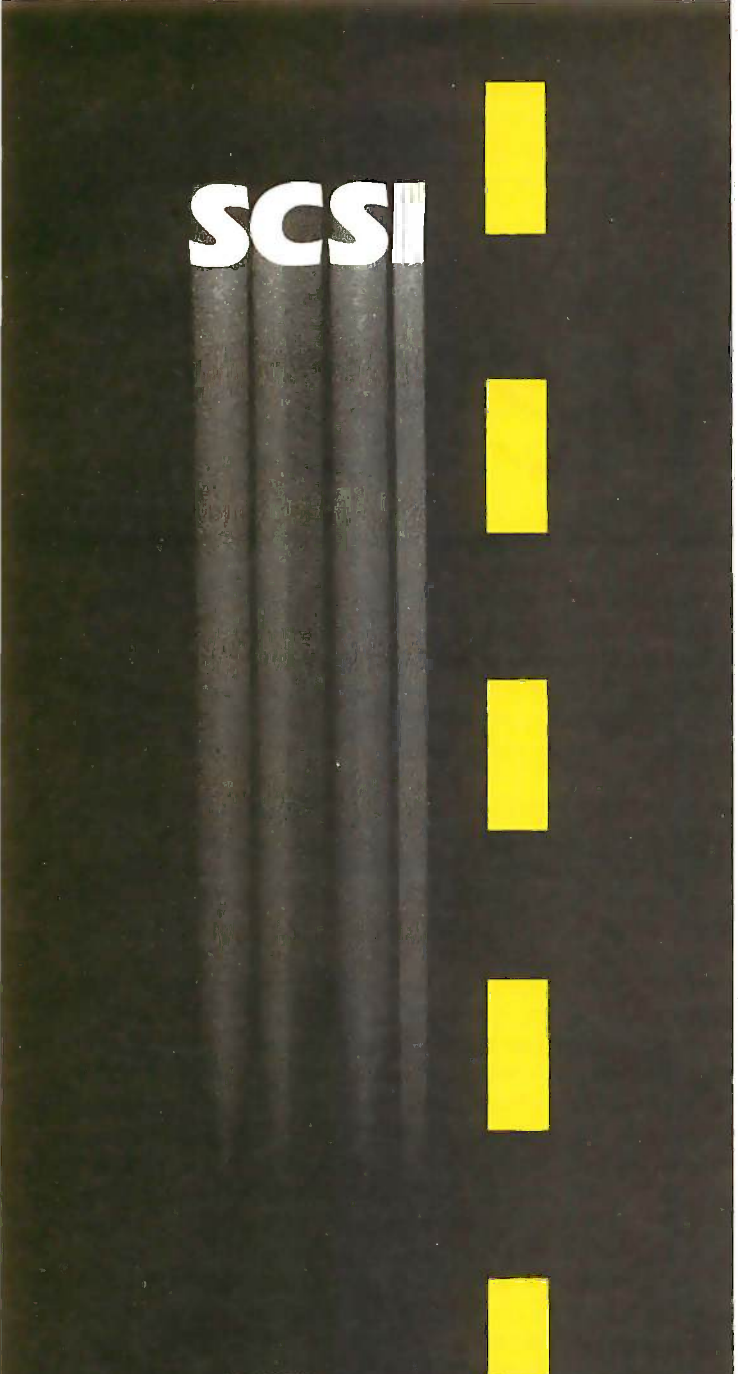
John also examines the Conquest Turbo PC, an IBM PC XT compatible with an 8088-2 central processor that you can switch between 4.77 and 8 MHz. He concludes that the machine, despite some small difficulties, is an excellent value that deserves consideration from experienced users.

William Wong examines two LISP implementations for MS-DOS. His comparative perspective explains the trade-offs you will face in deciding between a $70 package and a $169 package. BYSO LISP support of LISP 1.5 is relatively complete, but the author concludes that it may be inappropriate for very sophisticated work. Waltz LISP, based on Franz LISP, lacks floating-point numbers but is fast and very functional.

William Jacobs looks at ExperOPS5, a Macintosh implementation of OPS5. ExperOPS5 is an expert-system shell on which you can write microcomputer expert systems, but the author reports that using the production rule language for serious application development would be difficult.

Patricia Wirth and Lincoln E. Ford compare five laboratory interfacing packages. They conclude that the software packages differ in their emphasis, idiosyncrasies, quality of documentation, and ease of use. Those involved in the analysis of laboratory data will find the authors' views indispensable.

Finally, Robert D. Swearengin found that the IBM Wheelprinter E is a sturdy, no-nonsense daisy-wheel printer with slow speed but high quality. The documentation is good and the operation is flexible.

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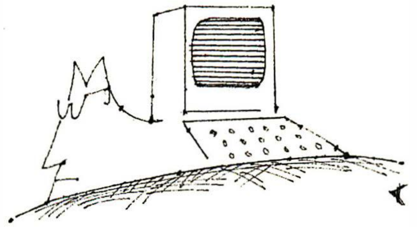
There are always impressive new developments at COMDEX. Spring COMDEX in Atlanta is smaller than Fall COMDEX in Las Vegas, but it still took technical editor Stan Wszola and me three and a half days to visit all of the exhibits.

Laser printers and desktop publishing were conspicuous; the *Show Daily* counted 15 different laser printers on the floor. There were the well-known units, including those from Hewlett-Packard, Ricoh, Kyocera, and Canon, but perhaps the most unusual was the LaserPro from Oasys. Though only $1895, the printer has some interesting features. It can accept envelopes and allow output to emerge print down to sequence documents in proper page order.

The Atari and Amiga booths were the center of most of the excitement. The Amiga Sidecar was particularly interesting. Scheduled for release this fall, this IBM PC hardware emulator allows you to run MS-DOS as an Intuition task. The prototype, which contains an 8088 running at 4.77 MHz and 256K bytes of RAM (expandable to 512K bytes), includes three IBM PC-compatible expansion slots and ran a variety of applications without crashing and with impressive speed.

We also saw a number of new peripherals, including Digi-View from NewTek, a video digitizer that produces high-quality views of stationary objects. Digi-View connects to the printer port and takes a signal from a black-and-white video camera. By photographing an object three times, each with a different primary color filter, you can obtain and then manipulate color images.

One change merits mention: Atari has decided not to include an RF modulator with its 1040ST. Some folks at Atari have intimated that third parties might market an RF modulator for the 1040ST; however, you should not expect, as Phillip Robinson and I suggested in our March preview, to be able to hook up the unit to your color TV in the near future.



Atari showed its own IBM PC-compatible box, a modest unit that will retail for under $300. For the moment, the prototype provides limited compatibility and possibly only one expansion slot.

Perhaps the most impressive ST development (scheduled for the third quarter) is Batteries Included's Thunder, a writer's assistant that, for only $39.95, will provide a 50,000-word spelling checker, a PRD+-like abbreviation facility, and a Borland Lightning-like thesaurus.

Pixelmaster, a color ink-jet printer from Howtek, caught our fancy. The printer uses hard, crayon-shaped plastic rods to produce near-offset-quality raised color text. A rotating print head has 32 separately aimed ink jets, 20 for black ink and 4 each for yellow, cyan, and magenta.

Another interesting new product is Toshiba's T3100, a PC AT portable that weighs only 15 pounds. The unit has an 80286 running at 8 MHz, a standard 640K bytes of RAM expandable to 1.6 megabytes, one 720K-byte 3½-inch disk drive, a 10-megabyte hard disk, and an 80-character by 25-line gas-plasma display.

IBM again showed off its Convertible. The major impact of IBM's announcement may well be to legitimate laptops and the 3½-inch drive in the MS-DOS world. A number of other new computers will also demand consideration, including the Bondwell 8 and the Toshiba T1100.

Torrington's Manager Mouse caught our eye. The mouse, which retails for $198, plugs directly into the serial port of an IBM PC or compatible. The durable dual-wheel design of the mouse gives it a smoother feel and should eliminate most maintenance problems. The unique design allows you to use it on any horizontal or vertical surface. You can use the mouse with Lotus 1-2-3, dBASE II, Symphony, Framework, and WordStar 2000.

There are also two interesting developments in mass storage. Iomega's Bernoulli Box Plus combines two removable cartridge 20-megabyte disk drives with an 80-megabyte hard disk drive. Archival backup software can back up the fixed disk to multiple cartridges at the rate of 4 megabytes per minute. An alternative for fast and virtually unlimited on-line storage and backup is IDEAssociate's Diskit 2, a compact external disk drive with twin 10-megabyte Winchester removable cartridges.

There were also small items that are often easy to miss. The Missing Link ($29.95) from Active Components (for a Commodore 128 or IBM PC, XT, or AT with a color graphics adapter) provides 16 shades of green or amber on a composite monitor. The Missing Link has a 9-pin connector on one end to attach to your system and an RCA connector on the other. The small device, which digitally combines an RGB signal into a standard composite black-and-white signal, requires no external power supply.

Comparative reviews will be appearing in coming issues. Please stay tuned for reviews of 24-pin printers, IBM PC AT multifunction boards, tape backup units, telecommunication software, laser printers, and more.

—*Jon Edwards*
*Technical Editor, Reviews*

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# THE COMMODORE 128 PERSONAL COMPUTER SYSTEM

BY WILLIAM WIESE JR.

*Compatibility with the Commodore 64, a Z80 for CP/M, a new BASIC, and more*

The Commodore 128 personal computer includes 128K bytes of RAM and uses two microprocessors, a Z80 and a 6502-compatible chip, the 8502, which supports bank-switched memory. The C-128 includes dual video outputs, a four-voice sound synthesizer, 80-column RGB text output with its own independent 16K of video RAM (supporting 640- by 200-pixel resolution), and the 40-column VIC-II chip, which supports 320- by 200-pixel high-resolution sprite graphics.

On power-up, the C-128 enters the "native," or C-128, mode, which uses the 8502 processor, switchable between a 1- and 2-megahertz clock speed. The mode accesses the 128K of RAM using bank-switching techniques and allows you to use BASIC 7.0, an advanced BASIC. In C-64 mode, you obtain full compatibility with the Commodore 64 but without access to any of the C-128's advanced features. Alternatively, you have a 2-MHz Z80-based CP/M machine that supports bank-switched CP/M version 3.0 (CP/M Plus).

## C-64 MODE

In C-64 mode, I had no trouble loading and running all my C-64 programs, including heavily copy-protected ones. There are three ways to switch to C-64 mode: In C-128 mode, you can type GO 64; you can hold down the Commodore logo key while powering up; or you can put a C-64 ROM cartridge in the expansion port. Note that you cannot leave the C-64 mode—the slight changes in the operating system necessary to implement the exit would reduce compatibility with the C-64. Note also that in C-64 mode, you will not normally be able to access any of the C-128's improved features, such as 80-column video output or high-speed disk drive usage with the 1571 drive.

There are only three slight differences between the C-64 mode and an actual C-64. The VIC-II video graphics chip has two extra registers, #47 and #48 (at locations 53295 and 53296). Register 47, a keyboard control register, uses 3 bits (the 5 highest bits are unused) to scan the extended key matrix. C-128 mode uses the register to read the numeric keypad, outboard cursor keys, Help, Tab, and other special function keys. To maintain full compatibility, the C-64 mode does not read the registers, but you could write code to read these keys even in C-64 mode.

Register 48 simply contains one bit that selects 1- or 2-MHz clock speeds. You can run many programs in C-64 mode at a 2-MHz clock rate, but you will not be able to access the VIC-II video chip; therefore, the screen will be blank. Additionally, the C-128 cannot communicate with its companion disk drive at this higher clock speed. The modem port and the sound chip do function properly when the system is running at 2 MHz.

The third difference results from having two 64K-byte RAM banks. If you power up in C-128 mode and select bank 0 or 1, that will be the bank of RAM that the C-64 uses. Of course, this "difference" has no effect on compatibility with a stock C-64.

I have experienced no incompatibilities, and I am completely satisfied with the C-64 mode, but I have heard that one program, Commodore's International Soccer, does not function properly because of incorrectly read

(continued)

*William Wiese Jr. (118 West 36th Ave., Apt. D, San Mateo, CA 94403) is currently a college student in San Mateo. His interests include amateur radio and classical piano.*

sprite definition data. Only programs that use locations 53295 and 53296 (D02F and D030 hexadecimal) will ever cause any small differences. Also, there may be minor incompatibilities due to the use of the new 1571 fast drive, which I discuss below.

### C-128 MODE

The C-128 mode supports 80-column text output via an RGB output port, and 40-column text or high-resolution graphics output through a composite video port. The 80-column mode supports escape sequences that toggle true underlining and flashing characters. The 80-column video generator is an 8563, a proprietary chip that is a descendant of the 6845 CRT controller used in the IBM PC. The 8563 has its own 16K of video RAM that is not part of the C-128's memory map. To access a memory location in this "detached" RAM, you must write the low and high bytes of the desired address to special registers in the 8563 and then read from or write to another special 8563 I/O register.

In the 2-MHz mode, you can only enable the 80-column screen; the VIC-II chip cannot generate video at 2 MHz. In 1-MHz mode, both the 8563 and the VIC-II are operational; you can have two displays running at once. There is an undocumented 640- by 200-pixel graphics mode on the 8563. This graphics mode doesn't support sprites and fancy multicolor graphics, and you cannot access the mode from BASIC 7.0; you will need a machine code routine or use cumbersome PEEKs and POKEs. A simple graph-plotting program, in listing 1, demonstrates this mode.

Listing 1: *A demonstration of 640- by 200-pixel graphics.*

```
100 DEF FNA(X)=SIN(X)
110 TRAP310:FAST:BANK15
112 WR=52684:RE=52698:REM EDITOR ROUTINE ADRESSES FOR
    8563 REGISTER READ/WRITE
114 FORI=0TO7:MA(I)=2](7-I):NEXT
120 INPUT "........ MAXIMUM (X)= ";MX
130 INPUT "........ MINIMUM (X)= ";MN
140 INPUT "EXPECTED MAXIMUM (Y)= ";Y2
150 INPUT "EXPECTED MINIMUM (Y)  ";Y1
160 IF MN>MX THEN T=MN:MN=MX:MX=T
170 IF Y1>Y2 THEN T=Y1:Y1=Y2:Y2=T
180 VS=200/ABS(Y2-Y1)
190 VO=100-Y2-Y1
200 HS=ABS(MX-MN)/640
210 GOTO 260
215 REM  PLOT X AND Y ON 640 X 200 BITMAP
216 REM LINE#220 CALCULATES ADDRESS HIGH & LOW BYTES
217 REM LINE#230 READS BYTE FROM BITMAP
218 REM LINE#240-  SETS APPROPRIATE BIT IN BYTE,
    WRITES TO BITMAP
219 REM
220 AD=INT(X)/8+INT(Y)*80:H=AD/256:L=ADAND255
230 SYS WR,H,18:SYS WR,L,19:SYS RE,0,31:RREG BY
240 SYS WR,H,18:SYS WR,L,19:SYS WR,BY OR MA(XAND7),31
250 RETURN
255 REM
260 SYS WR,128,25:SYS WR,113,26:REM HOUSEKEEPING,
    TURN ON GRAPHICS
270 SYS WR,0,18:SYS WR,0,19
280 FORI=0TO 64:SYS WR,0,31:SYS WR,0,30:NEXT:REM
    CLEAR SCREEN
290 FOR X=0TO639:Y=VO-VS*FNA(X*HS+MN):GOSUB220:NEXT
300 GETKEY A$
310 SYS WR,64,25:SYS WR,240,26:REM RETURN TO TEXT
    MODE
320 BANK15:FORI=0TO64:SYSWR,96,31:SYSWR,0,30:
    NEXT:SYS49191
325 REM SCREEN GARBAGE CLEARED,AND CHARACTER SET HAS
    NOW BEEN RESTORED
330 PRINT ERR$(ER); " ERROR IN ";EL
340 END
```

In contrast to the slow serial link between the C-64 and the 1541 disk drive, there is a very fast serial link between the C-128 and the new 1571 disk drive. The serial port is fully compatible with the older, slow devices; you can put both slow devices (like printers) and fast devices on the serial bus at the same time. I have not encountered any problems with serial bus lockup.

The C-128 mode uses all the keys on the keyboard. The function keys are predefined with commonly used commands. You can list definitions of all the function keys with the KEY command and redefine them with the KEY# statement.

### BASIC 7.0

The C-128 includes BASIC 7.0 in 32K of ROM. It is one of the most comprehensive BASICs I have seen and is upwardly compatible with the C-64's BASIC 2.0. BASIC 7.0 supports constructs such as IF. . .THEN . . .ELSE, and DO-LOOP, and you can modify the loop construct with UNTIL, WHILE, or EXIT. In addition to the standard implementation of PRINT USING, BASIC 7.0 also provides PUDEF, which replaces the standard space, dollar sign, decimal point, and comma characters used by PRINT USING with your own set of four special characters.

BASIC 7.0 includes a complete set of graphic commands, including BOX, CIRCLE, and PAINT. One of the graphic modes allows a split graphics/text screen with 5 text lines at the bottom of the screen; you can reset the number from 0 to 25. The screen coordinates can range from 0 to 65535, either in a monochrome or multicolor bit map. A sprite editor lets you create and save images of sprites. The BASIC command MOVSPR controls sprite movement. The WINDOW command takes parameters indicating the window's upper left row and column and lower right row and column. All output then appears there without overwriting text outside that window. Un-

Commodore 128

**Company**
Commodore Business Machines Inc.
1200 Wilson Dr.
West Chester, PA 19380
(215) 436-4200

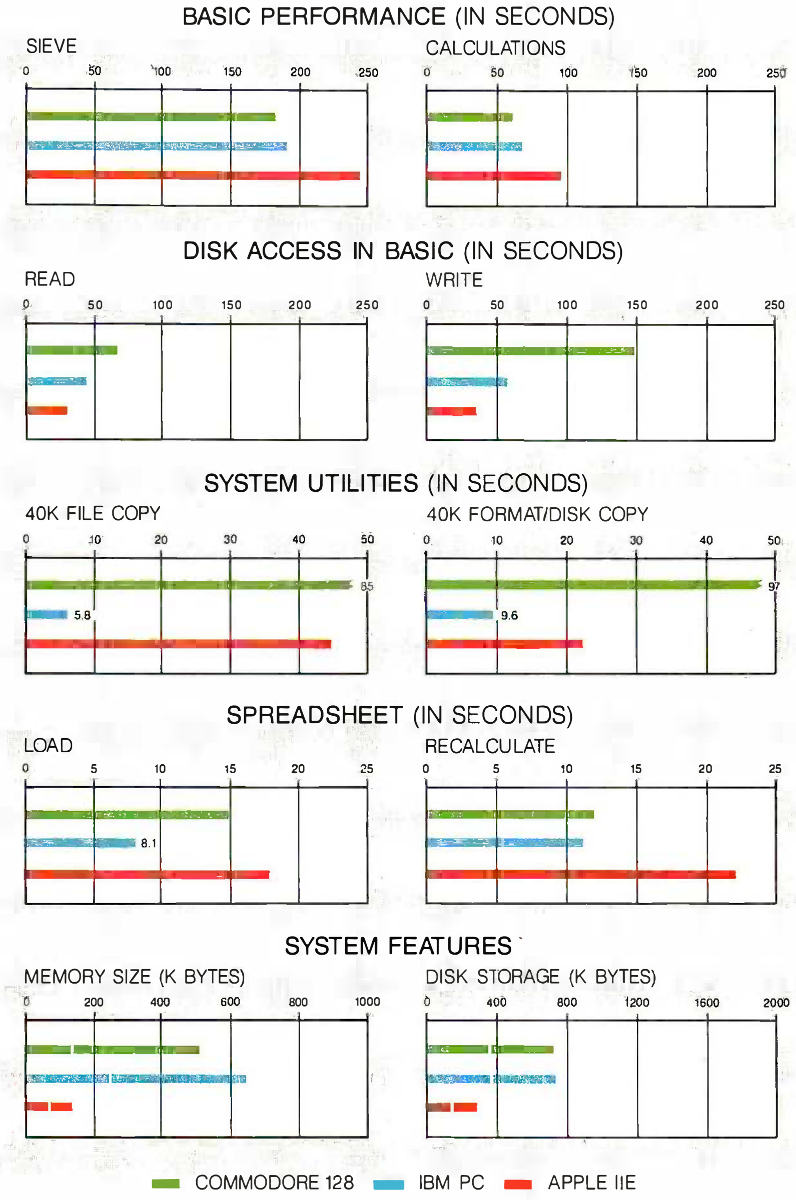
**Size**
C-128: 12½ by 17 by 2 inches
1571 disk drive: 13½ by 8¼ by 3 inches

**Components**
Processors: 8502 (6502-compatible), switchable 1 or 2 MHz
Z80A, 2 MHz
Memory: 128K RAM; 16K RAM, video RAM for 8563 video chip, independent of main memory; 48K ROM, containing BASIC 7.0, editor, monitor, and operating system; 16K ROM, containing BASIC 2.0 and operating system for Commodore 64 mode
Mass storage: 1571 intelligent disk drive; 5¼-inch double-sided double-density (340K)
Display: 40-column/graphics; 80-column text only
Keyboard: Commodore 64 layout; 14-key numeric keypad; 4 auxiliary cursor keys; 8 special function keys
I/O interfaces: One RS-232C 3-line interface, logical voltage levels; one serial bus for disk drives and printers; two joystick/paddle ports; one 8-bit I/O port

**Software**
BASIC, operating system, monitor in ROM; C-128 tutorial/demo disk; CP/M version 3.0 operating system and associated utilities

**Optional hardware**
256K/512K RAM expansion cartridge

**Price**
C-128 computer: $299
1571 disk drive: $279




The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a blank floppy disk. The System Utilities graphs show how long it takes to format and copy a 40K-byte file using the system utilities. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. The spreadsheet used was Microsoft's Multiplan. The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy disk drive and the maximum standard capacity for each system. Tests on the Commodore 128 used BASIC 7.0 and Epyx's release of Multiplan version 1.07. For the Commodore 128, the Disk Write and Disk Read tests were modified to overcome the limitations of BASIC 7.0's 80-character (maximum) input buffer. For the Disk Copy test, we used the DOS Shell program that comes with the 1571 drive. This has a sector-by-sector disk copy program, which includes disk format time. There are many public domain programs that will copy an unprotected disk in 3 to 6 minutes.

fortunately, BASIC 7.0 does not include text and graphic screen dump commands as in Simon's BASIC.

To program music in BASIC on the C-64 you must use the 6581 Sound Interface Device (SID) chip, which requires using a series of obscure POKE commands. By contrast, BASIC 7.0 includes fairly self-explanatory sound statements like VOL, FREQ, DURation, and VC (voice number). Other statements set parameters such as sweep, frequency, waveform, and pulse width. PLAY, TEMPO, and ENVELOPE commands support music programming. Ten "instruments" are predefined.

The disk-access commands in BASIC 7.0 are excellent improvements. DIRECTORY and CATALOG display the disk's directory without first loading it into memory. Moreover, you will not need to use the OPEN command to send most DOS commands. For example, to erase a disk file on the C-64 you must enter

```
OPEN 15, 8, 15, "S0:filename" :
CLOSE 15
```

To accomplish this same operation in C-128 mode, you simply type SCRATCH "filename". The CONCAT command links two disk files. DCLOSE is an especially important new command. When a BASIC program that accesses the disk drive encounters an error and stops, it often leaves all disk files open. DCLOSE sends an UNTALK command directly to the disk drive, closing all files properly. Remember, if a disk-accessing BASIC 7.0 program crashes, the first thing you should do is type DCLOSE.

There are several other helpful features. When a program stops due to an error, you can press the Help key and a program line. The line, with the offending statement underlined, will be listed. The Pointer function (Y = POINTER (*X*) ) returns the address of the variable used as the argument. DEC and HEX$ provide conversions between hexadecimal and decimal. You can obtain error trapping via TRAP and the reserved variables ER (error number) and EL (the line number where the error occurred). BANK *n* sets the memory configuration to any of 16 combinations of RAM, ROM, and I/O.

The SYS command now accepts parameters to be loaded into the 8502 accumulator (.A), .X, and .Y registers before the machine language routine is executed. The companion of the new SYS instruction is the RREG instruction. RREG (read registers) is not mentioned anywhere in Commodore's documentation, but it returns the contents of the 8502's accumulator, *x*,*y*, and status registers to a sequence of BASIC variables. Its format is RREG A, B, C, D. Finally, MID$ can be a result of an expression. MID$ (A$,5,3) = "WOW" is perfectly acceptable.

The C-128 provides a built-in machine language monitor that supports disassembly, memory dumps, and memory editing and has a one-line assembler. I was unhappy with disassembly because I was used to the Hesmon-64 monitor, which scrolls more easily both backward and forward through a disassembly or memory dump. The C-128 monitor includes a comprehensive base-conversion facility that accepts hexadecimal, octal, binary, or decimal numbers. In addition, the monitor's one-line assembler can accept operands in any of these bases. The monitor supports access to the disk command channel and can display the disk directory without first being loaded into memory. The L (load a program) command allows you to force-load a program into any area of memory by accepting an alternate load address as an optional parameter. Bank selection is easy. Instead of selecting a given bank and then doing all assembly, disassembly, and memory editing there, addresses can be five hexadecimal digits long, with the most significant digit indicating the bank to be used.

One feature that is missing is output diversion to the printer or a disk file. The only way to divert a disassembly, memory dump, or the like to an output device is to exit to BASIC with the X command and use the OPEN command to open a channel to device #4 (the printer) or #8 (the disk), use CMD to cause output diversion, then reenter the monitor and type in your desired commands. On completion of your task, you'll have to exit to BASIC again, type PRINT# *n* to cause any untransmitted data to be sent to channel *#n*, and then type CLOSE *n*. The C-128 monitor does not support relocation of machine code containing absolute address references.

## CP/M VERSION 3.0

The CP/M mode is a competent implementation of the operating system. It provides full CP/M compatibility at about the lowest price I've seen for a complete CP/M system, although I experienced some major problems.

The Commodore 128's third mode supports Digital Research's CP/M version 3.0 operating system, or CP/M Plus. The C-64 cartridge version of CP/M, which did not function with many C-64s, used the 40-column screen and was seriously inhibited by the slow speed of the 1541 disk drive. Furthermore, Borland International's Turbo Pascal is the only commercial software package available to C-64 CP/M users.

The C-128 has a standard CP/M system. It closely emulates a Lear Siegler ADM 31 terminal, whose commands are a superset of the famous ADM 3A terminal. The C-128's implementation of CP/M Plus supports all ADM 3A commands. It can use the slow 1541 drive, but CP/M Plus is designed to use the faster 1571 drive. In addition to the speed increase, the new drive can read many different disk formats, including MFM (modulated frequency modulation) disks that are used in standard 5¼-inch CP/M systems. The operating system can read four different, predefined floppy disk formats: the Osborne 1 single-sided double-density, the Kaypro 2 single-sided (or the Kaypro IV double-sided), the Epson QX-10, and the IBM PC CP/M-86 format. Note, however, that CP/M-86 programs will not run on the C-128; the operating system can merely read and write text or data files to or from the CP/M-86 disk.

The C-128 comes with the CP/M version 3.0 (banked-memory version) operating system on a 1541/1571 formatted disk. The operating system includes several standard utility programs—ED, PIP, REN, DIR, GET, PUT,

(continued)

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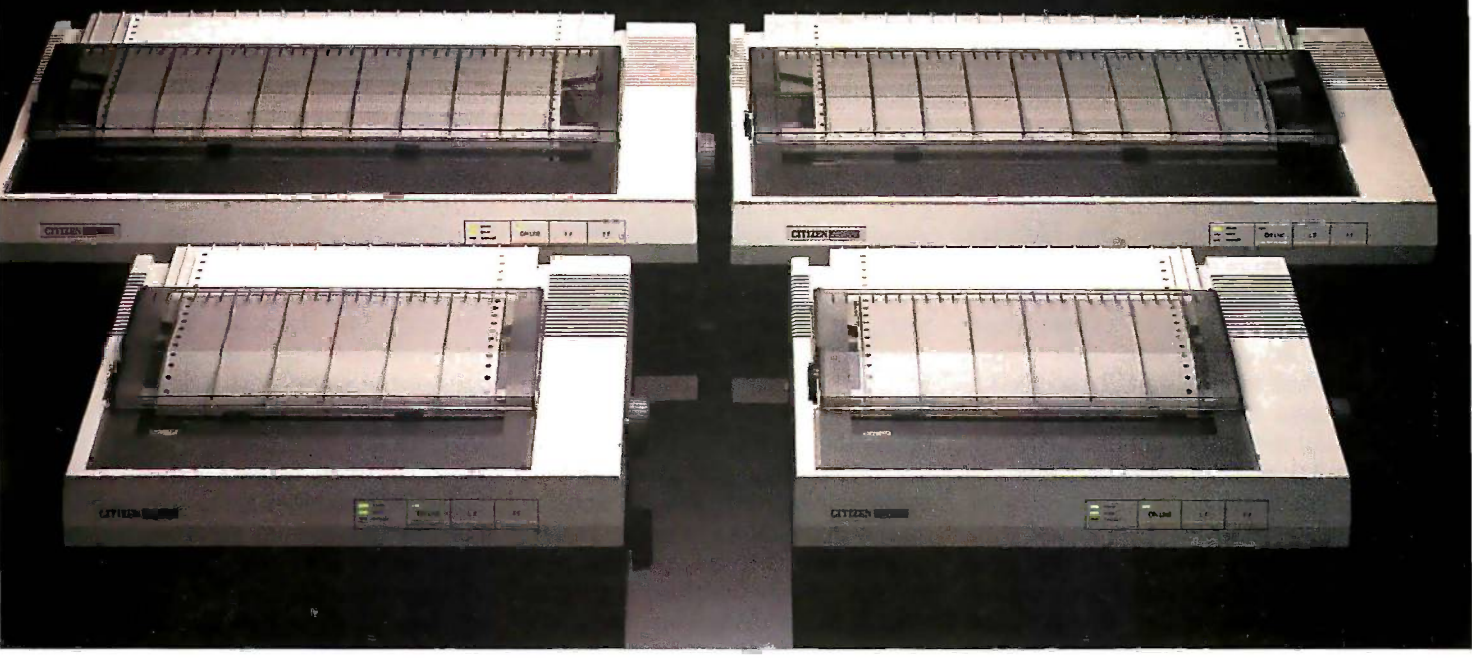


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Inquiry 65

*The C-128 uses the extra clock line on the serial bus to help make data transfer much faster.*

SUBMIT, etc., as well as a comprehensive HELP program and file. For $19.95, you can obtain additional CP/M version 3.0 documentation and programs from a joint Commodore/Digital Research offer. After a two-and-a-half-month wait, I received a complete user's and programmer's manual relevant to generic CP/M version 3.0, not the C-128 implementation specifically.

I also received two disks with, among other things, the SID debugger and its associated utilities (histogram generator and the like), and both the MAC macro assembler and the RMAC (the R is for relocatable) macro assembler. I especially like SID, which seems more powerful than the debugger/monitor packages for the C-64 and C-128 modes. These disks also contain several .LIB and .ASM files used to produce a customized operating system. One contained terminal emulation routines for a variety of standard terminals.

The banked-memory version of CP/M version 3.0 allows 59K bytes of transient program area to reside in RAM Bank 1, while much of the operating system resides in RAM Bank 0. Bank 0 also stores the console command processor, which interprets command-line entries. Storing the CCP in RAM makes it available without time-consuming disk access each time the system is "warm-booted." Extra RAM banks in the 256K/512K RAM expansion cartridge can function as a RAM disk. The version of CP/M Plus currently being shipped does not support RAM disk usage, although future versions probably will.

C-128 CP/M uses both the Z80 and 8502 processors. The Z80 executes most of the CP/M BIOS functions. The 6502-compatible 8502 handles I/O to and from the serial modem port, the serial port connecting the disk drive(s) and printer, and the keyboard. As a result, the BIOS is split into chunks: BIOS80 contains Z80 code, and BIOS85 contains 8502 code.

The C-128 CP/M mode does not support a standard UART chip for RS-232C serial I/O. Instead, the 8502 is switched in to assemble serially received bits into a data byte, or to break down a data byte into a bit stream. 8502 software handles parity and stop bits. Commodore emulates the 6551 UART chip in software, but the emulation can only support 1200 bits per second, while the real 6551 can support communication rates up to 19,200 bps. I consider this one of the more serious limitations of the C-128—what if a user wants to communicate with a mainframe or quickly dump data to a printer buffer?

There seems to be no compatibility problem with Commodore's implementation of CP/M Plus. Most any program that functions under CP/M Plus on another machine should function properly on the C-128, although some programs that run under the older CP/M version 2.2 may not run under CP/M Plus. The WordStar program bundled with the Kaypro left a set of "01" characters on the screen. An Osborne-bundled WordStar functioned perfectly.

Note that the August 1985 version of CP/M Plus cannot use the modem port. I was unable to use a simple terminal program that ran properly on Osbornes and Kaypros. Other C-128 users have reported occasional lockups during attempts at RS-232C communications; I experienced no such problems myself. Commodore says it is now shipping a bug-free CPM.SYS program that not only supports the modem port but also is able to use the 256K/512K RAM expansion cartridges as speedy RAM disks. They have promised to send the disk to all registered C-128 owners, but as yet I have received nothing from them.

### THE 1571 DISK DRIVE

Commodore uses an intelligent (microprocessor-controlled) disk drive connected via a serial version of the IEEE-488 bus. The 1571 drive has a built-in power supply; the unit measures 13½ by 8¼ by 3 inches. It is enclosed in a sturdy plastic enclosure that is the same off-white color as the C-128. The drive mechanism is fairly quiet, and I've had no alignment problems with it after several months of intensive use. There are two small switches on the rear panel of the 1571 that allow you to change the drive's device number from 8 to 9, 10, or 11.

The 1541 drive, the companion of the C-64, is slow and frequently falls out of alignment. The 1571 drive is almost 100 percent compatible with the old 1541. Used with a C-64 (or C-128 in C-64 mode), the drive operates at the same slow speed as the 1541. However, the C-128 uses the extra clock line on the serial bus to help make data transfer much faster, and faster DOS routines are used as well. For example, formatting an ordinary single-sided (683 sectors) disk takes 79 seconds under the old DOS. Under the new DOS (brought up when the 1571 senses the computer has a fast serial bus), formatting a double-sided (1366 sectors total) disk takes only about 40 seconds. Loading a 158-block program using a 1541 (or a 1571 in 1541 mode) takes 105 seconds. With the 1571 in its fast mode, the same program loads in only 10 seconds. There are public domain programs that convert an ordinary Commodore sequential file to a 1571 CP/M file. Unfortunately, they are quite slow. A 40K file might take over half an hour to convert.

A DOS command selects 1541 mode or 1571 mode. In the slow 1541 mode, you can select either head in order to read data from either side of a double-sided disk. (Note that you cannot read the data by flipping the disk because of the reversed direction of rotation.)

Besides reading GCR (group code recording) format disks—that is, ordinary Commodore disks—the 1571 can also read MFM format disks. Although Commodore CP/M Plus only supports Osborne, Kaypro, Epson, and IBM CP/M-86 formats, there is no reason why the 1571 could not read

*(continued)*

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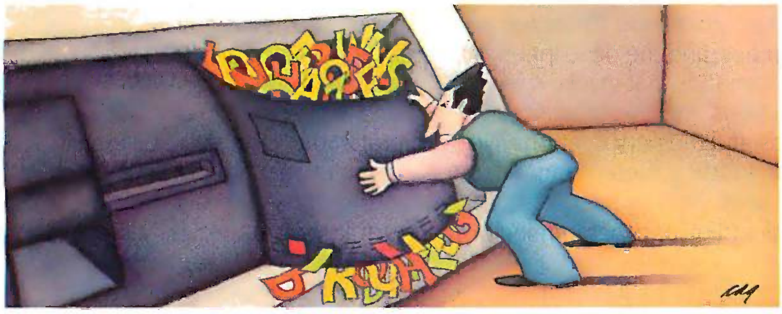

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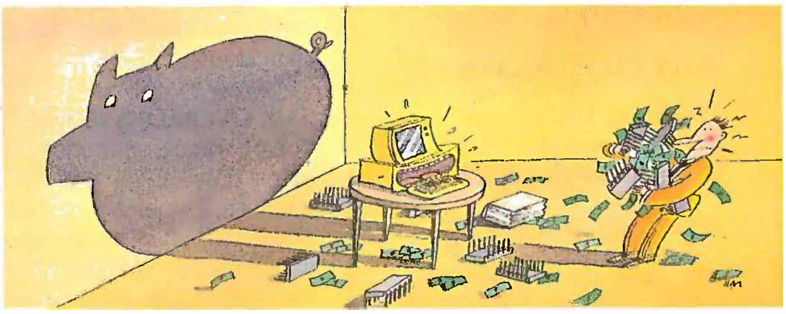

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Machine language programmers will like the 1571 because of the extra, unused 2K bytes of RAM. Because the 1571 reads GCR format disks, it seems possible that routines could be stored in this auxiliary RAM to read Apple DOS 3.3 and ProDOS disks.

When a C-64 (or a C-128 in C-64 mode) runs programs that have drive-controller-resident subroutines, there may be some slight incompatibilities between the 1541 and the 1571. I have not had any trouble with heavily copy-protected programs whatsoever. However, a popular utility for C-64 users, Datamost's Kwik-Load, sometimes seems to lock up the computer until the drive is turned off and then on again. I have found that, upon entering C-64 mode, typing OPEN 15,8,15, "U0>M0": CLOSE 15 will eliminate most compatibility problems.

The 1571 drive's instruction manual is an excellent one for the new and intermediate-level user, but not for experienced programmers. There are no memory maps, and the description of the U0 commands that invoke special DOS functions merely tabulate the commands and their error returns. No instruction in using these commands is offered at all, leaving the user to attempt trial-and-error programming or to disassemble Commodore's CP/M Plus and struggle to find out more about the multi-format capabilities and burst-mode (5K bytes per second) data transfer.

### THE OVERALL SYSTEM

The off-white Commodore C-128 measures only 12½ by 17 by 2 inches because it does not contain its own power supply. The external supply, which measures 6 by 4 by 3¼ inches, supplies much more power than a C-64; it's rated at 5 VDC, 4.3 amps and 9 VAC, 1 amp. The C-128 power supply is not sealed and potted; you can consider it user-serviceable. There is external access to the fuse, too—a real plus.

Along the side of the C-128 are two joystick ports, a reset switch, a rocker-style power switch, and the power connector. The reset switch works in all three modes. The standard 9-pin "D" game ports also accept paddle and trackball inputs; one also allows a light pen hookup.

The user port, expansion port, serial port, and composite video port are all the same as on the C-64. However, the RF modulator seems significantly more stable on the C-128 than on the C-64; I have experienced no rippling or sparkle when using a television. A 9-pin "D" connector supplies 80-column RGB video output. In addition to a Commodore monitor, you can drive any good-quality NTSC composite monochrome monitor simply by connecting it to the "monochrome" pin (7) and the ground pin (1 or 2) on the RGB output connector. I use a Taxan KG-12 amber composite monitor for both 40-column/graphics and 80-column text work. The text display is extremely sharp and easy to read.

The alphanumeric portion of the keyboard resembles the C-64 layout. The four function keys above the numeric keypad are in a horizontal row. The top row also contains Escape, Tab, Alternate, Caps Lock, Help, Line Feed, 40/80 Display, No Scroll, and four cursor keys. The keys have a rather soft touch, but I could tolerate the general keyboard arrangement and "feel." Some may find that the three keys separating the Return key from the L key make typing awkward. The numeric keypad, though, is arranged perfectly.

### DOCUMENTATION AND SUPPORT

There is good documentation provided with the system. A large system guide and a demonstration/tutorial disk explain BASIC 7.0 well and supply many example programs.

The C-64 mode is covered properly, but the CP/M coverage is skimpy; it is enough to get a CP/M program up and running and to do some primitive disk operations, but it is far from being complete. The Commodore 128 programmer's reference guide is as yet unavailable. For the moment, there is a summary of monitor commands and a few very primitive memory maps that serve only to describe the general layout of the system.

Unfortunately, Commodore has replaced its toll-free help line with a toll

*(continued)*

number that seems to be perpetually busy. Commodore's software division does publish the *C-128 Personal Computer Technical Notes*, which costs $20, but the manual only seems to be available to writers and established software developers. It gives comprehensive RAM memory maps, advanced memory management information, more CP/M information, and a discussion of external RAM cartridge usage. It doesn't include much on programming the 8563 video chip or even a memory map of useful subroutines in the BASIC 7.0 interpreter, monitor, or kernel. No 1571 disk drive programming information is included whatsoever.

### SOFTWARE

There is already a good amount of software for the C-128. Timeworks has Word Writer 128, Data Manager 128, and Swiftcalc 128, programs that take advantage of the extra RAM and the 80-column display. Batteries Included has a C-128 version of its Paper Clip word processor, and Epyx has a C-128 port of Microsoft's Multiplan.

Skyles Electric Works has released Blitz!-128, a full BASIC 7.0 compiler, but it only compiles to an intermediate p-code. Abacus Software has released a BASIC 7.0 compiler that generates not only p-code but true 8502 native code. This BASIC 7.0 compiler also features an optimizer and has a special high-speed floating-point library module. In addition, Abacus has released a full Jensen and Wirth Pascal compiler and a full Kernighan and Ritchie C compiler that both have extensions to support graphics and sound and generate native 8502 code.

### BENCHMARKS

The benchmark results are shown on page 271. The Commodore 128 performed respectably. Figures given are for fast mode operation. The disk operations test used the 1571 disk drive; use of the 1541 will substantially decrease performance. Disk read/write performance can be substantially increased by appropriate record deblocking.

In 1-MHz mode, some C-128 BASIC programs will actually run slower than their C-64 counterparts because BASIC 7.0 uses 2-byte tokens for some statements, requiring an extra "fetch" by the interpreter. Overall performance is generally higher than with BASIC 2.0, due to much-improved string-handling routines and the virtual elimination of "garbage collection" time delays.

### CONCLUSION

I am favorably impressed by the Commodore 128 system; I enjoy using my C-128, and I'm sure I'll use it for a long time. However, it does have some flaws that need correction. With good documentation for both the C-128 and the 1571 drive, a real UART (at least under CP/M), and software drivers to allow IBM PC-DOS disk compatibility, it would be a really superb system. ■





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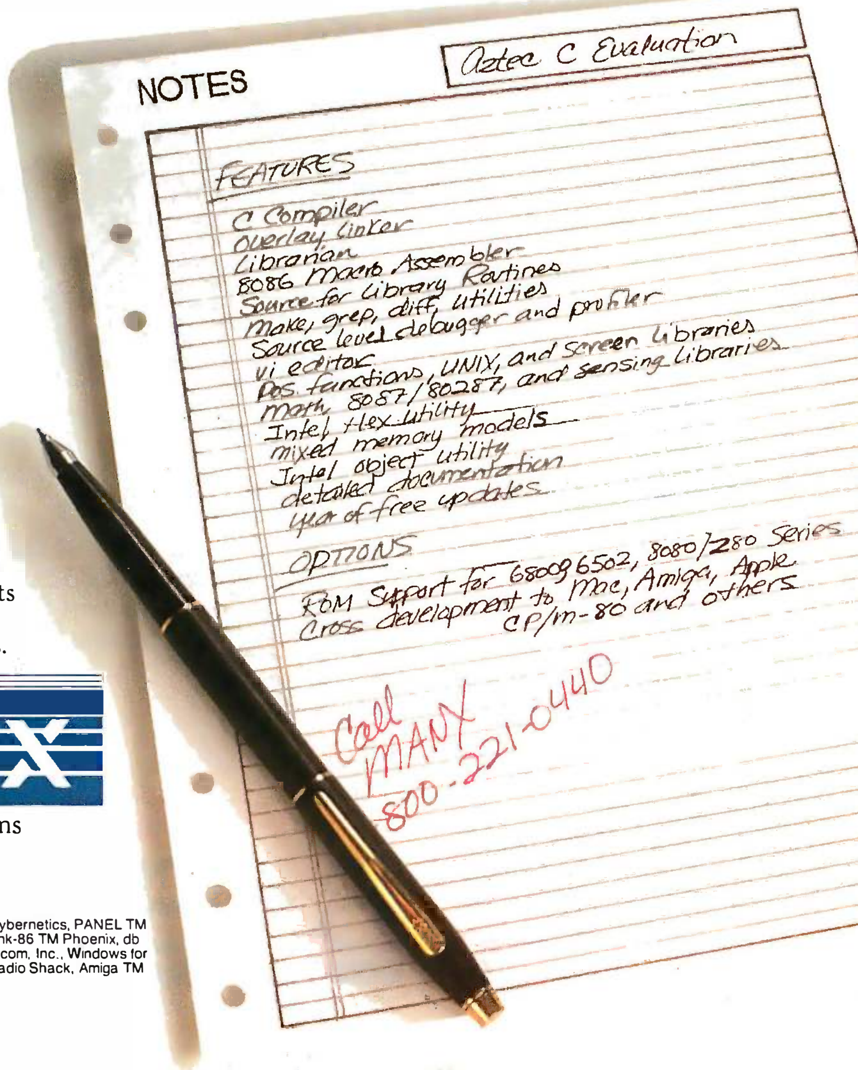


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# THE ITT XTRA XP

BY JOHN D. UNGER

## *A fast IBM PC AT clone with hardware and software enhancements*

The ITT XTRA XP is not simply another IBM PC AT clone; it is much more compatible with the IBM PC and PC XT, and it has hardware and software enhancements that make it capable of operating, in some cases, even faster than the AT. Although the XP will not accept cards made with a 16-bit data bus (such as those used in the AT), and while the unit does not have a 1.2-megabyte drive, the microprocessor is the 16-bit Intel 80286 running at 6 megahertz, the same clock speed as the PC AT. With a few keystrokes, you can also switch it to work at 4.77 MHz, which makes the XP compatible with those software applications sensitive to timing loops designed around that clock rate.

The central processor operates with zero wait states, thanks to fast dynamic memory chips used in RAM. Moreover, a disk-caching scheme, included in the operating system, markedly speeds up file transfers and other disk I/O tasks. Like an enhanced IBM PC AT, the XTRA XP comes standard with a 20-megabyte hard disk and 512K bytes of RAM. Its suggested list price is $4595.

### HARDWARE

Apart from insignificant cosmetic differences, the keyboard, monitor, and the external appearance of the XTRA XP are identical to the ITT XTRA that I reviewed in the April 1985 BYTE. The footprint is small, and you can place the 14- by 15.5- by 5.5-inch system unit on its side.

There are two versions of the XP. Each has a 360K-byte floppy disk drive and 512K bytes of RAM. The Model III has a 10-megabyte drive. I reviewed the Model V, which features a 20-megabyte hard disk. The unit had the maximum of 640K bytes of RAM.

The keyboard is similar to the IBM PC XT's but has LEDs for both the Caps Lock and Num Lock keys, and the left-hand Shift key is located just to the left of the Z key. I found the keyboard a bit stiff but comfortable to use. The keys have no audible feedback, but there is a definite "break" when they are pushed.

### INTERNALS

The XP's motherboard can hold 640K of RAM. This RAM connects to the microprocessor via a 16-bit data path, which speeds up I/O operations. Eighteen 256K by 1-bit DRAM chips provide the standard 512K bytes of memory. You can add eighteen 64K by 1-bit chips to empty sockets on the motherboard to bring the total system memory to 640K. The DRAM chips have to be the faster 150-nanosecond ICs because the CPU on the XP operates with zero wait states.

Inside the XP are five full-length slots. In the review unit, a disk controller and ITT's color graphics display board occupied two of the five slots. The 360K-byte floppy disk drive on my XP had a cable running from the motherboard to its controller bus, but the hard disk was connected to the board installed in slot 1 of my XP.

The expansion slots will accept only 8-bit expansion boards made for the PC or XT; the XP has no slots that are configured with the 16-bit data paths used for the AT expansion bus. The XP has an RS-232C serial port and a Centronics-compatible parallel port on the motherboard, so you will probably not find the limit of three empty slots a serious shortcoming. The ITT XTRA XP does not include an internal clock with a battery backup, but you can get one on ITT's optional integrated graphics controller card.

ITT offers an optional memory-expansion board that will add up to 2 megabytes of memory to the computer. However, the extended mem-

(continued)

*John D. Unger (P.O. Box 95, Hamilton, VA 22068) is a geophysicist for the U.S. government who uses computers to study the structure of the earth's crust in earthquake-prone regions.*

*The benchmarks showed that the disk-caching program more than made up for the slower disk-access time.*

ory is available only to the disk-caching, print-spooling, or RAM disk programs that ITT supplies with the operating system software, because the address area of the add-on RAM is above the 640K bytes of RAM used by MS-DOS.

The power supply is rated at 155 watts, which should be adequate for running all add-on cards that you need. Unfortunately, the cooling fan mounted in the power supply is rather loud and tends to be annoying.

ROM parity checking takes about 10 seconds with 640K of memory installed. A DIP switch on the motherboard allows you to disable the test. Another DIP switch enables a screen-blanking routine that will function automatically after 15 minutes of inactivity. In addition, ROM contains a menu-driven set of diagnostic tests similar to those that IBM supplies in its software. You can access the tests at any time by pressing Alt-Ctrl-Esc. The same keystrokes also activate a powerful utility monitor program. You can examine and modify memory and floppy disk parameters (such as head settle time and motor startup time).

### MONITOR AND DISPLAY

The review unit contained a color graphics display card and an optional RGB color monitor rather than the standard monochrome monitor. The display appeared to duplicate the IBM color graphics display exactly, although I find text displayed with this combination, especially the coarse 8- by 8-pixel characters, difficult to use for long periods of time, even with contrasting color combinations. On the other hand, the color graphics are impressive and clear and appear to be fully compatible with the IBM PC. If your main application for the XP uses text or numerical data, I would suggest installing ITT's integrated graphics board, which offers higher-resolution characters. The board supports IBM-type monochrome and color display modes, Lotus-compatible monochrome graphics, and extended color graphics modes. It also adds serial and parallel ports and a real-time clock.

### STORAGE

ITT offers only a 360K double-sided double-density floppy disk drive and completely ignores the 1.2-megabyte high-density AT-type drive. You may particularly miss using a 1.2-megabyte drive to back up the hard disk.

The 20-megabyte hard disk was initially disappointing. The drive itself operates fairly quietly, but early benchmarks indicated that the average access speed of the drive was in the same range as the XT's 10-megabyte drive (80 to 90 milliseconds). This is significantly slower than the 20-megabyte drive in the IBM PC AT, which has a 40-millisecond access time. However, the apparent access time of the hard disk decreased tremendously when I began using ITT's disk-caching program, FXP.COM.

### SOFTWARE

The benchmark tests showed that the disk-caching program more than made up for the slower disk-access time. Disk caching is a technique that allocates RAM as a buffer for all disk I/O requests from the system. FXP.COM monitors the most accessed files and keeps them in RAM along with other information, such as the directories of the hard and floppy disks on the system. Once invoked, the cache program operates completely in the background, although with a big time savings (see table 1), particularly if you are using a floppy disk drive. FXP.COM also provides a print buffer.

You can vary the amount of RAM available for the disk cache, although the caching program will automatically use extended RAM (more than 640K bytes) if you install it on your XP. Unfortunately, you will have to reboot if you want to change the amount of RAM used by the program, a consideration if you need to reclaim that area of RAM. You can easily disable FXP.COM, but doing so will not reclaim the RAM that was assigned to disk caching and print buffering.

Like many RAM disks, you can install ITT's as a device driver with CONFIG.SYS. However, ITT's RAM disk has two interesting options. You can set up multiple RAM disks and you can use the memory area above 640K bytes as a RAM disk. ITT's optional memory-expansion board makes it possible to have up to 2 megabytes of above-board memory to use for the RAM disk.

The XP also comes with ITT's version of MS-DOS 2.11 and ITT Advanced BASIC 2.0, which is essentially GW-BASIC. In addition to the nor-

(continued)

Table 1: *The size of the memory allocated to disk caching affects the speed of copying files from one area of the hard disk to another. I made successive copies of an 80K-byte ASCII source file after deleting the target file created during the previous iteration. The time for making the first copy is fairly constant, but subsequent copies become progressively faster as the amount of allocated RAM increases. Some of the trends are easy to decipher, but others are less easily explained. The apparent slowdown around 128K bytes may be due to some interaction with print buffering. All tests were run with the microprocessor in its 6-MHz mode.*

| 0 | 16K | 32K | 64K | 128K | 256K | 384K | 512K |
|---|---|---|---|---|---|---|---|
| 7.4 | 7.4 | 4.7 | 5.4 | 5.6 | 5.2 | 5.3 | 5.3 |
| 7.6 | 7.6 | 4.6 | 4.7 | 5.8 | 2.7 | 1.2 | 0.9 |
| 7.7 | 7.6 | 4.7 | 4.6 | 6.0 | 2.5 | 1.0 | 0.9 |
| 7.6 | 7.3 | 4.7 | 4.4 | 5.8 | 2.0 | 1.0 | 0.9 |

## ITT XTRA XP

**Company**
ITT Information Systems
2350 Qume Dr.
San Jose, CA 95131
(800) 321-7661

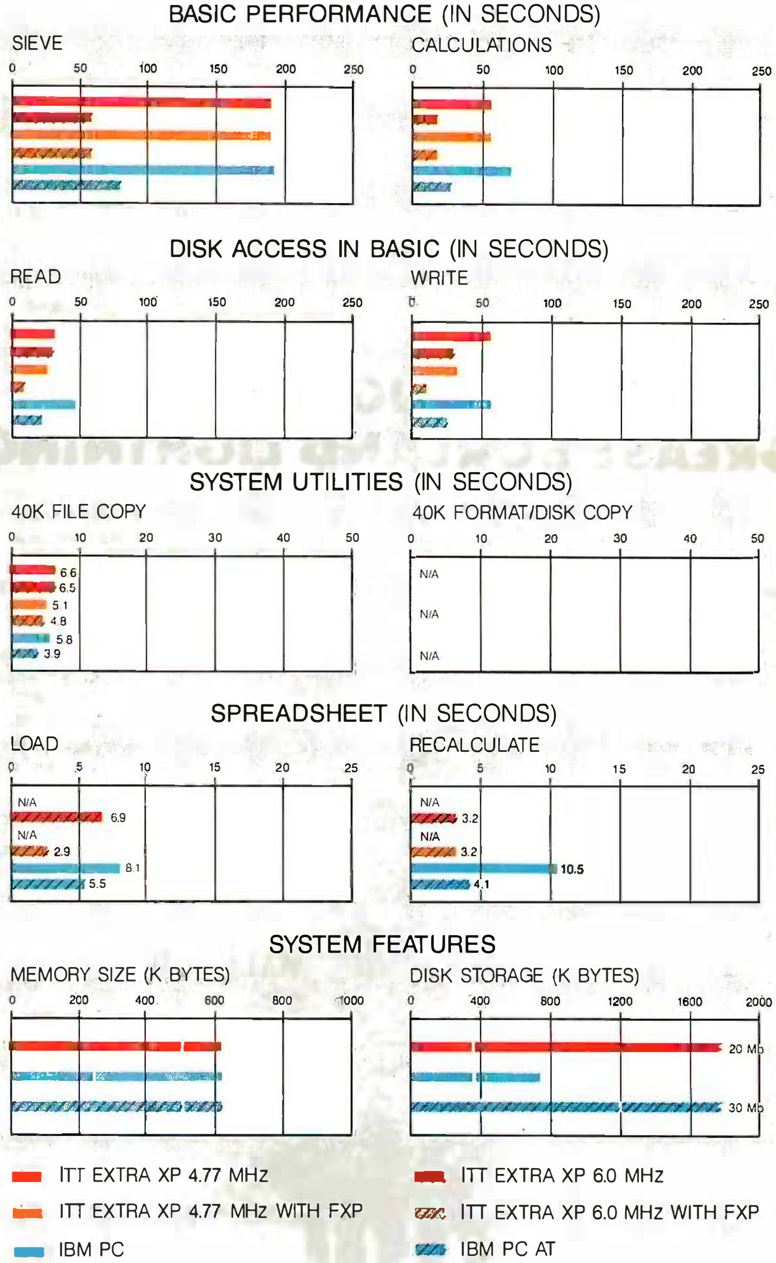
**Size**
14 by 15.5 by 5.5 inches

**Components**
Processor: 80286 at 4.77 and 6 MHz (switchable under software control or from keyboard); CPU operates with no wait states in 6-MHz mode; socket for 80287 coprocessor
Memory: 512K of zero-wait-state dynamic RAM (standard) expandable to 640K on motherboard; 64K ROM (BIOS, bootstrap, and self-test); 4K text video RAM on monochrome board; 16K graphics video RAM on color graphics board
**Mass storage:** One 360K-byte DS/DD 5¼-inch drive; 10-megabyte hard disk (Model III); 20-megabyte hard disk (Model V)
**Display:** 80 columns by 25 lines (monochrome); graphics: text—80 by 25 by 2 colors; text—40 by 25 by 16 colors; 640 by 200 by 2 colors; 320 by 200 by 4 colors
**Keyboard:** Detached 84-key QWERTY
**Expansion capability:** Five card slots (IBM PC bus); hard disk controller and color graphics card each use a slot
**I/O interfaces:** One DB-25P Centronics-compatible parallel printer port; one RS-232C serial communications/printer port; speaker (accessed from BASIC or assembly language)

**Documentation**
User Guide, ITT Advanced BASIC manual, ITT DOS 2.11

**Price**
Model III: 512K, single floppy disk drive, 10-megabyte hard disk: $3995
Model V: 512K, single floppy disk drive, 20-megabyte hard disk: $4595

(Note: Monochrome units include monochrome monitor and monochrome expansion board)




The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a blank floppy disk. The System Utilities graphs show how long it takes to copy a 40K-byte file from the hard disk to the floppy disk. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. The spreadsheet used was Microsoft's Multiplan. The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy disk drive and the maximum standard capacity for each system. Tests on the ITT XTRA XP used ITT DOS 2.11, ITT Advanced BASIC 2.0 (GW-BASIC), Multiplan 1.10, and ITT's FXP.COM disk-caching program, which was set up with 128K bytes of RAM. The XP had one 360K-byte floppy disk drive, a 20-megabyte hard disk drive, and 640K bytes of memory.

mal utility programs, ITT DOS 2.11 includes an adequate but simple asynchronous communications program.

## BENCHMARKS

The XP is fast! Given the disk-caching software and the switch between 6 and 4.77 MHz, I used the benchmarks to test many system permutations (see page 283). When it operates at the "slow" clock rate, the computer's performance is slightly better than that of the IBM PC XT. Performance is dramatically improved when the processor is running at 6 MHz. Pure calculation benchmarks like the single-precision calculations or the Sieve of Eratosthenes ran in two-thirds to three-fourths of the time that they take on the IBM PC AT. With the FXP.COM disk-caching program running, writing to and reading from the floppy disk with BASIC takes only half the time of the AT.

## DOCUMENTATION AND SUPPORT

You get three manuals with the XP—a user guide, a description of ITT DOS 2.11, and an ITT Advanced BASIC manual. The user guide contains complete and clear descriptions on how to set up and get the XP running. It is geared toward novices, but it also contains sections for advanced users on organizing the hard disk, using a RAM disk program, and using the disk-caching software. The DOS manual is thorough and well detailed. ITT's BASIC manual is also excellent.

The XP comes with a 90-day warranty; the dealer from whom you purchase the machine will be able to handle problems. The built-in ROM diagnostics should help both the owner and the service personnel to pinpoint difficulties.

## CONCLUSION

The ITT XTRA XP is essentially a hardware upgrade of the IBM PC XT. The combination of zero-wait-state RAM and disk caching put the XP ahead of the IBM PC AT in virtually all the benchmarks while maintaining high compatibility with the PC and XT. It is a true high-performance microcomputer with more speed and power than the PC, and with its disk-caching software installed, the XP can easily outperform the AT at 6 MHz.

There are drawbacks, however. It is uncertain, for example, if the 80286 in the XP can be operated in its so-called "protected" mode, which would allow it to support a 16-megabyte real address space and a virtual storage area up to one gigabyte (1 billion bytes). This limitation would prohibit you from using the multiuser XENIX operating system or future AT operating systems that take advantage of this feature of the 80286.

ITT claims 100 percent IBM PC compatibility in 4.77-MHz mode, and I had no difficulty running any software, even in the 6-MHz mode. Naturally, you should try software critical to you on the computer before you buy it. Finally, the XP represents a good value for its price, especially when compared to the AT. ■





Inquiry 31

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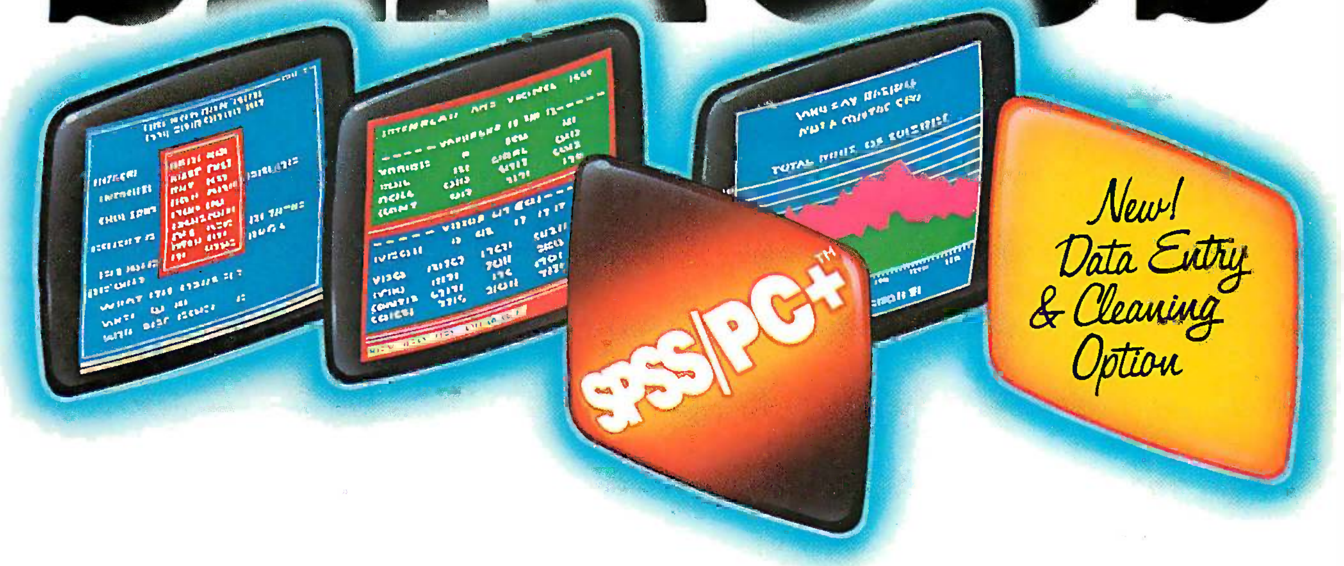


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# THE CONQUEST TURBO PC

BY JOHN D. UNGER

## This IBM PC XT compatible can be switched between 4.77 and 8 megahertz

The Conquest Turbo PC by Microshop Computer Products, an IBM PC XT–compatible machine with an 8088-2 central processor, is hardware-switchable between 4.77 MHz and 8 MHz. You can speed up the running of many standard software programs, although I was disappointed that the benchmark tests did not show the consistent increase in computational speed that I expected from a clock-rate increase of 65 percent. In addition, you may not be able to use programs that rely on the internal clock for timing (especially games, music, and communications software) in the 8-MHz mode.

The Conquest has ample internal capacity for a hard disk and IBM-compatible expansion cards. The power supply is rated at 150 watts, obviously enough power to support an internal hard disk and any expansion cards you may want to add. The computer I reviewed had two double-sided double-density floppy disk drives and 256K bytes of RAM.

The Conquest also comes with an RS-232C serial port and an IBM-style 25-pin Centronics-compatible parallel port installed on the motherboard. Therefore, unlike the IBM PCs, it is not necessary to add an expansion card to provide I/O for the computer.

The Persyst color board in the Conquest has connectors for either a monochrome or an RGB monitor. I used my USI pi3 high-resolution amber monitor with the machine because I did not receive a monitor with the review unit. At $1239, it is one of the least expensive of the IBM PC XT clones. However, don't expect frills with the machine. The review unit came with no software, no operating system, and little documentation.

### HARDWARE

The footprint of the Conquest is just slightly smaller than the IBM PC AT. The system unit holds two half-height floppy disk drives and one full-height floppy or hard disk drive. The two standard Toshiba FDD 5451E half-height double-sided double-density disk drives operated without any problem during the review, although drive A seemed to become progressively noisier, perhaps because I used it more. The optional full-height hard disk drive goes on the right-hand side of the front of the main unit. The cooling fan is quite loud and bothersome in my quiet environment, but in a busy office situation, the fan noise would be less noticeable.

Qubie Distributing supplies the Conquest's full-size, complete, and well-laid-out keyboard. In addition to the QWERTY layout with 10 function keys, the keyboard has two keypads. I configured one for the cursor keys and the other as a numeric keypad. This made for a particularly nice spreadsheet environment, since I could move between cells and insert numbers without toggling the Num Lock key. The keyboard also makes warm starts easier by using the Ctrl key in combination with a special Reset key. Across the top of the keyboard are the 10 function keys, a Pause key to start and stop scrolling, and a key to enable the second cursor pad setup. The Caps Lock and Num Lock keys have LEDs.

I found the feel of the keyboard a bit awkward. The keys have virtually no audible feedback unless you hit them harder than it takes to produce a character. The initial feel of the keys is rather light, but a higher spring tension seems to take over after a short travel until the key hits bottom. Therefore, I began pounding away rather vigorously to ensure that I was really getting the job done.

### INTERNALS

It is easy to remove the case of the computer. Internally, the Conquest ap-

(continued)

*John D. Unger (P.O. Box 95, Hamilton, VA 22068) is a geophysicist for the U.S. government who uses computers to study the structure of the earth's crust in earthquake-prone regions.*

Conquest Turbo PC

**Company**
Microshop Computer Products
2640 Walnut Ave., Unit K
Tustin, CA 92680
(714) 838-7530

**Size**
System unit: 19.5 by 16 by 5.75 inches; 30 pounds
Keyboard: 20.25 by 8.5 by 2.25 inches; 5.75 pounds

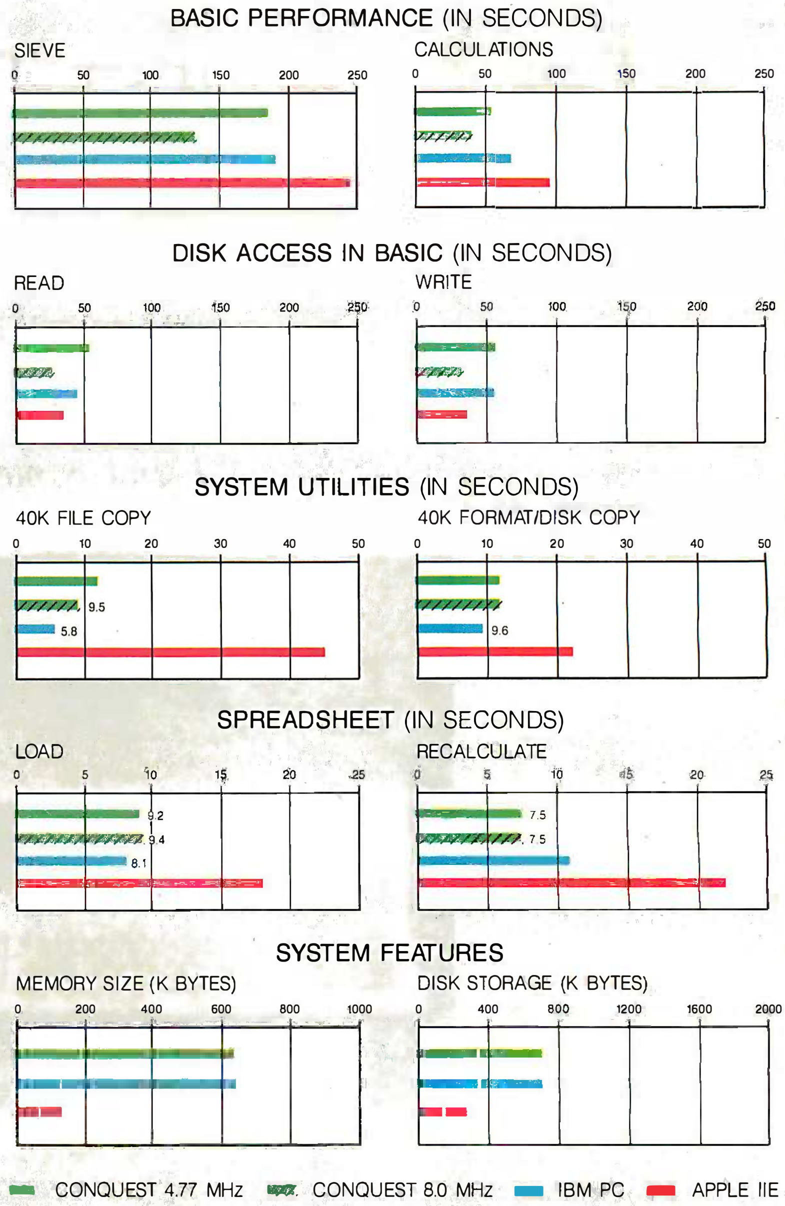
**Components**
**Processor:** 8088-2 switchable between 4.77 and 8 MHz; socket for optional 8087 coprocessor
**Memory:** 640K bytes of dynamic RAM (standard); up to 1 megabyte of RAM on motherboard (optional)
**Mass storage:** Two 360K DS/DD 5¼-inch half-height floppy disk drives (standard)
**Keyboard:** Detached QWERTY with 99 keys including 10 function keys and separate keypads for cursor keys and numeric keypad; Caps Lock and Num Lock keys have indicator lights
**Expansion capability:** Five full-length slots (IBM PC bus)
**I/O interfaces:** One RS-232C serial port; one DB-25P Centronics-compatible parallel port; one coaxial connector for monochrome monitor (Persyst board); one 9-pin D connector for color monitor (Persyst board)

**Options**

| | |
|---|---|
| Color monitor | $125 |
| Internal hard disk drives | |
| 10 megabytes | $499 |
| 20 megabytes | $525 |

**Documentation**
25-page *Guide to Operations and Technical References*

**Price**
Includes two DS/DD floppy disk drives, 640K bytes of RAM, monochrome card, and green or amber monochrome monitor $1239




The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a blank floppy disk. The System Utilities graphs show how long it takes to format and copy a 40K-byte file using the system utilities. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. The spreadsheet used was Microsoft's Multiplan. The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity for a single floppy disk drive and the maximum standard capacity for each system. Tests on the Conquest were done using MS-DOS 2.11, GW-BASIC 2.02, and Multiplan 1.10. The Conquest had two 360K-byte drives and 256K bytes of memory.

pears to be well made and has a substantial steel chassis. A disk controller made by Progressive Computer Products and a Persyst color graphics display adapter take up two of the seven slots for expansion cards. The disk controller board accommodates up to four floppy disk drives, giving you another hardware option for the space behind the removable front panel. To gain access to the 8087 coprocessor's socket, you have to remove the floppy disk drives.

Advanced Logic Research makes the motherboard. The one on the review unit came fully populated with 64K-bit RAM chips in four banks of nine chips for a total memory of 256K bytes. Like the IBM PC, the Conquest performs a memory parity check when you turn it on; the test takes about 15 seconds with 512K bytes of RAM installed. You can replace each of the four banks of 64K-bit chips with nine 256K-bit RAM chips to obtain a maximum of 1 megabyte of memory on the motherboard.

You can change the clock speed from 4.77 MHz to 8 MHz by simply flipping a small rocker switch on the rear of the computer. When you turn on the computer with the switch in its 8-MHz, or "turbo," mode, a message at the top of the screen confirms that you are in the high-speed mode while the machine performs its memory check. I had mixed success switching modes without rebooting the computer. I had no success trying to change modes while in the middle of using GW-BASIC or WordStar. Usually, the computer locked up, and I was unable to reboot without first powering down. I had somewhat better, but still unpredictable, results trying to switch clock speeds at the MS-DOS prompt. The machine still locked up occasionally. I found that the safest and surest way to change clock rates was to turn the computer off, flip the clock-rate switch, and power back up. A simpler and more consistent method for switching speeds would be a large improvement.

## BENCHMARKS

The results of running the standard BYTE benchmark programs are shown in the graphs at left. In the standard 4.77-MHz mode, the Conquest's results are comparable to the IBM PC's. The benchmark results in the 8-MHz turbo mode, although generally faster, are neither consistent nor easy to understand. For processor-intensive tasks, the turbo mode should show an increase in processing speed roughly proportional to the 65 percent difference in the two clock rates. However, as you can see from the benchmarks, the differences average somewhat less than I expected. The effects of the increased clock speed were particularly small for WordStar (version 3.30), Multiplan (version 1.10), and the MS-DOS utilities.

The Norton Utilities' (version 3.0) System Information program showed a performance index on the Conquest of 1.0 relative to the IBM PC in the 4.77-MHz mode and 1.5 in the 8-MHz mode. It seems clear, therefore, that you will increase performance by using the Conquest in the 8-MHz mode, but the machine does not appear to run programs as quickly as other MS-DOS computers with 8-MHz 8088 processors.

## SOFTWARE AND COMPATIBILITY

Although the computer comes with no software or operating system, I have encountered no compatibility problems. I had no trouble booting the machine with either MS-DOS 2.11 or PC-DOS 3.0. In addition to using WordStar 3.30, Multiplan 1.10, GW-BASIC, and a number of other commercial and public domain software programs, I used the Conquest to test a variety of C-language interpreters. However, you should contact the manufacturer if you need to run specific applications, especially if they are copy-protected.

The Conquest comes with a Persyst color display adapter designed for use in the IBM PC. I installed a Seattle Computer RAM+6 card on the Conquest to increase its memory to 512K bytes. The card is sold for the IBM PC XT, but I had no problems mounting the card or configuring it with the system RAM using the card's documentation. I recommend that you try products before you buy them or first find out about your dealer's refund or exchange policy.

*Flipping a rocker switch changes the clock speed from 4.77 MHz to 8 MHz.*

## DOCUMENTATION

I received only a terse 25-page document that is entitled *Guide to Operations and Technical References*. The only useful information is a description of the keyboard and information on a series of DIP switches that tell the computer how much memory is installed and that set other system-related options.

## SUPPORT

Unless you live in southern California, you'll have a long way to go for service. However, the Conquest is assembled from a group of generic, easily obtained components; you should be able to obtain service from any experienced microcomputer technician. There is a 180-day warranty on the entire system and a 1-year warranty on the motherboard. The warranty requires, however, that you bring or ship your computer to Microshop.

## CONCLUSION

The Conquest has an appealing price, given the overall quality of the hardware, the optional 8-MHz processor speed, and the fact that the motherboard can accommodate up to 1 megabyte of RAM and has built-in parallel and serial ports, leaving the expansion slots free for other options. However, I would not recommend this machine to a first-time user. Documentation is scanty, there is no bundled software, and it is not clear how much long-term support you can expect from the manufacturer. On the other hand, an experienced microcomputer user could assemble a custom machine by taking advantage of the ample internal space and power-supply capacity to add desired expansion cards. ■

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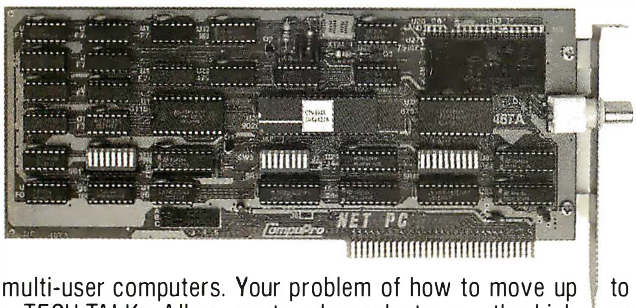


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# BYSO LISP AND WALTZ LISP

BY WILLIAM WONG

*Two implementations of LISP for the IBM Personal Computer and compatibles*

MS-DOS–based languages have matured over the years, and the LISP implementations are no exception. This article examines two implementations with different levels of functionality and support. BYSO LISP version 1.17 costs $69.95, and Waltz LISP version 5.01 is $169.

## DOCUMENTATION

BYSO LISP comes with a single user's manual, which is complete but laid out very poorly. The print quality is poor, too—BYSO LISP's documentation is its major fault. Read a good book on LISP before delving too deeply into this manual.

The Waltz LISP manual is very good. Layout, examples, and highlighting add to the product's worth. The table of contents provides a quick description of each function and its arguments along with the page number. There's a separate manual for Clog, a Prolog interpreter written in LISP.

## COMPATIBILITY

BYSO LISP supports the popular LISP 1.5 and MacLISP via a compatibility "switch." This switch affects the mode and parameter order of a number of functions. For example, the parameters to PUTPROP are atom, property, and value in 1.5 mode, and atom, value, and property in MacLISP mode. The LISP 1.5 mode is relatively complete, since this specification was basic to begin with. The MacLISP mode lacks quite a number of functions, partly due to a limited number of data types. The mode switch is useful when learning LISP, depending upon the book you are using. Extensions for PC-DOS support are available but often difficult to use.

Waltz LISP is based on Franz LISP. It mirrors it relatively well and comes suprisingly close to the UNIX-based versions of LISP. Waltz LISP's lack of floating-point numbers is its major deficiency. Extensions to support the operating system are consistent and well defined.

## DATA TYPES

Both implementations support lists and symbols (or atoms), which are the basis for LISP. BYSO LISP limits are fixed at 10,800 list cells and 768 atoms, while Waltz LISP is limited by the amount of memory—it uses 4-byte list cells (16K cells maximum).

In addition, both LISPs support various types of numbers. BYSO LISP supports 16-bit signed integers, while Waltz LISP supports "big integers." These are essentially binary strings of variable length, the same as those found in muLISP. The integers are limited to 2048 bits. Neither version supports floating-point numbers.

String and array support levels vary significantly between implementations. BYSO LISP supports multidimensional arrays, where elements can be Boolean values, characters (strings), integers, and symbolic expressions. Array space is limited to 10,240 bytes, and string manipulation functions are minimal. Waltz LISP only supports character strings and these are limited to 256 characters, but its support functions are more sophisticated and include pattern-matching string search.

BYSO LISP also supports user-defined data structures; Waltz LISP does not. These types of data structures tend to be more efficient in terms of storage space and access time. They also make programs easier to understand, since you can create access names such as SHIP-SPEED instead of CADDR to access the third element of a list.

Both versions support other data types, such as files.

## FUNCTIONS AND CONTROL METHODS

BYSO LISP supports MacLISP-style function definitions with &OPTIONAL and &REST specifiers for functions with a variable number of parameters, MACRO (including Common LISP–format macros), and the standard control structures, including PROG, PROGN, and DO. CATCH and THROW functions are part of the system, but there is no UNWIND-PROTECT.

Waltz LISP uses the Franz LISP–style function definition and supports LAMBDA (which evaluates parameters), NLAMBDA (which does not evaluate parameters), LEXPR (with a variable number of parameters), and MACRO. Waltz LISP supports local variables, but the parameter-binding methods it uses are not as clean as BYSO LISP's.

Like BYSO LISP, Waltz LISP supports CATCH and THROW, but not UNWIND-PROTECT.

## FILES

Both LISP implementations support sequential text files. BYSO LISP does not support random access files. Its support of directory functions is in-

*(continued)*

*William G. Wong (Logic Fusion Inc., 1333 Moon Dr., Yardley, PA 19067) is president of Logic Fusion and a developer of systems and applications software.*

| | BYSO LISP version 1.17 | Waltz LISP version 5.01 |
|---|---|---|
| **Company** | Levien Instrument Co.<br>Sittlington Hill<br>P.O. Box 31M<br>McDowell, VA 24458<br>(703) 396-3345 | Pro Code International Inc.<br>15930 Southwest Colony Place<br>Portland, OR 97224<br>(800) 547-4000 |
| **Requirements** | IBM PC or compatible<br>One floppy disk<br>256K bytes of RAM | IBM PC or compatible<br>(PC-/MS-DOS or CP/M-86)<br>Z80 CP/M system for 8-bit version<br>One floppy disk<br>128K bytes of RAM |
| **Copy-Protected** | No | No |
| **Price** | $69.95 | $169 |

complete and involves writing interrupt calls.

Waltz LISP supports random access files and all PC-DOS directory functions. These are well documented and easy to use. It also supports a strange entity called a QUARK, which allows reading of non-LISP-format text. Support for binary data is not very good; it can only read one character at a time, as there are no record, string, or line input functions.

## LOADING, SAVING, AND PACKAGES (NAME SPACES)

BYSO LISP supports a single name space (no packages). It lets you save the entire workspace and then restore it later, which is very handy. In addition, it lets you load and save function definitions and variable data incrementally in text form.

Waltz LISP also supports a name space. It does not let you save or restore the workspace, and functions and data may only be loaded. You can develop functions that will save the textual versions of functions and variables. Even so, the primary mode of operation is to edit a text file using the built-in screen editor and then read in the changed file, thereby keeping the most up-to-date function definitions on disk.

## USER ENVIRONMENT (EDITORS AND DEBUGGERS)

BYSO LISP has a built-in screen editor that you can use on single functions or variables. The editor is both character- and structure-oriented, and it works well if the text only fills one screen; the editor is not designed to work with text files. Source code is provided, so enchancements are possible. BYSO LISP traps errors but does not provide any debugging tools except TRACE.

Waltz LISP comes with a built-in WordStar-like screen editor that works on text files, and a structure editor, similar to line-oriented text editors, that can manipulate structures in memory. The latter takes a bit of getting used to, but it is the only type of editor that allows modification of circular list structures and graph structures created using destructive list functions like RPLACA and RPLACD. Waltz LISP includes source code for the structure editor but not the screen editor.

Waltz LISP also includes a built-in debugger with trace and error-trapping support. From the debugger, you can continue execution, and examine and modify function parameters.

## SYSTEM ACCESS AND ASSEMBLER INTERFACE

BYSO LISP provides limited access to the operating system and to functions written in other languages, such as assembler. BYSO LISP assumes that the support module is loaded as a memory-resident program prior to running BYSO LISP. The functions within the module are called through the interrupt table, which is modified by the resident program. A number of example programs are provided. However, this mode of operation tends to be quite cumbersome.

Waltz LISP provides an assembler interface identical to BYSO LISP. However, Waltz LISP provides more built-in functions to access system resources, such as directory functions. Even so, functions such as the current time are not provided and you must write them yourself. Direct access to hardware I/O ports must also be added externally.

## EXTENSIONS

I have already covered most of the extensions for BYSO LISP. Waltz LISP comes with a program called Clog, a Prolog interpreter, with source code and basic debugging tools provided. Clog provides a learning tool for Prolog and Prolog construction but it is too slow for any major Prolog program development.

## COPY PROTECTION, LICENSE AGREEMENT, AND SUPPORT

BYSO and Waltz LISP do not have copy protection on the disk. The license agreement for BYSO LISP provides low-cost replacement if the original disk is defective. Telephone support seems good, and updates are free if you are the first to report a problem. The Waltz LISP license agreement is not overly restrictive, and updates are provided for one year. Phone support for registered users is good when you can get through.

## PERFORMANCE

I timed the performance of simple operations repeated 5000 times to get reasonable test durations. Identical tests (although in slightly different syntax) were used on all three products. [*Editor's note:* *Benchmark programs for* BYSO LISP *and* Waltz LISP *are available under the filename* LISPTEST.DOC *from* BYTEnet *Listings at* (617) 861-9764.]

I did not perform a Read File test due to the lack of a "read fixed-size buffer" function required for such a test. Using the normal LISP READ function would cause the program to "intern" a symbol, which takes some time and is not comparable to the Write String function used for the

(continued)

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Write File test. For comparison, I also tested Golden Common LISP.

BYSO LISP did well on every test except the Write File test (see table 1). Evidently, BYSO LISP performs some buffering that is not as efficient as the other implementations, or it performs additional checks.

Table 1: A *comparison of benchmarks performed on* BYSO LISP, Waltz LISP, *and* Golden Common LISP. *The tests, performed on an* IBM PC XT *with* 640K *bytes of memory, used a* DO *loop* 5000 *times. The* Write File *test created a* 64K *file on an empty floppy disk. Times are rounded to the nearest second.*

LISP Benchmark Results

| | BYSO LISP | Waltz LISP | Golden Common LISP |
|---|---|---|---|
| Empty loop | 13 | 16 | 16 |
| CONS | 18 | 18 | 18 |
| Integer add | 18 | 19 | 18 |
| Integer multiply | 21 | 20 | 19 |
| Floating-point add | — | — | 19 |
| Floating-point multiply | — | — | 22 |
| Assignment | 16 | 19 | 17 |
| List index | 26 | 36 | 26 |
| Vector index | 16 | — | 18 |
| String index | 17 | 23 | 18 |
| Write file | 210 | 31 | 81 |

Waltz LISP also performed admirably and was the fastest when writing to disk. The indexing operations were slightly slower than BYSO or Golden Common LISP, but not excessively so. The times are still faster than many of the other LISPs on the market.

## SUMMARY

BYSO LISP is complete and runs well but lacks many of the features found in more expensive products. The documentation is complete but very poor. Even so, the implementation seems solid. As a low-cost learning tool, BYSO LISP is adequate, but it would be inappropriate for more sophisticated work.

At $169, Waltz LISP is a relatively good buy. Its compatibility with Franz LISP will be a plus to some. The implementation is fast and very functional. The major missing component is a compiler. The Clog Prolog interpreter is slow but can be an aid to learning Prolog. ■



# EXPEROPS5

BY WILLIAM JACOBS

## *An implementation of the OPS5 programming language for the Macintosh*

ExperOPS5 is a version of the relatively simple but very powerful OPS5 (Official Production System, Version 5) programming language.

ExperOPS5 was created by the Scientific Applications International Corp. and is marketed by ExperTelligence Inc. ExperOPS5 is implemented on top of ExperTelligence's version of LISP, ExperLISP, and requires a Macintosh with 512K bytes of RAM and two disk drives. ExperOPS5 currently sells for $325; ExperLISP costs an additional $495.

### A BRIEF OVERVIEW OF OPS5

OPS5 is one of a series of production rule languages created by Charles Forgy and his colleagues at Carnegie-Mellon University over the past decade (see reference 1). All production rule systems contain three basic parts: a set of production rules, a set of facts against which the rules operate, and an inference engine that governs the execution of the rules. From an initial state reflecting a specific problem, execution of the rules modifies the set of facts.

The rules themselves are simply conditional statements indicating that when certain conditions hold, certain actions, such as the assertion and retraction of facts, are to be performed. No rule ever directly calls any other rule; instead, all interaction between rules is by means of the database of facts. As the set of accepted facts is altered, the rules that are satisfied (and hence made ready for execution) changes. The inference engine controls the cycle of matching rules to facts, deciding which rules to fire, and causing their consequents to be performed.

In OPS5, the current set of accepted facts is called the working memory. Facts are represented as objects with up to 126 pairs of attributes and values. A typical OPS5 assertion might be

```
(mouse ^name Mickey
        ^disposition friendly
        ^favorite-foods cheese
        bread-crumbs table-scraps)
```

signifying that there is a mouse object whose name attribute has the value "Mickey," whose disposition attribute has the value "friendly," and whose favorite foods are cheese, bread crumbs, and table scraps. Associated with each element of the working memory is a time tag indicating the order of its creation or last modification.

The collection of OPS5 rules is known as production memory. Since this is treated as an unordered set, rule position does not affect firing precedence. The conditions of a rule are collectively referred to as its left-hand side, and the actions as its right-hand side. Each condition is a pattern that is satisfied by being matched against the facts in working memory. Thus, the single condition in the following rule

```
(p is-there-a-friendly-mouse
   (mouse ^disposition friendly)
-->
   (write there is a friendly mouse)
)
```

will match against the Mickey Mouse fact and print out the appropriate message. Since a rule will fire for each fact against which the left-hand side patterns match, if the working memory had contained the two facts

```
(mouse ^name Mickey
   ^sex male
   ^disposition friendly)
(mouse ^name Minnie
   ^sex female
   ^disposition friendly)
```

the previous rule would have been executed twice.

In OPS5, patterns can be matched against a single value, a complex set of values, or, by the use of variables, against any value whatsoever. Restrictive patterns can compare values in various ways. For example, the following condition will match any mouse object of either friendly or shy disposition weighing more than 10 grams and set the value of the variable x to the mouse's name for the duration of this rule:

```
(mouse ^name <x>
  ^weight {> 10}
  ^disposition << friendly shy >>)
```

With some restrictions, it is even possible to use negative patterns as conditions, that is, no working memory element has a given value.

On the right-hand sides of rules, working memory can be altered, files can be manipulated, information can be output, computations on variables can be performed, values can be assigned to variables, external user-defined functions can be called, additonal rules can be added to production memory, and execution can be halted via 12 action types. For exam-

*(continued)*

*William Jacobs (LinCom Corporation, 3200 Wilshire Boulevard, Suite 300, Los Angeles, CA 90010) is a knowledge engineer currently involved in the design and implementation of a microcomputer-based expert system to configure a satellite communications network.*

ExperOPS5 (July 1985 version)

**Type**
Expert-system programming language

**Company**
ExperTelligence Inc.
559 San Ysidro Rd.
Santa Barbara, CA 93108
(805) 969-7871

**Format**
One 3½-inch disk

**Requirements**
Apple Macintosh with at least 512K of RAM and two disk drives; ExperTelligence's ExperLISP

**Features**
An implementation of the OPS5 production rule language for the Macintosh

**Price**
$325 for ExperOPS5 and documentation; $495 for ExperLISP and documentation

**Audience**
Those wishing to develop expert systems on the Macintosh

ple, via make, modify, and remove commands, new working memory elements can be created, the values of the attributes of a current working memory element can be changed, and a working memory element can be completely deleted. To illustrate, the following rule fires when working memory contains elements representing less than 10 grams of unguarded cheese and a hungry mouse:

```
(p hungry-mouse
    (cheese ^weight {< 10}
      ^security unguarded)
    (mouse ^disposition hungry)
-->
    (remove 1)
    (modify 2 ^disposition satisfied)
    (make cat ^job catch-mice)
```

This alters working memory according to certain obvious, predictable consequences.

The inference engine in OPS5 proceeds by means of a recognize-act cycle:

1. |Match| Determine the set of production rules whose conditions are satisfied and hence await execution. Should this set, known as the conflict set, be empty, then the program exits.
2. |Conflict resolution| On the basis of the current conflict-resolution strategy, select one of the members of the conflict set for firing.
3. |Act| Sequentially execute each of the actions of the rule selected in step 2.
4. If either a halt action was performed or the maximum cycle count has been reached, then exit. Otherwise, return to step 1.

OPS5 programs are developed and executed under a top-level interpreter that permits user control of the system. Interpreter commands concern such program features as compilation and execution, important debugging options, the inspection and modification of working memory, the examination of the conflict set, and the control of the inference engine.

## The ExperOPS5 Implementation of OPS5

Given that a relatively inexpensive software package running on a Macintosh cannot be expected to perform up to the same standards as a $100,000 dedicated LISP machine and similarly priced software, how well does ExperOPS5 perform, and what can you use it for?

Although ExperOPS5 claims to be a complete implementation of OPS5, this simply is not true. It does contain most of the basic OPS5 knowledge representation and inferencing features, and it claims to implement the Rete algorithm (which accelerates the matching of objects to patterns) and the two standard conflict-resolution strategies. Unfortunately, ExperOPS5 lacks OPS5's build action, which permits run-time creation of new production rules; the default action, which formats I/O; the literal statement, a way of specifying the order of an object's attributes; and various output formatting functions.

Unlike standard OPS5, ExperOPS5 objects are limited to at most 20 attributes, although you can increase this number by modifying an initialization file. In addition, because ExperOPS5 differs from standard OPS5 by having a space following each attribute caret (^) and by prohibiting working memory elements from having the value "nil," porting source files in either direction will require at least minor reediting.

Nor are the standard OPS5 and ExperOPS5 top-level interpreters identical. Certain important debugging commands are not implemented at all, such as ppwm, which prints only those working memory elements matching a certain pattern, and matches, which displays the partial matches for productions.

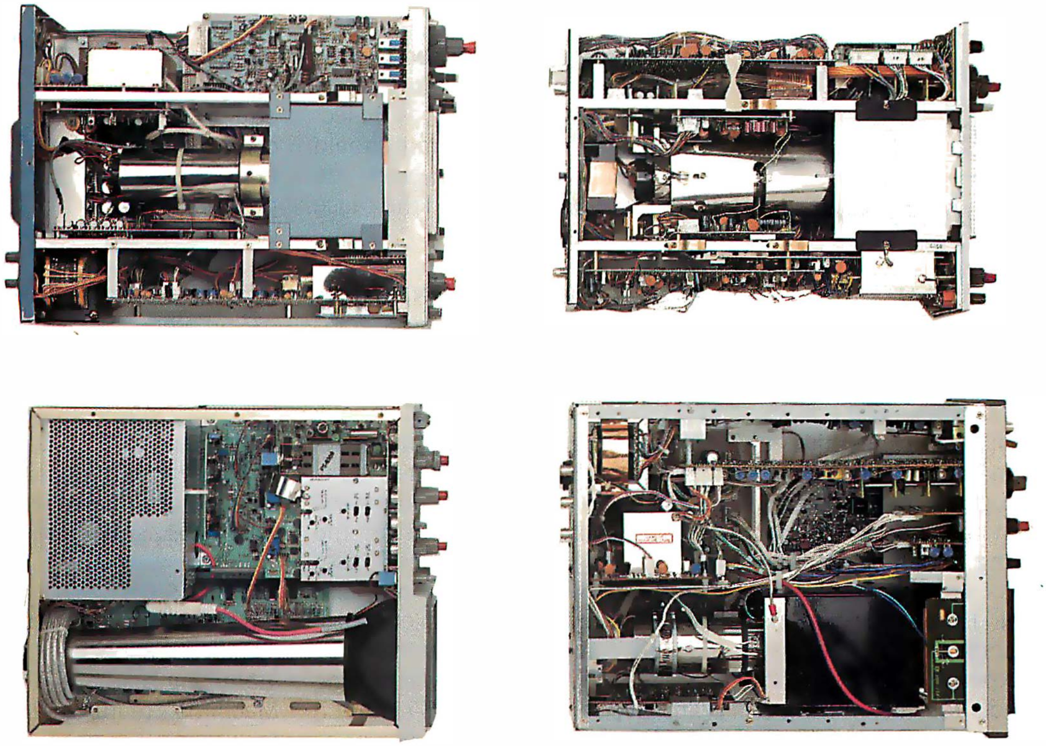
Other statements are not fully implemented. For example, in ExperOPS5 the working memory elements displayed by wm lack time tags, thereby complicating the debugging process. And the ExperOPS5 strategy command lets you change the current conflict-resolution strategy but doesn't let you determine what that strategy is; OPS5 does.

## Developing Software in ExperOPS5

During software development, ExperOPS5 relies upon Macintosh features

(continued)

# You can't judge a scope by its cover.



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*While it might provide a limited introduction to production rule systems, using ExperOPS5 for serious application development would be difficult.*

such as pull-down menus and multiple windows. You can create files using standard Macintosh text editors, from which the files subsequently can be compiled and run. Various common OPS5 debugging commands are available, such as break points, stepped rule firing, and the inspection of the contents of working memory or the conflict set. Except for various graphics functions that are already available in ExperLISP, ExperOPS5 provides no tools for customizing a user interface.

I found the ExperOPS5 interface to be quite a disappointment, especially when compared to the very attractive, highly interactive interfaces of many other Macintosh programs. Much more could have been done to produce a more user-friendly run-time ExperOPS5 environment. For example, the ability to create predefined windows that continuously display the contents of working memory and the members of the conflict set would make debugging much easier. With ExperOPS5, you can only obtain such vital information during program breaks.

In the July 1985 version of the software that I reviewed, the function that was designed to reset the environment did not work properly. Thus, I had no easy way of fully reinitializing ExperOPS5, and when I wanted to begin a run in a totally clean workspace, I first had to reload ExperOPS5 and then the specific application program. Needless to say, this slowed my software testing considerably.

Two other problems that complicate developing ExperOPS5 programs are inadequate error messages and limited access to source code. When the ExperOPS5 compiler encounters errors, it generates virtually useless, almost unintelligible comments. Unlike most LISP machine environments where you can inspect the actual system software, almost all of ExperOPS5 is concealed as object code. As a result, if a program should contain an obscure syntax error, you will be hard pressed to find the cause of the difficulty.

### EXPEROPS5'S DOCUMENTATION

Regrettably, ExperOPS5 lacks good documentation. True, the package does contain an attractively printed, well-written pamphlet that briefly describes the software. Unfortunately, this booklet lacks sufficient material to enable a novice to understand OPS5, and it does not answer the questions that an advanced user would ask. For example, nowhere does it provide a complete BNF (Backus Naur Form) grammar for ExperOPS5, an especially annoying point given that ExperOPS5 is not a complete implementation of OPS5. As a result, programmers are left to discover on their own which OPS5 features have been implemented and which have not.

The ExperOPS5 disk does come with several short, commented files that explain how to utilize certain OPS5 features, such as how to employ vector attributes or to accept keyboard input into a program. This use of examples is worthy of emulation but is not a substitute for a complete language description and more thorough documentation.

### SPEED AND SPACE

As part of a series of timing tests run by my associate, Gary Riley, using a 30-rule version of the well-known monkey-and-bananas problem (see reference 2), ExperOPS5 was found to fire rules at a rate of only 1.5 per second, considerably slower than the 4.3 firings per second obtained by running Artelligence's OPS5+ on an IBM PC or the 86 rules per second obtained on the Inference Corp.'s OPS5-based expert-system shell ART using a Symbolics LISP machine. Such results will not encourage the use of ExperOPS5 in the development of any computationally intensive programs.

After ExperOPS5 is loaded on top of ExperLISP in a 512K Macintosh, at most only about 45K bytes of RAM remain free; on a HyperDrive-equipped machine, the available RAM can be even less. Given the trade-offs between working memory elements, production rules, and run-time memory requirements, this space is, at best, only sufficient for small to moderate programs.

Can other developers learn from ExperOPS5's relatively slow speed and large memory requirements? One thing they may learn is that unless you implement OPS5 in a language such as C, it will be impossible to produce an adequate implementation of OPS5 for the 512K Macintosh.

### CONCLUSION

ExperOPS5 implements most of the significant aspects of the OPS5 programming language. It utilizes several Macintosh features, and, in contrast to certain other products that are currently being marketed as artificial intelligence tools, ExperOPS5 is a real expert-system shell on which you can write real microcomputer expert systems.

Still, ExperOPS5 is disappointing. While it might provide a limited introduction to production rule systems, using ExperOPS5 for serious application development would be difficult. ■

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ACKNOWLEDGMENTS

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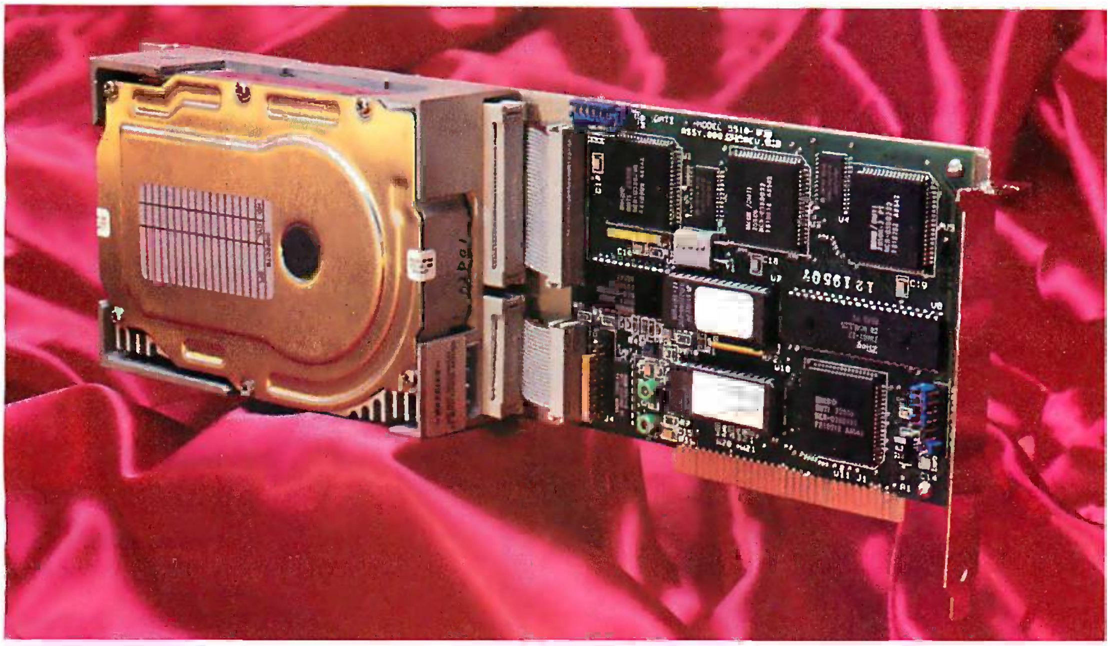



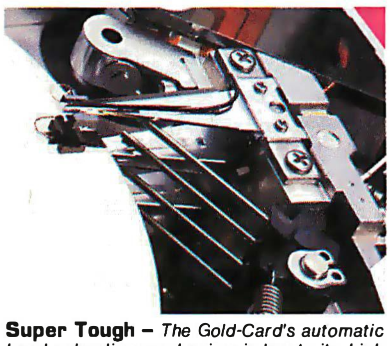

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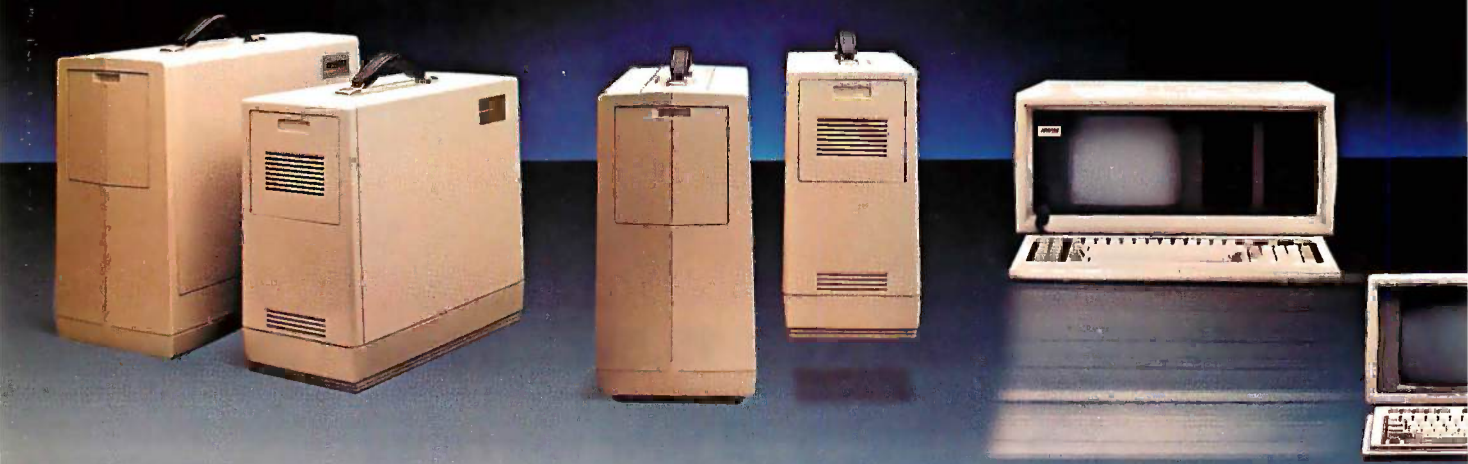

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# Five Laboratory Interfacing Packages

BY PATRICIA WIRTH AND LINCOLN E. FORD

EDITOR'S NOTE: This article is not a review in our usual sense. To understand the intent of the review, you must understand how it came to be written. Dr. Ford is a medical researcher at the University of Chicago. He wrote an extensive driver for the Tecmar Lab Master data-acquisition board and wanted to publish a description of it. The program is a threaded interpretive language interfaced to BASIC and embodies an essentially complete set of commands for controlling the Lab Master board. As a condition to publishing his description of the language ("SALT," June 1985 BYTE, with Samuel D. Fenster, who wrote most of the code), we prevailed upon Dr. Ford to make the program and its documentation available to our readers at the nuisance-value cost of filling orders ($50).

There are advantages and disadvantages to using programs written by researchers instead of commercial products. The primary disadvantage is that the program is written to do what the researcher needs to do, not to support the requirements of a large group of customers. In the case of Dr. Ford's program, his requirements are far-reaching, so SALT ends up supporting most Lab Master functions. For example, while he had originally used only the 100-kHz option of the board, he later acquired a 30-kHz board and extended the program to include that configuration. However, he does not use other boards, so he does not support them. Similarly, Dr. Ford does little on-line analysis with his data, so the routines for such functions are limited.

The primary advantage of using a program developed by a researcher instead of by a programmer is that a programmer debugs programs, while a researcher debugs experiments. For example, Dr. Ford points out that all the commercial packages that he examined are unable to synchronize exactly the A/D board timers with external-event triggers. This kind of problem can be critical in an experiment but will not show up as a program bug.

With all this in mind, we asked Dr. Ford to take a look at some of the commercially available software packages for running A/D boards. The question we posed to Dr. Ford was, Given that SALT is available for $50, why would anyone buy the commercial packages? Or, less sanguinely, what are the special strengths of these packages that make each of them uniquely attractive? What follows is the assessment by Dr. Ford and his research associate Patricia Wirth of what each package is best suited to do.

In the past two years, several general laboratory interface devices for microcomputers have appeared on the market, as well as a selection of software packages for running them. This review is aimed at the software packages, specifically at those products designed for use with two separate interface boards for the IBM Personal Computer.

Our perspective is that of physiologists. We acquire large blocks of digitized data, often controlling various aspects of the experiments at the same time that the data is being collected. In general, we have given a lower priority to on-line data analysis and to graphics, since we do most of our analysis after the experiments. At the other extreme, one of the products reviewed here, ILS from Signal Technology Inc., was developed primarily as a data-analysis package, with relatively little emphasis on laboratory control. Thus, the diversity in the software packages to be reviewed will accommodate many laboratory requirements, although not all specialized needs will be fulfilled by the same package. In this review, we have emphasized the data-acquisition and laboratory-control aspects of the packages.

### Interface Boards

All the software packages will control one or both of two interface boards, the Tecmar Lab Master and the Data Translation DT2801. See table 1 for the characteristics of the two boards. The major differences are that the DT2801 has a provision for direct memory access that the Lab Master does not, while the Lab Master has programmable counters not available with the DT2801. The direct memory access allows faster data transfers. The programmable counters on the Lab Master operate independently of the central processor, so accurate timing and control of experiments can be carried out much more rapidly than with the DT2801.

Both boards have a series of options. In addition to the standard characteristics listed in table 1, we have a DT2801 with a 16-bit A/D converter. This provides much higher resolution at the cost of a decrease in the maximum rate per conversion from 13.7 to

(continued)

*Patricia Wirth is a Ph.D. student at Northwestern University who is collaborating in biomedical research at the University of Chicago. Lincoln E. Ford, M.D., is associate professor of medicine and cardiology at the University of Chicago. Address all correspondence in care of Dr. Ford at Hospital Box 249, University of Chicago Hospitals, 950 East 59th St., Chicago, IL 60637.*

2.5 kHz. We have also obtained a Lab Master board with a 100-kHz option. Some other options that we have not tried are listed in table 1.

## SOFTWARE

A list of the packages reviewed and the major characteristics of each package appears in table 2. LABPAC and PCLAB are sold by the manufacturer of the Lab Master and DT2801, respectively, and so are intended for use with those boards only. In addition, ILS will operate only the DT2801. We wrote our own language, SALT, for only the Lab Master. The two remaining packages, ASYST (Macmillan Software Co.) and Labtech Notebook (Laboratory Technologies), have provisions for running both boards, as well as A/D boards from IBM, Cyborg, Keithley DAC, and MetraByte. In addition, Labtech Notebook will support Acrosystems, Burr-Brown, Datel, Action Instruments, Coulbourn Instruments, Interactive Microware, Advanced Peripheral, and Datatek Microsystems boards.

The commercial packages cost between $249 and $1490 for the laboratory-application portion of the program. Two of them have separate, additional modules for graphics and data analysis, each module costing about $500 to $1500, so it is possible to spend up to $2500 for a total package.

One major difference among the packages reviewed is the language they use. The two provided by the manufacturers of the boards simply use calls to assembly language routines from higher-level languages. Instructions for experimental functions are thus written as part of a larger program in the higher-level language. This can be a great benefit when you require on-line computation during the experiments, since you can program these computations in a highly structured, well-documented, and well-known language. Another advantage of this approach is that the data is stored in files that the higher-level language can read later, when future analysis is required. The disadvantage with BASIC as the higher-level language is that the calls to assembly language routines are slow, requiring about 2 milliseconds, so substantial delays can occur when several functions are to be run in sequence. This disadvantage is not as great when you use a compiled language, such as FORTRAN or Pascal, but these languages have the disadvantage inherent in any compiled language, namely, that they are not interactive, and you lose control of the program once you start it. You can stop an interpretive language such as BASIC anywhere in its operation without losing control. Once you stop the program, you can determine or change the value of a variable and change the direction of program flow. This provision is a major advantage in the laboratory, where you cannot always anticipate events external to the computer in advance of the experiments.

Two packages, Labtech Notebook and ILS, operate on single commands at a time. Labtech Notebook is entirely menu-driven, while ILS simply accepts single commands. These packages are easy to get started. ILS creates files that FORTRAN can read, while Labtech Notebook creates files that Lotus 1-2-3 can read.

A third approach is the use of a separate, specialized language for operating the laboratory functions. A form of languages especially suited to this type of operation is the threaded interpretive languages (TILs). These languages consist of a dictionary of routines, "words," for carrying out specific tasks. Primary words, called primitives, consist of machine language subroutines. More complex words, secondaries, consist of a sequence of calls to the primitives. Higher-level words may call primitives or previously defined secondaries in

*(continued)*

Table 1: *Comparison of Data Translation DT2801 and Tecmar Lab Master A/D interface board functions.*

| | DT2801 | Lab Master |
|---|---|---|
| Number of A/D channels | 16 standard | 16 standard—expandable to 256 optional |
| Resolution | 12-bit standard<br>14- and 16-bit optional | 12-bit standard<br>14- and 16-bit optional |
| Speed | 13.7 kHz standard<br>27.5 kHz optional<br>2.5 kHz with 16-bit resolution | 30 kHz standard<br>40 and 100 kHz optional<br>10 kHz with 14-bit resolution |
| Gain | Software-selectable up to 8 times on standard board<br>Up to 500 times optional with substantial slowing of A/D rates | Software-selectable up to 500 times optional<br>Resistor-selectable<br>Gains up to 2000 times are available |
| Number of D/A channels | 2 | 2 |
| Digital I/O | 16 channels configured as input or output in two 8-channel ports | 24 channels configured as input or output in three 8-channel ports or two 8-channel ports and two 4-channel ports |
| Clock | 400-kHz clock divisible by powers of 2 up to $2^{16}$ (163.8 seconds) | 1-MHz clock divisible by powers of 10 up to $10^4$ (10 milliseconds) or by powers of 2 up to $2^{16}$ (65.536 seconds) |
| Programmable timer/counters | None | 5 separate counters with outputs that can be made to change without intervention of the central processor |
| Direct memory access | Yes | No |

**Table 2:** *Overview of reviewed A/D software capabilities. Where optional packages are available, capabilities are for the most extensive set of compatible functions.*

| | SALT | LABPAC | PCLAB | Labtech Notebook | ASYST | ILS |
|---|---|---|---|---|---|---|
| Company | Sam Fensten<br>4949 South Woodlawn Ave.<br>Chicago, IL 60615 | Scientific Solutions Inc. (Tecmar)<br>6225 Cochran Rd.<br>Cleveland, OH 44139<br>(216) 349-4030 | Data Translation Inc.<br>100 Locke Dr.<br>Marlboro, MA 01752<br>(617) 481-3700 | Laboratory Technologies<br>255 Ballardvale St.<br>Wilmington, MA 01887<br>(617) 657-5400 | Macmillan Software Co.<br>866 Third Ave.<br>New York, NY 10022<br>(212) 702-3241<br>(800) 348-0033 | Signal Technology Inc.<br>5951 Encina Rd.<br>Goleta, CA 93117<br>(800) 235-5787 |
| Price | $50 | $495 | $249 | $895 | $550 (one module) to $2195[1] | $995 to $2490[1] |
| Supports DT2801 | No | No | Yes | Yes | Yes | Yes |
| Supports Lab Master | Yes | Yes | No | Yes | Yes | No |
| Language | TIL interfaced to BASIC | BASIC, Pascal, FORTRAN | BASIC, Pascal, FORTRAN | Menu-driven | Independent, FORTH-like TIL | Single instructions at a time |
| Memory size | 64K BASIC plus two 64K integer data buffers and one 64K floating-point data buffer | 128K | 64K in BASIC, more in newer version using FORTRAN and Pascal | Up to 400K for data | 320K for programs and data, 64K data buffers up to total memory in machine | Buffers up to total memory in machine |
| Digital I/O | Yes | Yes | Yes | Yes | Yes | No |
| File structure | BASIC or arrays transferred between disk and high memory | Same as higher-level language | Same as higher-level language | ASCII or DIF, compatible with Lotus 1-2-3 and Symphony | IBM BASIC-compatible ASCII or own binary files | FORTRAN-compatible |
| Documentation | Terse, not example-based | Obscure, not example-based | Satisfactory, example-based | Satisfactory | Extensive, example-based | Satisfactory, example-based |
| Lab Master maximum A/D rate (100-kHz board) | 48 kHz | 1 kHz | — | 20 kHz[2] (300 Hz) | 21.9 kHz[2] (1 kHz) | — |
| DT2801 maximum A/D rate | — | — | 13.7 kHz (2801)<br>27.5 kHz (2801-A) | 13.7 kHz (2801)<br>27.5 kHz (2801-A)<br>(300 Hz)[2] | 13.7 kHz (2801)<br>27.5 kHz (2801-A)<br>(1 kHz)[2] | 13.7 kHz (2801)<br>27.5 kHz (2801-A) |
| Lab Master maximum D/A rate (100-kHz board) | 26 kHz (two channels)<br>33 kHz (one channel)[3] | 1 kHz | — | 300 Hz | 14.4 kHz | — |
| DT2801 maximum D/A rate | — | — | 14.8 kHz (2801)<br>29.5 kHz (2801-A) | 300 Hz | 10.8 kHz | 16 kHz (2801)<br>33 kHz (2801-A) |
| Supports Lab Master timer/counters | Yes | No | — | No | Yes | — |
| Lab Master clock functions | 1 MHz divisible by power of 10 to $10^4$ | 5 kHz to 30.2 Hz | — | No | No | — |
| Background data acquisition | No | No | Yes | Yes | Yes | No |

| | SALT | LABPAC | PCLAB | Labtech Notebook | ASYST | ILS |
|---|---|---|---|---|---|---|
| GRAPHICS | No | Yes[4] | No | Yes[4,5] | Yes | Yes |
| Number of channels displayed | — | One in high resolution, three in low resolution | — | Four for each of five windows | Unlimited | One |
| *x,y* display | — | Yes | — | No | Yes | No |
| *x,y,z* display | — | No | — | No | Yes | No |
| Cursor positioning and reading | — | No | — | No | Yes | Yes |
| Graphing maxima and minima | — | No | — | No | No | Yes |
| Histograms | — | No | — | No | Yes | No |
| DATA MANIPULATION | Yes | No | No | No | Yes | Yes |
| Scale and offset | Yes | — | — | — | Yes | Yes |
| Differentiate and integrate | Yes | — | — | — | Yes | No |
| Moving averages | No | — | — | — | No | Yes |
| Maxima and minima | No | — | — | — | Yes | Yes |
| Filter | No | — | — | — | Yes | Yes |
| FFT | No | — | — | — | Yes | Yes |
| STATISTICS | No | No | No | No | Yes | Yes |
| Mean and variance | — | — | — | — | Yes | Yes |
| Mode | — | — | — | — | Yes | No |
| Standard deviation | — | — | — | — | No | Yes |
| Probability distribution | — | — | — | — | Yes | No |
| Linear and polynomial fit | — | — | — | — | Yes | Yes |

1 Prices increase with additional modules for graphics, statistics, and data analysis. Base price shown includes A/D module.
2 The highest A/D rate applies only when data is being acquired in the foreground mode and the computer is not performing other tasks. The lower rate applies when data is being acquired in the background, so that the computer can perform other routines simultaneously.
3 The D/A output for two channels is substantially faster than half the maximum conversion rate for one channel because both channels are converted following a single clock pulse.
4 These packages make displays in real time as data is being collected. Labtech Notebook makes only this type of display. LABPAC will display previously stored data as well.
5 Other graphics and analyses are intended for use with Lotus 1-2-3.

*Several types of data manipulations can be performed while data is being collected.*

any order. They consist of a list of calls to previously defined words. Program execution is rapid because all the primitives are run in machine language, and the only extra time is that required to pass parameters to each subroutine and to proceed from one routine to the next. A well-known example of a threaded interpretive language is FORTH. and one of the software packages, ASYST, is written in a FORTH-like language that provides a great deal of speed and flexibility. It also provides a disk-file structure that can be read later by other ASYST programs for subsequent data analysis. However, there are three major disadvantages in using a TIL for the entire programming. As with compiled languages, you lose control of the program once you start it. Also, many complex commands, such as print-formatting procedures, must be custom-built as secondary words that are listed in an individual user's "dictionary," the size of which usually increases with time. This type of language has a great deal of flexibility, but it fails to include a lot of procedures that exist in more complete languages. Finally, complex conditional branching routines are difficult to follow in threaded interpretive languages.

The approach we took with SALT was to interface a TIL to BASIC. The TIL is used just for the laboratory applications. such as data acquisition and experiment control, and for data storage. BASIC is used for program control and most analyses. This approach provides the speed of the TIL for real-time applications and the interactive characteristic of BASIC for all other applications.

## MEMORY LIMITS

Many forms of experiments are associated with the initial collection of a large amount of data. In some cases, the data is collected in much the same way that an oscilloscope trace is photographed. That is, one or more electronic signals are recorded in digital form for a specific period of time. To provide adequate resolution, the signals are digitized at fairly frequent intervals, so that in typical applications, a few kilobytes of data is collected for each signal. This much data would not tax the memory of computers that accommodate 512K bytes of memory, except when the entire program is run in BASIC.

The IBM PC BASIC is limited to 64K bytes of memory for program and data. Either a lengthy program or a large amount of data can easily outgrow this space. Thus, PCLAB or LABPAC run exclusively in BASIC can be inadequate in applications that require more than 64K bytes of memory, but when you encounter such limitations, you can use a compiled language such as FORTRAN or Pascal. The other programs provide considerably more space for data, as indicated in table 2.

## PERFORMING MULTIPLE FUNCTIONS

As described below, the A/D routines in some of the packages will perform single functions nearly as fast as the hardware on the boards will allow. However, program execution can be greatly slowed when more than one function is to be performed at once.

For example, it is often desirable to output a control voltage, either through a D/A channel or through an I/O port, at the same time that data is being collected in the A/D channels. ILS cannot do this, because it accepts only one command at a time. It is possible to perform multiple tasks in sequence using batch files in PC-DOS, but since the routines for each command are read from disk each time they are called, time between commands is extremely long and variable. At the other extreme, routines that are called from compiled languages can pass from one routine to the next within a few tens of microseconds. The exact interval required varies according to the numbers of parameters that must be passed to the new routine, and thus we cannot give a single interval here.

When commands are called individually from BASIC, the time required to pass from one command to the next is about 2 milliseconds, so the time required to stop sampling data, output a control voltage, and resume data collection would be about 4 milliseconds. The same sequence would take about 150 microseconds in SALT and about 600 microseconds in ASYST. We have examined only the BASIC versions of LABPAC and PCLAB, which each take about 4 milliseconds for this sequence. The FORTRAN and Pascal versions should run substantially faster.

Another example of desirable simultaneous functions is dealing with recently acquired data while more data is being collected. The packages that have provisions for background data collection (see table 2) have considerably slower A/D conversion rates, but these are still sufficiently fast for many purposes.

Several types of data manipulations can be performed while data is being collected. For example, some analysis might be carried out to reduce the amount of data to be stored. Alternatively, some display of the data and/or the analysis might be made. Those packages that provide for the sequential operation of multiple commands (all but ILS and PCLAB) will allow for some form of data manipulation during data collection, although the collection rates must be relatively slow for those programs that are run entirely in BASIC. A type of manipulation that is not possible with most of the packages is the simultaneous storage of data on disk as it is being collected, termed "streaming to disk." Only one of the packages, Labtech Notebook, provides for this streaming. This can be an extremely valuable feature when large amounts of data are to be collected continuously, as with an analog strip-chart recorder. The data-collection rates are necessarily slow when streaming is being performed, but it does allow an enormous amount of data to be collected. With a standard 10-megabyte

(continued)

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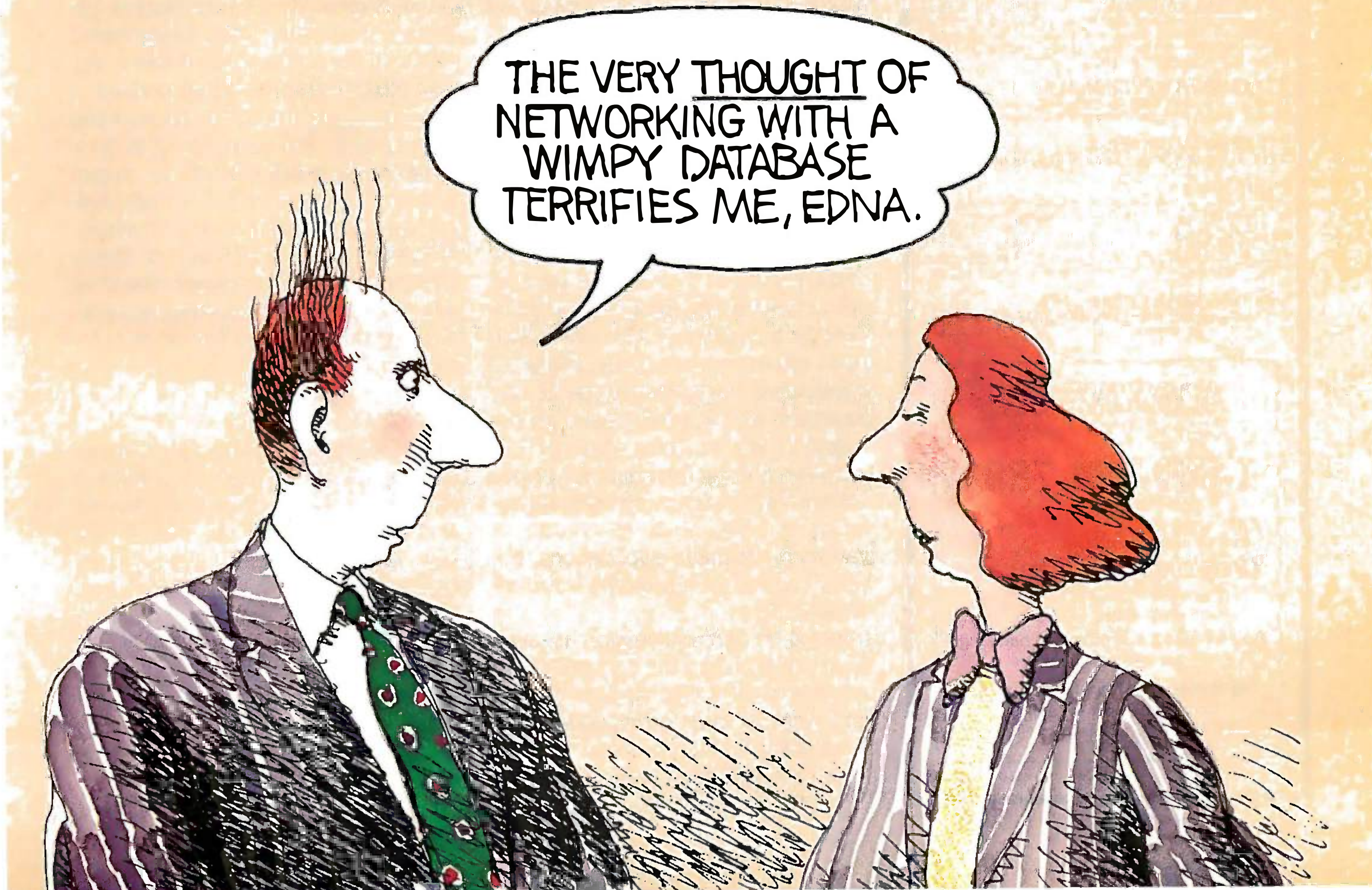

hard disk drive, 5 million integer samples can be collected at a rate of 300 Hz and stored for later analysis using Labtech Notebook.

### A/D Conversion

Perhaps the most time-critical function of an interface board is the rate at which it can digitize analog data and put it into memory. Except for the high-resolution converters that have slow conversion speeds, the converters supplied by the manufacturers can operate at least as fast as the software packages allow.

All the packages have provisions for A/D conversion, and most will run at speeds close to the maximum speed of the standard A/D converters on the boards. A disappointing exception to this is LABPAC, which Scientific Solutions provides for its Lab Master board. The maximum timing interval that this package provides for is 1 kHz, even though the clock on the board itself runs 1000 times faster. LABPAC has a provision for making faster conversions using a separate, external clock, but the manual does not specify a maximum rate and we have not used an external clock to test the routine.

### D/A Conversion

When you use the D/A converters to output voltages to control experiments, the speed of the output depends upon the required waveforms. If you require single voltage steps, great speed is not essential, and any of the packages that can operate the D/A converter will generally be sufficient for this purpose. However, when you require continuously changing waveforms, the smoothness of the waveform will depend greatly on the speed of the routines that run the converters; faster conversions let you use smaller voltage increments in providing a given total amplitude of waveform. In these applications, the faster routine will generally be more satisfactory.

Speed in D/A conversion is even more critical when the converters are used for oscilloscope displays. In general, displays must be made at rates of at least 15 Hz to avoid serious flicker. Since you will typically display as many as 1000 samples per sweep, you want a D/A converter capable of at least 15 kHz for this kind of application. Speed is not nearly so essential when you display hard copy using analog recorders, and since the computer also has the ability to display waveforms on its monitor, the use of D/A conversion for oscilloscope displays is not as essential as it might otherwise be. However, it can be useful in many laboratory applications.

### Digital I/O Ports

These ports, originally designed for transferring parallel digital data, are extremely useful for transmitting individual control signals between the computer and the experimental apparatus. All experiments have some need to synchronize the A/D recording of the computer with the experiments. Since each of the 8 channels in an I/O port can transmit a separate voltage signal, 24 separate channels are available on the Lab Master and 16 come with the DT2801.

The packages that provide the ability to use these I/O channels (table 2) allow a great deal of interaction between computer and experiment. Without the ability to use these ports, you must find some other method of synchronizing the computer with the experiment. For example, it is possible to use a D/A channel to output a control voltage and to accept digital signals through the A/D channels. However, there are fewer of these channels, and to the extent that they are used for digital communication, they cannot be used for other functions.

### Clock Functions

Each board has a clock, and the frequency of these clocks is divided down by powers of 2 on both boards, and by powers of 10 as well on the Lab Master (table 1). Division by powers of 2 can produce some awkward clock frequencies, so in developing SALT we have used only the powers-of-10 dividers. You can obtain frequencies other than those provided by the clock dividers by using the timer/counters on the Lab Master board, but they are not available on the DT2801. Thus, you can obtain much finer gradations in the clock frequencies with the Lab Master.

With most of the software packages reviewed, the actual operation of the clock and timer/counters is invisible. You select a trigger frequency, and the software establishes the correct timer output. In some cases, this reduces the number of timer/counters available to you when a timer/counter is not necessary for the desired frequency.

### TIMER/COUNTERS

We have found these timer/counters extremely useful in high-speed operations. For example, it is possible to put out a control voltage to the experimental apparatus at precise times during data collection at the maximum rates. This is done by initializing the timer/counters to count the same pulses that are being used to trigger the A/D converters but inhibiting their operation until the series of A/D conversions is initiated. When each of the counters reaches its terminal count, the voltage output changes without any intervention from the central processor, so the operation of the timer/counters does not take up program-execution time during the critical period of data acquisition. It is also possible to generate different frequencies of trigger signals for different purposes. For example, one frequency might trigger A/D conversions, while the other triggers external events in the experiment.

Of the commercial packages that run Lab Master, only ASYST provides control of the timer/counter (table 2). However, ASYST reserves four of the timer/counters for its own operation so that only one is available to you. Our own SALT usually uses one of the counters for clocking the A/D conversions, so that when you use it in that mode, four of the five timer/counters are available to you. It is possible, however, to use the output of the clock dividers directly in SALT, so that all five timer/counters can be available.

### SYNCHRONIZATION

When you program the computer to send or receive digital signals, you can synchronize its data collection with external events. The accuracy of this synchronization depends upon whether the timing clocks can be synchronized and whether the interrupts within the computer can be disabled. The time-of-day clock within the computer generates a 250-microsecond interrupt every 55 milliseconds. If this interrupt is not disabled, an uncertainty of 250 microseconds occurs in every synchronization. As nearly as we could determine, most of the packages disabled this interrupt during data collection, but PCLAB requires that you write a routine specifically for this purpose when the interrupt is to be disabled.

A less serious problem occurs when the clock is made to run continuously and an external event initiates A/D conversion. In that state, synchronization uncertainties equivalent to one clock interval occur with each conversion. The commercial packages do not provide for synchronizing the timers exactly with external events.

### GRAPHICS

Like SALT, PCLAB makes no provision for graphics. Two other packages, Labtech Notebook and LABPAC, let you display the channels of digitized data as they are collected. LABPAC also allows display of previously stored data and *x,y* plots of two separate channels. Neither of these two packages offers any more extensive graphics.

Most of the graphics routines come as part of the basic ILS package, although some additional graphics are part of an extra-cost data-analysis module. The graphics in ASYST come as part of an extra-cost module. Data obtained with Labtech Notebook can be graphed using Lotus 1-2-3.

### DATA ANALYSIS

As with the graphics, ASYST and ILS offer extensive data-analysis routines at an increased price. These two products also offer substantial statistical packages. ASYST's statistics are included in the graphics option, while in ILS the statistics are included in the data-analysis option. As with the graphics, you can perform analysis of

(continued)

*Labtech Notebook was easy to learn but was either too simple or too slow.*

data obtained with Labtech Notebook in Lotus 1-2-3.

### DOCUMENTATION

Most of the manuals were easy to understand and gave satisfactory explanations of each of the commands in the package. The documentation with ASYST was voluminous, mainly because it had to describe a whole new language. We found that it would take longer than we were willing to spend to fully appreciate the richness of this system. One of our colleagues and his technician spent several weeks studying the manual and at the end of that time still did not feel that they had mastered the language.

At the other extreme, we quickly learned the single-command package, ILS, and the menu-driven package, Labtech Notebook. We have worked with only the BASIC version of PCLAB. We found the manual for PCLAB very helpful in its explanations of the routines and the board. It gives numerous useful examples. We had some difficulty in obtaining specific information from the LABPAC manual, which gives very few examples.

### IDIOSYNCRASIES

As with all new software, some relatively minor aspects of these packages did not operate exactly as we would have expected after reading the manuals or the advertising. In many instances, the manuals were inaccurate or misleading. For example, the documentation for the early version of Labtech Notebook stated that data could be acquired in the background mode at rates of up to 600 Hz when in fact the highest possible rate was only 300 Hz. Later versions of the manual have been changed to reflect the more limited rate. This type of disparity between manual and program differs from an actual bug, in which the program does not operate correctly. An example of a relatively harmless bug in ASYST was that voltage values obtained through the A/D converters were half those expected from the input voltages and the amplifier settings. We never did know the reasons for this discrepancy.

We have refrained from cataloging these small deficiencies for two reasons. First, we did not test every aspect of every package, so such a catalog would be incomplete at best. The unwary reader might thus be given the false impression that some aspect of a particular package worked perfectly because we failed to state that it didn't. Second, for most users, the major difficulty will not be an actual bug in the program but some subtle characteristics of the routines that prevent them from carrying out a required task.

A good example is the problem described above of exactly synchronizing the initiation of A/D conversion to an external event. We once had such a problem with synchronization in the laboratory and have written the SALT A/D routines so that they can start the A/D clock after the external trigger is received. We could not find a process for such synchronization in any of the other packages, and it is not possible with the DT2801 board, which has only a free-running clock. This problem of synchronization is just one of many that you might encounter in a specialized application, and it is not possible to give a comprehensive list of the pitfalls that you might encounter in the diversity of laboratory applications. We can only caution prospective buyers of any of the packages to examine its characteristics carefully in light of individual protocols before purchasing the package.

Consequently, we have chosen to describe only a few of the major problems we found with the different packages.

We had the greatest difficulty with ASYST because it was so complex. It is undoubtedly a powerful system, but we estimate that it would take an experienced programmer at least a few months of full-time work to be able to use the routines effectively. However, the company has a user-support program that we found to be very helpful when we telephoned.

Labtech Notebook was easy to learn but suffered from the drawback that it was either too simple or too slow. When run in its fast foreground mode, it could not do anything but the laboratory interfacing tasks assigned to it. It cannot, for example, collect data for brief periods at a rapid rate and then spend some time analyzing or displaying the data before beginning another period of rapid data collection. This deficiency occurs because Labtech Notebook does not provide data-analysis and display routines of its own but relies on Lotus 1-2-3 for these functions. Lotus 1-2-3 and Labtech Notebook cannot operate in the foreground mode simultaneously. When collecting data in the slower background mode, Labtech Notebook can analyze data using any other language, but the highest conversion rate is 300 Hz.

We found LABPAC to be very limited in its functions, and we found the manual to be somewhat misleading. Scientific Solutions has a user-support system, but it took us six telephone calls to the company before we could speak to someone willing to answer our questions. Even then, the individual with whom we spoke was not able to give specific answers to some questions about the capability of the routines.

### CONCLUSION

The software packages reviewed here differ in their emphasis on hardware control, data manipulation, and data analysis. At one extreme, ILS provides few experimental control functions but extensive data analysis. Other packages (PCLAB, Labtech Notebook, and ASYST) provide background data acquisition while other programs operate in the foreground. The two most general packages, ASYST and Labtech Notebook, operate both boards. Labtech Notebook is menu-driven and therefore very easy to operate. ASYST, perhaps the most extensive package, offers separate modules for analysis, acquisition, and graphics/statistics but requires a great deal of time to learn its independent language. ■

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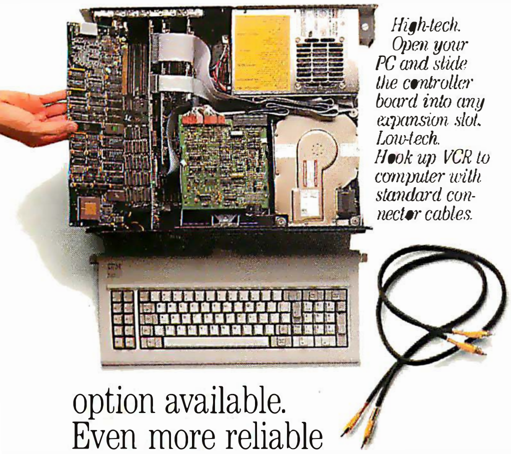

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BY ROBERT D. SWEARENGIN

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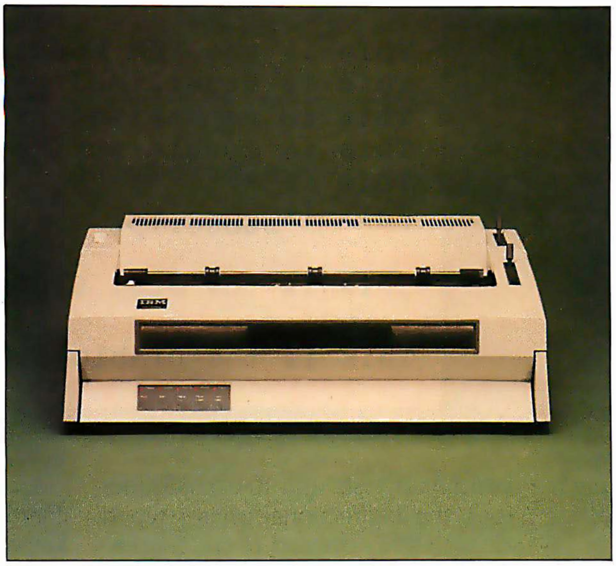


## CONTROLS

I connected the printer and reached for the platen knob to roll in some paper, but there was no knob. I found this disconcerting at first; however, it really isn't needed. You simply align the paper against the backstop and pull the paper bail lever all the way forward. The paper feeds properly to the top of the form and the bail returns automatically to the platen after 6 to 10 carriage returns. That's all there is to it.

You can manipulate the paper directly with three of the five dual-function control panel buttons: Stop, Start, Paper Up, Paper Down, and Form Feed. The Stop and Start buttons switch the printer off- and on-line. The Paper Up and Paper Down buttons move the platen one line per touch, or continuously if held. Form Feed moves to the top line of the next form. The paper buttons work only when the printer is off-line.

To activate secondary functions, you simply hold down Stop/Code while pressing the desired button. Reset restores all printer defaults and is equivalent to turning the power off and on. Incr Up and Incr Down move the platen 1/96 inch for fine adjustments. Set establishes the current line as the first line of the next form.

Five indicator lights supplement the switches. These include power on, on-line, end of paper, end of ribbon, and daisy wheel not installed.

The printer's ten DIP switches are easily accessible under a flip-up door on the top of the printer. Three of them set the printer for foreign-language daisy wheels. The others are for hexadecimal dump, skip perforation, automatic linefeed with carriage return, audible alarm for end of paper and ribbon, form length (11 or 12 inches), line spacing (6 or 8 lines per inch), and line length (8 or 13.2 inches). Maximum line length on the 15¼-inch platen is pitch-dependent, ranging from 132 columns in 10 pitch to 198 columns in 15. And with the 15-pitch daisy wheels, you can condense to 17 pitch.

## FLEXIBLE OPERATION

The Wheelprinter E accepts both sheet and fanfold paper. The basic unit is friction feed and comes only with what IBM calls a "paper table"—a 2¼-inch-high backstop with a scale for aligning the paper. It does include auto-stop for single sheets. The printer goes off-line at the end of each page and beeps three times. You insert the next sheet, punch the reset button, and it begins again without losing any copy.

For long documents you may find that it is too much trouble to insert the sheets by hand; you would then want the optional cut-sheet feeder ($350) or the pinwheel feeder ($75). The friction feed handles fanfold paper, but I found that the margin began to shift after three or four pages of text.

The IBM Cartridge Printwheel II, the fancy name for the daisy wheel, is easy to change. My printer came with 10-pitch Courier, which is a clean and readable face. Others, available for

(continued)

*Robert D. Swearengin (127 Hunter Farm Rd., Peterborough, NH 03458) teaches English and journalism at North Adams State College in Massachusetts.*

IBM Wheelprinter E

**Type**
Daisy-wheel printer

**Company**
IBM Corporation
1 Culver Rd.
Dayton, NJ 08810
(800) 426-2468

**Size**
21⅜ by 14½ by 6½ inches; 29 pounds

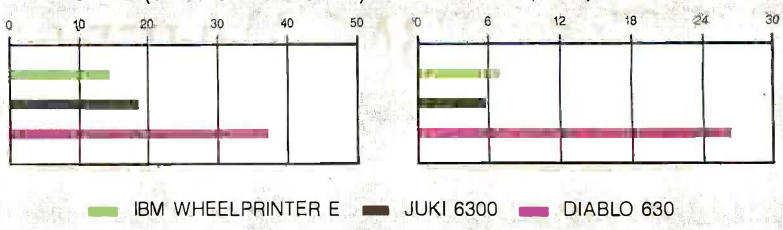
**Features**
2K-byte buffer

**Options**

| | |
|---|---|
| Cut-sheet feeder: | $350 |
| Pinwheel feeder: | $75 |
| Daisy wheels for 10, 12, and 15 pitch and proportional spacing: | $25 each |
| Technical reference manual: | $16 |

**Documentation**
User's manual, spiral-bound
147 pages

**Price**
$699




The IBM Wheelprinter E (using the 10-pitch Courier daisy wheel) is compared with the Juki 6100 (using a Courier 10-pitch daisy wheel) and the Diablo 630 (using a Courier Legal 10-pitch daisy wheel). Print speeds were determined by timing how long it took the printers to print the Shannon test (573 characters). For more information on benchmarks, see "The Art of Benchmarking Printers" by Sergio Mello-Grand, February 1984 BYTE.

This is the IBM Wheelprinter E.
This is underlined printing.
**This is emphasized printing.**
This is double-strike printing.
This is$^{\text{superscript}}$
This is$_{\text{subscript}}$

This is the Juki 6100

This is the Diablo 630 printer.

$25 each, include Artisan in 10 pitch; Courier, Letter Gothic and Prestige Elite in 12; Courier and Gothic in 15; and Boldface and Essay in proportional spacing. The printer uses IBM Easystrike ribbon cassettes ($13.25). You can choose the fabric ribbon for general-purpose drafts or the multipurpose cassette for high-quality images on a range of paper types.

The printer supports underline, double strike, superscript, subscript, and emphasized—an effective boldface produced with a 1/120-inch offset. Instead of making a second pass for these features, the print head pauses along the way. It's about half as fast as normal printing, but it probably reduces wear and tear. The platen moves up and down 5/96 inch for superscript and subscript.

## Speed Tests

The Wheelprinter E plods along steadily. Using the BYTE printer benchmark tests with 10-pitch Courier font, the bidirectional printer typed close to IBM's claimed 16 cps. Surprisingly, the printer was slightly slower on the 80-column Shannon test (15.1 cps), which has fewer linefeeds, than on the 60-column benchmarks (15.6 cps). On 60-column American English first-order random approximations it typed a full single-spaced page at 15.9 cps. (For more information on the benchmarks, see "The Art of Benchmarking Printers" by Sergio Mello-Grand, February 1984 BYTE.)

## Documentation

The manual covers the operation of the printer well. The chapters on setup, operation, and options are clear, well written, and profusely illustrated. In just a few minutes, the manual takes you step by step through unpacking, plugging in a standard parallel cable, loading paper, and working the five buttons on the front control panel.

An excellent printer control code chart provides explanations and examples for manipulating the printer manually. You will have little trouble accessing features such as the bell, backspace, tabulation, linefeed, page length, skip perforation, print direction, and line length, or using the control codes to change the print mode, pitch, or character set.

Unfortunately, there is insufficient technical information. For example, the manual says the buffer holds "about one page" of text but doesn't give its size (2K bytes). For detailed information, you must order the technical reference manual ($16), which contains sections on the parallel interface, hardware design, and the data-transfer sequence.

Overall, I was pleased with the Wheelprinter E. It will undoubtedly satisfy those who require the output of a daisy wheel but not the speed of a more expensive printer. ■

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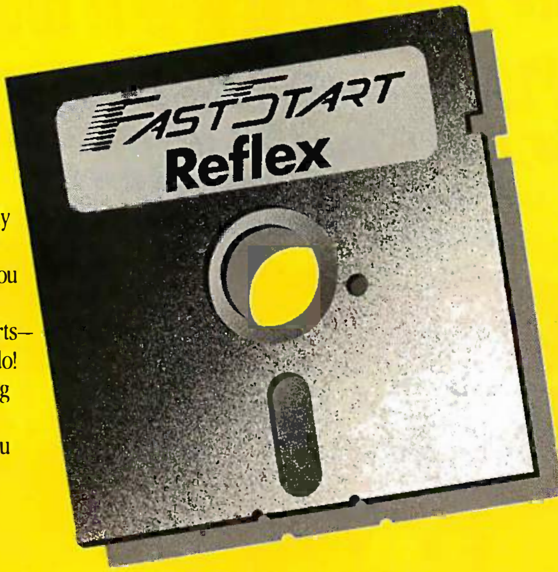


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## ZBASIC

I was pleased to see TJ Byers's review of ZBasic (May) because the product deserves attention. But I don't think a user needs to relearn BASIC to the extent that you suggest. I've been using ZBasic for a few months, and it is not hard to convert MBASIC or BASICA to ZBasic with a text editor using search and replace commands.

A nice feature not mentioned in your review is the CALL statement and command in MS-DOS. From the editor you can make changes to one module of a chained program, compile, and then CALL the starting module without exiting ZBasic. You can also CALL batch files, full-screen editors, and most other applications.

One problem not mentioned in your review is that ZBasic variables default to integers. Complicating this are the parentheses, which are interpreted as variables. Thus, in the following computation, X# (a double-precision variable) is calculated as 1: X#=(1.3*(1.2)^2). To correct this, the manual suggests multiplying by 1. I found this was necessary at each embedded pair of parentheses as well.

On the whole, I would have given ZBasic more than just a "good" rating. This is a real breakthrough for less sophisticated programmers like me.

GLEN JANSMA
*Austin, TX*

## NON-KEYBOARD INPUT DEVICES

There were a couple of factual errors in "Non-Keyboard Input Devices" by Chris H. Pappas (May).

First, he says that Ctrl-G acts as a destructive backspace in WordStar. This is not true: Ctrl-G deletes the character above the cursor, not the one immediately before. The destructive backspace does exist, though; it can be accessed by the Delete key or by Ctrl-hyphen.

Second, he says that you have to toggle the Num Lock key to use the cursor numeric keypad for numeric input. This is not true: You can also use the Shift key.

The intention behind the much-maligned IBM keypad seems to be to allow the user to type numbers with the right hand and then to press the Shift key with the left while moving the cursor with the right to the next cell or field. Ergonomically, this keypad makes sense, since it does minimize hand movement. Unfortunately, IBM chose to hide the instructions on how to use it in a little-read section of the manual.

TIMOTHY HORRIGAN
*Durham, NH*

## LETTRIX

I was very interested in Alan R. Miller's review of Lettrix (May), which I now use. Although the program's print quality is very good, I have some complaints to add.

I have gotten no support whatsoever from the vendor, Hammerlab Corporation. I have written to them about the problems and called them long distance, but I have not received a reply.

One of my problems is that I cannot get the program to run with Lotus 1-2-3. Since Hammerlab says the program is Lotus 1-2-3–compatible, this is disturbing; being ignored is even more disturbing. I also cannot get it to run with Turbo Lightning.

Another problem is the manual. It states that Lettrix is not compatible with spoolers, but this is only partly true. The DOS spooler works fine, but the foreground task runs very slowly. The operation on a print buffer might work similarly, although I haven't tried it. Those that have buffers should certainly give it a try rather than taking the manual's word for it.

My copy of Lettrix is not copy-protected, but if it had been I would have asked for my money back and not used it. Since the company only takes orders and will not talk to customers, such a demand would probably have been useless. Vendors that ignore customers usually go out of business sooner or later.

ROBERT A. DAY
*Livermore, CA*

## AT&T PC 6300

I would like to support Al Sargeant's sentiments about the AT&T PC 6300 in his letter in the March Review Feedback.

I, too, have a PC 6300. It is less than one year old and has been laid up in the shop twice. So far it has gone through two power packs and three motherboards, and the problem remains unsolved. Sometimes only the fan comes on with no power-up. This is an expensive mystery.

I wonder how many people have had similar major overhauls of their 6300s?

I think BYTE could provide an excellent reader service by issuing a "frequency of repair" rating of computers and printers, similar to *Consumer Report*'s automobile evaluations based upon surveys.

RICHARD KELLY
*Knoxville, TN*

I am amazed that the question of DIP switch settings and memory chips on the AT&T PC 6300 motherboard was ever an issue with your readers. When I read Bob Troiano's review (December 1985), I thought that his criticisms of a lack of documentation for the settings required for adding RAM and the compatibility with 256K-byte RAM chip sets were due to the preliminary documentation that he had.

I bought my AT&T PC 6300 in September. The user's guide had clear documentation of settings and confirmation that 256K-byte RAM chip sets are welcome on the motherboard. Michael J. Sobota's letter (March Review Feedback) might give the impression that AT&T documentation is flawed, but I have had no cause to complain, despite having to refer to other optional AT&T manuals from time to time for other questions.

I can, however, complain about AT&T's quality control, as did Al Sargeant (March Review Feedback). My personal computer initially had a faulty floppy disk controller and was "dead on arrival"—it couldn't boot the system disk, even after the drives were changed. After I changed the motherboard, it blew its parallel port two weeks later and repeated this feat a month after that. Each time I had to replace the motherboard. Now, with the fourth motherboard in place, everything has been fine for four months.

I agree with Mr. Sargeant that the PC 6300's performance is amazing. Add an 8087 with the right software, and it flies.

KENNETH ALAN CROSSNER
*Somerset, NJ* ■

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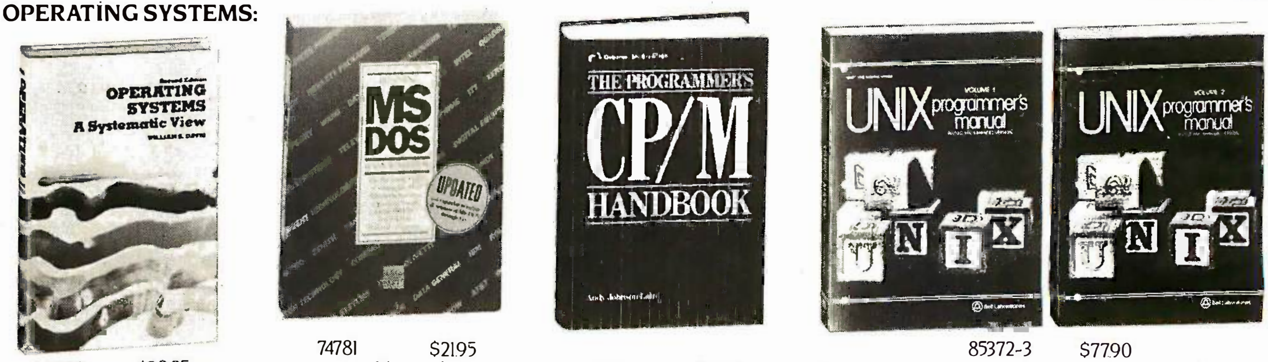


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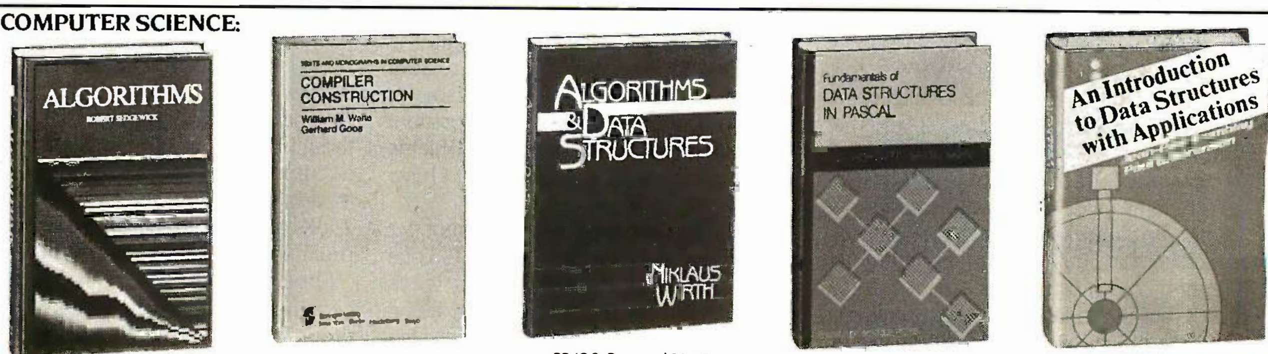


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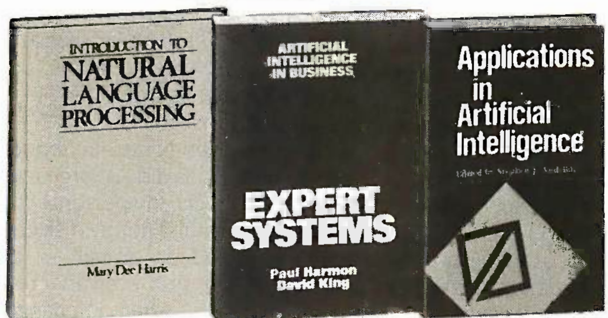


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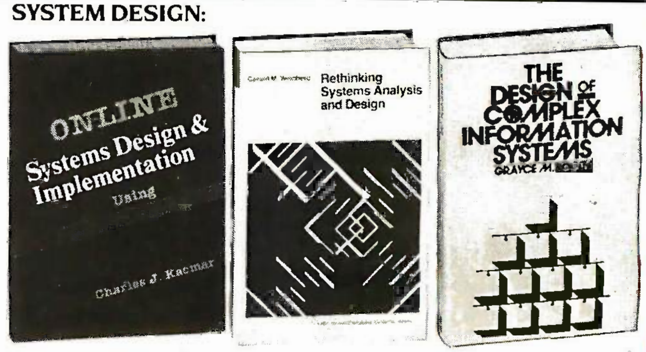


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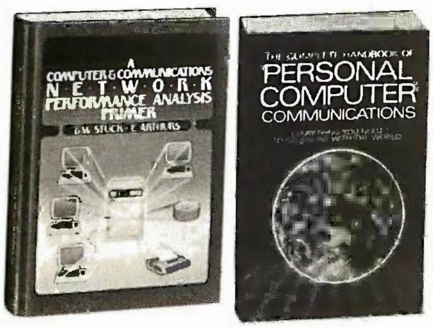


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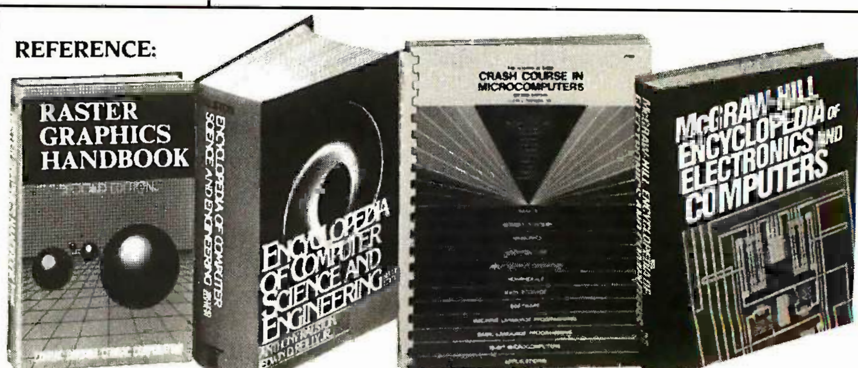


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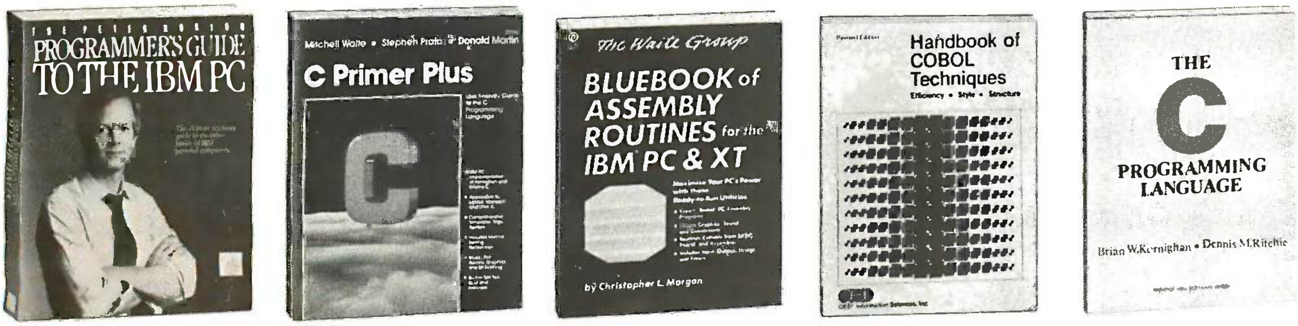


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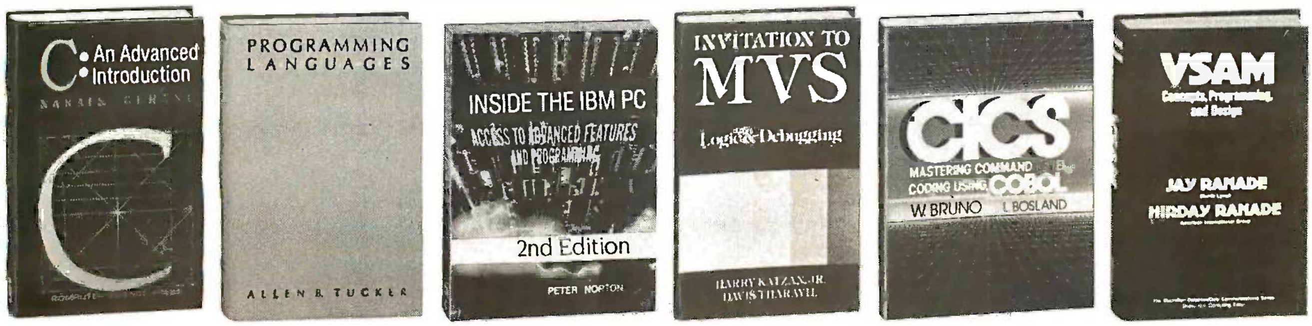


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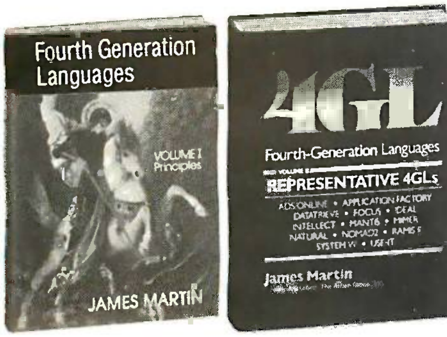


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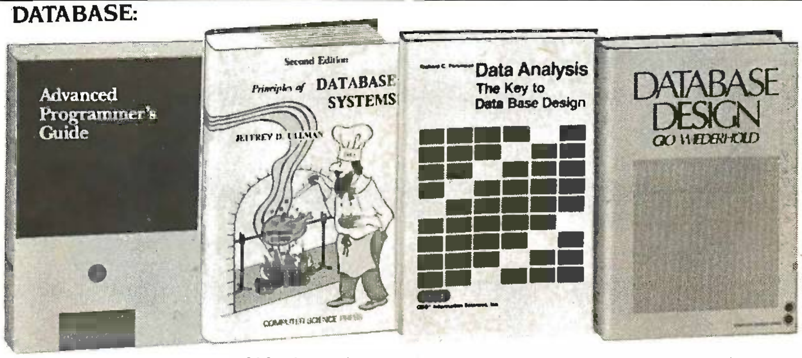


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# Kernel



CHAOS MANOR REACHED what may be a new high in disorganization this month. Jerry was putting the finishing touches on *two* books, so things got very hectic indeed. However, he was still able to do his column. It begins with Jerry using a program called Fastback to back up the files on Big Kat. The major theme he touches on is how to compute while traveling. New products help make this an easier task.

In According to Webster this month, Bruce looks at some programming tools, products that help you develop programs. Bruce finds himself impressed with the quality of some recently released products. What was once an insignificant segment of the software industry has mushroomed into a significant market, with rising quality and decreasing prices. Bruce's product of the month, Personal Pascal, is one of these tools.

In the U.K., Dick revisits the subject of the Inmos Transputer, which he introduced in his first BYTE U.K. column two years ago. He also discusses Meiko's Transputer-based Computing Surface.

And in Japan, Bill talks about this year's not-so-exciting COMDEX in Japan show and about Oki's laptop portable and some new NEC machines.

Ezra talks about several products that fit into a category he calls "disposable software." That is, each of these programs—It Figures, Dac-Easy Word, AI:Typist, and Datatext—costs less than $100.

# TRAVELING COMPUTERS

BY JERRY POURNELLE

*Jerry backs up Big Kat and talks about his lapboard computers*

This place is a mess. I suppose that's no surprise in a place called Chaos Manor. but in fact it's worse than usual. A couple of days ago, Larry Niven, Steve Barnes, and I finished our new novel (*The Legacy of Heorot*) and got that off to our agent; and last night I completed a new anthology, *Imperial Stars*. As is usual when I'm in the final throes of creating a book, everything else gets neglected; and this time there were two books. The result is stacks of mail, unsorted piles of software, journals, partial drafts, books open to passages we copied out, notes, clippings, unread newspapers and magazines, and heaven alone knows what else, all draped artistically across every conceivable flat surface. The only things missing are empty bottles and dirty glassware: the housekeeper can't be sure about scraps of paper, but she *knows* dirty dishes don't belong here.

All this is by way of indicating that this month's column will be a bit disorganized; but since *every* column lately has been a bit disorganized, I don't suppose I've told you anything unexpected. Sigh.

## FASTBACK

Fastback is a program that backs up your PClone's hard disk onto floppies; it really works. The good news is that Fastback can be installed on your hard disk. The bad news is that you can no longer get an unprotected copy of it.

I have mixed emotions on that. The copy protection that Fifth Generation Systems has employed isn't onerous: it's one of the "key disk" things. Moreover, the Restore program is *not* copy-protected. You can make several backup copies of that and run them, even if your main program disk is dead or lost. Finally, in their favor, you don't use Fastback very often, and when you do use it you aren't going to be using anything else, so it's only a minor inconvenience that you have to put the master disk into drive A before you get started. It's hard to make a valid case against copy protection that causes no real hardship to legitimate users.

I used Fastback to back up the files on Big Kat, my Kaypro 286i IBM PC AT work-alike. When I'd tried once before, I discovered that if Fastback detects that your disk drives are the modern ultrahigh-density megabyte-plus floppies, it automatically uses that format; or so it seemed to me. I didn't have any of the special disks needed to make use of that ultrahigh-density format. For that matter, I didn't really trust it. That's an awful lot of data packed onto such a small area.

Then Priority One had a big sale, and right there on the back cover of the flyer was ultrahigh-density disks. I figured I might as well bite the bullet, so I bought a couple of boxes; and one Saturday morning I sat down to back up all the stuff on Big Kat's hard disk.

## A DIVERSION

My first attempt at backing up the hard disk was utterly unsuccessful. In fact, it was worse than that. You install and customize Fastback and save it off on your hard disk. The installation process is tedious enough that I didn't want to go through it again. I already had an installed Fastback somewhere on the hard disk, but on a subsidiary directory, and I didn't remember which, so I did DIR/W and got the message "Invalid Parameter."

This didn't seem reasonable, but I'm not a DOS wizard, so off I go to look it up. First place is Alan Boyd's *PC-DOS/MS-DOS*; I look in the table of contents. There it is. "The DIR command," so I turn to page 25—and there's nothing about parameters. Shriek. Look in the index. There are dozens of references under the entry "DIR" but nothing to indicate which, if any, tells about parameters. Look up several. Nothing. Shriek and throw the book across the room. Go find Van Wolverton's *Running MS-DOS*. That has no index entry to "DIR" but does have a pointer to "Directory Command," which, although it says nothing about parameters, has only three index references; and the second one shows the /w and /p parameters. Lo! I had it right all the time. . .except that DIR/W and dir/w and dir /W and all other permutations and combinations inevitably produced the same result, namely, "Invalid Parameter."

This was getting pretty irritating. Eventually I did Ctrl-Alt-Del; of course, I had the Fastback disk in drive A, and it has no operating system on it, so that was another delay. But, eventually, I got the machine reset and booted up; and DIR/W worked fine.

There's a moral to that story. I generally leave Big Kat running at all times; I'm told it's less strain on the hard disk, and anyway the machine with SideKick and Ready! has become my Rolodex, tickler file, calendar, tele-

(continued)

*Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future.*

phone dialer, logbook, memo pad, and just about everything else; I don't *want* Big Kat turned off.

But every now and then some feature of one of my memory-resident programs won't work. Once, when I was doing some work on-line, SideKick wouldn't upload stuff I'd written in the notepad. It would save it all right; but it just wouldn't squirt it uphill. Another time, another minor glitch. Each time the problem was cured by resetting the machine, just as the "Invalid Parameter" glitch was.

CP/M used to reload itself and rewrite the bit maps every time you did a warm boot, which was generally each time you exited a program. MS-DOS does *not* do that. The result, apparently, is that once in a while something can drift. It isn't just Big Kat the Kaypro, either: I've asked others with PC and PC AT machines, both genuine IBM and clones, and they report having had mysterious glitches that went away after resetting.

Anyway, I now reset Big Kat at least once a day; and since I took up doing that, I haven't had any more drift problems.

## BACK TO FASTBACK

So. Once I got all that straightened out, I was ready to back up my hard disk; and off I went again. This time I found the proper directory, invoked Fastback, and—

I watched things blow up again. Fastback would get started, but it clearly wasn't working right.

There is a telephone number in the Fastback document. Two, actually: an 800 number and one for a normal exchange in Baton Rouge, Louisiana. The 800 number didn't answer—this was a Saturday morning—so I called the other, and Lo! I got one of Fastback's designers. We set to work on the phone.

The first problem was the number of buffers. The "buffer" command in your AUTOEXEC.BAT file is vital. Some numbers for "buffers" won't work. It's safest (but slower) to have no buffer command at all. It's not that much slower. This is not properly documented in the Fastback documents.

Once that was settled we started again. Fastback tells you what to do: put a blank disk in drive A, drive A done, put a blank disk in drive B, and so forth, and it trundles along *very* fast. You do have to pay attention to those prompts, but there's no disaster other than wasted time if you're a bit slow in responding. Fastback formats the disks for you if they aren't already formatted, so you needn't be bothered about that, either.

About halfway through the job, Fastback died. It didn't say it had died; but nothing happened for quite a long time. Since I was on the phone with one of the program's authors, I could ask what to do next.

"Are the disk lights on?"

"No."

"Hmm. It's dead, all right. We never worked with a Kaypro AT before. I

(continued)

*With Fastback, I backed up 20 megabytes in less than 15 minutes.*

think it got retry errors and timed out."

Fortunately there's a solution. You can invoke Fastback with options. Some, like /360 and /720, will cause the disk drives to format disks to 360K or 720K bytes per floppy; I didn't *have* to buy the special ultrahigh-density disks and let the machine do the 1.2-megabyte format. This isn't well documented, but it does work. ("Isn't well documented" means "I didn't find it when I needed to." The information is in the book, but it has neither index nor analytical table of contents; you have to read *all* of it to find out things like that.) Anyway, if you have 1.2-megabyte drives, you can still use normal floppies by doing Fastback /720, or /360 if you're feeling conservative and have lots of floppies lying about. Of course, that wasn't the option I needed.

The option needed for Big Kat is Fastback /slow. You wouldn't deduce that, because when you install Fastback there's a "test" routine that runs and tells you whether or not you ought to invoke it with the /slow option, and Big Kat passed that test; but that's what I had to do. Incidentally, the /slow option doesn't *really* slow the program, or at least not by much; what it does do is make the program believe that you have a somewhat erratic disk controller and thus do more retry attempts if things get out of sync.

So. Next step: Fastback /slow.

That worked. It worked wonderfully well. Faster than you'd believe. In less than 15 minutes, I'd backed up 20 megabytes of stuff.

Now for the acid test: will it restore? Fastback's Restore program has a test mode: you can invoke the program in a way that won't write anything but verifies that what has been backed up is what's on the hard disk. I tried that. Worked fine.

There's more. Fastback has an error-correction feature. You can take your backup disk and *put a staple through it*. I don't recommend that you do that, at least not to your only backup copy, but you can do it, and chances are very good that the program will be able to restore your data anyway. (You do have to remove the staple . . .)

So. I love Fastback. I use it. It works with Big Kat (as it does with both the IBM PC and the Zenith Z-150 with the Hardcard). The documents are awful, but they're good about support if you call on the telephone; and I guess I can live with their form of copy protection for this kind of program. (Sigh. Every time I think I have rules established . . .)

### TRAVELING

Last summer I went through The Great Portable Quest looking for a computer to carry with me to Europe. This year I won't have the problem. I know what I'll take.

My requirements are pretty simple. I want something light, battery-powered, with a reasonable text editor. I want *plenty* of storage space. I'm a fanatic about not losing text; I really want redundant storage if I can get it.

I don't need big number-crunching power, or Lotus 1-2-3, and I'm not likely to do any programming while on the road. I would like to have ways to update my calendar and address book and make notes for future reference.

I've left out the most important requirements of all: it has to be truly portable. I need a lapboard because I work in airplanes; I have to be able to *see* the screen in the not-always-good light that airplane cabins provide; and the thing has to be light enough to carry around airports.

For a while I solved the problem by carrying Adeline the Otrona, for use in hotels and for disk storage, and Percy the NEC PC-8201 lapboard, to use on the airplane and in lounges. This works reasonably well. Spin and Pop Enterprises (P.O. Box 6458, Denver, CO 80206) provides better service and support (including memory expansion and general updating) for the Otrona than the Otrona Company did before that outfit went south; and the Otrona, with hard disk and large monitor, is just one delightful machine to use. More, the NEC can be stuffed in alongside the Otrona in the Otrona's carrying case, and it's a very simple matter to squirt text from Percy to Adeline.

Alas, this combination is heavy. It's bad enough on short domestic trips; on long trips, or when I have to change planes, it's sheer murder. I already have plenty to carry, since I generally have a briefcase and shoulder bag, often a garment bag, and, if returning from a computer show, a couple of plastic bags of software and books. Adding 25 pounds of computer to that load is just a bit much.

One possibility is Purple Computing's Sidecar for the NEC. This is a removable bank of 98K bytes of memory with its own battery. It works wonderfully well, and last year when I decided not to take the Otrona to Europe, Sidecar was a real lifesaver. (On reflection, it should have been mentioned as one of my Products of the Year in the April issue. My apologies.) A NEC with Sidecar certainly works.

There are problems. Clearly you have no redundancy, unless you buy *two* Sidecars, and they're not cheap. Second, transferring text files between the NEC and the main computer—PC-DOS or CP/M—isn't too difficult, but it is a bit tedious, since you have to connect the machines with a cable and use serial-transfer methods. Finally, there are severe limits to the programs and electronic files you can carry. Still, for all the problems, the NEC PC-8201 with Sidecar worked and was the best thing around for me.

### TS-DOS AND LAPDOS

Now enter Mark Eppley, whose Traveling Software company specializes in lapboard computer products. Eppley got hold of the Brother FB-100 battery-powered 3½-inch disk drive and put together a package to mate it with either the TRS-80 Model 100 or the NEC PC-8201. The result is called TS-DOS. TS-DOS works with the Ultimate ROM II, a ROM chip with application

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software, to be installed in the NEC or TRS-80 lapboard machine. You can also buy TS-DOS separately and load it from a 3½-inch disk. A 5¼-inch disk called LAPDOS enables your PC to access the disk drive through a serial port. Although I've used only the Brother FB-100, everything works with the Tandy portable disk drive you can get at your neighborhood Radio Shack.

The result is little short of wonderful. I can write a ton of text and save it onto a disk. If I'm feeling paranoid—I often do—I can then put in a fresh 3½-inch disk and save it all again. When I get home, I plug the disk drive into Big Kat's serial port and transfer the files.

There's more. I can also transfer files from the PC to the portable disk: calendar, telephone book, notes; anything I like. All this works simply and easily. It sure makes traveling easier. The Brother FB-100 is quite small and can be carried in a case with either the TRS-80 Model 100 or NEC PC-8201. It's also rugged. You probably want to take the batteries out, since it would be pretty easy to accidentally turn on the switch, but otherwise there's absolutely no reason why you shouldn't roll the FB-100 up in your pajamas and send it along in checked luggage.

Traveling Software also sells a small TTXpress thermal printer. This little jewel is 12 inches wide by 5 inches deep by 2 inches thick and prints normal 8½ by 11 pages. It's larger than the little NEC roll printer I used last summer, but unless you're *really* fanatic on traveling light it's worth it. I can already hear the cheers from the BYTE staff who last summer had to type in my column from the "adding machine tape" output of the NEC printer.

One tricky point about the TTXpress printer: the NEC and Radio Shack computers have their printer ports reversed! A cable that works to connect the TTXpress to the NEC has to be twisted 180 degrees to make it work with the TRS-80 Model 100. I don't have the foggiest notion why.

Traveling Software has a deal on either TRS-80 Model 100 or NEC PC-8201 systems complete with the Brother FB-100 disk drive, the Ultimate ROM II, TS-DOS, LAPDOS, and carrying case. They'll also sell you the TTXpress printer; the Ultimate ROM II has a formatting program that works fine with the TTXpress.

Ultimate ROM II does a few other things, too, like adding a global replacement command to the text editor (the Radio Shack and NEC editors have good search commands, but not replace) and remedying a few other omissions.

Thus, for less than a thousand bucks you can get a complete portable word-processing system about as good as my first computer ever was. The text editor built into the NEC and Radio Shack machines isn't as fancy as I like, but it's surprisingly good and very easy to learn. Add an Epson printer—the Ultimate ROM II's format-

*For about $1000 you can get a portable word-processing system about as good as my first computer.*

ter knows how to work with those—and you'd have a system good enough to be your *only* computer, at least to get started with. Eight lines of 40 characters isn't really optimum for writing, but that's all right; the Ultimate ROM II can set the system to display 60 characters, and that's quite enough.

Roberta and I have "his and her" NEC PC-8201s that we take with us everywhere; we share the printer and disk drive. We like these machines a *lot*. If you're at all interested in lapboard machinery, I strongly recommend you look into either the NEC PC-8201 or the TRS-80 Model 100. Probably the simplest way is to talk to Traveling Software and ask about their latest deal.

I especially recommend that you talk with Traveling Software or some other expert if you want to use the small disk drives on both the lapboard and a PC. Cables and stuff like that can be tricky.

### NEC or Radio Shack?

I now have both NEC PC-8201 and TRS-80 Model 100 machines. Both are equipped with Traveling Software's Ultimate ROM II, meaning that both work with the FB-100 battery-powered 3½-inch disk drive, TTXpress printer, etc.

On my most recent trips I carried both computers. It makes me look a bit odd as I board the airplane festooned with shoulder bag, briefcase, a sack full of software and books, and *two* computers. Oh, well. The purpose was to get a good comparison of the two machines.

I'm glad I did. I can honestly recommend either machine. Each has ad-

(continued)

vantages and disadvantages.

Both machines are made by the same Japanese company and thus have a great deal in common. The major advantages of the NEC PC-8201 are that it has more memory, external (removable) memory cartridges are available, and the arrow keys are *much* better arranged than on the TRS-80 Model 100. The main advantages of the TRS-80 Model 100 are a built-in 300-baud modem, Selectric keyboard layout, and a resident address program that can function as a traveler's Rolodex.

The Radio Shack's built-in modem is tempting, but it's not all that inconvenient to carry a little external modem for the NEC; the modem is quite small and doesn't cost much. I originally got the NEC rather than the Radio Shack because of the external memory cartridges. The advent of the FB-100 disk drive makes that largely—though not totally—irrelevant. Although I like the NEC's large, easy-to-use arrow keys, I do *not* like the keyboard layout, which is the old "TTY" arrangement with quote marks as a capital 2 and the semicolon where the quotes ought to be. I very much prefer the Radio Shack's straightforward Selectric keyboard. Yet, having said that, I'm strangely reluctant to convert to the Radio Shack. I'm used to the NEC, and of course that's what Mrs. Pournelle has. It's all purely subjective.

If you want to compare machines without buying either, you could do a lot worse than to get Marvin C. Mellon's twin books, *Exploring the NEC PC 8201* and *Exploring the Radio Shack Model 100* (CBS Computer Books, Holt, Rinehart & Winston). Between them they'll tell you just about everything you can learn intellectually; after that you'll want to get your hands on a machine. Incidentally, you're better off ordering the books directly from the author at 6914 Berquist Ave., Canoga Park, CA 91307.

Mellon's books are also good introductions to using the machines; they're more clearly written than the manuals you get with the computers. The manuals are more complete, and once you learn to use them you can find everything you need, but they'll take getting used to; Mellon's books make it easier to get started.

## TRAVELING SIDEKICK

Generally, when Borland has new products, I find out before they're released; but I discovered Traveling SideKick through an ad. It seemed like an excellent idea. After all, I use SideKick to keep my phone book and calendar. It would make sense to have a program that would print those out properly formatted, and even more to have a notebook the printouts would fit into.

Then too, every est graduate seems to be equipped with an enormous notebook that contains calendar, scheduler, phone book, expense record, and a whole raft of stuff; I don't know if they come with est training or the graduates are persuaded to buy them; I do know the books look like a pretty good idea.

Later I ran into Philippe Kahn, and he was carrying a Traveling SideKick, complete with shoulder strap. He said he'd developed the notion for his own use, and certainly he was using it. I mentioned that I didn't have one.

A couple of days later mine arrived. I think I've been bribed. What I got was an extremely handsome ostrich-skin notebook with my name tooled in it. Otherwise, I guess it's the same as the ones they sell. Certainly the software is.

The Traveling SideKick software formats calendars and address files. Another program included is Convert, which will take stuff from just about any database and format it so that Traveling SideKick can print it. The Convert program is infuriatingly good: it really works, but I had a heck of a time figuring out how it worked and finally had to get someone at Borland to explain. The young woman who walked me through on the telephone hadn't the foggiest notion who I was, so I presume they'll do that for any customer. Of course, they'd do better to improve the documents and help files.

Convert does the job, though. What you do is teach it what your data format is: what separates fields, and what is in the various fields, and which

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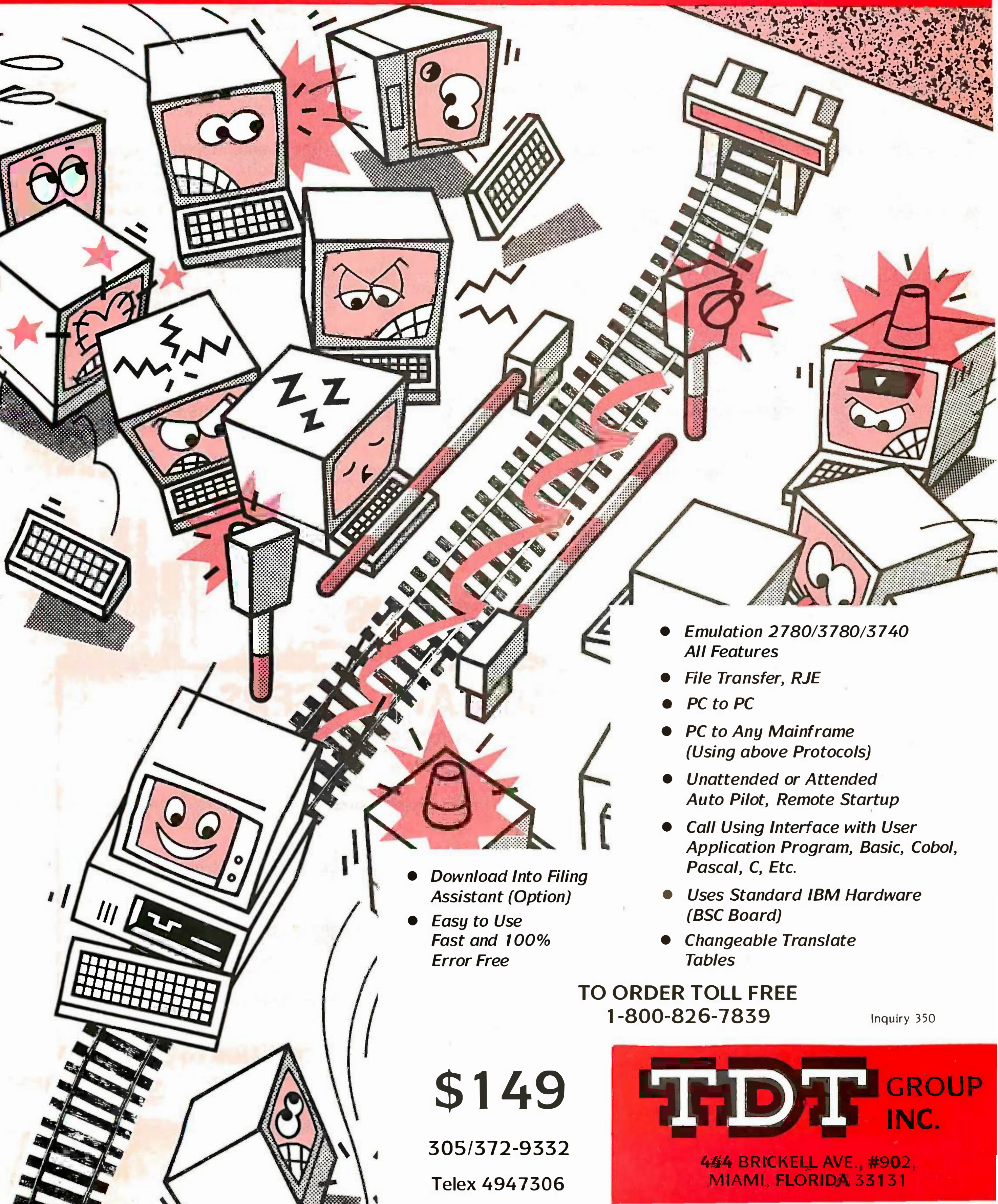

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of those fields you'll want printed in your portable address book. Convert does the rest. It converts one record at a time, as you watch, meaning that you can intervene and change things or update data if you like; or it will do them automatically. "Automatic" still displays each one on the screen, and if you have a couple of hundred records to convert, it will take five minutes or so; there's nothing speedy about it. Fortunately, you don't have to do it often.

Once the files are formatted properly, Traveling SideKick prints them quite nicely in a format that makes it easy to use a three-hole punch and bind them in the notebook. Each page has the date it was printed, too, so you know just how current you are.

Traveling SideKick also prints calendars: by the month, the week, and the day. For my upcoming trip, for example, I'll have each: the current month, the two weeks I'll be gone, and a separate one for each day. New appointments can be put into the daily calendar by hand. Nifty.

I did have one problem printing. My HP LaserJet insisted on cutting the pages short. I should have known, of course, because the LaserJet thinks paper is only 63 lines long; every other printer believes it's 66. Once again I called Borland; this time after hours, so I had to tell them who I was. I pleaded a deadline, and a very nice young man did some experimenting with their LaserJet. Eventually he found the magic escape sequence—it's a dozen characters long!—that you can set up in the SideKick notepad and send out to be "printed," after which the LaserJet will believe paper is 66 lines long after all. This information was also given to all the people in customer support, so anyone calling in will get it; and they're going to put the HP LaserJet in as an installable printer option for Traveling SideKick.

I've had it only a few days, but already it's beginning to organize my life. I wish I'd had it for years.

There are a couple of drawbacks. For one thing, you have to use that Convert program, which is slow and a bit tedious. I kept wishing there were some way to tell Traveling SideKick what my phone book format was and have it print the phone file without conversions.

The main problem, though, is that it's big; some people may find it too big. Philippe carries his everywhere. Me, I wonder; I can just see me getting on the airplane, with garment bag, briefcase, shoulder bag, computer, and on a shoulder strap a book every whit as large as the famous book of conquests Leporello carries for Don Juan. It may have to go in the briefcase.

I'm sure I'll carry it, though.

### TRAVELING WARS

I don't insist that my friends like each other, but it helps.

*(continued)*

*Prolok doesn't work on an AT with ultrahigh-density floppy disk drives.*

For the last couple of years, Mark Eppley has been trying to build a company identity under the name Traveling Software. Enter Philippe Kahn and Borland, who decided to market their new product under the name Traveling SideKick. This got Eppley worried that his identity would be submerged, given the size of Borland and the amount of advertising they would do.

Eppley tried to negotiate, but Philippe Kahn is a hard man to get hold of. Eventually lawyers got in the act, which in my judgment will aid no one but lawyers. Eppley's point is that he has a trademarked name and it has been usurped. Philippe's is that "traveling" is a generic name that can't be appropriated by some private company. "Where will they stop?" he asks rhetorically.

Me, I don't really care. Traveling Software already helps me interface my NEC with Traveling SideKick. I wish Kahn and Eppley would work together to simplify their customers' lives rather than hire lawyers to complicate things.

### A Neat Hack

It's from Klynas Engineering and calls itself "Los Angeles on a Disk—A game with a touch of reality." It's like nothing I've ever seen. It's a game, in that there's a score, and opponents, and even a touch of arcade action—although fortunately not much. On the other hand, it's an exploration: the game contains a map of most of Los Angeles and Orange counties. Naturally, all the LA streets aren't in there—how could they be?—but all the freeways are, and more than enough surface streets to make it interesting. In addition, there are some 300 "points of interest," ranging from the LA County Art Museum to Troubadour to Disneyland.

You play the game by moving about LA in search of a treasure. There are clues to the treasure's location in various points of interest; your job is to go to those places until you figure out where the treasure is. Meanwhile, four "trackers" are on your trail, and if one catches you the game is over. To make matters more complicated, you have to earn money to keep your car gassed and in repair and keep yourself fed and in good health. You have to sleep, meaning you have to find hotels and pay for rooms.

All the points of interest are real. Some of the descriptions are great. There were places left out that I thought should have been there. This turns out to be no problem: the game comes with a bunch of databases and instructions on how to alter them. I found it no trick at all to add streets and places. One place I added was the Los Angeles Science Fantasy Society. Another is Andre Lion's Mon Grenier, a restaurant Niven and I have written into many of our works. I'm sending those back to Scott Klynas, who says he'll incorporate them into the copies he ships.

He's also fixed a few minor bugs I found. For example, the game lets you control your walking and driving speed; but when I put it up on Big Kat, even the slowest speed was almost too fast. The new version takes care of that by asking if you have an AT.

The game visuals aren't spectacular. They're just lines, a two-dimensional map; actually a section of the map, since you'd never find anything if you put the entire LA map on a PC screen. The action isn't much; you just use the arrow keys to steer your car around LA until you find someplace you want to go into. The fun of the game is in the exploration.

More than that, though, it's a neat hack. If you don't like LA, you can use the system to create your own city. This can be a little tedious, but it's all explained in the rule book, and not difficult. You could put in Cincinnati or Chicago, or Dubuque for that matter, adding in your own points of interest. The game recognizes water boundaries, freeways, and surface streets. All these are line segments, so the resulting map is a bit crude and stylized, but even so it's surprisingly well done. I found myself fooling about with the game for at least as long as it would have taken to read a couple of books, and every now and then I bring it up to add a few more places, like Dangerous Visions Bookstore. . .

### Prolok Problems

I've said this before: I find copy protection annoying, but I can certainly tolerate it for games. I wouldn't trust my business to a program I couldn't back up, but games aren't that critical.

However, Los Angeles on a Disk taught me something new about copy protection: the Prolok "key disk" scheme doesn't work on an AT with ultrahigh-density floppy disk drives. That is: I could copy the program to my hard disk all right. However, when the program asked me to put my master disk in drive A, I got horrible grinding sounds and eventually a disk error. It just wouldn't run. When I telephoned Klynas about that—I confess that I was interested in seeing Los Angeles on a Disk—he sent two more copies of the game. He *knew* they worked; and so they did, in my PC and the Zenith Z-150; but when I tried running them on Big Kat, the same result happened each time. Lots of grinding noises.

When I reported that, Klynas said to hell with it: the company has dropped copy protection entirely. Klynas hopes to get his money back—about five dollars a disk—for the Prolok disks he won't be using. I wish him the best of British luck . . .

Another game company wasn't so lucky. Last summer I got a copy of Quest for the Ring from Icon. This is a game built around Wagner's *Der Ring des Nibelungen*, and from the instruction book it might be interesting. I wouldn't know: again, the game will copy to my hard disk, and I can even play the first-level game; but as soon as I try to go to the next level of play, the program demands the master disk in drive A. Complying with that instruction results in endless grinding as if the floppy drive is shaking itself apart. Consequently, I've no report on Quest for the Ring.

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I could, I suppose, make use of FUProlok, a public domain program available from bulletin boards or Workman and Associates. It's a program that can defeat the Prolok "key disk" system. There's also Copy II PC. I could use one of those, but I haven't got around to it, and I probably won't. Why should I fight Icon's copy protection? It isn't as if I don't have plenty to write about.

Meanwhile, I had those two spare copies of Los Angeles on a Disk, meaning that I had Prolok to play with. It turns out that if you erase all the files on a Prolok disk, a hidden file remains. I used the Norton Utilities. (Note: If you have a PC and don't have the Norton Utilities, run, do not walk, to your nearest dealer and get them. Nearly vital: They make DOS tolerable.) Anyway, the Norton Utilities found a hidden PROLOK.EXE file. That, when run, generates the copy-protection scheme. It's quite a small file, but running it generates about 10K bytes of code. I've been tempted to play around with a good debugger and see just what's going on in there, but I guess I'm not that interested.

## ELECTRONIC MAILBOXES

A couple of months ago someone signed me up for MCI Mail.

I put it that way because I don't recall doing it, and I was signed up under a form of my name that I never use. The address was right, though. It's possible someone asked if I wanted to be signed up, and I said something that sounded affirmative, and I've since forgotten.

It hardly matters, except that once you're signed up with MCI Mail, other subscribers can find your name and send you messages. By the time I realized that the big packet of stuff MCI sent me wasn't just information but actually contained a log-in name and password, a couple of months had gone by; so when I logged on to the system out of curiosity, I found about 30 messages. Of course I answered each one of them, generally with much the same apology. That, I found out later when I read the MCI explanation of charges, was fairly expensive (about 50 cents per reply).

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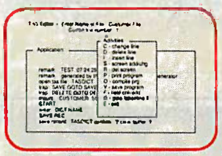

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MCI Mail is certainly easy enough to learn. There are menus, and while they're not as self-evident as they might be, they're good enough. I found I was able to use the system quite easily. There was one moment of panic: I'd begun replying to a letter. Once in the text-creation mode, you can't ask for help. When I finished the answer, I couldn't figure what told the program I was done editing and wanted to get back to command level.

BIX uses the UNIX convention of a line containing a dot and nothing else. MCI doesn't. I had to experiment; eventually, I found that a line containing nothing but typing "/" and hitting Return sends you to command level.

But, while MCI Mail is easy to learn, using it's a bit different. After 10 minutes I was familiar enough with the MCI menus that I could dispense with them—only you *can't* dispense with them. You have to grind through menu after menu.

I'd have known all this and a lot more if I'd looked at my incoming books shelf before I logged on to MCI Mail. *The Electronic Mailbox* by Ira Mayer (Hayden Books, 1985) does a good job of summarizing not just MCI Mail, but Delphi, The Source, CompuServe, and a bunch of others. It's really quite a good book, and if you're contemplating signing up for electronic mail, it would be worth reading this first. I hadn't read it because in the first chapter there's a "case history" that contains the flat statement that in 1980 no small computer measured up to dedicated word processors as a tool for writers. That's so patently false it made me put the book down in anger. Fortunately, Mayer has done more research on electronic mail systems than he did on small computers.

Mayer's book does not mention BIX because it was published in early 1985. I find the BIX system preferable: while MCI has no connect-time charges, it does charge a flat minimum for each "letter" you send. I find I can answer 15 BIX mail communications in 10 minutes. I don't pay for either BIX or MCI, but if I did, BIX would be cheaper. Of course, nothing says you *have* to answer all your mail, although I try to.

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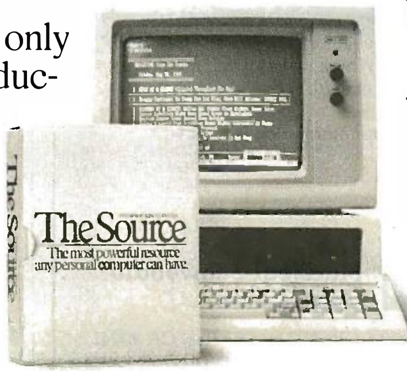




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MCI has one other problem: some of the "mail" I received was self-promotion stuff from MCI. In one case, I had to wait almost a full minute from asking for my "next letter" to receiving a message telling me about additional services MCI could provide. As a test, I asked for it again. Same result. A long wait. Maybe there's only the one copy, so if a bunch of people ask for it at once you have to wait your turn?

Problems and all, MCI is a pretty useful service, and a number of people I respect swear by it. I still think BIX is better, but you can certainly reach more people through MCI. Not only are more people signed up (as of now, anyway), but MCI has a "paper mail" option: they'll send your letter electronically to a place near the final destination, print it, and send it on first class by the U.S. Snail.

I expect I'll hang on to my MCI account; but I will have to get out of the habit of routinely replying to all messages. I even replied to MCI's house ad . . .

### SHAREWARE

I recently saw Bob Wallace, president of Quicksoft, and he tells me that PC-Write, the original "shareware," continues to sell. He also continues to improve the program. An awful lot of people swear by PC-Write as not only the most bang for the buck in a PClone text editor but about as good as an editor gets.

Then there's Proindex, also shareware. This isn't an automatic indexing program. Automatic indexing programs aren't much use; indexing is a black art requiring human judgment. Proindex searches out words from your file of keywords, shows you the word in context, and asks if you want to reference this instance in the index. The instruction book that comes with Proindex is complete enough and has some useful hints on constructing indexes.

PC-Write and Proindex make a good pair of programs for a writer who uses PClones.

### DOCUMENTERS

I don't normally review capabilities, but I recently got something worth mentioning. Computer Possibilities (320 South Pacific Ave., Pittsburgh, PA 15224, (412) 441-8949) is a start-up company that prepares documentation. One of the partners, Jeffrey Bonar, recently sent me a letter expressing their "philosophy," which I agree with. Sample: "Bringing a 'beginner's mind' to the primer. The designers of a sophisticated system are often the least appropriate people to be designing the documentation. They have no idea what makes their system hard to use."

They also enclosed a sample of their work, a primer for the Xerox Lisp Machine.

Clearly, any company in need of documentary services ought to look at a range of possibilities, from hiring an established firm like Stephanie Rosenbaum's Tec-Ed to doing it in house; and clearly which is best depends on a lot of factors. I can only say I was impressed with the sample Computer Possibilities sent.

## Items Discussed

Fastback .................. $179
Fifth Generation Systems
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Los Angeles on a Disk .... $39.95
Klynas Engineering
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MCI Mail ....... Contact company
MCI International
International Drive
Rye Brook, NY 10573
(800) 221-7902
(914) 937-3444

NEC PC-8201 ....... starts at $499
NEC Home Electronics (U.S.A.) Inc.
Personal Computer Division
1401 Estes Ave.
Elk Grove Village, IL 60007
(800) 323-1728
(312) 228-5900

Traveling SideKick
till 9/1/86 ............... $69.95
after 9/1/86 ............. $99.95
Borland International
4585 Scotts Valley Dr.
Scotts Valley, CA 95066
(408) 438-8400

TRS-80 Model 100 .. starts at $599
Tandy Corporation
1800 One Tandy Center
Fort Worth, TX 76102
(817) 390-3011

Ultimate ROM II ......... $229.85
TS-DOS .................. $69.95
with Ultimate ROM II ..... $49.95
LAPDOS ................. $89.95
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TTXpress Printer ........... $129
Brother FB-100 Disk Drive
with TS-DOS .......... $249.95
Traveling Software Inc.
11050 Fifth Ave. NE
Seattle, WA 98125
(800) 343-8080
(206) 367-8090

### Winding Down

We had another Great Software Purge at Chaos Manor; anything sent before January 1986 was tossed in the garbage with military honors. As usual I had mixed emotions: joy at seeing some free space on the shelves and considerable sadness that I couldn't get to everything. I know just how much work that stuff represents.

For those who sent stuff I didn't get to, I can only suggest that you try again. There's a considerable element of luck, not to say whim, involved in selecting what I review. Given the volume that comes in here, how could it be otherwise?

The game of the month is Core Wars. This insidious shareware game (I got mine from Terry Ward of Uni-Academic Computing in Cedar Falls, Iowa) simulates a battle between computer programs for domination of the MARS computer. The version I have runs on the Macintosh; I gather there may be versions for other machines, but I haven't seen any.

Tactics in Core Wars include worm programs that crawl into the other guy's code; imps and dwarves that do terrible things to the computer memory; and other stuff. You can have one player or two. Core Wars is fascinating to watch and will teach you more about assembly language programming of an imaginary computer than you ever wanted to know.

The book of the month is by Eliot A. Cohen, *Citizens and Soldiers: The Dilemmas of Military Service* (Cornell University Press, 1985). This is the best summary and discussion of military policy and conscription that I've ever seen. Cohen may not settle the questions he raises, but he has assembled all the facts and arguments.

The computer book of the month is by Edward Joyce, *Modula-2: A Seafarer's Guide and Shipyard Manual* (Addison-Wesley, 1986). Like most Addison-Wesley books, this one is extremely well done. It's easy to read, written in a lighthearted style that tells you what you need to know without being pedantic. It's well edited, and there are plenty of examples. The best introduction to Modula-2 that I know of.

In addition to everything else I'm doing, I've continued to run a BIX conference on space policy; about the time you read this, we'll fill Larry Niven's house with another big face-to-face meeting of experts, astronauts, science fiction writers, hackers, engineers, lawyers, and financial wizards; and with any luck we'll have some recommendations for the U.S. space program. BIX has been very helpful in doing the preliminary spadework for the conference. As one participant observed, an electronic conference's strengths are mirror images of its weaknesses, and we've yet to develop optimum ways to use it; but we're sure glad we have it. ■

*Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o* BYTE, *One Phoenix Mill Lane, Peterborough,* NH 03458. *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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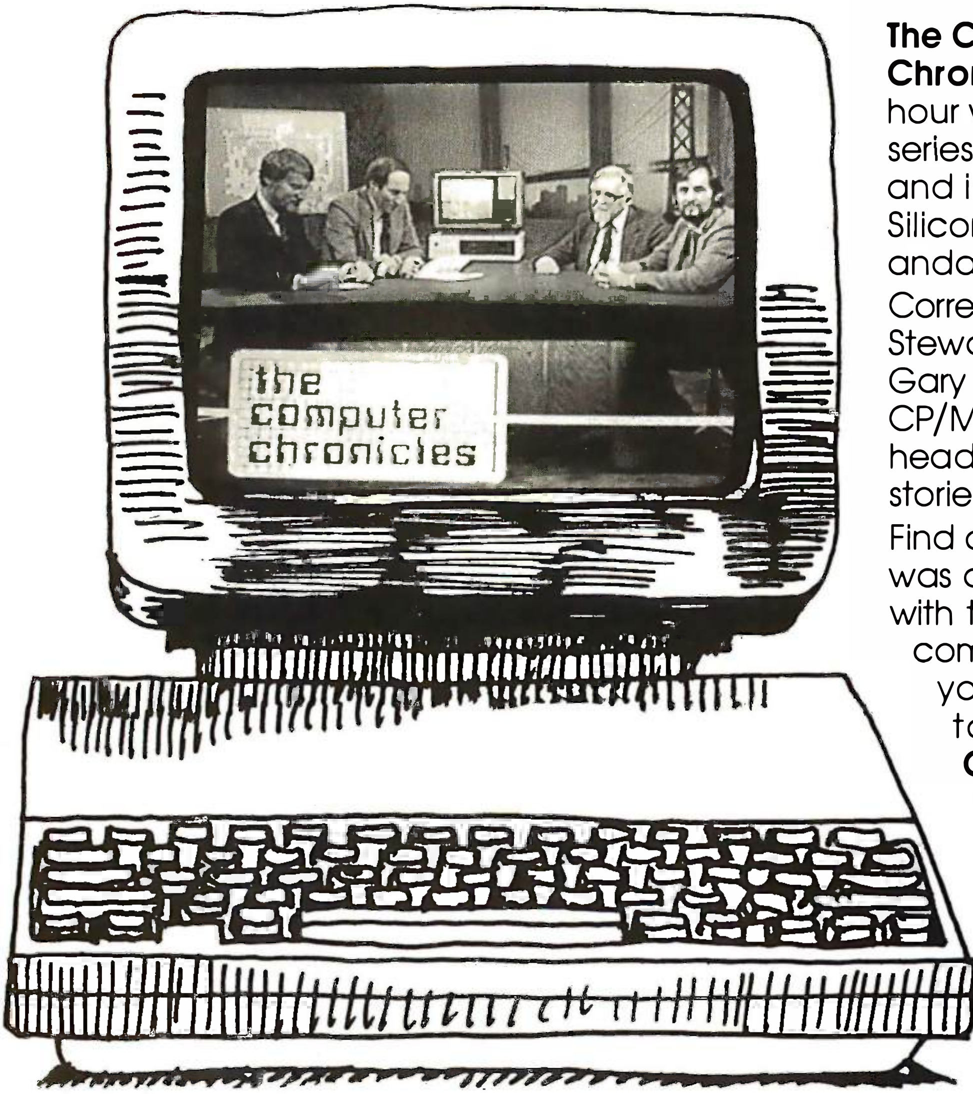


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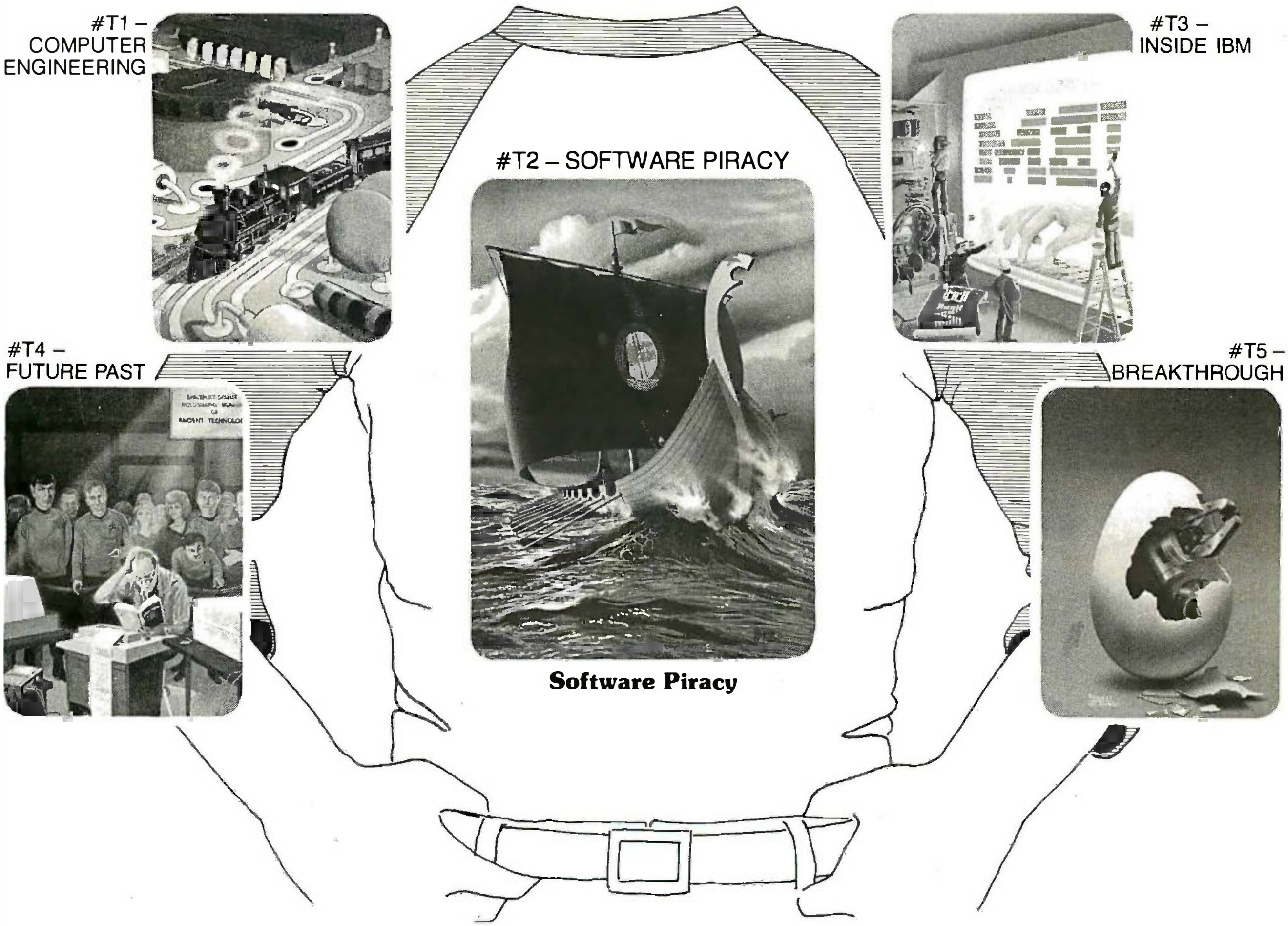


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# PROGRAMMING TOOLS

BY BRUCE WEBSTER

> *Products with a high degree of quality are being released*

It's now late March as I write this, and there isn't a whole lot new and exciting going on in the industry. Atari has finally started shipping the 1040ST, much to the relief of Atari dealers, who spent a long, dry month with nothing to sell. Prices on the Macintosh Plus have plummeted from an official list price of $2600 to a street price of $1900. Commodore is reputedly about to cut the list price of the Amiga to $995 (from $1295) and to offer another $200 off if you buy the 512K-byte upgrade and the monitor at the same time. Summer is typically a slow time for computer sales, so by the time you read this, additional price cuts may be in effect.

Around here, things have been anything but slow. A rising tide of software—mostly unsolicited—has been flooding the door. Much of it appears to be worthwhile and well done, and it's a bit frustrating to have to pick and choose which ones to look at and which ones to set aside for now. This month, I'm going to look at some programming tools, products to help you develop programs.

A few comments before I get started. I'm impressed with the quality of the programming tools—compilers, editors, utilities, libraries, and so on—that have been released in the last year or so. The common wisdom a few years ago was that the majority of computer owners were not—and never would be—interested in programming, that just a few hackers and computer nerds actually wanted to write their own code. The phenomenal success of Borland's Turbo Pascal—selling half a million copies in a market previously estimated at 30,000 units—has spurred a renaissance of sorts, turning a small, sluggish, uncompetitive segment of the software industry into a significant market, with prices going down and quality going up. Most welcome has been the disappearance of licensing fees, so that you no longer have to pay companies an annual or per-copy amount for programs developed using their products. The winners have been both the consumers as well as the companies willing to adjust to the new market conditions. The losers, of course, are those firms unwilling or unable to change their approach or to deliver a useful product at an acceptable price.

### PRODUCT OF THE MONTH: PERSONAL PASCAL

I have groused much—probably too much—about how long it took for a native code Pascal compiler to appear for the Macintosh. Imagine, then, my pleasant surprise when Optimized Systems Software released Personal Pascal for the Atari ST machines early this year, only about six months after the ST hit dealers' shelves. Even more pleasant is that it looks to be a well-done, complete, and reasonably priced package. Personal Pascal costs $69.95 and comes with a 200-page manual and a single 3½-inch disk (not copy-protected).

Personal Pascal meets the ISO standard and—like all good Pascals—significantly extends it. Strings are implemented as in UCSD Pascal and Turbo Pascal, with most of the "standard" procedures and functions (except for Str and Val). Many other common procedures and functions are also present, like SizeOf, IO_Result, Seek, and MemAvail. Language extensions include long (4-byte) integers, hexadecimal constants, an OTHERWISE clause in CASE statements, and a LOOP statement, with an EXIT IF clause allowed anywhere in the loop. The last two are particularly useful in keeping a program's flow of control straightforward.

The developer(s) of Personal Pascal (the manual just credits one "J. Lohse") obviously gave much thought to modular programming. The directive EXTERNAL lets you reference and call separately compiled Pascal and assembly language routines, while the directive C lets you call routines compiled using Digital Research's (Alcyon) C compiler. Systems procedures and functions can be referenced using the GEMDOS, BIOS, and XBIOS (extended BIOS) directives. The manual doesn't make it clear how to use those directives, but it's easy once you understand it. You declare the procedure or function with its parameter list, just as you would an EXTERNAL procedure. Instead of using the directive EXTERNAL, however, you would use GEMDOS(X), where X is the corresponding GEMDOS function number. For example, to be able to call the GEMDOS routine GetDate, you might declare the following:

```
function GetDate : Long_Integer;
GEMDOS($2A);
```

The BIOS and XBIOS directives work in an identical manner.

To use Personal Pascal, you run a program that provides a GEM user interface with three menus: desk accessories,

*(continued)*

*Bruce Webster, a consulting editor for* BYTE, *is reached c/o* BYTE, P.O. Box 1910, Orem, UT 84057, *or on* BIX *as bwebster.*

file (edit, compile, link, run program, quit), and options (for compiling and linking). The options items let you predefine libraries to be linked in and set certain compiler options (range checking, stack checking, etc.) without having to use compiler directives (like {$R−}) within your program.

The editor is a basic screen-oriented editor, using a WordStar-like command interface (as does Turbo Pascal) and ignoring the mouse and menus. The editor works well but has one major lack: no block marking for moving and copying text or writing text to a file. Instead, you must delete text to get it into a copy buffer, which you can then write to disk or write back into your text at some other point. The danger with this approach (as users of the old UCSD p-System editor can tell you) is that a wrong move—like a deletion when you get to where you want to insert the text—will clear your copy buffer, losing forever the text you were holding there. The block-marking approach of WordStar works a lot better; I hope OSS will consider improving the editor in future releases.

After editing your text, you can hit the F9 function key to save your file to disk and automatically start the compiler. The compiler itself is not blindingly fast, though that may be due more to the ST disk drives than the compiler itself. (A quick aside: The ST disk drives are depressingly slow. In just about every test I've run—format, file copy, disk copy, program load, and file reads and writes from within a program—the ST has been slower than the Mac or the Amiga. A good hard disk should improve things greatly.) If an error is encountered, you have the option to abort, to continue compilation, or to return to the editor. If you choose the last option, your file is loaded in, the cursor is placed where the error occurred, and an error message is printed at the top of the screen. If the compilation succeeds, the linker is run to build an executable program file. You can then run the program using the run program item in the file menu.

The biggest problem that ST programmers have had is the lack of adequate GEM documentation. About the only way to get it has been to pay $300 for the developer's package, which includes Digital Research's C and the GEM documents (written for the IBM PC). Having done that, the programmers then have to figure out how to use the GEM routines, something said documents don't always do a great job of explaining. To remove these problems for their customers, the folks at OSS have performed a wonderful service: They have written their own GEM/Pascal library to (in their words) "make working with GEM as painless as possible." Instead of just giving access to all the GEM routines (which you can have anyway, using the C directive), they have provided a selection of regular GEM routines along with "higher-level" routines that take some of the tedium and confusion out of using GEM. Then they do a good job of documenting every routine in the library, with examples and an explanation of how each is used. Frankly, I find their explanation of how the GEM routines are used easier to understand than the GEM manuals themselves.

*(continued)*

Technical support is provided in two ways. First, each copy of Personal Pascal has a unique ID number printed on both your registration card (which you should send in) and on a label that you can stick inside your manual. When you call with questions, you'll be asked for that number. It's an understandable approach to limiting technical support to legal owners of Personal Pascal. The second source of help is via OSS's bulletin board (available to registered users), which has sample programs, technical notes, and discussions about various problems and issues.

What complaints do I have about the product? Well, the manual is sparse in places, is not always well written, and needs an index. The editor could use some improvement, especially in cut-and-paste techniques. However, I prefer it over any language I've used on the ST to date, and I recommend it for anyone interested in programming on the ST, since it provides what is probably the most painless introduction to GEM I've run across.

### PASCAL EXTENDER

I praised Personal Pascal for its efforts to make GEM manageable. Pascal Extender, from Invention Software Corporation, makes writing applications for the Macintosh easier. The Macintosh Toolbox routines, though more complete and better implemented than GEM, can still be overwhelming for someone programming the Mac for the first time. Or the second. Or the third. Or... well, you get the idea. One version supports MacPascal; another is for use with TML Pascal. It costs $69.95 (seems to be a popular price) and comes with a 180-page manual and a single 3½-inch disk (not copy-protected). There are no licensing fees—though the agreement requires any software created using Pascal Extender for resale have a "Created Using Pascal Extender" statement in the manual.

The goal of Pascal Extender is to provide you with predeclared routines and data types that make the Toolbox routines easier to use. This is done with a unit (for MacPascal) or an include file (for TML Pascal). Pascal Extender helps you in seven areas: event handling, menus, windows, controls, scroll bars, text editing, and dialog and alert boxes. For each area, you have a set of routines to help you create, use, and dispose of the appropriate items. For example, the following two routines for handling menus are among those provided in both MacPascal and TML Pascal:

- BuildMenu(Num,Title,Items): This function lets you add a menu to the menu bar, specifying the menu number, the title (for the bar), and the items in the menu itself (separated by semicolons).
- StdMenus(aMenu,fMenu,eMenu): This procedure creates and adds to the menu bar three "standard" menus: the Apple menu, with desk accessories and an "About xxx" item; the file menu, with items like "New," "Open," "Save," "Save as," and "Quit"; and the edit menu, with "Undo," "Cut," "Copy," "Paste," and so on.

A number of other routines—SetMenuItem, GetMenuItem, MarkMenuItem, DisableItem, EnableItem, Hilite-

*(continued)*

Menu, GetMenu, GetMenuBar, and DisposeMenu—allow MacPascal to have direct access to these Toolbox routines (or equivalents); for TML Pascal, all are supported either by the Extender or by the TML libraries themselves.

Listing 1 shows a short demo program written using TML Pascal and Pascal Extender. This program brings up three "standard" menus—Apple, file, and edit—as well as a custom menu. It also brings up a window with scroll bars, a "go away" box, and a grow box. I've written a few dummy menu-handling procedures as well to show you how you might expand the program to actually do something. Figure 1 shows this program in action, with a few desk accessories up and running and one of the menus pulled down.

Pascal Extender is most useful for MacPascal, since it provides many standard Toolbox calls that aren't available in MacPascal (but are in TML Pascal). If you're already comfortable programming in TML Pascal, you might not want or need Pascal Extender—but I still find it useful. You will have to decide whether it's worth $70 or not. And if you're using both MacPascal (for writing and debugging small routines) and TML Pascal (for producing final code), it's worth having for both compilers to help make your code as identical as possible. And for those of you who prefer C, Invention Software advertises two "C Extender" packages, one for Megamax C and one for Aztec C.

### LATTICE SCREEN EDITOR

The Lattice Screen Editor for the Amiga has made my work on that machine easier. LSE, while not the best program editor I've used, beats the ED and EDIT programs that come with the Amiga. LSE is a straightforward, relatively complete, screen-oriented editor. It does not use menus or the mouse but is strictly keyboard-driven. It sets aside a few lines at the bottom for command options and menus. There are two layers of commands: those that execute directly, like Control-Q to abandon the file, and those that bring up a second, single-letter, menu, like Control-C for the Close File menu. This interface is easy to use and easy to learn.

LSE also has two types of help. First, a number of the function keys bring up quick summaries of your basic commands. These do help but are sometimes hard to decipher due to their terse nature. The Help key on the Amiga will summon a text file with more detailed instructions on how to use LSE. Unfortunately, the Help key is right below the Backspace key and next to the Return key, so I usually hit it accidentally a few times per editing session, causing a delay while LSE brings up the help window and another delay while I close it to go back to editing. Poor keyboard layout on Commodore's part.

One nice feature is the ability to have two files open and being edited at the same time. When you do this, LSE sets up two windows, one above the other, each taking up about half the screen. You can switch back and forth between the two with a single command (Control-X) and make either one take up the full screen (Control-D). This feature is great for referencing a definition file while editing

*(continued)*

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**C Self-Study Guide**
(Purdum, Que Corp.) Designed for those learning C on their own. The book is filled with questions-answers designed to illustrate many of the tips, traps, and techniques of the C language. Although written to complement the Guide, it may be used with any introductory text on C.
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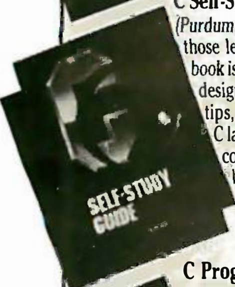


**C Programmer's Library**
(Purdum, Leslie, Stegemoller, Que Corp.) This best seller is an intermediate text designed to teach you how to write library functions in a generalized fashion. The book covers many advanced C topics and contains many useful additions to your library including a complete ISAM file handler.
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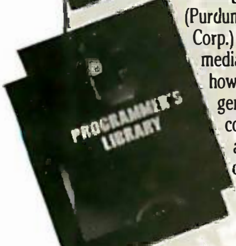


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**PC Tech Journal,**
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from:
Dr. David Clark
**Byte**, Jan., 1986

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4. PC or MSDOS 2.1 or later to include the MSDOS linker.

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| | Eco-C88 | Lattice | Computer Inn. C86 | Microsoft | Mark Williams |
|---|---|---|---|---|---|
| sieve | 12 | 11 | 13 | 11 | 12 |
| fib | 43 | 58 | 46 | 109 | – |
| deref | 14 | 13 | – | 10 | 11 |
| matrix | 22 | 29 | 27 | 28 | 29 |

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**ECOSOFT**

Listing 1: *A short demo program written using* TML *Pascal and Pascal Extender.*

```
program ExtTest;

{$I MemTypes.ipas    }
{$I QuickDraw.ipas   }
{$I OSIntf.ipas      }
{$I ToolIntf.ipas    }
{$I MacPrint.ipas    }
{$I PackIntf.ipas    }
{$I Extender.ipas    }

const
  AM              =  1;
  FM              =  2;
  EM              =  3;
  NM              =  4;
  T               =  True;
  F               =  False;

  AppleMenu       = 11;
  FileMenu        = 12;
  EditMenu        = 13;
  MyMenu          = 14;

var
  Done            : Boolean;
  theEvent        : EventRecord;
  WH              : EventStuff;
  iBeam,Cross,
   Plus,Watch     : Cursor;
  MenuList        : array[AM..NM] of MenuHandle;
  MainRec         : WindowRecord;
  MainPtr         : WindowPtr;

procedure Initialize;
{ purpose: set program up }
var
  theRect         : Rect;
begin
  XTendInit;
  Done := False;
  FetchCursors(iBeam,Cross,Plus,Watch);
  StdMenus(MenuList[AM],MenuList[FM],MenuList[EM]);
  MenuList[NM] :=
  BuildMenu(MyMenu,'Options','Do This;Do That;Do Nothing');
  SetMenuItem(MenuList[AM],1,'About This Program');
  SetRect(theRect,5,40,508,330);
  MainPtr :=
  CreateWindow(MainRec,theRect,'This Program',0,T,T,T,T,T);
end; { of proc Initialize }

procedure CleanUp;
{ purpose: clean program up }
begin
  KillWindow(MainPtr)
end; { of proc CleanUp }

procedure ShowInfo;
begin
{  here's where you'd put a box with
   info about your program          }
end; { of proc ShowInfo }

procedure DoFileMenu(Item : Integer);
begin
{  here's where you'd handle all the file options }
  if Item = 12
    then Done := True
end; { of proc DoFileMenu }

procedure DoEditMenu(Item : Integer);
begin
{ here's where you'd handle the edit options }
end; { of proc DoEditMenu }

procedure DoMyMenu(Item : Integer);
begin
  case Item of
    1 : { do this } ;
    2 : { do that } ;
    3 : { do nothing }
  end
end; { of proc HandleMyMenu }

procedure HandleMenu(WH : EventStuff);
var
  MVal,Indx,Item      : Integer;
begin
  MVal := -1; Indx := AM;
  Item := WH.ItemNum;
  while (Indx <= NM) and (MVal = -1) do
    if WH.MenuH = MenuList[Indx]
```

(continued)

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```
      then MVal  := Indx
      else Indx  := Indx + 1;
  case MVal of
    AM          :  if Item = 1
            then ShowInfo;
    FM          :  DoFileMenu(Item);
    EM          :  DoEditMenu(Item);
    NM          :  DoMyMenu(Item)
  end
end; { of proc HandleMenu }

begin { main body of program ExtTest }
  Initialize;
  repeat
    repeat
      SystemTask;
      MaintainCursor(Arrow,iBeam,Cross)
    until GetNextEvent(EveryEvent,theEvent);
    HandleEvent(theEvent,WH);
    HandleMenu(WH)
  until Done;
  CleanUp
end. { of program ExtTest }
```

the source file or copying text from one file to another.

If you're using the Lattice C compiler on the Amiga, and you save the error messages out to a file (using the -e option), you can then invoke a special error mode with LSE. In that case, it goes to the line where each error occurred, shows you the corresponding error message, and gives you a chance to correct it. It works nicely, if not always perfectly, and it does make program correction a lot easier.

LSE also has a macro facility, allowing you to load in up to 10 keyboard macros, which can then be summoned by typing the function key F10. It works by saving your keystrokes into a file, then playing them back upon request.

I do have some complaints with LSE, though they tend to be minor. The manual is a bit sparse in some places, and it's not always easy to find what you want. As for the editor itself, an auto-indent mode would be nice for writing in Pascal or C. You can go to the Set Mode command (Control-M) and adjust the tabs, but having to hit multiple tabs for each new line can get tedious (though not as tedious as having to move over space by space). Also, I disagree with their implementation of the Quit (abandon changes) command. If you have two files open and hit the direct Quit command (Control-Q), LSE will close and abandon both files, not just the one you're working in at the moment. True, it does ask "ABANDON ALL CHANGES?" but it asks only once and then abandons both. Given the potentially catastrophic effects of abandoning all your changes to a file, it should either abandon just the active window or should ask for verification twice, once for each window.

LSE is a good, if not outstanding, program editor. You might want to test it out to see if you consider it enough

*(continued)*

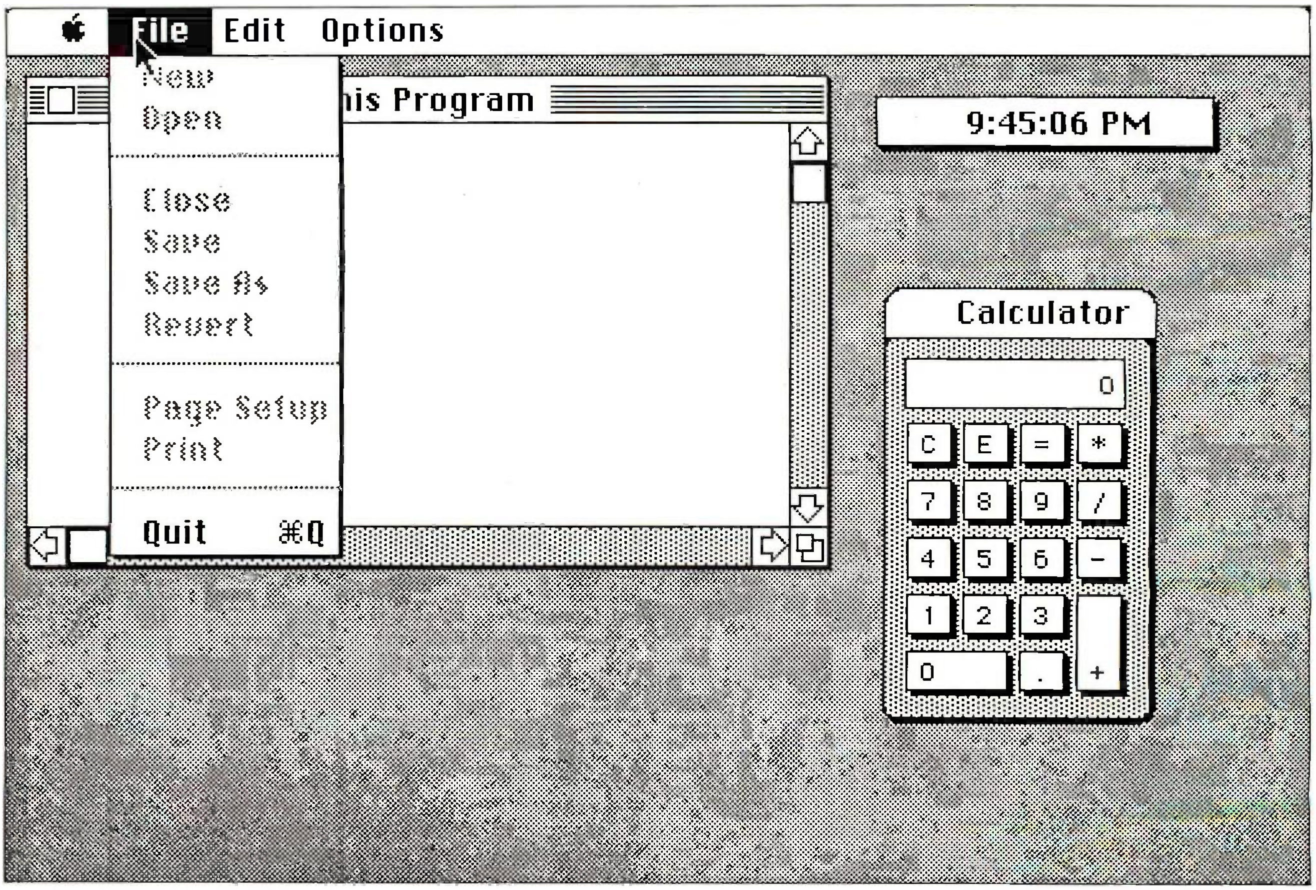


Figure 1: *The program in listing 1 up and running, with a few desk accessories running and one of the menus pulled down.*

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Pascal Extender ........................ $69.95
Invention Software Corporation
P.O. Box 3168
Ann Arbor, MI 48106
(313) 996-8108

Personal Pascal ........................ $69.95
Optimized Systems Software Inc.
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San Jose, CA 95129
(408) 446-3099

of an improvement over ED and EDIT to plunk down $100 for it.

### Books as Tools

My favorite programming text is *Algorithms* by Robert Sedgewick (Addison-Wesley, 1983). I fell in love with the book the first time I saw it, and I strongly recommend it to anyone who wants to program. *Algorithms* has 40 chapters of, well, algorithms, that is, solved problems. The actual routines, written in Pascal, are short, easy to read, and readily translated into other languages. The book itself is divided into seven major sections: mathematical algorithms, sorting, searching, string processing, geometric algorithms, graph algorithms, and advanced topics. The book is easier to use, more relevant, and less intimidating than Donald Knuth's *The Art of Computer Programming* series . . . and costs a lot less, as well. Not that it's cheap—I believe the current list price is around $35—but it's worth it.

In my efforts to come up to speed in C, I have turned into a collector of C books. I have been somewhat frustrated, as each book seems to have glaring omissions, and I end up keeping a stack of three or four books handy for each time I need to research a particular topic (like string handling). I have, though, found three books from Que that form an ideal set for someone wanting to learn C: *C Programming Guide* (2nd ed., 1985), *C Self-Study Guide* (1985), and *C Programmer's Library* (1984). Jack Purdum wrote the first two by himself, and they're great for sitting down, learning the language by keying in programs, then testing your understanding by trying to answer questions given in the *C Self-Study Guide*. The third book, which Purdum coauthored with Timothy Leslie and Alan Stegmoller,

*(continued)*

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| ZBasic™ | 13.7 sec. | ZBasic™ | 30 sec. |
| BASICA™ | 2,190 sec. | Mbasic™ | 2,520 sec. |

10 iterations of the Sieve from Byte, January, 1983

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serves much the same purpose as *Algorithms*: to give working solutions to problems like sorting, searching, and linked lists. It is nowhere as complete as *Algorithms*, but it is in C, and the code does work. All three books cost less than $20 each; the first two are especially valuable for a C neophyte, while the third is not quite as crucial.

As far as a C reference text goes, the one I like the most is a thin tome jointly published by AT&T/Bell Labs and Prentice-Hall, entitled *The C Programmer's Handbook*. Written by M. I. Bolsky, it's a small spiral-bound book, about 90 pages long, that reads like an extended reference card. I keep it handy while programming in C.

I also have been collecting books on the 68000, for similar reasons. Again, each has its strengths and weaknesses, but the best overall introduction I've found so far is the *68000/68010/68020 Primer*. It's written by Stan Kelly-Bootle and Bob Fowler and published by Howard W. Sams as one of the Waite Group books. Note that this is a primer on the chip itself, not a guide to 68000 programming. It covers some of the design philosophy behind the 68000 family, the instruction set, and the differences between the different chips. I have yet to find a good general text on 68000 programming—I have two and am not fond of either one—but there are a couple of books dealing with 68000 programming on the Mac that look pretty good. I may talk more about them next month.

### A WISH LIST

While we're on the subject of programming tools, I'd like to see a set of standard libraries (in C or Pascal) to aid parallel development on the Mac, the Amiga, and the ST. I've been tempted to work up something like this myself, and the MacLibrary from Lattice (C library for the Amiga that gives you some equivalent Mac Toolbox calls) is a start, but there's still a lot that could be done. The best solution might be to take a product like Pascal Extender or Simple Tools, both of which attempt to make use of the Mac routines easier, and redesign it to a more generic version that can then be used on all three systems.

Incidentally, I understand that Creative Solutions—the folks who developed MacFORTH—are coming out with a new FORTH that will run on the Amiga, the ST, and the Macintosh. Apparently, they're attempting to make it "source-compatible" across all three machines, so that you could write an application on one and port it, unmodified, to the other two. Don Colburn, chief wizard at Creative Solutions, said that this effort forced them toward a "lowest common denominator" approach on menus, windows, and so on, but they do have extension files for each version to take advantage of each machine's specific features. I should have the Amiga version in a week or so; look for a report on it (at least a preliminary one) next month.

I would also like to see a Pascal-to-C translation program. I had someone call me looking for one of these; the only one he could find cost $2500 (yes, that's "two thousand five hundred dollars"). He and I both ran across a small ad for another one, but the company no longer appears to exist. Because of Pascal's strict type checking and simple syntax, such a translator shouldn't be too hard to write, especially with user interaction to help resolve problems.

Finally, I'd like to see some good single-sheet reference cards on C and the 68000. When I was developing programs for the Apple II, I had a nifty 8½- by 11-inch plastic-coated, three-hole-punched reference card that told me all I wanted to know about the 6502: instruction set, op codes, register usage, condition flags, how to do unsigned tests, and so on. I don't know who made it—I don't have mine anymore—but I think one on the 68000 (and, for that matter, the 8086) would be very popular. A single-sheet card on C would also probably do well, though it might be harder to organize the information into a usable form.

### IN THE QUEUE

It's always dangerous for me to predict what I'll cover next month, because I'm never sure what might show up between now and then. I hope to take a look at MultiFORTH for the Amiga. The SupraDrive 20-megabyte hard disk for the Atari ST has shown up and deserves some careful inspection. In addition, I've been making a collection of software packages for the Mac—MacSpin, StatView, PowerMath, PSI—that turn it into a kind of specialized supercalculator or data processor. Until then, see you on the bit stream. ■

# QNX vs UNIX

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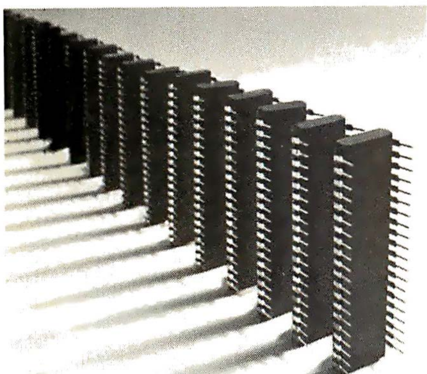

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# PERSONAL SUPERCOMPUTERS

BY DICK POUNTAIN

**Dick looks at Inmos's Transputer and Meiko's Transputer-based Computing Surface**

Two years ago I wrote my first BYTE U.K. column, introducing the Inmos Transputer (August 1984, page 361). Since then I've received a lot of mail asking for more information on this chip, and so I decided to revisit the subject in this month's column.

The Transputer is now on sale, although it differs slightly from the design I described in 1984. A variety of evaluation boards, including one that plugs into the IBM PC, are also available from Inmos. But before I get down to details, some history first.

Samples of the Transputer were delayed well beyond the late-1984 date that the company was aiming for originally. The delay was not due to technical problems, as some reports suggested, but was a consequence of the 1984–1985 semiconductor industry slump. Inmos got hit where it hurt, in its valuable RAM business, and some company retrenchment and reorganization ensued. To cut the story very short, Inmos transferred fabrication of the Transputer from the U.S. to its U.K. plant in Newport, Wales, and modified the design so the chip could be made in Newport's existing process technology. With this change, Inmos gained more time to bring up the new and untried tungsten-silicide process it had planned originally. In the meantime, the firm settled for a chip design with a larger RAM cell and hence a lower density.

The resulting chip, called the IMS T414 Transputer, was formally launched on October 1, 1985. It combines a 32-bit RISC (reduced instruction set computer) processor, four 10-megabit-per-second full-duplex serial channels (called "links"), and 2K bytes of 50-nanosecond static RAM on a single chip. The links can all run concurrently with the processor, giving the chip a potential I/O bandwidth of 80 megabits per second. The amount of RAM is only half the 4K bytes orginally planned, due to the simpler process technology used. The other major change from the original design is that the links are capable of concurrent block transfers as well as word-wide communication. This enhancement is supported by Occam, the language in which the Transputer is programmed.

The T414s being shipped as I write this column (March) run at 75 percent of their design speed of 10 MIPS (million instructions per second), and that figure should be up to 100 percent (50-nanosecond cycle time) by the time this article is published. A 16-bit version of the Transputer called the T212 is already running at 50 nanoseconds, with 45-nanosecond parts being sampled.

The most exciting news, however, is that the full 4K-byte Transputer, using the now-perfected tungsten process, will have an on-chip hardware floating-point processor. When the decision to go for the 2K-byte T414 was made, the chip layout had to be extensively redesigned (achieved in an heroic three months, thanks to Inmos's sophisticated CAD system). As a result, several improvements to an already remarkably clean layout were made, reducing the die size and making room for the floating-point circuitry. The resulting 32-bit chip, dubbed the IMS F424, should be without rival as the world's fastest microprocessor, capable of around 1 megaflop (million floating-point operations per second). It's fully pin-compatible with the T414, and samples are due late this year.

Inmos has also announced that by late 1987 the large-volume price for Transputers will be reduced to $50 apiece, which will make using them by the thousand a practical proposition for fifth-generation applications. (Currently, single-piece prices are $500 for the T414 and $350 for the T212.)

A lot of work is going on in the U.K. and elsewhere to gain experience in Transputer-based architectures, and it is becoming clear that the chip delivers everything that it promised—supercomputer performance from a desktop-size box of parallel-computing Transputers. Much of the research is in signal processing, some of it in areas from which the Official Secrets Act excludes this columnist. The British Home Office has commissioned a pilot study of a fingerprint identification system that uses arrays of Transputers to perform hugely computation-intensive pattern-recognition tasks and I/O-intensive database searches. Results from the prototype system suggest it will work ten times faster than, and for a tenth of the cost of, present systems built around superminicomputers with dedicated array processors. Another hot area of interest is graphics, and the film industry is beginning to appreciate the possibilities that a box of Transputers can offer for real-time, broadcast-quality animation.

The Occam language that I described briefly two years ago has

(continued)

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*The Computing Surface is a modular machine, built from combinations of four different kinds of boards.*

mutated into Occam 2, with some significant changes. (At this point I ought to mention that I wrote the tutorial manual for Occam 2, acting as a freelance author.) Occam is the first programming language to fully incorporate I/O, concurrency, and interrupts into the structure of the language itself, rather than as afterthoughts. The language is based on a model of independent processes that communicate over self-synchronizing channels and can run sequentially, concurrently, or alternatively (i.e., by interrupting each other). Occam programs can be developed on a single processor and then distributed over an arbitrary number of Transputers to achieve the desired performance level.

Occam 2 has become a typed language, supporting INT, BOOL, and a variety of lengths of REAL types. Since the hardware now supports block transfers, channels in Occam 2 have protocols describing the structure of the objects that can be communicated (Occam 1 channels are untyped and communicate only single words). Whole arrays can now be input and output in a single process, rather than element by element. Protocols allow message passing within programs to be type-checked at compile time and improve both security and readability. Occam 2 retains its interactive folding editor (developed several years before ThinkTank) but now supports separate compilation, using the fold as the unit of compilation.

The Occam 2 compiler will be ready for full release in the summer of this year, with its alternative C, Pascal, and FORTRAN front ends following in the last quarter. Transputer systems at the moment are supplied with a Development System based on Occam 1.

## MEIKO'S COMPUTING SURFACE

The U.K. launch of the Transputer took place in London's hypertrendy Institute of Contemporary Arts last fall. Inmos showed some classy graphics demonstrations, including multicolored ray-tracing programs that speeded up as more Transputers got switched in and a neat animated butterfly that flies off one monitor screen onto another. The finale was a demonstration that was breathtaking for those in the know, but whose significance may have escaped the less technically knowledgeable people in the audience. In the demo, four layers of the actual CAD database files containing the layouts for the T414 were animated in three dimensions and real time so that we "flew" through the chip layout itself, like a flight simulator or one of those sci-fi landscapes so popular in TV advertisements. The significance of the demo is that it takes Inmos's VAX-11/780 eight hours to convert four layers of this database.

The box of tricks that performed this feat was the first prototype of the Meiko Computing Surface, a Transputer-based "personal supercomputer," and it contained 128 early 16-bit Transputers of a now-discarded design.

Meiko is an 18-month-old start-up company formed by several former employees of Inmos, all of whom were intimately involved in the development of the Transputer. The Computing Surface is, without exaggeration, a personal supercomputer—not a supermini, but a supercomputer. In its largest current configuration, with 150 32-bit Transputers in the box, it provides 1 GIP (1000 million instructions per second) of computing power for a single user. Meiko designed the computer for that group of people who so far have been left out of the personal computer revolution—the scientists, engineers, animators, and others whose computational needs are so large that they must still wait to share time on a Cray.

Choosing a parallel processor architecture to satisfy the needs of these different classes of user is not easy, and so Meiko decided to give the machine a highly flexible and variable topology; hence the name Computing Surface, which suggests cubes, spheres, donuts, and other exotic possibilities. The user can configure the processors in a vast number of different ways. Someone who's accustomed to using an array processor, for example, could just string all the Transputers together into a pipeline, or perhaps a simple two-dimensional array. Others may want to partition the Transputers into several different functional groupings; in graphics one might devote a processor to each object on the screen, or to each bit plane, or whatever.

The Computing Surface is a modular machine, built from combinations of four different kinds of boards. Two models are being offered, with 10 or 40 slots. The 40-slot model is the size of a water cooler, while the 10-slot box can fit on a desktop or into a 19-inch rack mount. Both models are air-cooled by a fan. The backplane is Meiko's own design, since none of the standard buses can handle the communications requirements of such a system. Because of the "constructor set" design, users can specify special backplanes for special I/O demands.

Configuring the topology of the processors is currently performed manually using jumper leads on the reverse side of the backplane board, like a telephone switchboard. However, Meiko has designed a custom VLSI switching chip, due for delivery later this year, that will allow the topology to be set up electronically; sockets for this chip are included on the processor boards.

The four kinds of processor board are the Local Host, Compute Element, Display Element, and Storage Element. Of these, only the Local Host is compulsory; every system must have at least one.

The Local Host board is a powerful computer in its own right. It contains one 32-bit T414 Transputer, 3 megabytes of dynamic RAM, 128K bytes of EPROM, two RS-232C interfaces, and an IEEE-488 parallel interface that can be used to attach hard disks to the

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system. Meiko can also provide a SASI interface or an attachment for using a MicroVAX II as a front-end processor.

The Local Host is responsible for booting the system and performing all housekeeping operations, including running the Occam Development System, source-level software debugging, and hardware monitoring (all the memory is parity-checked). In the event of hardware failures, the Local Host can pinpoint and report the site of the error, since all the other boards contain a channel leading straight back to the host that relays their "dying words." When the switching chip is ready, the Local Host will also control configuration of the network.

The workhorse component of the Computing Surface is the Compute Element, a board containing four 32-bit T414s, each with its own 256K bytes of dynamic RAM. The off-chip RAM on these boards is faster, at 16 megabytes per second, than the 12.5-megabyte-per-second RAM used on the Local Host.

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The processes of a typical number-crunching Occam progam get distributed and executed on one or more Compute Elements. Meiko's FORTRAN compiler allows existing FORTRAN programs to be distributed over these processors, using Occam as the "glue" to keep the individual processes communicating and cooperating.

The Storage Element board contains one T414 processor and 8 megabytes of dynamic RAM. These boards are used for applications that need to keep large data structures in memory for maximum speed. An example is graphics applications, in which complex pictures might be constructed in memory and then scrolled and panned through by a display processor (see figure 1).

The Display Element board contains one T414 processor, 1.5 megabytes of dual-ported video RAM, and three of Inmos's G170 8-bit Color Lookup Table chips. These chips contain a writable 256-entry color palette that governs the translation of colors on a graphics monitor. Each chip also has a D/A converter on board so that it can directly drive the gun of an RGB monitor.

As with the rest of the machine, Meiko has kept the options wide open with the Display Element board. One board could be used as a single 1.5-megabyte video buffer, with 8 bits per pixel (for 256 colors). It could also be used as a 0.5-megabyte buffer with 24 bits per pixel or as two 0.75-megabyte buffers for double-buffered animated graphics in 256 colors. Of course, it is possible to add as many Display Element boards as you need, to give more pixels per screen, or more bits per pixel, or more drawing speed. You could, for example, gang up these boards as separate bit planes for complex animation effects. For ultimate drawing power, the solution is to divide the screen into tiles or strips and devote one Transputer to updating each area.

Meiko's customers can mix and match a system by buying these boards in any numbers and combinations. More power can be added so long as there are slots, and whole boxes can be ganged together if you need more slots.

F424 Transputers, when they are available, can be retrofitted to the Computing Surface to give capability of over 100 megaflops—number-

(continued)

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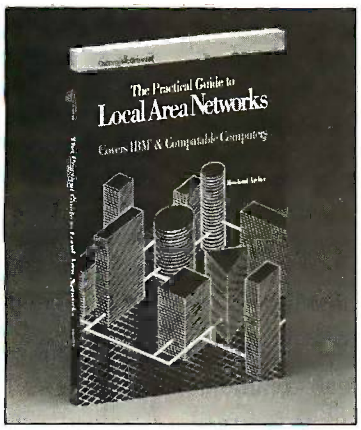


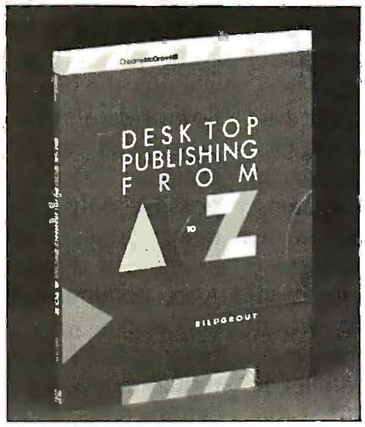


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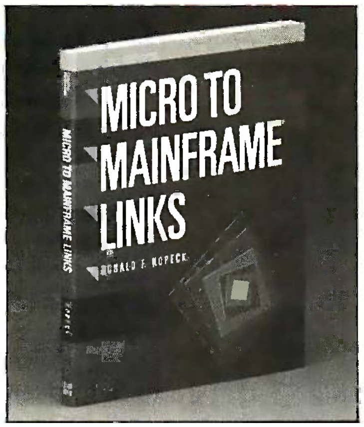


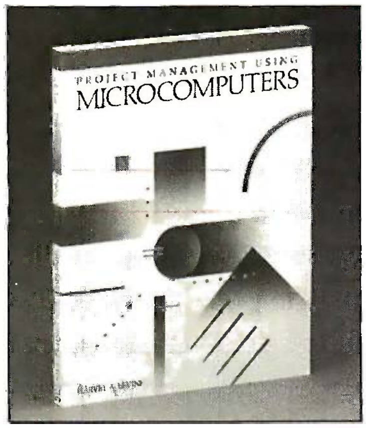


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crunching power that begins to enter Cray territory.

### USING THE COMPUTING SURFACE

Programmers who have not yet used Occam will have to take my word for it that the language makes writing massively concurrent programs a pleasure rather than an ordeal. Occam frees the programmer from concern with the details of synchronizing processes in a way that Ada and Modula-2 cannot begin to approach.

Nevertheless, when programmers deal with massively concurrent systems, issues arise that not even Occam can hide; they are only now being understood as such systems become more readily available. One such problem is achieving a correct balance between communication time and computation time. When you break down a problem into small pieces to be computed in parallel, it is possible to go too far, so that the time to communicate the partial results exceeds the computation time and the individual processors don't have enough work to keep them busy. The program then runs more slowly than a more sequential equivalent would. The ideal is to keep each processor working flat out all the time.

Programmers like Meiko's Eric Barton (who wrote the fly-through-the-chip demo) and Inmos's Phil Atkin are now tackling this tricky area, drawing on detailed analyses of the execution of concurrent test programs. They are exploring the technique of "dynamic load balancing" in Occam programs, whereby the program can redirect the flow of data at run time to keep the processors as busy as possible. Dynamic load balancing becomes possible only if there is spare communications bandwidth, permitting freedom of choice for routing results. Also, communication needs to be concurrent with processing. Transputer-based systems meet both these requirements; concurrent communication comes with the chip, and you can always get spare bandwidth by adding more processors.

The fly-through-the-chip demo provides a good example of the communication versus computation issue. This program involved taking the CAD database, which contains thousands of polygons that represent transistors and interconnections on various layers, transforming the polygons into three-dimensional perspective, and shading them in different colors. Barton and his colleagues first tried using a pipeline of Transputers for each layer, each chip performing only a part of the three-dimensional transformation, in textbook fashion.

The performance of this program was disappointing, and a close look showed that the Transputers were so fast that they were being underused. The final version of the pro ram makes each Transputer perform the whole transformation, then uses the spare communications capacity to through-route the results to the display Transputers. The hardware configuration for this demo is shown in figure 1.

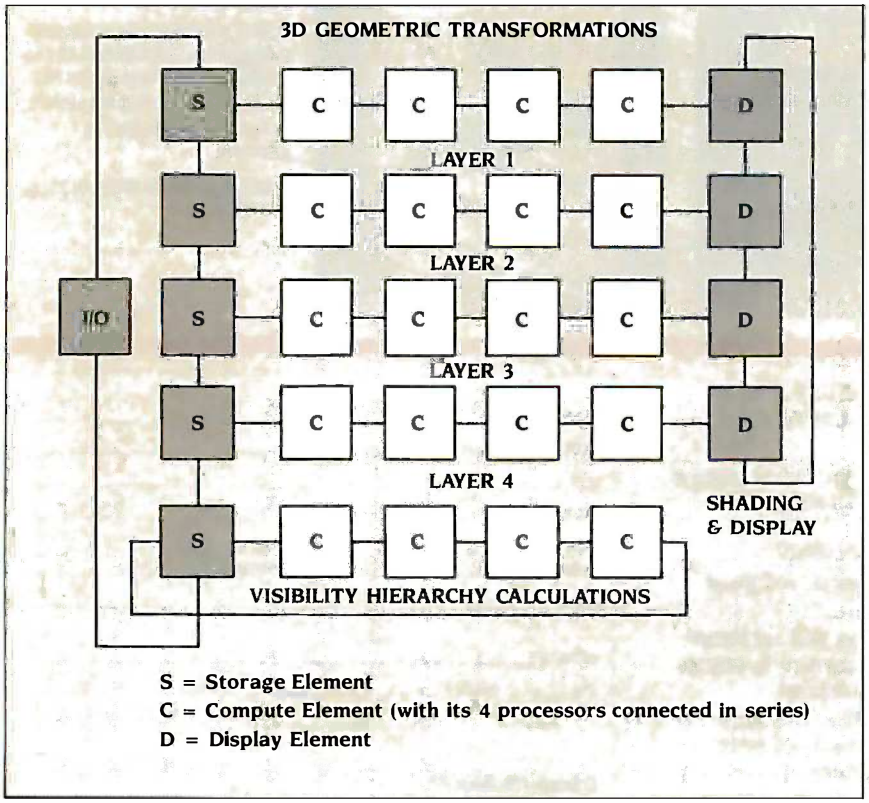


Figure 1: *Meiko's prototype Computing Surface used this configuration for processing the three-dimensional views of the T414 chip layout.*

### TWO YEARS LATER

At heart, I'm fond of fast motorbikes and fast computers. There is, however, a rational component to this addiction because in computers, at least, speed buys increased utility.

Meiko and other firms that will shortly be announcing Transputer-based products are pioneering a new generation of computing where seemingly impossible amounts of computing power can be made accessible to individuals. This power could be used to provide new programming tools and user interfaces that will make HAL seem old-fashioned. What is it that excites people about the Commodore Amiga, if not the fact that it's a little bit closer to the real world than its competitors? Transputer-based computers can be even closer. In time, Transputer-like processors will be integrated at wafer scale, and Alan Kay's Dynabook will cease to be a dream.

Two years later, I still find the Transputer the most exciting thing that's happening in silicon, and I make no apologies for preaching about it to U.S. readers who are understandably more aware of their own domestic chip manufacturers. Check it out. After all, you grew to like Porsches. ■

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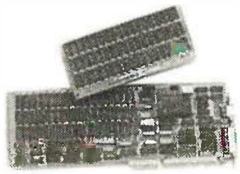

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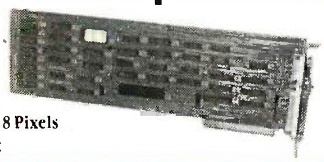

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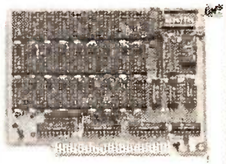

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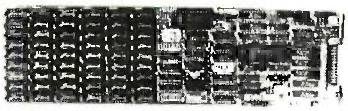

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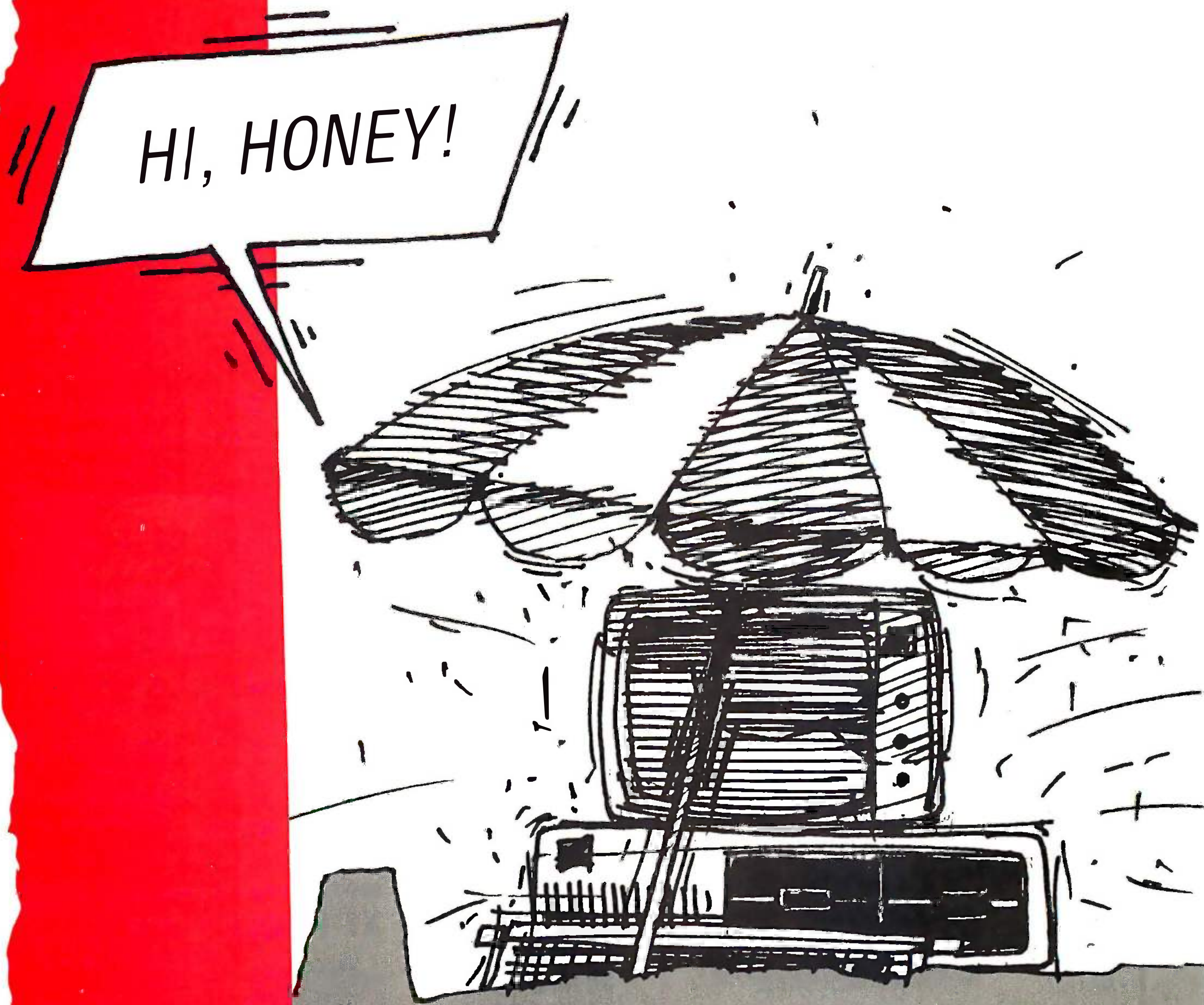


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# A JAPANESE COMDEX AND MORE

BY WILLIAM M. RAIKE

## *Bill attends COMDEX in Japan and looks at new NECs and Oki's laptop*

Not many dramatic developments, but some interesting possible future trends—that's my summary of the recent COMDEX show in Japan. Elsewhere, Oki Electric Company showed off its new MS-DOS laptop computer with an unexpected "feature." And NEC has introduced the latest model in its PC-9801 series of personal computers and new versions of its PC-8801 8-bit machines.

### COMDEX IN JAPAN

Yawn. The best thing that can be said about this year's COMDEX in Japan is that there were only about 20,000 attendees, or about half of last year's meager crowd. That meant that the noise stayed down to a dull roar. Few new products were introduced at the show; most manufacturers wait until the annual Microcomputer Show, held two months later, to introduce interesting new computer products.

TEC was showing its LB-1301 desktop laser printer—again. Each time I see this printer at a show, I want to buy one, and each time the date it's supposed to be available ends up being pushed back a few months. This time TEC promises that you'll be able to buy one by autumn of this year. The printer is compact, its print quality appears to be every bit as good as the Canon laser printer, and the price is estimated to be in the $2000 to $2500 range. Don't hold your breath, though. [*Editor's note: All prices mentioned in this column refer to the exchange rate of 179 yen to the dollar that was in effect when this was written.*]

It was interesting, however, to see a handful of IBM PC AT clones offered by Japanese manufacturers who say that they are interested in selling these machines in the domestic Japanese market. So far, major vendors have shown only lackluster interest in supporting AT-compatible machines for the domestic market, which is understandable in view of the difficulty of selling computers in Japan that don't speak Japanese. Among the companies coming out with AT-compatible computers are Ricoh and Micro Research. The Ricoh machine will probably be priced out of the market, but the Micro Research PC-ATLAS, running its 80286 processor at 8 MHz, should be priced somewhere close to $3000. Micro Research was also showing a prototype of a small portable AT-compatible machine.

Another small company, Tomcat Computers, says it has developed a PC AT clone, but I wasn't able to see it at the show. However, in view of the inexpensive IBM PC, PC XT, and PC AT compatibles starting to come from Taiwan, I'm skeptical of the Japanese manufacturers' prospects for successful competition in an arena full of IBM compatibles. Nevertheless, it's possible that this could be the beginning of a move to push these machines for the first time within Japan.

### A LAPTOP PORTABLE FROM OKI

Oki has never had much success with its personal computers, and I'm not sure why, except that its prices are a bit high. The Oki if800/60 desktop computer, in particular, is an interesting machine; it uses an 8086-2 microprocessor running at 8 MHz, comes with 512K bytes of RAM (expandable to 1 megabyte), and is available in both dual floppy disk and hard disk versions. And it has the highest-resolution graphics, as standard equipment, of any personal computer available here—720 by 512 dots.

But Oki is hoping to broaden its market with its new ifCOM7 laptop computer. I saw the ifCOM7 last month at the OA Fair, and it indicates to me, among other things, that Japanese personal computer manufacturers are finally taking telecommunications seriously.

The ifCOM7 is the first laptop portable made in Japan (not counting the Tandy laptops) that features a built-in modem. The initial models will be equipped with only a 300-bps modem (but will be able to communicate at 1200 bits per second in half-duplex mode), but a full-duplex 1200-bps modem is promised. All of this is a sign of the late-to-arrive, but fast-growing, popularity of bulletin boards and computer communication services in Japan. In addition to numerous privately operated bulletin boards, services like The Source, CompuServe, and MCI Mail have been available in Japan for some time,

*(continued)*

*William M. Raike, who has a Ph.D. in applied mathematics from Northwestern University, went to Japan in 1980 looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer. He can be contacted c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.*

and the market is now getting set for an explosion of Japanese-language information services. In fact, there are more than 1000 subscribers to The Source in Japan—giving it the largest single number of subscribers outside North America.

The ifCOM7 uses an MSM80C86 (a CMOS version of the 8086) as its microprocessor; it runs at 5 MHz. Standard RAM is 256K bytes, but you can expand the memory up to 512K bytes. The ifCOM7 has an additional 32K bytes of RAM backed up by a special nickel-cadmium battery and a kanji ROM containing the 2965 characters in the JIS No. 1 character set. An expanded kanji ROM with the extra 3000-plus characters in the JIS No. 2 standard character set is optional. Built-in interfaces include one RS-232C interface and two parallel printer ports.

The 80-character by 25-line (640- by 200-dot) liquid crystal display isn't hinged but instead is installed in a fixed position above the keyboard, inclined slightly toward you. I thought the display was quite legible, despite its slightly greenish cast. I keep hearing rumors about backlit LCDs, but until I see one I'll rank the Oki's LCD, along with the one on my own laptop (a Fujitsu FM-16$\pi$), as among the best. The keyboard, unfortunately, has a slightly nonstandard layout; the Control key is located at the top left of the keyboard along with other function keys. That "feature" could be a major nuisance.

Unlike most other laptop machines available in Japan until now (with the exception of the expensive Data General/One and the SOTEC portable made by Kohjinsha and sold in the U.S. as the Datavue 25), the new Oki computer has a built-in 3½-inch floppy disk drive, formatted to hold 720K bytes, and it runs under Japanese-language MS-DOS 2.11.

I tried out the ifCOM7 running a simple editor and a primitive terminal-emulation program. Disappointingly, although Oki promises that all kinds of word-processing, spreadsheet, electronic desktop, and other applications software will be available, I didn't see any of them working. Limited software availability has been one of Oki's vulnerabilities in the past; the future of this portable will depend on the availability of enough software to make it useful. The price is certainly right; it lists for only about $1425, and you get a wide choice of options at reasonable costs. In addition to additional memory and add-on disk drives, Oki plans to offer peripherals like bar code readers, magnetic-stripe card readers, hand-held optical character readers, and a touch panel.

**NEC's PC-9801VM4**

The upper end of the NEC personal computer line gained a new member recently—the PC-9801VM4. The V designation refers to NEC's V-series microprocessors, which are fully code-compatible with the Intel 8088 and 8086 processors but run considerably faster. The PC-9801VM4 uses a V-30 microprocessor that NEC refers to as the $\mu$PD70116; you can switch-select either an 8-MHz or a 10-MHz clock rate. The only drawback of the 10-MHz rate is that memory boards for previous PC-9801 models won't run that fast, and the newer and faster boards are somewhat more expensive.

Another feature of this microprocessor is that it provides on-chip emulation of the 8-bit 8080 microprocessor, which opens up the possibility of retaining access to older CP/M-80 software. The EM/3+ operating system extension I wrote about in the May column provides the necessary software support to accomplish this; the 8-bit emulation is done in software on my Fujitsu computer, but the new NEC machines do it in hardware about six times as fast.

The letter M in the model name refers to its 1-megabyte floppy disk drives (actually 1.2-megabyte drives). The PC-9801VM4 has two built-in floppy disk drives (the same as the VM2 model) and can also read and write disks recorded in the 640K-byte format used by the earlier PC-9801 models bearing an F letter designation.

But the major feature of the VM4 is its built-in 3½-inch 20-megabyte hard disk drive. Although hard disk units in Japan are still much more ex-

*(continued)*

pensive than in the U.S., prices are starting to come down. More and more high-end personal computers are being sold with built-in hard disks, especially for business applications, in conjunction with database management software. Japanese-language database programs are proliferating rapidly, and sales of personal computers that can take advantage of them are certain to climb.

The PC-9801VM4 comes with 384K bytes of main memory in addition to 192K bytes of graphics video RAM; 640- by 400-dot color graphics is standard. NEC puts its version of BASIC into an additional 96K bytes of ROM. You can expand the main RAM only up to 640K bytes (unlike the Fujitsu computers that can hold up to a megabyte of RAM), but third-party vendors offer expansion boards that provide still more memory for RAM disk applications. A mouse interface is standard along with an RS-232C serial interface.

You get extensive Japanese-language support with the PC-9801VM4. It's supplied with both the JIS No. 1 and No. 2 standard kanji character sets, for a total of over 6000 characters, in addition to the ASCII character set and the Japanese katakana phonetic alphabet. The Japanese-language capability gets software support at the operating system level, too; Japanese-language MS-DOS (versions 2.11 and 3.1) is available, as is Japanese-language CP/M-86, which enjoys a wide, if slowly diminishing, popularity in Japan. You can also buy a (very expensive) version of UNIX, called PC-UX. And NEC makes a big point of offering Concurrent CP/M-86, although in my opinion that operating system doesn't have much more of a future here in Japan than it did in the U.S.

The PC-9801VM4 offers absolutely nothing in the way of compatibility with U.S. computers like the IBM PC family, but its power is certainly in the same league as the PC AT, despite the fact that its microprocessor is less complex than the 80286 that's used in the PC AT and clones. Much more important, as far as the Japanese market is concerned, is the fact that

*(continued)*

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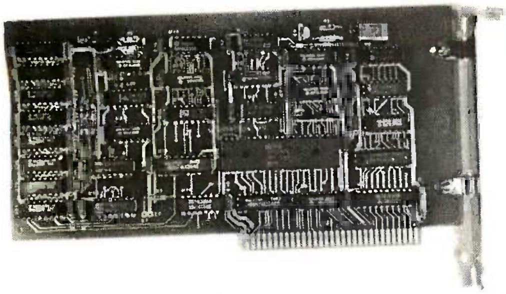

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*I wish NEC would simply use a new number for its next model instead of adding suffixes.*

it's fully compatible with earlier models in the PC-9801 series. This philosophy has put NEC in the driver's seat as far as personal computers in Japan are concerned, and it is likely to stay there.

The list price for the PC-9801VM4 is 830,000 yen, or about $4635 at current exchange rates.

## 8-BIT NECs

For the past few years, NEC has managed to maintain its position as a leader in personal computers for the Japanese market. In the U.S., manufacturers of personal computers introduce new models relatively infrequently, but here in Japan new models appear every few months. NEC continues to offer upgraded models of its 8-bit personal computer, the PC-8801, while the American 8-bit computer market is essentially moribund.

NEC's latest computers in its 8-bit PC-8801 family are 1-megabyte floppy disk versions of the PC-8801 MkII MR and FR series. These aren't new computers in any sense, but they represent further refinement of the original machine, which traces its ancestry all the way back to NEC's PC-8001 machine that appeared over five years ago. Based on NEC's μPD780C-1 microprocessor, which is software-compatible with the Z80, and running at the usual 4 MHz, you can now buy one with up to 192K bytes of main memory. Their graphics performance is more than respectable—640- by 400-dot resolution for color graphics, using a palette of 8 out of a possible 512 colors. Most owners run only NEC's N88-BASIC, but the machines can run the CP/M 2.2 operating system, too.

The half-height, 1-megabyte floppy disk drives in the latest models are considerably faster than the sluggish 320K-byte drives NEC had used for so long in earlier models. Combine that speed with an additional μPD780C-1 subprocessor and 8K bytes of dedicated RAM for handling disk I/O tasks, and these computers should be able to overcome one of the major drawbacks of this otherwise very useful computer. BYTE Japan readers may recall that, before buying my first in a series of Fujitsu 16-bit computers, I owned an original model of the PC-8801 (see BYTE Japan, November 1984). Apart from the slow disk access, my only other complaint about that computer was the slow speed for updating the screen, which I suspect was partly due to the demands imposed by the PC-8801's powerful Japanese-language display capabilities. My Fujitsu, even though it's a 16-bit computer, uses a separate microprocessor as a coprocessor to relieve the main processor of the burden of handling the keyboard and the display.

It's hard to imagine a comparable market niche for an 8-bit computer in the U.S. these days, but these computers continue to sell well here in Japan, one step above the much cheaper MSX machines that most buyers still use as no more than video-game devices. And they're not cheap; there are various configurations available, but the list price of the PC-8801 MkII MR, without a display, is about $1325.

I wish NEC would simply use a new number for its next model, though, instead of adding suffixes. At this rate, I nearly run out of breath before I can say the name of the computer.

## NEXT MONTH

I'll look at Fujitsu's new 80286-based computers. And a different compatibility problem keeps coming up. ■

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and 1 stop bit, or 7-bit words, even parity, and 1 stop bit. You may call at either 300 or 1200 baud.

**Step 2:** To reach BIX via Tymnet.*

* BIX *is accessible from anywhere in the country through local Tymnet numbers. If you don't know the Tymnet numbers for your area, contact the* BIX *Customer Service Line (see below). At other times, numbers can be obtained by calling Tymnet at* 800-336-0149.

- Call your local Tymnet number and log on.
- Depending on your baud rate, Tymnet will respond with "garble" or request a terminal identifier. Enter the letter "a". (Ignore quotation marks in this and succeeding entries.)
- Tymnet will ask you to log on. Enter "byteneti" and a carriage return (CR).
- Tymnet will ask you for a password. Enter "mgh" and (CR). You will then be at the door to the BIX computer.

**Step 3:** (If there is no prompt requesting a login at this point, hit a (CR) which should produce it.) When you see a phrase ending in "login:", enter "bix". (Echoing of this response is normal.)

You should now see the BIX logo scroll onto the screen and a prompt asking you to enter your name. Since this will be your first time on the system, enter "new" and a carriage return. This will take you to a special section where you enter the information we need to register you as a BIX user. Follow the on-line prompts and supply the information requested. BIX lets you re-enter data if you make a mistake.

When you've completed your registration, BIX will automatically take you to a special "Learn" conference where you'll get a quick tutorial on how to use the system. (Typing "help" or "?" at any prompt while you are on BIX will give you an immediate review of available commands.)

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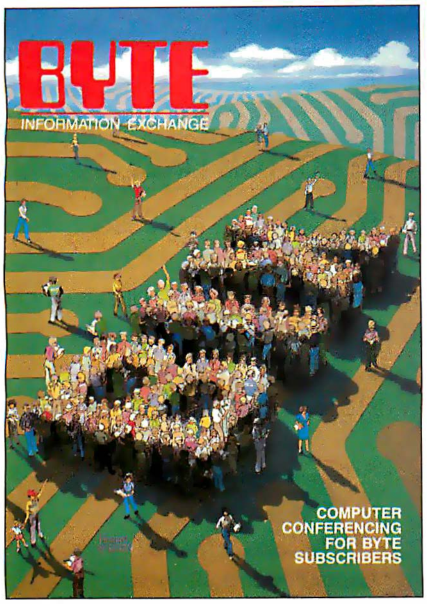


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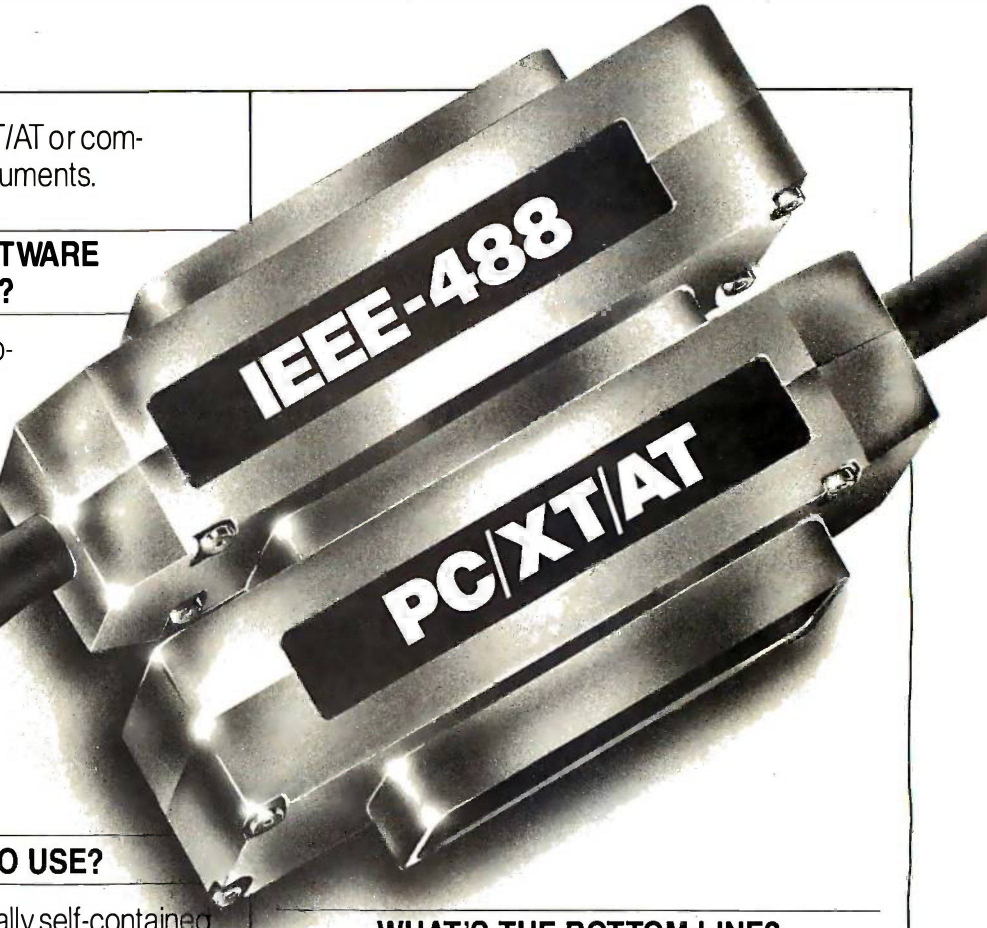


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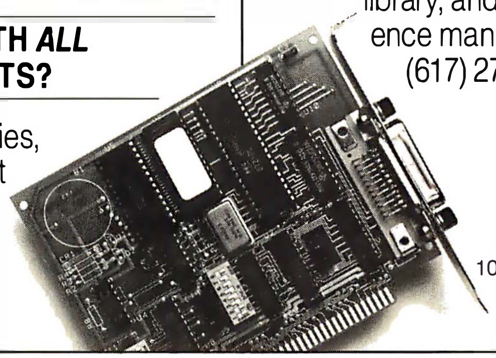

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# CHEAP STUFF

BY EZRA SHAPIRO

## *Low-cost software: It Figures, Dac-Easy Word, AI:Typist, and Datatext*

None of the products in this month's selection costs over $100, so every one of them fits into a category I'm beginning to call "disposable software." That is, you can buy any of these programs on a whim, without having to swear to your spouse that it's your last computer purchase, ever.

I used to have real problems with inexpensive software; I never felt very good about applying a double standard, but I'd overlook a program's flaws if it did interesting things for cheap. These days, I'm quite a bit harsher. The producers of low-cost items have learned to tout their products with just as much hype as the large companies who hire advertising agencies. Once upon a time, I felt that by buying this stuff I was helping poor starving programmers with good ideas and no money. Today, as I pick my way through the outrageous claims and overblown adjectives, I have no such delusions—everyone wants to be a millionaire, and quickly, too. Every so often, I'll stumble across a nifty product from an honest shop, and I'll bend over backward to be nice—but that's not happening frequently.

### TOP HONORS

This month's column would have been a sorry list of losers were it not for **It Figures** (SimplSoft, $39.95), a program that makes such perfect, logical sense that I'm surprised no one thought of it before. It's nothing fancy, and that's why it's so good.

The idea is blindingly simple. It Figures is a three-column, 20-row mini-spreadsheet. Period. The first column holds formulas, the second shows the results of calculations, and the third is for comments. You enter your data on a command line at the bottom of the screen, the program puts them up on the worksheet and computes your results, and you get your answer. Bingo.

It's designed for people who don't need all the complexity of a big spreadsheet, but that doesn't mean the program isn't powerful. You've got the full range of numerical, statistical, and trigonometric functions; named variables and line referencing; global variables loaded from a standing file; and worksheet chaining if you need more than 20 lines for your computation. You can't do any "either. . .or" branching, but that's not what this program is for.

Anyone who has ever sweated over trying to set up a template for a trivial problem on a big spreadsheet will appreciate the convenience of It Figures. To make life even easier, the program comes with 45 templates, including linear regression, Ohm's law, ACRS depreciation, return on investment, Rule of 78, auto MPG and cost, IRS 1040, the Pythagorean theorem, and 37 others.

It Figures is rock solid, clearly documented, and a snap to use. Rush out and buy this one.

### LOSS LEADER

What to say about **Dac-Easy Word** (Dac Software, $49.95)? It's inexpensive, that's for sure, and it has a lot of features that make it sound like the greatest thing since. . .whatever. Reeling off the list, I'll give you the good things: automatic hyphenation, four editing windows, database-like mail merge, saving of special layouts as format files, a thorough list of supported printers, and all the usual word-processing operations.

I suppose if it were the only word processor available, or if I were incredibly stingy, I could learn to live with it. However, I find myself loathe to give it a recommendation; there are a number of *little* things that irk me.

First, the documentation is poorly organized and poorly written, and it is typeset in boldface, which is amazingly difficult to read.

Second, although the program accepts MS-DOS directory paths, it's obviously designed for a floppy-based system. It defaults to the root directory, not the current directory, every time it's loaded, which means that if you want to use it in a subdirectory on a hard disk, you have to reset the path every time you bring it up. You also can't avoid the default format; you have to enter the changes manually or load a format file.

Third, every file operation (directory, load from disk, save, rename, etc.) starts with a read of the current directory, which can take some time, particularly on a hard disk. This gets to be a real pain when you're dealing with windows. As multiple windows into the same file are not updated automatically, changes made in one window are not reflected in the second unless you save and reload the file. If you're viewing different files, you've got the same problem—you're going to be looking at those directory screens more than you'd like.

Fourth, many of the program's basic operations are controlled by secon-

*(continued)*

*Ezra Shapiro is* BYTE's *West Coast Bureau Chief. Contact him at* BYTE/McGraw-Hill, 425 *Battery St., San Francisco,* CA 94111.

dary menus generated from the function keys. Every time you complete a task, you remain stuck in the secondary menu; you have to press F10 to exit back to editing.

Fifth, there's this delete/insert business—the only way to delete single characters is with the Backspace key; the Del key triggers a delete mode in which you can erase longer chunks (words, sentences, paragraphs). It's three keystrokes to delete from the cursor to the end of a word—Del, F4, Del. Likewise, the Ins key toggles an insert mode. If you move the cursor into a block of text and begin typing, you overwrite what's there. To insert, you have to press the Ins key, which breaks the line at the cursor. Enter your text, tap Ins again, and your paragraph is closed up and reformatted.

Finally, my copy of Dac-Easy Word didn't seem to like large files. I tried to load a 32K-byte pure ASCII file and then save it without changing anything. After countless carriage returns to get past "memory filled" error messages, I got the thing saved—with 2K missing. Not at the end, mind you—the program had eaten lines out of the text, every 10 to 12 lines or so, in no discernible pattern. "Okay," I muttered. "This program doesn't like alien files. Let's try to create a long file within the program itself and see what happens." I built a 640-byte block of text and began duplicating it with cut-and-paste. Well, the program began swapping to disk after about 5K. After zillions of error messages, I finally tried to save what should have been, by my calculation, a 32K file. Only got 14K of it.

Confused, I called Dac's customer-support department. For pure ASCII files, Dac plans to ship a conversion utility shortly, which should (the company claims) solve *that* problem. As for the Dac-generated big file, well, the woman to whom I spoke was as baffled as I was. With 640K bytes of RAM, she told me, I should be able to handle documents as large as 500 pages. Since there had been some revisions since my copy had been shipped, she suggested I send in my disk for a free upgrade. That's nice; Dac earns a bunch of points from me for friendly phone help.

Okay. Assuming the conversion utility is shipped and the big-file problem is fixed, what have you got? An adequate word processor with some annoying quirks that costs 50 bucks. I don't much care for it, but for 50 bucks the product is probably fine for an occasional memo or letter or short report. The menus make Dac-Easy Word moderately simple to learn, and if you're not going to use a word processor regularly, they'll protect you from silly mistakes.

## ITEMS DISCUSSED

IT FIGURES ............... $39.95
(MS-DOS)
SimplSoft Products Inc.
5330 Sterling Dr., Suite C
Boulder, CO 80301
(303) 444-8772

DAC-EASY WORD ........... $49.95
(MS-DOS)
Dac Software Inc.
4801 Spring Valley Rd.
Building 110-B
Dallas, TX 75244
(214) 458-0038

PC-WRITE .................. $75
(MS-DOS)
Quicksoft
219 First North #224
Seattle, WA 98109
(206) 282-0452

AI:TYPIST ................. $99.95
(MS-DOS)
Airus
11830 Southwest Kerr Parkway
Lake Oswego, OR 97034
(503) 246-1782

DATATEXT .................. $95
(MS-DOS, CP/M-86, CP/M-80)
Datatek Inc.
909 State Road 584 West
P.O. Box 850
Oldsmar, FL 33557
(813) 855-4408

On the other hand, if you're a heavy user, the little irritations will drive you crazy and cost time and frustration. If you're going to need a word processor for more than a couple of hours a week, check out **PC-Write** (Quicksoft, $75), which only costs $25 more and has *lots* more power (although it's tough to learn, and the documentation is so chunky you could eat it with a fork). It's not perfect either, but at least it's nicely configurable. I promise a thorough look at version 2.6 of PC-Write next month.

### Gimme a Break

**AI:Typist** (Airus, $99.95) is a simple word processor designed for first-time users, and boy, is it simple. Do first-time users really need all those complicated features other software firms throw into their products just to make their customers feel inferior? After all, first-time users might burst into tears when confronted with such technically complex concepts as mail merge, multiple windows, headers, footers, and page numbers, so AI:Typist just leaves them out. Therefore, the program is a stunted skeleton of a word processor, suitable for one-page memos and shopping lists, but not much else.

The product's only innovation is an as-you-type real-time spelling checker that operates character by character, supposedly designed using advanced artificial intelligence programming techniques. When you've typed far enough into a word for AI:Typist to figure out that it's not in the dictionary, the program beeps at you and highlights the rest of the word. Unlike older, less-sophisticated spelling checkers, this one is incapable of suggesting other spellings. It just sits there and beeps as you go rummaging around for your Funk & Wagnalls.

The press handouts for the product state that it was developed as a demonstration of a brilliant new AI technology (which Airus is trying to license to other companies). There probably is a pretty impressive engine under there somewhere; if I were an AI expert, I might even be drooling. However, my job here is to evaluate applications software. As a word processor, not an AI demo disk, AI:Typist is inoffensive, but so limited as to be nearly worthless.

### Curiouser and Curiouser

For me, the beauty of modern microcomputing is that I *don't* have to develop arcane skills with cryptic commands in order to achieve mastery over the machine. Face it, does anyone really *like* using UNIX editors and formatters to manipulate text on a serial terminal? Come on now, wouldn't you rather slide over here to this nice copy of WordPerfect or XyWrite and just type away contentedly? Sure you would.

But, to prove that every rule has its exception, **Datatext** (Datatek, $95) takes you back, back, back in time to the days when men were men, computers were computers, dinosaurs roamed the earth, and text had to be beaten over the head with a sledgehammer to make it come out right.

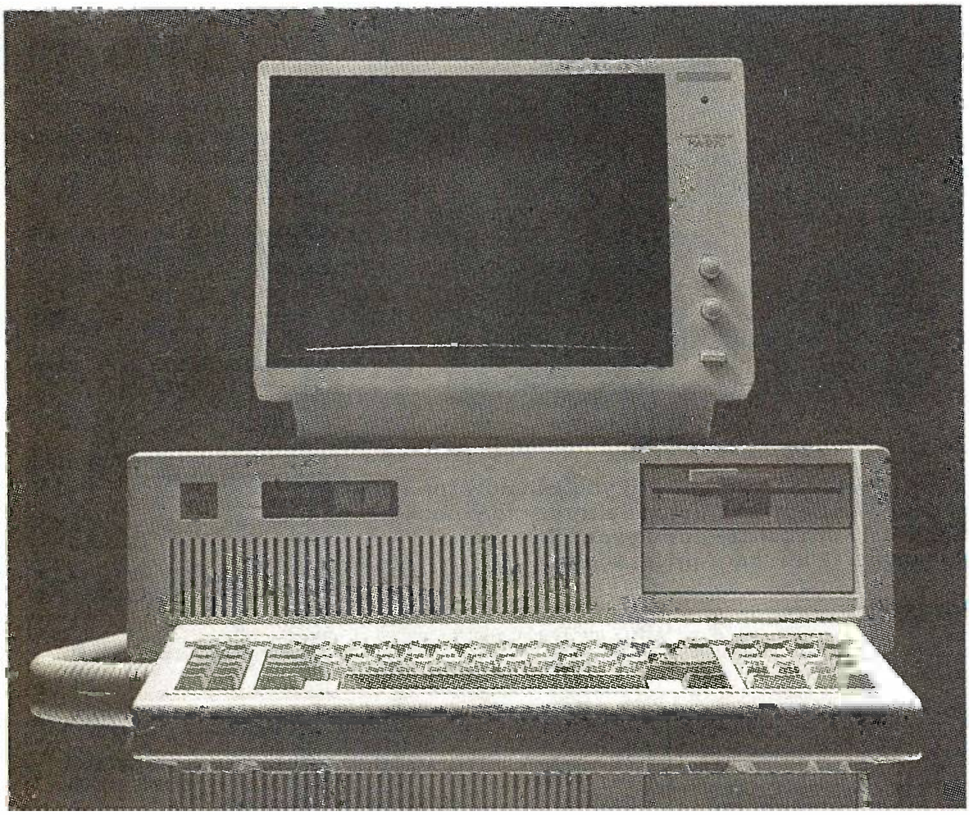
What we have here is a two-part word processor (editor and text formatter) written mostly in 1981. The editor itself is horribly archaic; every time you want to do something, you have to change into the appropriate mode. The formatter makes the dot commands of WordStar, PeachText, and ROFF look positively wimpy. What's more, you get a manual that rivals a metropolitan phone book in size, shape, weight, and readability, and complete source code in Pascal/M.

Before you programmers out there leap at the opportunity to get your hands on the source, let me point out that the program was written for CP/M-86 (yeah, right); in order to run it on an MS-DOS machine you need a CP/M-86 emulator. Datatext throws one in, and gives you the assembly language code for one, but do you really want to spend your time figuring out your way around this labyrinth?

This is an outdated product written in a dying language for a nearly dead operating system. It didn't make it the first time around as a commercial product; now it's gussied up and remarketed as a programmer's toolbox. More like a programmer's nightmare, when you consider the editing needed to turn the code into anything useful.

I can't deal with this. I don't dislike Datatext; I just break into a cold sweat every time I think about it.

If this sort of masochism appeals to you, go for it, but please don't call me to tell me about it. I don't want to know. ■



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(continued from page 24)

and object code of programs includes a protection of the screen displays and user dialog, I wish to caution you that this is not as simple as he would have you believe. Things that are purely functional, or that can only be expressed in a limited number of ways, are not eligible for copyright protection. I would say that one could not copyright the use of a picture of a floppy disk as an icon and have it be upheld. I can only think of two methods for pictorially conveying the idea of a disk—a picture of a floppy disk or a picture of a disk drive. Anything that's that limited can't be copyrighted. There is, therefore, argument that a trash can icon could also only be expressed in a limited number of ways (a trash can, a bit bucket, a spittoon, or a garbage truck). On the other hand, a slavish copying of the entire setup of icons and menus would be less supported by this argument.

In addition, it is not at all clear that the greeting card and TV show cases are dispositive of the issue. In such products the look and feel is everything. In computer software the look and feel is only one component of the total package. Programs have more than user interfaces; they have data manipulation functions, operating system interfaces, and numerous control structures and data structures that are connected to, but not dictated by, the user interface. To point to the way the program's screen looks and say that if it looks like some other program it is an infringement, in the way that the copying of the look and feel of greeting cards, cartoons, and television characters is an infringement, is a rather large jump in both legal and practical logic.

It is important to keep in mind that there are no court decisions that *directly* address these issues.

Mr. Bransfield failed to properly characterize the nature of both *SAS Institute, Inc. v. S&H Computer Systems, Inc.* and *Whelan Associates, Inc. v. Jaslow Dental Laboratory, Inc.* Neither of those is a "look and feel" case. In both cases the issue was whether or not the defendants violated the copyright holders' rights by translating the source code of a program to another machine/operating system environment. It is important that the defendants had access to the *source codes* of the programs and were copying not only the user interface but also the program structure and logic. This is clearly distinguishable from a "look-alike" or "work-alike" program that was written without access to either the source code or the disassembled object code of the original program.

(continued)

In *SAS*, there was far more copying of the code than Mr. Bransfield indicates. The number of lines he mentions were the number of lines that the court and the experts identified as being *directly* copied. Throughout the defendant's code were obvious examples of thinly disguised copying of the original statistical analysis program. There were also examples of dead-end bits of code that had no function in the SAS program. Equivalents of those dead ends were also found in the defendant's code. It was clear that the *SAS* case involved much more than a similarity between the two programs with respect to screen displays and user interaction.

*Whelan* is an even worse example for Mr. Bransfield to use. In *Whelan*, the defendant, Jaslow, attempted to write a program to computerize his dental lab. Upon realizing that the project was beyond his abilities, he hired a consulting firm. The consulting firm's agreement made the firm sole owner of any software that resulted from the work they did for the defendant. Jaslow assisted the consulting firm in designing the screens and user interaction dialog. If Mr. Bransfield's analysis of computer programming as merely "grunt work" is correct, then Whelan Associates rooked Mr. Jaslow. To anyone who has done any programming or read large amounts of other people's code, Mr. Bransfield's assertion that there is no artistry in writing code is absurd. Writing good code is a lot like writing good formal poetry. There are a lot of restrictions on how one may express an idea, and the object is to convey exactly what one wants to convey in the most concise and powerful fashion within the rules of the genre.

When the original code was written for Jaslow's lab it was in EDL on an IBM series 1 system. Later it was converted to BASIC on a DataMaster 26. Sometime after that, Whelan and Jaslow had a falling out. Later, Jaslow decided to convert the program for the IBM PC. With the help of another consultant, he did so and began marketing the product in competition with Whelan's version, also converted for the PC. Whelan sued; Jaslow lost. The case is now being appealed. It is clear that this is not just a "look and feel" case. Ethically, the rights to the screens and user dialog should belong to Jaslow. Legally, he gave up those rights in the original contract he and his company signed with Whelan. While Mr. Bransfield is correct in saying that the defendants in *SAS* stole the user interface from SAS's copyrighted program, it is not fair to all to characterize Jaslow's actions in the same breath. Given Apple's usurpation of Xerox PARC's interface, the characterization of DRI is a little like a defense of the pot calling the kettle black.

As for Mr. Bransfield's analysis of what drives software producers to make improvements to the user interface, he has made an error in interpreting history. Those user-vicious programs on mainframes were more a product of the environment and type of users such machines had, and not of the level of competition. The point he misses is that all of those developers are busy reinventing the wheel each time they come out with a more "user-friendly" interface. If one could use a common set of standards and improve on them within a particular program, both the developer and the user would be that many steps ahead of the game.

These user-friendly interfaces are important mostly for people who want an automatic entry into new programs. If each user interface is different from every other, not much is accomplished. If, on the other hand, there are similarities where they would be helpful and innovations when they are needed, users would be much better off. This even applies to people who prefer the "stick-shift method" of controlling a computer. I am glad that Borland put the WordStar command set in the Turbo Pascal editor rather than something I had never seen before when I started using it in 1983. I am also glad that there are substantial similarities between MS-DOS and CP/M-80 and -86—it makes jumping back and forth between machines much easier and much less frustrating.

Conversely, I agree with most of Mr. Williams's reply. It is clear that Apple bullied DRI. Apple knew well that DRI did not have the resources for a prolonged legal battle and Apple probably saw it as a quick way to limit the impact of newer 68000 machines on the Mac's share of the market. As for the legality of visual copyrights in the context in which they are presently being discussed, I submit that things are not as cut and dried as Mr. Bransfield implies. I also second Mr. Williams's notion that the use of this concept should be curtailed in the area of computer software by either the courts or Congress.

In closing, I would like to make the suggestion that you do an article examining the ADAPSO plan for a hardware "key" system of copy protection. Now that the Justice Department has decided that it will not prosecute such a system under the antitrust laws, the system's legal viability has been increased. If anything will kill the plan, a good article on the costs and headaches this system is likely to cause for users should do the trick.

HENRY C. DAVIS
*Carlisle, PA*

Mr. Bransfield's letter never broached the crucial issue: Why is it Apple, not Xerox, that is entitled to believe it has proprietary rights over the Xerox Star/ Macintosh-type interface? If Apple has paid royalties to Xerox for the interface pioneered at Palo Alto Research Center, then Apple's stance is justified. But I recall that present Apple Fellow Alan Kay originally dismissed the Macintosh as a cheap knock-off of the work done at PARC. In any case, as owner of an Atari 520ST, I was confident that Apple would run into a buzz saw had it tried to strongarm Jack Tramiel.

Mr. Bransfield has apparently done little or no programming, even on a hobbyist level. Even given the idea to be computerized and a general outline of how to accomplish it, writing sufficient code is creative and nontrivial: It is not grunt work.

DANIEL M. HOWARD
*Oakland, CA*

### THE PERSONAL COMPUTER OF THE NINETIES

I have had the opportunity to work and play with microcomputers since I first owned a TRS-80 Model I in 1978. I sold it long ago to pay the rent and feed three kids as I worked toward a computer science degree. As I starved my way through school I often thought about just what personal computer I would like to have when, and if, I graduated.

I have watched with interest as both my expectations and the technical abilities of personal computers grew over the years. I clearly remember when few people could figure out how anyone would be able to use the 48K you could get on a Model I. Now there are Ada compilers for the PC AT that require a minimum of 3 megabytes of RAM.

With this evolutionary process in mind, I have been thinking about what the personal computer of the nineties ought to be like. The perspectives I bring to this question are somewhat diverse. I am in my mid-thirties and have earned my keep as a programmer, microwave systems engineer, data communications technician, and small business systems consultant. Thus, I have dealt with everyone from the "power user" to the poor slob trying to balance his books. Given that, here is my "infinite wisdom," directed at the systems designers of the world, on what this next decade needs in a personal computer:

CPU: 80386. Compatibility with the massive base of 8086 software is absolutely critical. This 32-bit CPU offers it at a mind-blowing 3 to 4 MIPS! Make sure that there are provisions for a multiprocessing environment in the design.

Display: Minimum 1024 by 1024 by 16 colors. That may seem like a tall order, but chips capable of supporting this are already in development at Intel and other companies. Users will demand it from an ergonomic viewpoint as more time is spent in front of CRTs. EGA may be nice, but is it really good enough for CAD, desktop publishing, or even Volkswriter?

Memory: 4 megabytes, no wait state, in the system as a minimum, with the capability to go much higher. The 80386 supports 4 gigabytes of RAM. Multitasking, multiuser, and multiprocessor environments will demand this much RAM.

I/O: The mouse, or its equivalent, will have to be supported directly from the system and not use up a serial port. Microsoft needs to put a standard interface in DOS. The growing use of environments such as Windows makes this necessary.

I challenge not only the American manufacturers but also those in Taiwan, Korea, and the rest of the Far East to look ahead. This system closely parallels the 3M university proposal while maintaining the path to the present software world. The use of the graphics device interface would remove any portability problems.

I estimate that a machine with these capabilities could be prototyped before the end of 1986, with the possible exception of the graphic capabilities. It could be on the market by the end of 1987.

The power it would provide to the user would be tremendous. It would take years for our software designers to come close to using the capabilities that a system like this would provide, but after they did, the benefits to the user and to society would be more than we can now imagine.

JIM TRUDEAU
*Chico, CA* ■

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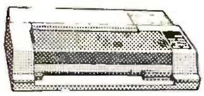

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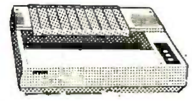

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Inquiry 216

# C·H·A·O·S M·A·N·O·R M·A·I·L

*Conducted by Jerry Pournelle*

### ALIEN NAMES

*Bob Albrecht tells me that the Alien Names program mentioned in a previous column is freeware and is available with source code from*

*Dragon Quest*
*P.O. Box 7627*
*Menlo Park, CA 94026*

*Those who need to generate names and/or insults for aliens are advised to write.*

### AN URGENT REQUEST

*A group of prisoners at San Quentin are trying to learn a vocation. They are in dire need of donated PCompatible software in quantities of five copies or so. This includes the latest revisions of DOS, spreadsheets, and nearly anything else that might be useful in vocational classes. Those interested should write to Correctional Education Institute, Attn: Mr. Allan Jensen, Barclay's Bank, 3400 Central Expressway, Santa Clara, CA 95050.*

*The Institute is a 501(c)-3 organization and donations are deductible.*

*All the machines at San Quentin are PCompatibles except for one Apple IIe and one HP 150. I'm sure they could use hardware as well as software; none of their machines have clock boards, graphics cards, or memory extensions.*

### LANGUAGE SELECTION

Dear Jerry,

The letter in the March Chaos Manor Mail ("Language," page 293) was excellent and thought-provoking. I'm writing to encourage you to give your readers input from your experiences and perspective on considerations to keep in mind when choosing a programming language.

For some time I have been thinking about learning another programming language, but I'm not a professional programmer and don't have contacts with people to ask for guidance. I learned and used FORTRAN on a mainframe many years ago, and I quickly picked up BASIC after buying an Apple II+ four years ago. A year or so ago I began to wonder if I should learn a structured language, but which? Pascal turns me off (maybe for the reason David Suits cited), C is so "symbolic" it is harder to read than Pascal, etc. Recently, several BASICs have been introduced that enable structured programming, and they would still be easy to read as well as more easily learned. But which one should I choose? (And many others must be in similar dilemmas.)

Your remarks on True BASIC in the same column were stimulating, but there are quite a few other BASICs now—BetterBASIC, Professional BASIC, QuickBASIC, and ZBasic among others. What considerations should a nonprofessional programmer, with needs somewhat like your own, keep in mind when deciding between the BASICs available now?

WAYNE L. ST. JOHN
*Carbondale, IL*

*There's an excellent BASIC conference on BIX; it's conducted by Bruce Tonkin, who consistently proves that you can write good, practical programs in BASIC. He's quite fond of Microsoft's new QuickBASIC, which is fully compiled and very fast.*

*I also recommend Baen Software's QuickScreen (distributed by Simon and Schuster).*

*I still don't recommend True BASIC; it's not so much the language itself as that it's neither interpreted nor compiled and in my judgment incorporates many disadvantages of both. It does have features not found in other BASICs.*

*And, of course, those who want to learn new languages would do well to check out Modula-2 and Ada.*

*Best.—Jerry*

### LISA

Dear Jerry,

David Brandt's comments in the January bag of Chaos Manor Mail ("Sour Apples," page 366) caught my attention. He objected to the Macintosh because he felt it lacked the fundamental requirements of a "business computer": an ergonomic keyboard with separate numeric and cursor keypads; a large, clear display, with an option for color; two disk drives; and expansion slots.

Mr. Brandt failed to note that Apple once produced a product with most of the very features he desires, plus more that were highly advanced. But despite all that, it still failed. And it was this irony that caught my attention.

The Apple product in question? Why the Lisa, of course.

It's true. The Lisa (later the Macintosh XL) had numeric and cursor keypads; a large, high-resolution display, with an option to correlate shades and patterns to different hues in order to produce printed output in color; two disk drives, or a disk drive and a hard disk; and expansion slots for memory up to 4 megabytes.

So, if it was so good, why did it fail? (And, for that matter, why bring up a defunct product?) The reason is that the Lisa had shortcomings that every microcomputer manufacturer must resolve: price and marketing, and performance and enhancements.

The Lisa was introduced with what was at the time a huge price tag—$10,000. Whether Apple (or any other vendor) is justified in charging such fees is debatable. But if you charge such a high price, your customers are going to demand (and should get!) a lot of machine for their money.

Apple took an interesting approach to the Lisa software. They provided a package of closely related applications they felt met most of the needs of the typical business user: spreadsheet, word processor, graphics, etc. These applications were provided by various software houses. And while all were adequate, and some remain to this day among the best of their kind, the user was dependent upon Apple to provide timely enhancements with the abilities of equivalent stand-alone products. Though this was the need, enhancements were slow in coming, often buggy, and not always easy to use.

If performance of the software was questionable, that of the hardware was less equivocal. Microcomputer users have come to expect fast response time, especially if their machine has a hard disk. The Lisa was distressingly slow. One can find many reasons for this (the demands on the CPU to do graphics and multitasking; Lisa Pascal instead of assembly language; the slow ProFile disk, a carryover from the Apple III, that seemed hard-pressed to

*(continued)*

serve applications that went to the disk often; etc.). But the fact remains—performance was slow; the users expected more.

No matter how good your gear is, you've got to convince someone to buy it. Let's face facts: IBM is one of the best marketers in the world.

I have no ties to Apple, professionally or otherwise. But I like the Macintosh. A lot. I like it for reasons that are both technical and aesthetic and that go beyond the scope of this discussion. (Though you might ponder this: Because of the ability to *draw* information and controls as *needed* for an application, software can be liberated from many of the limits of interface hardware. This may be as significant as superseding teletypes with CRTs.)

I do not say that it is an ideal machine (some of the design decisions revealed in *Inside Macintosh* make me cringe). Nor that the IBM PC is a bad machine (though the history of IBM shows that they have always pursued goals that might make Mr. Brandt pause in his enthusiasm). I do hope that Apple has learned from its mistakes and that the potential of the Macintosh evolves and flourishes. And that it does not meet the same fate as the Lisa.

TIM ALLEN
*Seattle, WA*

*Gee, I'd have thought that Apple's "interesting approach" to software had more to do with Lisa's death than anything else.*

*Apple was built around open systems that generated not only user loyalty but third-party support. No company, no matter how large, can afford to have on staff as many skilled programmers and hardware designers as are out there in the user community; thus, other things being equal, the open system will always slaughter the closed one. Of course, other things aren't always equal.*

*There's a lot of evidence that Apple is no longer the same company. There are even rumors that Woz will be back. There are said to be frantic efforts to "open up" the Mac. I wish Apple well.*—Jerry

## MODULA-2

Dear Jerry,

In your February and March columns, you mentioned a CP/M Z80 Modula-2 compiler from Workman and Associates, but you gave no address for Workman or for any source that supplies it. How cruel of you!

Please send me the address ASAP so that I can order my copy. Professionally, I do Ada programming, and from what I hear about Modula-2, it sounds like it offers most of what Ada offers but is designed with smaller hardware systems in mind. Thanks.

DAN SANDERSON
*Austin, TX*

*The addresses usually appear in the "Items Discussed" box; apparently not in this case:*

*Workman and Associates*
*112 Marion Ave.*
*Pasadena, CA 91106*

*They've improved FTL Modula-2 since it came out. Workman also handles a CP/M version of RR Software's Janus/Ada, which is one of the best tools for teaching the essentials of Ada; but for practical Z80 programs, FTL Modula is better. Ada and Modula-2 have more in common than most suppose.*—Jerry ■

**THE BEST OF BIX is a selection of the most interesting messages from BIX, the BYTE Information Exchange conferencing system. The conferences covered for this month include those for the Commodore Amiga, Atari 520ST and 1040ST, the IBM PC family and compatibles, and the Macintosh computers. These pages represent only a small fraction of the material discussed in these conferences.**

**For information on joining BIX, see the instructions on page 378.**

# AMIGA

This month's Amiga highlights include a short tutorial on Amiga's joystick ports, a report on Transformer and 5¼-inch floppies, and discussion of hard disks and memory expansion options. The Bugs and Fixes section outlines problems and solutions involving Pascal, screen editors, and some mysterious vanishing icons. The Amiga highlights conclude with helpful hints for photographing Amiga display screens.

## JOYSTICK PORTS

**amiga/main #2447, from cmcmanis [Chuck McManis]**

Amiga A/D Converters?
On the pin descriptions of the mouse port are two pins labeled "POT X" and "POT Y." Does this imply that the Amiga will also accept "analog-type" joysticks such as those available for the IBM PC? Further, are these pins looking for a resistance (change in current) or a change in voltage? If I knew, I would like to try a homemade A/D input circuit. The next thing would be how fast I can read the joystick port.

**amiga/main #2448, from w.volkaegis [William Volk, Aegis Development]**
**a comment to 2447**

The POT X and POT Y will measure resistance only, sort of like the old APPLE II pots; you can hook up analog joysticks or paddles or a photoresistor (hint, hint, ThunderScan).

**amiga/main #2449, from jsan [Jez San, Argonaut Software]**
**a comment to 2447**

Chuck, the Amiga A/D converters (labeled POT X and POT Y on the joystick port) are indeed for use with analog joysticks. They look for a resistance by discharging a capacitor at the vertical sync pulse (start of TV frame), and they time how long it takes for the capacitor to get charged up, which naturally depends on the resistance of the POT at the time.

I believe you must read a latch to determine which particular TV scan line was active at the time the capacitor was charged up. Since each scan line takes *n* microseconds, you can multiply through to find the exact resistance of the POT.

I'm not definite about this. Can someone from Commodore-Amiga confirm the actual method of reading the POT? Or have I gone and been "naughty" and described the "dirty" method of accessing it. Perhaps there is a "clean" OS call for reading the POT!

**amiga/main #2454, from cheath [Charlie Heath, MicroSmiths]**
**a comment to 2447**

There are device driver functions for the game port for several different types of controllers, including proportional joysticks. Incidentally, one of the mouse buttons actually is read via a resistive input, I believe the right (menu) button.

However, I tried to implement the digital joystick on the rear input port; I got it working so long as I didn't close and reopen the device. It required about 100 lines of C code and crashed when I closed and reopened it. Then I switched to just reading the PIA and custom chip registers; it requires about five lines of C and doesn't crash.

**amiga/main #2471, from pselverstone [Peter Selverstone]**
**a comment to 2447**

I have gotten two 8-bit proportional pots (at 60 samples per second) and five buttons out of the right port by going directly to the chips. The A/D conversion seems reasonably linear with respect to resistance. No noise or crosstalk problems.

## TRANSFORMER CAVEAT

**amiga/main #2615, from rayzim [Ray Zimmerman]**

Need Help with 5¼-inch Floppy and Transformer
I just got my Commodore-Amiga 5¼-inch floppy with Transformer and was amazed to find that it is not an "Amiga disk"—i.e., it is not recognized by AmigaDOS or Workbench. Furthermore, there is no known method to move files from PC-DOS/MS-DOS to the 3½-inch floppies, according to Commodore Tech Support.

Furthermore, Commodore Tech Support said there are no plans to integrate the 5¼-inch floppy with the rest of the Amiga. Is this true? I guess I was light-headed in assuming that I could do these things.

Do you, gentle reader, know of any software that will (a) make my 5¼-inch a "df2:" for AmigaDOS and/or wb, or (b) allow transfer from MS-DOS disks to Amiga disks?

I suspect that the public will be looking for such software also, or else they'll shun the drive.

**amiga/main #2616, from pariseau [Bob Pariseau, Commodore-Amiga]**
**a comment to 2615**

V1.2 will treat an external 5¼-inch floppy as an AmigaDOS disk with the exception of automatic recognition of disk change. You are correct in noting that no data transfer software comes with the v1.0 Transformer product. I do not expect a Transformer-based solution from Commodore very soon. This would be an ideal area for someone to make a quick buck (or perhaps some public domain software?).

## HARD DISKS AND MEMORY OPTIONS

**amiga/main #2510, from cmcmanis**

SCSI for Amiga
By the by, at the West Coast Computer Faire the guys from MicroForge were showing their hard drives and expansion stuff. But what I found most intriguing was that their hard disk interface had only one 50-pin cable running from it.

After some marketing chit-chat it boiled down to the fact that they were indeed running an SCSI bus to the hard disk. Seems that one of these and an Ampro SCSI/IOP would provide nearly unlimited I/O capabilities. (The Ampro IOP is a board that has a programmable Z80 on it, an SCSI bus with built-in target firmware, and an STD bus edge connector.)

**amiga/product.dcsn #717, from sparta [Tracy Icard, Sparta Inc.]**
**a comment to 2510**

MicroForge Drive
A few weeks back I received my 40-megabyte MicroForge hard disk and put it on my machine. There were some problems with spurious read errors from files installed on the drive. The suspected problem hinged around the fact that my Amiga has a CSA piggyback board with 68020/68881 and 512K bytes of static RAM. This suspicion was

*(continued)*

substantiated by the fact that the drive appeared to work fine with a standard Amiga.

The other day I received my 7-slot expansion box and, I'm happy to report, this solved the problem. Once the drive was installed in the expansion box I had no more problems. The drive works magnificently so far. The problem is probably related to one (or both) of two things:

1. Using the single-slot adapter supplied with the disk. The controller board is powered from the Amiga rather than from the 130-W supply that powers the drive. The expansion box powers the entire expansion bus from the 130-W supply.
2. The design of the 7-slot adapter may act differently with respect to my machine, causing the error to no longer appear.

Whatever the cause, the unit now works fine. One new item that MicroForge passed on to me is regarding its 2-megabyte RAM board. They have shelved this board, as another company (RS Data Systems) is producing a better board that MicroForge is going to sell instead. This board will be available very soon and has a capacity of 2 to 8 megabytes. The basic board has sockets for 4 megabytes and comes either with 2MB ($995 list) or 4MB ($1395 list).

There will also be a piggyback board with capacity for another 4MB. The main board, with piggyback, loaded with 6MB will list for $1675 and fully loaded with 8MB will list for $1995.

Those who already ordered the 2MB MicroForge board will be shipped the basic board with 2MB on it. Just for the cost of 2MB of RAM, it can be upgraded by the purchaser to 4MB!

**amiga/product.dcsn #718, from mposehn [Mike Posehn]**
**a comment to 717**

How much memory is lost when the hard disk is attached? Is it 17K, like when a second floppy is installed?

**amiga/product.dcsn #721, from cheath**
**a comment to 718**

I would guess none, depending on the device driver. So far all of the hard disks I have heard about read via CPU rather than DMA; I would guess that the drivers are doing sector I/O rather than DMA track I/O. But the driver itself would also have to be in RAM, so it might use up a fair amount of RAM even doing sector I/O.

**amiga/product.dcsn #723, from althoff [Tom Althoff, Indian Park Electronics]**
**a comment to 717**

I just hooked up my 20MB MicroForge hard disk and 7-slot box. Yes, it works well, but I have two minor complaints. The top lid sags under a few pounds of weight (mine was bent during handling at MicroForge). I can set the Amiga RGB monitor on the case carefully, though, without causing a permanent bend.

The other concern is RF sensitivity. In a strong RF field, the Amiga itself is surprisingly resistant to any erratic behavior or even blooming of the monitor. However, with the expansion box on-line, the sensitivity to RF increases by a factor of 10. At some point, I will take the time to scrape the paint off the junctions of all the panels that make up the assembly and perhaps improve the shielding a bit. RF leaving the Amiga and MicroForge did not, however, seem to increase when monitored in a nearby HF receiver.

Just curious what your impression of the mechanical strength of the MicroForge unit itself is? Good luck with it!

**amiga/product.dcsn #745, from mikeduffy [Mike Duffy]**

I picked up a Comspec 2-megabyte memory expansion at the San Jose Amiga Faire on Saturday and brought it home to L.A.. Works like a charm (so far), and everything is much faster—I really don't need the disk drives except to load and unload the RAM disk. It really speeds up development, and they have an attractive price for developers. The box lists for $1079 U.S. (Comspec is Canadian), and I got a 30 percent discount. The only drawback is that it is only a 2-megabyte box (not like the ones that expand to 4 to 8 megabytes). On the other hand, it plugs into the side of my Amiga and doesn't require its own power supply.

Best of all, it's available *now* (unlike some other products). Comspec can be reached at (416) 787-0617. As far as price/performance, I would say that RAM is more useful than a hard disk for most developers. In addition, it helps to catch all those "it should be in CHIP memory to work" bugs that are lurking about.

**amiga/product.dcsn #748, from langeveld [Willem Langeveld]**
**a comment to 745**

Notice that one can chain those modules. So four of them give you the full 8 megabytes, but by then you've spent $4000, still not bad compared to the price of 1 megabyte for a VAX.

## BUGS AND FIXES

### VANISHING ICONS

**amiga/main #2411, from apl [Andy Levy]**

Is anyone here interested in the following phenomenon?

1. Boot Workbench with active CLI.
2. Open main disk window.
3. Select an icon and move it out of disk window and onto main Workbench screen (in my case I moved "AmigaBasic").
4. Close the window.
5. Click in CLI, and on the same disk make a copy of the associated icon.info file but *without* the .icon extension (example: copy AmigaBasic.info to "dummy").
6. Reopen the window, move the icon back into it, and close the window.
7. Reopen the window and the icon will now be *gone*. However, the icon.info file is still on the disk (viewable via a "dir" or "type" command)—it just won't display its icon.

The icon can be made to reappear in at least three ways:

1. Delete the duplicate copy of the icon.info file (example: delete dummy). Or
2. Add the .info extension to the copy of the icon.info file (example: rename dummy to dummy.info), which will make two icons appear, the original and a duplicate named dummy. Or
3. Rename the original icon.info file (example: rename icon.info to newname.info), which will make the icon reappear as "newname".

You can now name it back to its original name, and it will remain. The changes appear to be due to alterations in the disk's main .info file. Using "list" you can see it lose/gain bytes as the icons disappear/reappear.

Also, the disappearance will *not* occur if the original copy of the icon.info file is given the .info extension (example: copy icon.info to dummy.info); it will just create a duplicate icon with the name "dummy".

Anybody know what's happening? Looks like there may be a time bomb lurking in the operating system.

**amiga/main #2412, from jdow [Joanne Dow]**
**a comment to 2411**

Out of idle curiosity, where did the files go when you moved them off onto the main Workbench screen? If they stayed in the usual directories, when CLI looked at them, it seems to me that you confused Workbench. I would hope that moving things that way would create a copy in RAM.

Along these lines, I have noticed that AmigaDOS can become very confused if there are two disks, produced by a prior "diskcopy", followed by a reboot. I have learned to relabel immediately to avoid the problem (if there is ever a chance I will attempt to load both disks).

I thought AmigaDOS had a special tag field that guaranteed that the uniqueness of disks would be noted. I suppose two disks by the same name as system disks seems to confuse the SYS: and C: search paths.

amiga/main #2422, from apl
a comment to 2412

The files stayed where they were (in the root directory). The only thing that changed was the main .info file and of course the lack of the icon on the window. Funny thing, now I'm having trouble duplicating this. I can get icons to disappear, but the change is not permanent; rebooting clears it. This is *not* what happened before, but I'm using different disks, so maybe it's related to some problems on the specific disks I was using. Oh well, mark it down to a haunted Amiga.

amiga/main #2426, from cheath
a comment to 2412

I haven't run across the relabel problem. If you use a program like Marauder, which makes an "exact" duplicate of a disk, you will definitely have problems such as you mentioned; but I have never seen any problems using disks together that were created with "diskcopy". Maybe I've been lucky?

amiga/main #2428, from jdow
a comment to 2426

These are indeed Marauder disks, so I suppose that explains things more than a bit. No wait—one was a Maurauder disk and the other was a "diskcopy" disk without the DPaint stuff on it. Strange effects here. It definitely goes fufu with two Marauder duplicates. It gets most confused, poor thing.

I wish there was a way to log in to or assign to a generic df1: disk rather than a specific disk. That'd make searching for a file on one of several disks much easier. Log to generic df1: and dir successive disks to my heart's content. Sigh—CP/M ain't all bad.

amiga/main #2431, from duck [Dale Luck, Commodore-Amiga]
a comment to 2428

Multiple Marauder disks are a good way to confuse the poor DOS. The secret ID numbers are duplicates, so its last-resort measure of telling the difference is broken.

### PASCAL PROBLEMS

amiga/main #2452, from jveg [John Veregge]

Lattice and Amiga Pascal Questions
I have kludged a Pascal environment using Lattice Screen Editor and Amiga Pascal. I use the following execute file for debugging my source files:

```
.key F,WS/k
.def WS "25"
pascal > ram:<F>.err ram:<F>.pas cem ws <WS>
lse: ram:<F>.pas ram:<F>.err
```

This compiles and puts the error messages into a file and loads LSE, source file, and error file. The problem occurs when a true boo-boo creates many spurious error messages. LSE cannot load a 250K error file. A solution would be to echo the error file to the screen while it is being written, put in a break flag, so I can manually stop the compile, and have the execute file continue and put me back in the LSE to fix the real bug.

Is it possible in AmigaDOS to direct output to two different locations (screen and error file)? Suggestions? Aside from "switch to C"; I am teaching myself programming and have enough problems. Also, the manual for Amiga Pascal is !@#$%±&*? and I am anxiously awaiting (but not with bated breath) the next release. In the meantime, what is the "double" option in Pascal 1.09? I can see it changes the size of the object file slightly, but I am too new at this to tell what it really is doing.

Compliment: I as an amateur like the compiler for learning purposes. An environment is easier, but sticking to the standard makes it complementary to a great many textbooks, and the error messages are easy to understand. I don't think this is possible (I am also asking in the Lattice C conference), but can anyone think of a way to use the LSE error-checking mode with other compilers? This would be extremely useful for many and widen the consumer base for Lattice.

*(continued)*

amiga/main #2453, from jim_kent [Jim Kent]
a comment to 2452

What's the Lattice Screen Editor error-checking mode?

amiga/main #2456, from cheath
a comment to 2453

They have a mode in their editor that reads in an error file from their compiler and allows you to jump to the error lines in the editor. I personally prefer to have the errors in the console window, and just click the editing window behind the console when I need to find the next error line.

amiga/main #2462, from jdow
a comment to 2452

Um, perhaps you have two paths to happiness. Trim your source to smaller modules, or first edit the error file and cut the last half or whatever, and then edit in the error-flagging mode.

I don't think a forked path is possible for redirection. Oh! Write a filter to trim the error file to perhaps 100 lines and run it before entering the LSE editor. That ought to nicely mechanize the process for you.

amiga/main #2463, from jdow
a comment to 2456

Actually, the error locater is a nice development feature. The LSE reads the error file along with the source file. It will do a Turbo Pascal and position the cursor on the line with the error in it. It will do TP one better by then positioning to the next error. The only gripe I have with it is the cluttered screen LSE gives me. When you have more than a screen full of errors this is a handy way to find the errors without bothering to create a listing of the error file in hard copy.

On the other tentacle, you might worry about your techniques if you get much more than a screen full of errors. Breaking up a huge file into smaller pieces is generally a good thing, has fewer error messages, and better data hiding.

### Photographing Amiga's Display

amiga/main #2443, from rgoldberg [Robert Goldberg]

Monitors

There has not been much discussion recently about monitors. I suppose everyone has bought one by now. I am doing a lot of photography directly off the screen, and the resolution of the Amiga monitor leaves me cold, especially for text in 400-line mode. Are there any monitors around that do a better job of resolution, especially for 400-line text? I have heard about the Sony, as well as the Atari (but does Atari's advertised 200-line resolution support Amiga hi-res?).

And what about the rumored "new" Amiga monitor? Will this be higher resolution or just a cosmetic redo with two tiny speakers?

If anyone has good thoughts about this problem, I would appreciate the advice.

amiga/main #2444, from cheath
a comment to 2443

What would be needed to display the Amiga's NTSC color without flicker in 400-line resolution is a higher-persistence monitor. Such monitors exist, and I have heard they aren't too much more expensive than standard analog RGB monitors; but I have no idea who makes one. I am baffled as to why Commodore has not pursued this at least to the point of finding out what sources are available for these monitors.

amiga/main #2446, from cmcmanis
a comment to 2444

Heath/Zenith is now selling a "high-persistence" color monitor specifically for interlaced color displays; the only drawback is that it is RGBI rather than analog RGB. (Seems some other manufacturer has made digital RGB quite popular.) Possibly a call into them might get a lead on one that accepts analog.

I remember looking in one of those RGBI monitors and seeing four op-amps as hysteresis input buffers. If they really are there just to convert the signal from the cable into full on or full off for the RGB amp stages, then it might be possible to add a feedback resistor/cap to make them analog once again.

amiga/main #2470, from bgill [Bill Gill]
a comment to 2443

I was at a NASACOM64 banquet here in Houston last night, and the guests from Commodore had nothing much to say about a new Commodore monitor, but they discussed briefly what can be done about the high-res flicker. Just about the only thing you can do is to get a monitor with a slow phosphor, and then you may get some smearing if you try to do animation.

They said there are several monitors with the long-persistence phosphor, but the only one they could remember right off the top of their heads was the Electrohome. I have heard the name in other contexts, so I guess you might want to investigate that. They also said that they had heard of a new Sony monitor that took the interlaced feed from the Amiga and converted it to a noninterlaced signal for the display. That sounds a bit tricky to me, but I suppose it is technically possible. It would take care of the high-res flicker.

amiga/main #2472, from pselverstone
a comment to 2470

I saw a reference to an RCA patent (4,573,068) that might relate to interlace-to-noninterlace conversion. It provides "twice the usual number of scan lines per picture frame." Next-generation TV sets will have digital field storage and therefore should be able to generate noninterlaced displays from interlaced signals. Does anyone know anything about this?

amiga/main #2473, from jdow
a comment to 2472

I don't know about the patent you mention, but the technology exists. In Europe the current method of scan conversion involves such tricks. All that such a scan converter would have to do to convert the signal to true RGB analog would be to sample at perhaps 10 MHz with a 6-to-8-bit flash converter.

The images are stored in a RAM large enough to store one full frame. The RAM would have to be fast enough to allow all the needed accesses for both scan rates. The output rate would be twice the input rate in order to complete the pictures fast enough.

No, I take that back. The conversion could also go to completing a picture perhaps 50 times per second for average viewers. (I do, however, remember French high-res TV mode, which wiped the picture to the screen 25 times per second.) I was younger at the time and could plainly see the sweep effect and found it unwatchable.

Anyway, the technology exists. It is rather expensive these days as perhaps (oops—Amiga pix would require sampling nearer 30 MHz to make Mr. Nyquist happy—equivalent to 960 dots per line, counting visible 640 and retrace period). The horizontal frequency is about 15,750 Hz, giving a dot rate of about 15 MHz.

The actual number would be twice our processor clock to be exact. A 640 by 400 picture fills the screen, giving 256K per color or ¾ megabyte of *very, very* fast RAM. If the RAM is organized perhaps 64 bits wide, then the access rates can bring it down to reasonable speeds for merely expensive RAM, perhaps 200 ns.

# ATARI ST

Several applications developers and other conference members have recently been debating the pros and cons of a unified user interface for the Atari ST. While GEM's mouse-and-menus user interface established a precedent for ST applications, not all developers agree it should be used exclusively—it's a discussion that any ST owner should find interesting. Other topics covered this month are how to change the physical display base, information on a broad-band video bug, and discussions of the new OS-9 C compiler and Alcyon C.

## UNIFIED USER INTERFACE

atari.st/clubhouse #141, from mmanlove [Mike Manlove]

I have a serious problem with the unified-user-interface approach: Much as we like our menus and so on, they are not always the best way to solve a given problem. I'm currently working on a sizable project that uses a fixed, always-present command list on the side of the screen. I won't go into my reasoning at the moment, but I think it's the right way to go. Now, the big question: What is the trade-off between a consistent but clunky interface and one that's different but better suited to the task at hand?

atari.st/clubhouse #142, from jruley [John Ruley, University of Dayton]
a comment to 141

OK—there are *some* applications that are *not* suitable for menu/mouse operation. As a regular user of MacTerminal, I am pleased to be the first to agree on that! However, if you're going to have a GEM application that uses the menu, then you ought to stick with standard conventions.

One other convention—whether or not you are using the GEM menu bar, the Help key should give you a command list. If we can all agree on this much, then I think the rest of the problem will largely take care of itself.

atari.st/clubhouse #143, from mmanlove
a comment to 142

I couldn't agree more about the Help key. One of the first things I did with my ST was to hack a little terminal emulator, and it used the Help key because I forget what's going on in my own programs. Then I found out that most commercial software doesn't use it.

atari.st/clubhouse #145, from cheath [Charlie Heath, MicroSmiths]

a comment to 143

I prefer to assume the user can get to the menu, which should be self-documenting as to functionality. Is that a bad assumption?

atari.st/clubhouse #147, from jruley
a comment to 145

Yep. The menu bar ought to be self-documenting, but what's wrong with a little redundancy here? If I'm typing away on my word processor, it is very irritating to lift my hands from the keyboard to the mouse.

atari.st/clubhouse #148, from cheath
a comment to 147

I guess we have a difference of opinion re Help key versus menu. My

(continued)

feeling is that it is easier to wander through various menus with the mouse and just release the menu button to have the help/menu retracted. I'm not sure how easy that is to do with GEM; I know the default is to leave the menu up, but I think a clever program can get the menu to disappear when the button is released. When you use the Help key, if there are multiple pages, you need some other keystrokes to get between pages, and you need a final keystroke to get rid of the "help" and get back to work.

**atari.st/clubhouse #157, from dmenconi [Dave Menconi, co-moderator of the atari.st conference]**

How about this: I think most programs should have a Help menu that gives information about all the other menus and about the program in general. If the Help key were a synonym for a help item that told all about functions of the program, then different types of users would be satisfied.

**atari.st/clubhouse #177, from jruley**

Hmm...on the Mac I've seen a lot of applications that use the "About..." item under the "Apple" menu bar for a form of on-line help. What I suggest is that we use the Help key the same way—it ought to (at least) list the major command headings, what their general function is, and (briefly) how to use them.

For a non-GEM application (no menu bar) this is more important, but in the interest of consistency, why not do it on GEM applications as well? I mean, since we *have* a Help key, why not *use* it?

**atari.st/clubhouse #144, from cheath**
**a comment to 141**

Interfaces depend a lot on the application, but I'll assume you are writing a "mass-market" application in which there are two priorities: (1) the interface has to be simple to learn, and (2) the interface should allow "power users" to quickly access the functions they need.

I don't think a standard is necessary or good. It is nice if there are conventions; that is, if you have a choice of two equally good alternatives, you should probably pick the most likely to be used in similar applications. But to assume that all programs should use a particular interface is to limit the definition of a program.

**atari.st/clubhouse #189, from mmanlove**

I am on record as being a bug about the Help key. *Use it, implementers!*

**atari.st/clubhouse #154, from dmenconi**
**a comment to 141**

Right now the proposed interface guidelines are not at all consistent—*no one* uses them—so your method would not have to be much better.

I would caution, however, that, in my experience on the Macintosh, a developer ignores the user interface guidelines at his peril. In fact, it seems to me that there are few really good reasons not to use menus other than a simple dislike of pull-down menus.

**atari.st/clubhouse #156, from dmenconi**
**a comment to 144**

On the Mac the interface may or may not be simple to learn (I think it is, but everyone is allowed an opinion), but it's the *only* interface you will ever have to learn. All decent products on the Mac use the interface (this is a slight exaggeration, but if a product doesn't use the guidelines, many users won't use it because it is too hard to use).

Besides, if there are guidelines, we can use them where appropriate and ignore them where not.

### Changing the Physical Display Base

atari.st/questions #68, from cheath

Glitch Changing Physical Base
We're having a problem doing a double-buffered display. Occasionally, the display will glitch for what seems to be a single display frame. This happens about once every 10 minutes. We are updating the physical display base about eight times/second, and it seems that the problem must be related to this. Anybody know about a problem like this?

atari.st/questions #102, from cheath
a comment to 68

My partner figured out the problem here; it's a glitch in The *Hitchhiker's Guide to the BIOS*. To switch physical screen base, use the Setscreen call. The *Hitchhiker's Guide* states incorrectly that the actual physical base is updated during the next vertical sync; 'taint so. Instead, the physical base is changed immediately. That can cause an intermittent screen flash if the Setscreen call is made at any time other than during vertical sync. Therefore, just prior to the Setscreen call, you should call xbios(37), which will wait for vertical sync.

Also note that the Physbase( ) call does not wait until vertical sync, as implied in the *Guide*.

atari.st/questions #103, from jim_kent [Jim Kent]
a comment to 102

Amazing. I was just down at Atari today and found this out myself. Actually, there is a system counter tied to the horizontal sync you can use too if you don't feel like waiting too much. I haven't gotten this to work yet. Interrupt vectors are scary!

### Broad-Band Bug

atari.st/questions #79, from sprung [Ron Sprunger, R & D Tech]

On occasion, as when loading DEGAS, or a DEGAS picture, I get a half-dozen widely spaced broad black bands on the monochrome. I also have gotten them when returning from the control panel. Is this a system bug, or have I got a hardware problem?

atari.st/questions #80, from jim_kent
a comment to 79

I think I know the source of the broad-band bug. It is what you get—more or less—in the color system when you load a low-resolution picture when you are actually in medium-resolution mode. You may have the bigger, broader version of this for monochrome. It's the way the "interleaved" part of the bit map goes.

atari.st/questions #86, from jruley
a comment to 79

The vertical bars are a system problem—I also get them in DEGAS, and in Megaroids. A funny thing, though, they seem to go away after you've had the system on for a while.

Maybe it *is* a hardware problem, after all—does anyone know?

atari.st/questions #89, from dmenconi
a comment to 86

I have the same problem except that it seems to happen after the machine has been on for a few hours while running the monochrome (I also have color). I suspected a heat problem, so I got a can of freon, took apart my ST, and waited until it did it again. The problem goes

(continued)

away when I hit the video chip with a blast of cold freon, so my problem is almost certainly a bad video chip. I also have a concurrent problem that the screen is shifted over about a half-inch to the right with the right edge showing up on the left. This is *not* fixed by freon, but I still suspect the video chip.

atari.st/questions #111, from alexl. [Alex Leavens, Dynamic Software Design]
a comment to 86

Do you have a homebrew 1-megabyte system (with RAM chips piggybacked)? If not, then my fix is worthless. It only applies to those of us crazy or power-hungry enough to piggyback. I had the same problem (you shoulda' seen my original boot screen 'til the machine warmed up!) but had it fixed by Atari engineers. Seems you need to add a couple of resistors to the extra bank of RAM. If anybody needs the info, I'll see if I can dig up the exact documentation on the resistance, and where you put 'em, and all that good stuff.

atari.st/questions #116, from sprung
a comment to 111

Yes, I'm piggied. Got the machine from MicroTyme with their upgrade. I looked inside and found the chips neatly stacked and tied down the line. The locations that were mentioned elsewhere show the values they should, and MichTron's RAM disk allows a 709K disk, so memory seems to be working, but the screen is really quirky.

atari.st/questions #118, from alexl.
a comment to 116

OK, I'll see if I can dig up the info on the resistors.

atari.st/questions #129, from dsmall [David Small]
a comment to 118

Use 47-ohm resistors in series with the RAS and CAS leads coming from the MMU. They help damp the ringing and undershoot from the DRAMs. Also, be sure you use nice thick stranded wire for the top buses (like 18-gauge) and connect the wires from the MMU to the center of each bus.

## OS-9 C COMPILER

atari.st/main #101, from jim_kent

Have you had experience with the OS-9 68K C compiler? Could you relate raves and/or flames if you have? I'm not all that wild about the 6809 version, though it is a gem compared to Alcyon.

atari.st/main #102, from jimomura [Jim Omura, moderator of os.9 conference]
a comment to 101

I haven't tried the 68K version myself yet, although I have the manual. My own 68K system is halted in mid-construction in part because the 68K port for it isn't done yet and in part because I'm short of cash. The current C compiler seems to have some bugs in it but not so many as to make it unusable. The OS-9 version of microEMACS, which is posted in the os.9 conference, has been compiled with it.

The latest version I know of doesn't handle bit fields within structs and unions, preprocessor #if <constant expression> (this is according to the manual—#if is partly working at least since the microEMACS has #ifdef, #ifndef, and #endif), structure assignments and functions returning type struct, and the enum and void data types.

On the other hand, it seems to support the whole OS-9 68K system itself and long relative addressing via the "remote" data type.

atari.st/main #104, from ktracton [Ken Tracton, Prima]
a comment to 101

The OS-9 68K C compiler is *great*, though it's missing some things such as nonunique struct member names. Otherwise I find it to be excellent, free from bugs, and relatively fast—remember, OS-9 uses position-independent reentrant coding. Highly recommended.

atari.st/main #105, from jim_kent
a comment to 104

Did you say nonunique struct member names? Does this mean if I have

```
struct block
{
        short xoff, yoff, width, height;
};
and
struct block_list
{
        struct block_list *next;
        short xoff, yoff, width, height;
};
```

that I get to do lots and lots of hairy editing? I hope not. Woe to me for not choosing the lowest-common-denominator compiler to develop on.

atari.st/main #111, from ktracton
a comment to 105

Normally, elements/members in a structure can be differentiated by context. Of course, as a matter of style one would use only similar names for very closely related entities. I think that this will be cleared up shortly along with the other missing bits by Microware Systems.

atari.st/main #106, from jimomura
a comment to 104

You know, both ktracton and I have noted the deficiencies of the compiler. But it's extremely powerful as it is. There is a substantial set of libraries included: ctype, dir, direct, errno, events, math, modes, module, procid, setjmp, setsys, sgstat, signal, stdio, strings, time (all of which I'm hoping to give brief descriptions of in the os.9 conference someday). The compiler options are complete *and* outside the actual compiler. We have "make" and a shell supporting wildcards, and the overall structure of OS-9 itself is, of course, like UNIX.

Many UNIX system calls are translated by the C compiler. It works for OS-9 because there are similar calls in OS-9 to substitute.

atari.st/main #107, from jimomura
a comment to 104

Ken, which version are you using? Do you have Revision D (February 1986)? It might be that nonunique struct member names are supported now.

*atari.st/main #113*, from ktracton
a comment to 107

I'm on Revision E version 1.3—haven't tried nonunique yet. You caught me quoting from the book—I'll try and report back Real Soon Now.

atari.st/main #116, from timoren [Tim Oren, KnowledgeSet]
a comment to 104

We have found a couple of gotchas in constant initialization: "xxxxx" initializer is not supported. All number constants evaluated are as 32-bit

*(continued)*

quantities (can cause embarrassment in switch( ) statements).

atari.st/main #117, from jimomura
a comment to 116

As for the 32-bit initial constants, that's what I'd have expected. The compiler is based on a VAX model, and I expect type int is probably 32-bit also (I don't have my manual handy).

### ALCYON C

atari.st/c.language #20, from timpanton [Timothy Panton]

Registers in Alcyon C
Has anyone out there had any problems with registers in the Developer's C compiler? I have a function that goes

```
t_bug(lpt)
BYTE *lpt;
{
WORD val;
register struct g_box *gb;
        gb = g_boxes;
        while ( /* some condition that's true for about 8 iterations*/)
                {
                /* do some stuff with this g_box */
                gb++;
                }
        }
}
```

It seems to hang the machine when lots of stuff is coming in the RS-232. The RS-232 is read by a function that is called every 20 ms by a multi-event call. All is well when the "register" is removed.
Has someone been lazy with an interrupt routine, or have I goofed?

atari.st/c.language #21, from cheath
a comment to 20

We had problems using structures, period. The structure offsets are sometimes random (or at least I could see no correlation between the output assembly code and the C source). You might do best to have a look at the assembly output.

atari.st/c.language #24, from sak [Sal Magnone, CIA Software]
a comment to 21

I agree, if the register wasn't pushed, the routine would probably blow from the first trap you got. From what I hear, Developer's C likes to be creative with struct and union offsets.

atari.st/c.language #26, from swestrup [Stirling Westrup, Xuclid Research Inc.]
a comment to 20

The bug is in Alcyon C. It doesn't properly support the register option. If you look at the machine code generated when you have the register versus the code when you don't have it, you will see that everything is done correctly except that there is either one too many pushes or pops in the register version. I forget the exact case. There is also a bug concerning arrays of structs.

atari.st/c.language #28, from cheath
a comment to 26

Does anybody know if these Alcyon problems are in all of their compilers or just in the Atari version? Has there been any attempt to get this compiler updated?

atari.st/c.language #29, from jim__kent
a comment to 28

Leonard the T. [Leonard Tramiel of Atari] assures me that Alcyon is working on it.

# IBM PC AND COMPATIBLES

This month coverage of the MS-DOS conference includes some answers on how to work with the Link program and an involved discussion of memory-resident sofware, clock interrupts, and "de-resing" or freeing memory space.

### PROBLEMS WITH LINK

ms.dos/commands #208, from geosch [George Schiro]

Is anyone out there in DOS linker land aware of any problems that can arise from using response (@) files from within a batch invocation of Link? Here's exactly what I'm getting at: l.bat contains precisely

link @r1 \ object \ %1, \ execute \ %1, \ maps \ %1, @r2

The batch variable %1 contains *the main* object filename we need linked; r1 and r2 are response files. They contain three and four filenames (with paths), respectively. Each filename is 10 to 15 characters in length. The filenames are separated by spaces. r1 contains names of object modules to precede \ object \ %1 in the link list, and r2 contains the names of all the libraries to be searched.

The problem is that when I invoke the linker with "l <filename>", the linker seems to process only the contents of r1 and *nothing* else. This leads to a "library \ maps \ <filename> not found" error, which is strange, since the linker doesn't even acknowledge the presence of the \ maps \ . . . entry (through the usual previous redisplay) prior to this error message. Can anyone out there rescue this poor soul before he succumbs to the $300+ PLINK-86 boat nearby. One more bad link and I'm sunk!

ms.dos/commands #209, from barryn [Barry Nance]
a comment to 208

I think that if you use the Automatic Response File facility, it has to contain the entire series of responses for the linker. I don't think you can split it out between an ARF and a command-tail series of arguments.

Can you put all of the arguments (object, execute, and maps) in the ARF?

ms.dos/commands #210, from dthielen [David Thielen]
a comment to 209

I have been forced to use linker response files due to a problem with the compiler that I use. It tries to link, runs out of segments, and quits, leaving me with a response file (with the extension .CLD).

I wrote a batch file that is "link /se:1024+@%1.cld". It has worked perfectly for months. My .CLD files are usually 10 to 20 lines long.

I hope this is of some help.

ms.dos/commands #211, from leroy [Leroy Casterline]
a comment to 208

Why not try this: let "l.bat" contain:

echo (stuff from original r1 file)

*(continued)*

\ object \ %1, \ execute \ %1, \ maps \ %1 > r1.lnk
echo (stuff from original r2 file) >> r1.lnk
link @r1.lnk
erase r1.lnk

I use a file of this nature for linking and find it works well.

ms.dos/commands #212, from rlang [Robert Lang]

On page 9-21 of the DOS 3.x manual the example used is

Link @RESP + mymod,@RESP2

Note the comma after the first entry. I didn't see a comma after @r1 in your example. Perhaps that's what's wrong.

ms.dos/commands #213, from geosch

Linking Resolved (I hope)
I just want you all to know I think this BIX idea is just great! I joined expressly for the purpose of resolving my linker problems. Even if I'm jumping the gun a little, you can't beat the attention of so many caring souls. I think I'll hang around.

Believe it or not, I hit on what is essentially rlang's solution just after I logged off last night. Rob, the key is not the comma but the plus sign after the first ARF. The comma won't work because that would exclude the main object file from the list (it isn't and can't, for sake of generality, be a part of r1) of object modules. Thank you very much, all of you, for responding.

If I have any more problems, first I'll try the "echo" solution. It sounds great to me. Then I'll let everyone know.

## Let My Memory Go

ms.dos/other #338, from hans [Henry Bottjer]

I just read about a program called Ready! (see Jerry Pournelle's Chaos Manor column in the February BYTE). It loads into high memory and stays resident. Any idea how it does this? Also, how does SideKick free up memory if you "de-res" it (by pressing Ctrl-Home Ctrl-End)? Sounds interesting.

ms.dos/other #340, from denis.gilbert [Denis Gilbert]

I wrote a little resident program that displays the time of day in the upper right-hand side of the screen. Unfortunately, it seems to lock everything up very quickly. I think it's because I'm using INT 21 to get the time of day and that more clock interrupts come in while I'm processing the current one. Does anyone know how to turn the results of INT 1A into hours, minutes, seconds, and milliseconds? Thank you.

ms.dos/other #341, from barryn
a comment to 338

Programs that want to attach themselves to DOS ("terminate but stay resident") usually do it by issuing INT 27H instead of INT 20H. Freeing up the memory later is similar; there's a DOS function (49H, as I recall) for it.

ms.dos/other #342, from barryn
a comment to 340

It's easier to issue the DOS function call to get the time of day; why not try that instead? The result will come back nicely separated in the CX and DX registers and will even tell you the day of the week.

ms.dos/other #343, from rschnapp [Russell Schnapp]
a comment to 340

No! Don't try calling INT 21 from an interrupt routine! You shouldn't even call INT 1A, though you have a better chance of getting away with it. The problem is that neither DOS nor the BIOS are reentrant. That is, if the currently executing program happens to be requesting service from DOS or the BIOS when a timer interrupt comes in and invokes your clock program, you will attempt to call the DOS or BIOS yet again. This messes up the system something awful.

Your better bet is to locate the BIOS memory location that contains the value returned by INT 1A. It is discernible from the Tech Reference Manual's BIOS listing. If you can't get it from there, let me know. I can dig it out from somewhere.

ms.dos/other #344, from jimkeo [Jim Keohane]
a comment to 343

If Denis Gilbert's resident program is invoked only by a calling program (via interrupts or long calls), then he should be OK.

I think, though, his resident routine attaches itself to the timer interrupts and gets invoked 18.2 times a second. If so, he's probably better off issuing a DOS time-of-day call before tying in his ISR and then bumping a counter whenever he's invoked. He can keep adding 10 to a counter. When the counter exceeds or equals 182, he redisplays the time and subtracts 182 from his counter. I assume, also, he's passing control (via user INT) to whatever ISR initially had the timer interrupt. By redisplaying the time I mean previous time + 1 second.

ms.dos/other #345, from dthielen
a comment to 340

There are two possible major causes of your resident program locking up your computer: (1) Does your program have its own stack that is constant? If so, and your program is called when you are in your program, you will cream your stack. If you use the DOS stack, you can fill it up fast. You need to have a stack that will allow your program to be called inside itself. (2) If your program is called while you are in DOS (like the prompt), you will cream DOS and it's all over. Only if you do *not* use DOS can your program run while in DOS.

ms.dos/other #346, from rduncan [Ray Duncan]
a comment to 341

In DOS version 2 and later, the "preferred" method of terminating and staying resident is with INT 21H function 31H, rather than INT 27H. INT 27H had a particularly bad bug in it for one thing. And INT 21H function 31H allows you to reserve more memory.

ms.dos/other #347, from denis.gilbert
a comment to 344

Thanks for all the suggestions. The idea of using a CS:relative counter and incrementing it is good, but I wonder how accurate it would be. If interrupts are turned off, which happens quite a few times, then wouldn't my "clock" slowly lose time? Perhaps another way would be to continue using the INT 1AH call but set a flag on entry to my ISR such that any interrupts received while "not yet done" would simply be ignored. Sort of like setting a variable to prevent reentrance.

ms.dos/other #348, from jimkeo
a comment to 347

The timer interrupt should be delayed only, not lost, unless INTs are off for more than 1/18 of a second. Even then I'd issue an INT 1AH once every couple of minutes just to stay in sync.

If your timer routine is in control for more than 1/18 of a second (highly unlikely), there probably still wouldn't be a problem, since it just goes back to sleep 17 of 18 times.

I'm just making suggestions to preclude issuing any INTs 18 times a second. You can poke the updated time direct to screen memory every second or every 5 seconds or whatever.

Dave's suggestion about setting up your own stack makes sense if you're gonna be issuing INTs or doing any stack pushing/popping. I don't think you have to, though.

ms.dos/other #349, from dthielen
a comment to 347

A flag would stop your program from clobbering its own stack. However, it doesn't answer the problem of calling INT 1A while in DOS and clobbering DOS. Also, if you use over about 16 bytes of stack, make sure you have your own stack. When resetting the SS:SP for the stack, you must change SP as the NEXT instruction after SS.

ms.dos/other #350, from rschnapp
a comment to 347

Denis, the problem is not with reentrance to *your* code, it's with reentrance to the DOS or BIOS code. You cannot protect against that without some severe measures. Really, there is a good counter, fixed at 40:xxx in the BIOS data segment. I forgot to dig it out of my manual at work today. If you've got one handy, just trace it down from the INT 1A ISR. You could even disassemble the code with Debug. Check the vector at 0:68; it points to the INT 1A ISR. Then disassemble from there.

I'll try to remember to get the BIOS address for you.

ms.dos/other #351, from rschnapp
a comment to 347

Here is the IBM (and compatible) solution: The location of the 32-bit clock counter is 40:6C through 6F. The low word is at 6C, the high word at 6E. I believe that the value there is the number of ticks since midnight.

For details on how to build this into a clock, see the July 1984 *Softalk/PC*, page 82, if you can get it. I have a copy of just such a program, but I don't have permission from the copyright holder to republish it. Sorry. The program is from that issue.

ms.dos/other #356, from denis.gilbert
a comment to 350

I did some digging around. The two locations used for the timer are 0040:006C (the low word) and 0040:006E (the high word). The high word is the number of hours, the low the number of seconds. This way, I don't clobber DOS's stack by issuing any INT 21s or INT 1As.

ms.dos/other #367, from dmick [Dan Mick]
a comment to 338

Regarding "de-resing," or freeing up memory that has been used to save a resident program, here is what I think, and someone please correct me if I'm wrong, 'cause I'm still kinda confused.

If a program such as SideKick or Quadram's print buffer relocates itself to hi-mem, then resets top-of-mem by fooling DOS, releasing the memory is no problem. Just re-reset top-of-mem to the original value saved somewhere in resident program's reserved area, and disable INT calls, etc. Then just let whoever wants at hi-mem next have it (COMMAND.COM, probably).

If, however, a program stays in lo-mem (above DOS) and terminates with either an INT 27H (and I hope no more systems programmers are still using this INT—read your DOS 2.xx manuals!) or INT 21H function 31H—you can't let go of the memory you reserve via either of these calls, because it "doesn't belong" to whatever process is trying to free it up. The best you can do is disable the resident program and, perish the thought, do an INT 19H to reboot (on IBMs, anyway) or live with the used memory. Granted, this is *usually* not much memory, but does this strike everyone else as just reprehensibly inelegant and nonrobust? What about the multiuser system where 20 users may want to install/deinstall the same moderately large resident program?

Any comments here will be appreciated, any solutions profusely welcomed.

ms.dos/other #368, from jimkeo
a comment to 367

De-resing
Dan, Mark Welch has uploaded MARK-REL.ARC to the IBM area of Listings. Basically, the program takes a "snapshot" of critical portions of RAM before a "resident" program is brought in. You can then run the REL side of the package and it releases the memory by restoring those critical pieces of info. See pascal/turbo #922 for more info. Also, as to "de-resing" do's and don'ts, see pascal/source #25 and 26 for a

*(continued)*

posting by Dave Winer of Living Videotext (Ready!, ThinkTank).

John Fistere, moderator of the ibm.pc conference, has also made Dave Winer's posting available to members of that conference in ibm.pc/long.messages #2 and 3.

Purportedly, MARK-REL.ARC handles the lo-mem and hi-mem resident programs, and there will be a version that even handles those resident programs that can reside in extended memory (Ready!).

**ms.dos/other #370, from dmick**
**a comment to 368**

It really doesn't seem as though that's what I want. A snapshot of the low 512 bytes will restore the INT calls, but the problem is the memory that DOS allocates (see INT 21H functions 48, 49, 4A). My documentation says or, rather, implies that a program that deallocates memory not belonging to it can destroy DOS's memory management blocks, resulting in an "area trashed" error return.

Any other comments?

**ms.dos/other #371, from jimkeo**
**a comment to 370**

MARK-REL.ARC
Dan, I haven't looked at MARK-REL yet, but I'm sure that it does more than just take a snapshot of the lower 512 bytes! I believe it takes snapshots of interrupt vectors, DOS memory control blocks, and all pertinent info required to later restore DOS to the exact state (including memory allocation) as before. I recall a comment somewhere on BIX from some authors of resident software stating that MARK-REL didn't free up extended memory but that it would handle extended memory in a future release. Ready! loads itself into extended memory (on the AT) if possible.

I'm guessing, but it may even restore previous directory, previous environment(s), previous DOS prompts, previous paths, etc., to as they were at MARK time. Obviously, it could dump/restore the entire contents of RAM, jump to its original return point, and have you back where you were (with the exception of a few bytes of RAM for its own termination).

**ms.dos/other #374, from rschnapp**
**a comment to 371**

I downloaded MARK-REL and examined it. It sure looks like it is only "snapshotting" 1K bytes of low memory.

**ms.dos/other #375, from jimkeo**
**a comment to 374**

Thanks for the correction, Russ. Sorry if I misled anyone. I certainly had the impression from a comment elsewhere on BIX that MARK-REL addressed the freeing up of resident memory, too!

**ms.dos/other #377, from rschnapp**
**a comment to 375**

You're quite right, Jim. I'm sorry. In addition to snapshotting the lowest 1K of RAM, MARK-REL lets you peel off memory-resident code. Nevertheless, the only memory it is saving/restoring is the lowest 1K.

By the way, this is just from examination of the source code. I haven't tried running it yet.

**ms.dos/other #380, from dmick**
**a comment to 375**

Yet Another Message About MARK-RELEASE
Sorry, Jim, I looked only at MARK.ASM, partially out of laziness, partially because RELEASE is written in Turbo Pascal, and I'm not much of a Turbo'er yet. In particular, the variables and functions and nested procedures used will keep me busy for a while. It sure seems as though the author has access to some information about DOS's memory management that I've never seen anywhere, though, and since really what I'm looking to be able to do is to release memory through assembly language, the listing, once I understand it (substitute "if" for "once"), should lead me down the right path. It looks as though the RELEASE section hunts through memory for DOS memory control blocks (described but not documented in my DOS 3.0 Reference Manual) and then determines which were allocated after the MARK procedure saved a few bytes of text. From this, and I don't know how he knew to do it, it looks as though the DOS deallocate block is called for the remaining ones in the list.

Any thoughts on just where in the *&*&^ one finds info on memory management? Or, alternatively, is Kim Kokkonen (the listing gives him as author) on BIX? If you are, Kim, I'd like to keep this discussion here—if not, all you other interested parties, I'll phone and ask him. Also listed is a company called TurboPower Software. How do I find out if he's on BIX, anyway? Is there a way?

For that matter, I don't know if the party in question is male, sorry about that! (Replace "he" with "he/she", or perhaps "she/he"? It really was an innocent mistake. . .) Anyway, Jim, thanks for the info, and everyone else interested in memory allocation, stay tuned.

**ms.dos/other #381, from jimkeo**
**a comment to 380**

Dan, Kim Kokkonen's not currently on BIX—shame. I've done a little playing with DOS allocation blocks to see that it's not a linked list. When you do a DOS ALLOCATE, you get back the SEG value for that block. The paragraph (16 bytes) at SEG-1:0 contains some info. A word at offset 3 (yup, odd address) contains the number of paragraphs. Another byte (forget which one) indicates whether this block is free or allocated. I don't know where the first DOS mem block is, but knowing any DOS block, I can determine free and allocated blocks at higher mem locations. I also don't know of any such docs on DOS mem allocation nor whether it can be counted on with future releases of DOS.

**ms.dos/other #382, from dmick**
**a comment to 381**

I recently took apart the DOS loader (for the EXEC call in particular), which, of course, must allocate memory. I wondered what all that stuff at pspseg-1 was! Man, the carbon-arc light may have just clicked.

I think I'll phone Kim anyway, and I'll post the results here tomorrow. I'd like a good discussion of this if one is available, as well as the knowledge of whether or not this is one of those SWITCHAR deals that is undocumented only because it's not going to continue.

**ms.dos/other #383, from billn [Bill Nichols]**
**a comment to 382**

The initial DOS allocation scheme is not robust enough for multitask support, so I expect it will change in 4.0 and possibly again in 5.0. But it may be supported by calls at some point, so the internal details won't be so critical. Suggest you isolate any allocation stuff.

**ms.dos/other #386, from dmick**
**a comment to 383**

Sorry it's taken me so long, but I called Kim K., and he says "there's no good reference." He got info from snooping, did refer me to the August 1984 *PC Tech Journal*, which I have not yet had the opportunity to search for. I think I'll look for a back issue at a library, then report here; meanwhile I'll still be snooping!

ms.dos/long.messages #3, from dmick
a comment to 386

De-resing, Releasing Resident Program's Memory, MARK-REL, et al., More on the TSR Question, and DOS Memory Allocation

If you are good at Turbo Pascal, reading RELEASE.PAS (available on Listings as part of MARK-REL.ARC) is a good way to get an idea of what DOS does for memory allocation, but if you're not, perhaps you'll benefit from my experience.

When a program is executed by DOS, either in response to a program's EXEC function call or to a user's request as processed by COMMAND.COM, DOS builds a 5-byte memory control block as follows (note that this works the same on PC-DOS 2.10 and MS-DOS 2.11 on the Zenith IBM clones):

First byte: either 4D or 5A depending on whether this is the last block allocated (5A) or middle block (4D)
Next 2 (word): segment address of segment this MCB references
Next 2 (word): length, in paragraphs, of the referenced segment

Example: 09CB:0000 4D CC 09 68 00 is an MCB that says:

1. this is *not* the last MCB that exists (4D)
2. it exists to control the block of memory beginning at segment 09CC
3. that block of memory is 68 paragraphs long (i.e., 680H bytes)

Note that the next MCB should appear at segment address 09CC + 68.

The MCB appears one paragraph before the PSP segment; thus, if 09C5 is the PSP segment address, 09C4:0 will contain the MCB for the PSP and its process (immediately following the PSP). PSPs may be identified by the first 2 bytes containing the process termination call, CD 20 (INT 20H).

The MCB for the environment of a process (environment segment address may be found at PSP:2C) has, as its "segment address of segment this MCB references" address, the PROCESS'S PSP SEGMENT ADDRESS, which seems rather confusing. The MCB for the environment also directly precedes the environment, which (near as I can tell) always directly precedes the process and its PSP. The environment MCB's length field is correct.

Sometimes, and it may depend on things about the way DOS manages memory that I don't understand, there exists an MCB as follows:

XXXX:0000 5A 00 00 YY YY

where YYYY represents the currently available RAM. This seems to me to say, "There is a segment starting directly after this MCB (i.e., at segment XXXX + 1) that consists of YYYY paragraphs." This MCB is the last in the list, since its ID byte is 5A. I've never been able to find any other kind of "last MCB," so maybe if a process loads and takes all of available memory, it has a "5A" ID byte but a real segment address and length, distinguishing its RAM from available RAM (as in the example above) by the fact that it has a real segment address in the MCB's second and third bytes. I'm not sure.

The whole reason I got into this mess is that I was trying to solve the following problem: I'd write a resident routine, say an A/D interrupt setter-upper/interrupt service routine. It installs itself and some buffer area, reserves memory, and terminates with "Terminate and keep process" function (31H). Fine; now later I want to deinstall, which at the very least involves undoing the ISR (which is no problem, just get its address from the vector and, knowing where in the ISR the old vector address is stored, restore the vector). Problem: How do I dump the memory it used (no longer needed and not necessarily wastable. . . small systems and/or a large buffer in the ISR) with a process that is executed later on? Granted, I knew I had to be reasonably sure that nothing had installed itself above me, but I thought I could say that OK. The problem was, the deallocate function (49H) has this error that's described:

9: Arena trashed—DOS's memory management arena has been corrupted.

This is probably due to a process reallocating memory that does not belong to it.

Well, that scared me off from even trying. As it turns out, though, if you can figure the address of the PSP of the process that reserved memory last, you can also get the address of its environment, and you can pop them both from the process that has (necessarily) loaded higher in memory and then terminate the deallocating process (of course, terminate and deallocate via function 4CH or equivalent) and get all your memory back leaving DOS unscathed.

Whew! That was an awfully long discussion, but the information would have been invaluable to me two or three months ago. For related information, look at MARK-REL.ARC in the IBM listings. Also, the author of that package has written several others that are now public domain, to use up memory (to test programs that may run on smaller systems) and a program that prints out all the MCBs that now exist on the system and what interrupts they may be controlling. The author also told me via phone that the August 1984 *PC Tech Journal* (which I have *still* not found) has an article referencing memory allocation.

Good luck all. I'll elaborate further or, if no one cares, I'll at least *feel* as though I've done a great public service.

ms.dos/other #389, from pittore [William Pittore]

The word that comes after the 4D or 5A is the segment address of the "owner" of the block of memory. For instance, if a program does several 48H (allocate) calls, it will have created several blocks of memory and each memory block descriptor will have that program's PSP as its owner. The last block of memory that has a 5A 00 00 means that no program owns this block of memory.

# MACINTOSH

This month in the Macintosh conference we have a fix to the power supply dilemma posed by the pin-out change on the Mac Plus. We have programming questions about windows and resources. There is also a question on whether to upgrade from a Lisa to a Mac Plus.

### THUNDERSCANNER POWER SUPPLY FIX FOR MAC PLUS

macintosh/tech.talk #171, from rkaapke [Richard Kaapke]

I have got my ThunderScanner working with my Macintosh Plus. I wired a "toy" transformer to two pins on the DB-9 connector that the ThunderScanner adapter box connects to. First, let me give you the correct pin-outs for making an adapter from the peripheral-8 (aka mini DIN-8) to DB-9 connector:

| Pin | Peripheral-8 | DB-9 Female |
|---|---|---|
| 1 | +12 | 6 |
| 2 | Handshake | 7 |
| 3 | TxD – | 5 |
| 4 | GND | 3 |
| 5 | RxD – | 9 |
| 6 | TxD + | 4 |
| 7 | N/C | |
| 8 | RxD + | 8 |

Important: Jumper pins 1 and 3 together on the DB-9 side (this brings GND to both places it's expected). Next, to make this a port that can run peripherals requiring +5-V supplies, connect the ground lead of the power supply to pins 1 and 3 on the DB-9 and connect the +5-V lead of the external power supply to pin 2. If you don't want to use an exter-

(continued)

nal +5-V supply, find a way of jumpering the +5-V line from the mouse port (DB-9 pin 2 of the mouse port) to pin 2 of the adapter cable. This makes a bit of a tangle on the back of the Mac, and the +5 V cannot survive more than a 200-milliamp drain, mouse included. Therefore, it's not useful for many peripherals (although I know someone whose ThunderScanner is running off the +5 V from the mouse port).

I feel safer with an external +5-V supply myself; it's up to you to decide which way to do it. If you have no idea how many milliamps the peripherals requiring +5 V draw, it's better to be safe than sorry, as messing around with the voltages coming from your Macintosh Plus may possibly void your warranty.

## MAC C UPGRADES, WINDOWING, AND RESOURCES

**macintosh/softw.devlpmt #195, from rgball [Richard Ball]**

Help Needed with Window Definitions
I have a question for the experienced Mac programmers out there. I am writing a program to display and rotate molecules taken from a variety of databases (as an X-ray crystallographer in a university chemistry department I do this professionally and I figure the Mac should be a good tool to use). The program runs fine using an on-screen window for display, an off-screen bit map into which each new view is written, and COPYBITS to get the picture from one to the other. My question is this: Since rotations are simplest when they are centered at 0,0, the best window to have would be one in which 0,0 was at the center rather than the top left corner; however, all my attempts to get the two bit maps to behave in this way have failed. Presently I get around the problem by shifting each point by half the window dimension, but I would think that the proper set of definitions would make this kludge unnecessary. What is the best sequence of Toolbox calls and window definitions that will accomplish this task? Has anyone actually done this? It seems like it should be very simple, and any concrete help would be appreciated.

**macintosh/softw.devlpmt #196, from rschnapp [Russell Schnapp]
a comment to 195**

I know there is a Toolbox call to relocate the local coordinate system. Yeah, there it is, on page I-154 in the Addison-Wesley edition of *Inside Macintosh*. SetOrigin( x, y: integer) should do the trick. It should be in the QuickDraw chapter of whatever documentation you've got.

**macintosh/softw.devlpmt #206, from dweikert [Daniel Weikert]**

Mac C and HFS
Can anyone tell me if Mac C is HFS-compatible?

**macintosh/softw.devlpmt #207, from lloeb [Larry Loeb]
a comment to 206**

Mac C should be shipping an HFS-updated product. Some of the equates were in the January *MacTutor*. Note that the HFS equates for MDS are sitting in the "mac.supplmnt" area of the Listings conference as a .pit file.

**macintosh/softw.devlpmt #208, from rkaapke
a comment to 206**

There's a version 4.5 that is totally compatible with HFS and the Mac Plus. I have it on order, but it hasn't arrived yet. I also understand that it has support for the 68881 math coprocessor and the 68020. Of course, it has an intelligent linker that includes *only* those library routines your code requires, *not* the entire module the routine lives in.

This is a great boon for Mac 128K compatibility, at least as far as the code space requirement is concerned. The 68020 support team is real keen for producing custom software for those folks with the Levco or GCC Macintosh add-ons that include this and the 68881.

**macintosh/softw.devlpmt #209, from msackett [Michael Sackett]
a comment to 208**

I just received version 4.5. It supports HFS and I've seen additions to the COMMONLIB.ASM file with comments like "clear out 68020 cache" followed by a series of NOOPs. However, support for the 68881 boards that are out there is supposedly being provided by the "Direct Access" versions (extra cost) of the compiler.

**macintosh/softw.devlpmt #210, from tom_thompson [Tom Thompson, Technical Editor, BYTE]
a comment to 209**

Did you have an earlier version of Mac C and get an upgrade, or what? What do owners of version 2.0 or 4.0 have to do to upgrade?

**macintosh/softw.devlpmt #212, from rgball
a comment to 196**

Yes, I thought that would do the trick also. However, when I actually tried it, I had no luck. You do change the origin of the off-screen bit map, but it doesn't stamp on in the proper place. I'm still doing (or not doing) something wrong. I'll play some more. . . .

**macintosh/softw.devlpmt #213, from msackett
a comment to 210**

Yes, I had 4.0, and I sent in my registration card. About three weeks ago Consulair sent me a letter describing the upgrade and the "Direct Access" versions of the compiler. I suppose that anyone who sent in a registration card got the letter. The upgrade cost was $20 if you sent back your old disks and $35 if you didn't. It arrived in about a week.

**macintosh/softw.devlpmt #214, from cecpate [Charles Pate]**

Help on Understanding Resources
I need help on understanding resources. *Inside Macintosh* has information, but it just hasn't made my light bulb go on. I have checked out all books on the Mac and found they all have even less on resources and how to utilize them. It's so bad that I haven't been able to get my own icon for applications to appear on the desktop.

**macintosh/softw.devlpmt #218, from rgball
a comment to 212**

OK, I got it figured out. It's critical where the SetOrigin call is placed in the flow of the code. The "bounds.rect" of the off-screen bit map must also be defined properly (i.e., ignore the SetOrigin). One call to SetOrigin to set it to negative values must be balanced by another to 0,0 for the routine to be reentrant.

**macintosh/softw.devlpmt #219, from chrismason [Christopher Mason]
a comment to 214**

What are you using to create the resources? If it's RMaker, give up. I never could get the thing to work right. I use Mac C also, but I create all my resources in assembler. A great reference that I still use is vol. 1 no. 7 of *MacTutor* magazine, where most of the common resource formats are described. Here's how to create a program icon:

1. You have to have the bundle bit on in your application. Use the bundle option on the MDS or Consulair linker.
2. You need several resources in your program. (Make sure the resource REL files are located in the resource section of the link file.)
3. Here's a sample:

```
.align 2
resource 'ICN#' 128
<<dc.l, 128 bytes for icon, 128 bytes for mask >>
```

```
.align 2
resource 'BNDL' 128
dc.l 'xxxx' ;signature
dc.w 0,1 ;unknown data
dc.l 'ICN#'
dc.w 0 ;# of mappings-1
dc.w 0,128 ;map local 0 to icon 128
dc.l 'FREF'
dc.w 0 ;#
dc.w 0,128
.align 2
resource 'xxxx' 0 ;same signature as above—use also as type in linker
dc.b len,'version/name'
.align 2
resource 'FREF' 128
dc.b 'APPL',0,0,0
```

Then just follow the instructions for the linker; be sure you have bundle and type.

**macintosh/softw.devlpmt #221, from paul.hoffman [Paul Hoffman]**
**a comment to 219**

I have no problems using RMaker, except that the Mac RMaker uses a different format (slightly) than the Lisa RMaker. Still, I've never had any problems with the Mac RMaker when I followed the examples that came with my compilers.

## A Problem with Characters in Pascal

**macintosh/softw.devlpmt #223, from paul.hoffman**

I am trying to count the number of CR characters in a file as part of a larger program. I have read the file into a buffer pointed to by lPtr.
I tried the following procedure:

```
PROCEDURE CountCR(lPtr: Ptr; Size: longint; var Ct: longint);
Var
     nCRs, i:     longint;
     testbyte:    byte;
     testptr:     ^byte;
Begin
     nCRs := 0;
     for i := 0 to Size-1 do
          begin
               testptr := POINTER(i+ORD(lPtr));
               testbyte := testptr^; {crash-o-rama}
               if testbyte = 13 then nCRs := nCRs + 1;
          end;
          Ct := nCRs;
End;
```

The line with the comment causes a system crash (ID=02). If I take out the commented line and the one following it, it runs just fine. If I take out the commented line and substitute "testptr^" for "testbyte" on the following line, it crashes again. My guess is that something is wrong with using testptr^.

I'm compiling with TML Pascal. Can anyone hazard a guess what I am doing wrong? Is it a compiler problem? Is there another graceful way to step through a buffer without knowing the size ahead of time?

**macintosh/softw.devlpmt #224, from ccrawfor [Chris Crawford]**
**a comment to 223**

At last *I* get to help somebody else for a change! Your problem lies in the fact that you have a pointer with an odd value. That is, when your loop index "i" has an odd value, the value of "testptr" will be odd. This is a severe no-no with the 68000, which is why you got an ID=02 error.

How, then, does one access individual bytes in a long sequence? Well, you could make a hibyte and lobyte function in assembly language that takes a 16-bit word and returns the two constituent bytes of that word. That's the "trust nobody, do it yourself" solution. It is also possible to do the same thing in Pascal with modulo-256 computations. Alternatively, you might bring the file into a string 256 bytes at a time and then use string manipulation functions directly.

**macintosh/softw.devlpmt #226, from paul.hoffman**
**a comment to 224**

Thank you, thank you, thank you. I know virtually nothing about the 68000, but I understand your explanation about the pointer being odd. I will simply try bringing two bytes in at a time and working from there.

## Another MacPlot Question

**macintosh/prod.discussn #375, from rweaver [Robert Weaver]**

I have some questions about MacPlot:

1. Does it use the maximum resolution of the plotter?
2. Are all objects clipped properly with respect to other objects? (E.g., if I draw a white filled box over a black filled box, will the plot look the same as the screen?)
3. Is MacPlot a driver or an application?
4. Does it work with Houston Instrument plotters?

**macintosh/prod.discussn #376, from bvanantwerp [Bill Vanantwerp]**
**a comment to 375**

Using the HP 7475 plotter, the resolution of the plotting is about the maximum of the plotter. The plots are scaled very closely to the screen if the drawing was done in MacDraft or MacDraw. MacPaint I cannot comment on. MacPlot is definitely an application and cannot be built into the normal applications except through Switcher. Several Houston Instrument plotters are supported. Caveat: The outputs are still not as good as from several of the IBM programs available.

## Lisa or Mac Plus?

**macintosh/lisa #18, from johnbell [John Bell]**

Apple has made the offer to accept our Lisas and $1500 of our cash for a new Mac Plus with an HD20. Is this a good deal? How many of us are willing to switch? What are the benefits/faults of this idea?

I desire to switch, but it is extremely unlikely that I can raise a spare $1500 by the deadline (mid-August, right?). Also, I'm a little leery of getting an HD20 with it, as I understand that it is slow, because it connects to the external drive port. There are rumors that Apple is coming out with a faster HD for the Mac Plus, and I'd rather get that (or a HyperDrive) for my system. I've heard that there are some incompatibility problems between software written for the Mac and the Mac Plus—are these vendors going to rewrite their software? Are these the same incompatibility problems that I'm having with my Lisa in Mac Environment? I'm really not sure that trading to a Mac Plus will get me anything but sound if all of the incompatibility problems are addressed with a new version of MacWorks XL and by having vendors change their software to become more generic. Any ideas?

**macintosh/lisa #19, from lloeb**
**a comment to 18**

The incompatibility problems are HFS-related, mostly. The future incompatibility problems will arise when software tries to use calls in the 128K ROM that are not in 64K ROMs, but those are not showing up yet. Depends on what you want to do. I don't want a machine I can't carry around with me, so I'm committed to the original case Mac. That doesn't mean there won't be alternative solutions for people who want different things from their machines. The HD20 will have an SCSI port soon, so that may speed it up. ■

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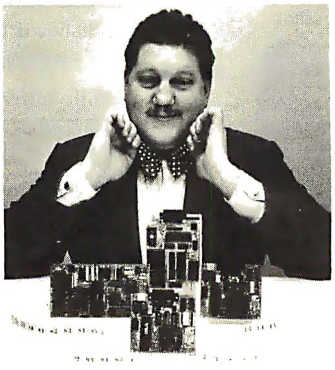

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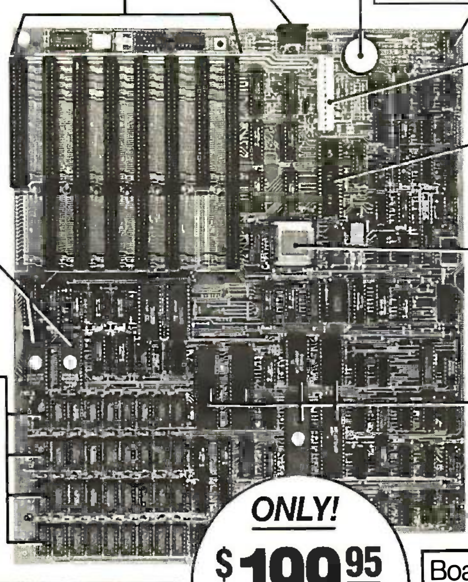

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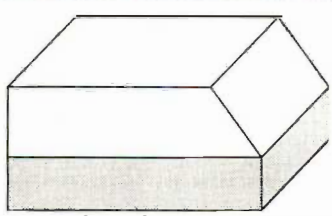

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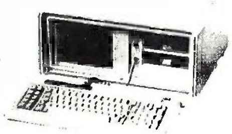

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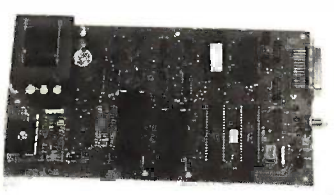

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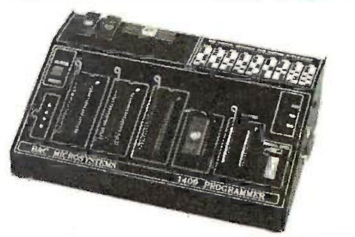


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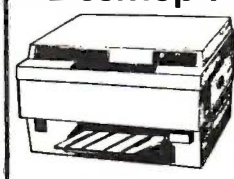

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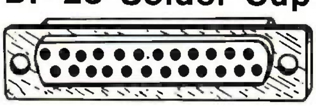

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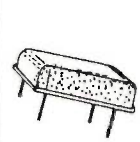

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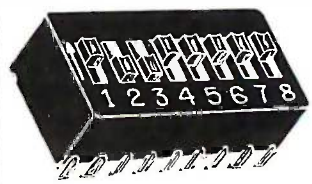


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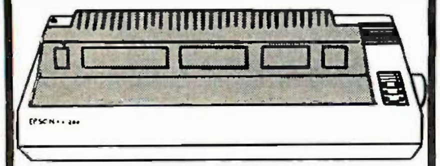

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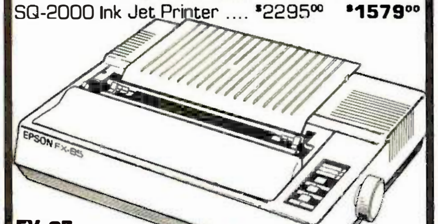

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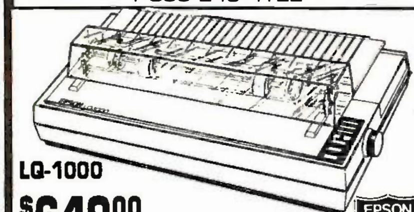

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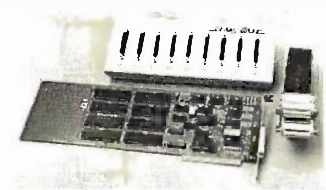

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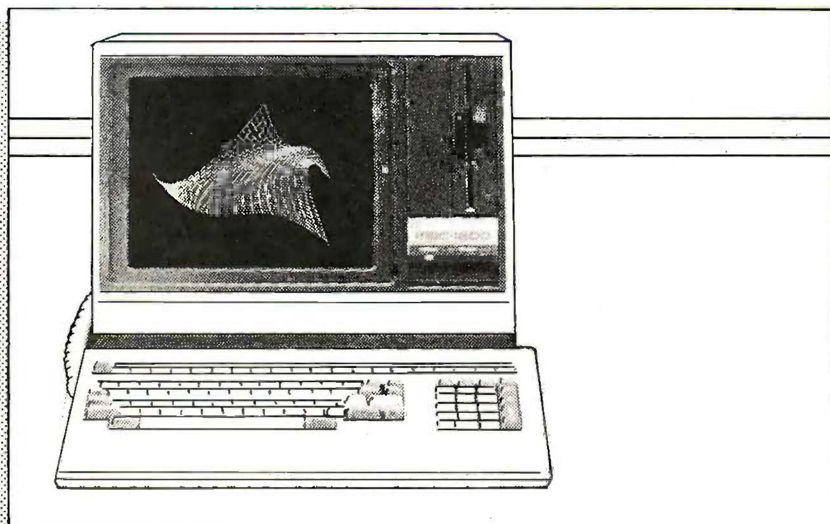

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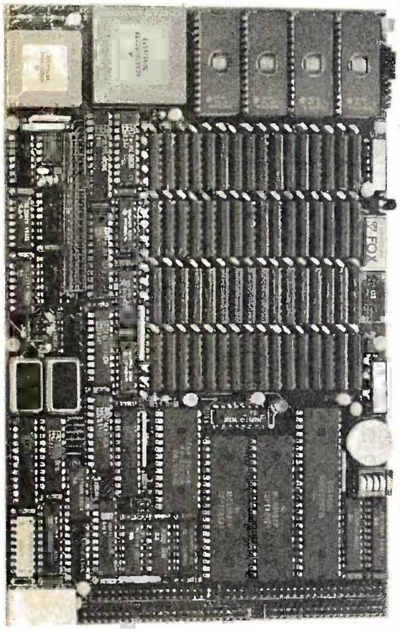

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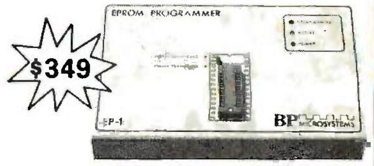


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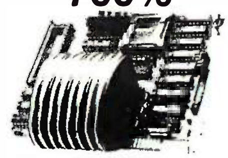

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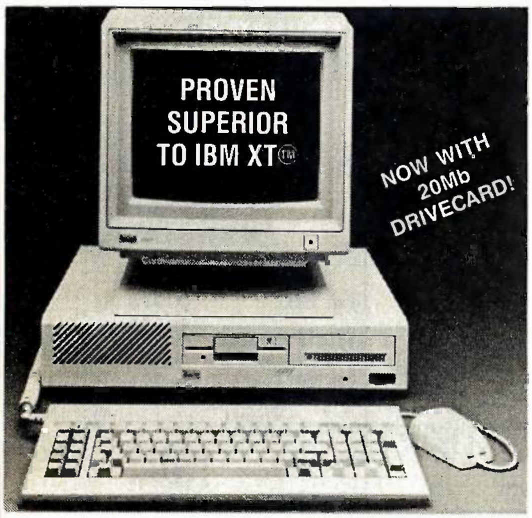


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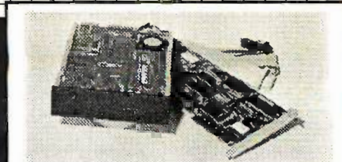

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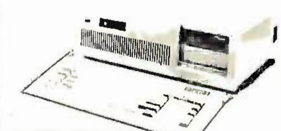

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| Ribbon Edgecard | IDExx | 1.70 | 2.15 | 2.50 | 2.60 | 3.70 | 3.95 |
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|---|---|---|---|---|---|
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| | | | | | |
|---|---|---|---|---|---|
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| 80C85A | 9.95 | 8228 | 3.40 | 8262 | 6.25 |
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| 8088 | 17.50 | 8238 | 4.25 | 8266 | 6.45 |
| 8089 | 68.95 | 8243 | 3.95 | 8287 | 6.45 |
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| 8156 | 6.75 | 8251 | 4.25 | 8289 | 44.95 |
| 6185 | 26.95 | 8251A | 5.95 | 8292 | 12.95 |
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| 6203 | 37.95 | 8255 | 4.25 | 8746 | 24.50 |
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| Z80-SIO/0 | 8.50 | 9.50 | 22.95 |
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| | | | | | |
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| Z8530 | 34.95 | Z8002 | 34.95 | Z8671 | 37.95 |

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| 1793 | 21.50 | 2795 | 32.95 | 2143 | 6.95 |
| 1795 | 21.50 | 2797 | 27.95 | 9216 | 12.95 |

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| 68B45 | 17.95 | 7220 | 34.95 | 8350 | 39.95 |
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| 46505 | 14.75 | 5037 | 21.95 | 8002 | 19.95 |
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| 1013A | 3.95 | 8250 | 10.50 | TMS5501 | 14.95 |
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|---|---|---|---|
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| 2708 (450nS) | 3.65 | 2732A (250nS) | 6.95 |
| 2758 (5V) | 5.50 | 2732A-2 (200nS) | 8.95 |
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|---|---|---|---|
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| 21L02 (450nS) | .99 | TMM2016-2 (200nS) | 4.10 |
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| 4002 | .22 | 4030 | .39 | 4066 | .39 | 4507 | 1.10 |
| 4006 | .79 | 4034 | 3.25 | 4069 | .28 | 4508 | 1.90 |
| 4007 | .22 | 4032 | 2.15 | 4070 | .35 | 4510 | .79 |
| 4008 | .95 | 4034 | 1.91 | 4071 | .28 | 4511 | .79 |
| 4009 | .39 | 4035 | .75 | 4072 | .28 | 4512 | .79 |
| 4010 | .39 | 4037 | 1.95 | 4073 | .28 | 4514 | 1.18 |
| 4011 | .24 | 4040 | .75 | 4075 | .28 | 4515 | 1.79 |
| 4012 | .24 | 4041 | .75 | 4076 | .75 | 4516 | 1.19 |
| 4013 | .35 | 4042 | .65 | 4077 | .35 | 4518 | .85 |
| 4014 | .75 | 4043 | .85 | 4078 | .35 | 4520 | .75 |
| 4015 | .39 | 4044 | .69 | 4081 | .29 | 4555 | .95 |
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| LM305H | .95 | LM710 | .68 | MC4024 | 3.75 |
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| LM311CN | .62 | LM733 | .98 | CA3023 | 2.75 |
| LM312H | 1.75 | LM739 | 1.85 | CA3039 | 1.25 |
| LM318CN | 1.45 | LM741CN | .33 | CA3046 | 1.25 |
| LM318H | 1.55 | LM741H | .40 | CA3059 | 2.85 |
| LM319N | 1.20 | LM741N | .29 | CA3060 | 2.85 |
| LM320 (see VRs) | | LM747 | .65 | CA3065 | 1.69 |
| LM324N | .55 | LM748 | .55 | CA3080 | 1.10 |
| LM339N | .95 | LM1014 | 1.15 | CA3081 | 1.60 |
| LM340(see VRs) | | LM1303 | 1.90 | CA3082 | 1.60 |
| LM348N | .95 | LM1310 | 1.45 | CA3083 | 1.55 |
| LM358CN | .65 | MC1330 | 1.65 | CA3086 | .80 |
| LM359 | 1.75 | MC1349 | 1.85 | CA3089 | 2.95 |
| LM360N | 2.95 | MC1350 | 1.15 | CA3096 | 3.45 |
| LM370N | 4.95 | MC1358 | 1.65 | CA3130 | 1.29 |
| LM373N | 3.95 | MC1372 | 6.75 | CA3140 | 1.15 |
| LM376N | 3.75 | LM1414 | 1.55 | CA3146 | 1.79 |
| LM377N | 1.90 | LM1558H | 2.99 | CA3160 | 1.49 |
| LM380CN | .65 | LM1800 | 2.35 | LM13080 | 1.25 |
| LM380N | 1.05 | LM1812 | 8.10 | LM13600 | 1.45 |
| LM381N | 1.59 | LM1830 | 3.40 | LM13700 | 1.45 |
| LM382N | 1.35 | LM1871 | 5.45 | LF347 | 2.19 |
| LM383N | 1.95 | LM1872 | 5.45 | LF351 | .60 |
| LM384N | 1.75 | LM1877 | 3.20 | LF353 | .99 |
| LM386N | .89 | LM1889 | 1.90 | LF355 | 1.10 |
| LM387N | 1.29 | LM1896 | 1.70 | LF356 | 1.10 |
| LM389N | 1.15 | ULN2001 | 1.95 | LF357 | 1.39 |
| LM392N | .69 | ULN2003 | 1.49 | TL071CP | .79 |
| LM723N | .48 | XR2206 | 3.75 | TL072CP | 1.35 |
| LM723H | .55 | XR2207 | 2.90 | TL074CN | 1.90 |
| NE531 | 2.85 | XR2206 | 2.40 | TL081CP | .59 |
| NE555 | .35 | XR2211 | 3.75 | TL084CN | 1.90 |
| NE556 | .65 | LM2877P | 2.00 | TL494 | 4.10 |
| NE558 | 1.49 | LM2878P | 2.25 | TL496 | 1.65 |
| NE561 | 23.50 | LM2900 | .83 | TL497 | 3.20 |
| NE564 | 2.85 | LM2901 | .99 | MC3423 | 1.49 |
| LM565 | .95 | LM2903 | .69 | MC3453 | 4.95 |
| LM566 | 1.45 | LM2907 | 2.45 | MC3456 | 1.29 |
| LM567 | .85 | LM2917 | 2.85 | MC3459 | 3.75 |
| NE570 | 3.85 | LM3900 | .55 | MC3469 | 5.25 |
| NE571 | 2.90 | LM3905 | 1.15 | MC3470 | 7.95 |

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|---|---|---|---|
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| 78L05, 12, 15 V | .65 | 79L05, 12, 15V | .75 |
| 78M06C | .89 | LM309K | 1.25 |
| 76MG/79MG | 1.49 | LM317H/K | 1.25/3.85 |
| 78H05KC | 6.75 | LM323K | 4.85 |
| 7805K Also 12, 15, 24V | 1.29 | LM337K | 3.75 |
| 7905T Also 8, 12, 15, 24V | .79 | LM338K | 6.75 |
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| 7405 | .23 | 7453 | .19 | 74136 | .75 | 74182 | 1.15 |
| 7406 | .49 | 7454 | .19 | 74141 | .85 | 74184 | 2.25 |
| 7407 | .49 | 7459 | .25 | 74142 | 2.95 | 74185 | 2.25 |
| 7408 | .24 | 7460 | .37 | 74143 | 3.70 | 74190 | .67 |
| 7409 | .19 | 7470 | .29 | 74144 | 2.95 | 74191 | .67 |
| 7410 | .19 | 7472 | .29 | 74145 | .50 | 74192 | .67 |
| 7411 | .24 | 7473 | .33 | 74147 | 1.49 | 74193 | .67 |
| 7412 | .38 | 7474 | .33 | 74148 | 1.19 | 74194 | .67 |
| 7413 | .34 | 7475 | .38 | 74150 | 1.09 | 74195 | .67 |
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| 7416 | .49 | 7479 | 4.60 | 74152 | .67 | 74197 | .86 |
| 7417 | .49 | 7480 | .69 | 74153 | .53 | 74198 | 1.15 |
| 7420 | .19 | 7482 | .95 | 74154 | 1.19 | 74199 | 1.15 |
| 7421 | .35 | 7483 | .45 | 74155 | .69 | 74221 | 1.19 |
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| 7423 | .58 | 7486 | .35 | 74157 | .59 | 74273 | 1.65 |
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| 7427 | .29 | 7491 | .65 | 74160 | .79 | 74283 | 1.40 |
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| 7437 | .25 | 7495 | .50 | 74164 | .69 | 74298 | 1.49 |
| 7438 | .29 | 7496 | .59 | 74165 | .69 | 74365 | .55 |
| 7439 | .58 | 7497 | 2.70 | 74166 | .65 | 74366 | .55 |
| 7440 | .19 | 74100 | 1.50 | 74167 | 2.75 | 74367 | .55 |
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| 7442 | .45 | 74109 | .37 | 74172 | 4.75 | 74390 | 1.45 |
| 7443 | 1.15 | 74116 | 1.45 | 74173 | .89 | 74393 | 1.33 |
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| 74LS02 | .15 | 74LS122 | .45 | 74LS249 | .98 |
| 74LS03 | .15 | 74LS123 | .45 | 74LS251 | .59 |
| 74LS04 | .24 | 74LS124 | 2.75 | 74LS253 | .59 |
| 74LS05 | .25 | 74LS125 | .49 | 74LS257 | .59 |
| 74LS08 | .27 | 74LS126 | .49 | 74LS258 | .59 |
| 74LS09 | .26 | 74LS132 | .59 | 74LS259 | 2.95 |
| 74LS10 | .25 | 74LS136 | .39 | 74LS260 | .59 |
| 74LS11 | .33 | 74LS138 | .59 | 74LS261 | 2.49 |
| 74LS12 | .33 | 74LS139 | .59 | 74LS266 | .55 |
| 74LS13 | .39 | 74LS145 | 1.19 | 74LS273 | 1.45 |
| 74LS14 | .59 | 74LS148 | 1.38 | 74LS275 | 3.29 |
| 74LS15 | .33 | 74LS151 | .55 | 74LS279 | .55 |
| 74LS20 | .26 | 74LS153 | .55 | 74LS283 | .69 |
| 74LS21 | .29 | 74LS154 | 1.49 | 74LS290 | .88 |
| 74LS22 | .29 | 74LS155 | .69 | 74LS293 | .78 |
| 74LS26 | .29 | 74LS156 | .69 | 74LS295 | .98 |
| 74LS27 | .29 | 74LS157 | .69 | 74LS298 | .88 |
| 74LS28 | .29 | 74LS158 | .69 | 74LS324 | 1.75 |
| 74LS30 | .25 | 74LS160 | .69 | 74LS347 | 1.95 |
| 74LS32 | .33 | 74LS161 | .69 | 74LS348 | 1.95 |
| 74LS33 | .53 | 74LS162 | .69 | 74LS352 | 1.25 |
| 74LS37 | .35 | 74LS163 | .69 | 74LS353 | 1.25 |
| 74LS38 | .39 | 74LS164 | .69 | 74LS363 | 1.29 |
| 74LS40 | .25 | 74LS165 | .90 | 74LS364 | 1.95 |
| 74LS42 | .44 | 74LS166 | 1.90 | 74LS365 | .48 |
| 74LS47 | .74 | 74LS168 | 1.15 | 74LS366 | .48 |
| 74LS48 | .74 | 74LS169 | 1.15 | 74LS367 | .45 |
| 74LS51 | .25 | 74LS170 | 1.40 | 74LS368 | .45 |
| 74LS54 | .29 | 74LS173 | .67 | 74LS373 | 1.39 |
| 74LS55 | .29 | 74LS174 | .67 | 74LS374 | 1.33 |
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| 74LS78 | .39 | 74LS192 | .78 | 74LS390 | 1.15 |
| 74LS83 | .59 | 74LS193 | .78 | 74LS393 | 1.15 |
| 74LS85 | .69 | 74LS194 | .69 | 74LS395 | 1.15 |
| 74LS86 | .39 | 74LS195 | .69 | 74LS399 | 1.47 |
| 74LS90 | .54 | 74LS196 | .79 | 74LS424 | 2.95 |
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| 74S08 | .39 | 74S114 | .55 | 74S188* | 1.49 | 74S374 | 2.09 |
| 74S09 | .39 | 74S124 | 2.69 | 74S194 | 1.49 | 74S387* | 1.95 |
| 74S10 | .35 | 74S132 | 1.39 | 74S195 | 1.49 | 74S471* | 5.95 |
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| 74S85 | 1.49 | 74S287* | 1.69 |
| 74S86 | .35 | 74S288* | 1.69 |
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| 74S175 | .79 | 74S472* | 3.49 |

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| | | | |
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| 74ALS02 | .35 | 74ALS174 | .89 |
| 74ALS04 | .39 | 74ALS175 | .89 |
| 74ALS08 | .35 | 74ALS240 | 1.79 |
| 74ALS10 | .35 | 74ALS244 | 1.79 |
| 74ALS27 | .39 | 74ALS245 | 2.49 |
| 74ALS30 | .35 | 74ALS373 | 1.95 |
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| 74ALS74 | .55 | 74ALS573 | 1.95 |

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| 6840 | 6.75 | 8224 | 2.25 | AY-3-1015D | 4.95 |
| | | 8228 | 3.49 | AY-5-1013A | 3.95 |

| Part No. | Function | | Price |
|---|---|---|---|
| **DYNAMIC RAMS** | | | |
| 4116N-15 | 16,384 x 1 | (150ns) | .89 |
| 4128 (Piggyback) | 131,072 x 1 | (200ns) | 5.95 |
| 4164N-150 | 65,536 x 1 | (150ns) | 1.25 |
| 4164N-200 | 65,536 x 1 | (200ns) | 1.15 |
| TMS4416-12 | 16,384 x 4 | (120ns) | 4.95 |
| MM5280 | 4096 x 1 | (200ns) 2107 | 1.95 |
| 8118 | 16,384 x 1 | (120ns) (+5V Only Required) | .99 |
| 41256-150 | 262,144 x 1 | (150ns) | 2.95 |
| 50464-15 | 65,536 x 4 | (150ns) (4464) (41464) | 6.49 |
| **STATIC RAMS** | | | |
| TMM2016-12 | 2048 x 8 | (120ns) | 1.69 |
| 2102 | 1024 x 1 | (350ns) | .89 |
| 2102-2L | 1024 x 1 | (250ns) LP. (91L02) | 1.49 |
| 2114N | 1024 x 4 | (450ns) | .99 |
| 2114N-L | 1024 x 4 | (450ns) LP. | 1.09 |
| 2114N-2 | 1024 x 4 | (200ns) | 1.05 |
| 2114N-2L | 1024 x 4 | (200ns) LP. | 1.49 |
| 21C14 | 1024 x 4 | (200ns) (CMOS) | .49 |
| 2149 | 1024 x 4 | (45ns) | 4.95 |
| 5101 | 256 x 4 | (450ns) CMOS | 3.95 |
| HM6116P-3 | 2048 x 8 | (150ns) CMOS | 1.45 |
| HM6116LP-3 | 2048 x 8 | (150ns) LP. CMOS | 1.49 |
| HM6264P-12 | 8192 x 8 | (120ns) CMOS | 4.09 |
| HM6264LP-12 | 8192 x 8 | (120ns) LP. CMOS | 4.29 |
| HM6264P-15 | 8192 x 8 | (150ns) CMOS | 3.75 |
| HM6264LP-15 | 8192 x 8 | (150ns) LP. CMOS | 3.89 |
| 6514 | 1024 x 4 | (350ns) CMOS (UPD444C) | 4.49 |
| **PROMS/EPROMS** | | | |
| 1702A | 256 x 8 | (1μs) | 5.95 |
| TMS2516 | 2048 x 8 | (450ns) 25V | 4.95 |
| TMS2532 | 4096 x 8 | (450ns) 25V | 5.95 |
| TMS2564 | 8192 x 8 | (450ns) 25V | 9.95 |
| 2708 | 1024 x 8 | (450ns) | 3.95 |
| TMS2716 | 2048 x 8 | (450ns) 3 voltage | 9.95 |
| 2716 | 2048 x 8 | (450ns) | 3.49 |
| 2716-1 | 2048 x 8 | (350ns) 25V | 4.95 |
| 27C16 | 2048 x 8 | CMOS | 7.95 |
| 2732 | 4096 x 8 | (450ns) | 4.75 |
| 2732A-20 | 4096 x 8 | (200ns) 21V | 4.95 |
| 2732A-25 | 4096 x 8 | (250ns) 21V | 4.49 |
| 2732A-45 | 4096 x 8 | (450ns) 21V | 4.25 |
| 27C32 | 4096 x 8 | CMOS | 7.95 |
| 2758 | 1024 x 8 | (450ns) Single +5V | 3.95 |
| 2764-20 | 8192 x 8 | (200ns) 21V | 4.49 |
| 2764-25 | 8192 x 8 | (250ns) 21V | 4.25 |
| 2764A-25 | 8192 x 8 | (250ns) 12.5V | 4.49 |
| 2764-45 | 8192 x 8 | (450ns) 21V | 3.95 |
| 27C64 | 8192 x 8 | CMOS 21V | 5.95 |
| 27128-25 | 16,384 x 8 | (250ns) 128K 21V | 3.95 |
| 27128A-25 | 16,384 x 8 | (250ns) 12.5V | 5.95 |
| 27256-25 | 32,768 x 8 | (250ns) 256K (12.5V) | 6.95 |
| 27C256-25 | 32,768 x 8 | (250ns) 256K (CMOS) (12.5V) | 10.95 |
| 68764 | 8192 x 8 | (450ns) 25V | 15.95 |
| 68766 | 8192 x 8 | (350ns) 25V | 16.95 |
| 74S387 | 256 x 4 | PROM O.C. | 1.69 |
| 74S471 | 256 x 8 | PROM T.S. | 4.95 |
| 82S123 | 32 x 8 | PROM T.S. | 2.95 |
| 82S129 | 256 x 4 | PROM T.S. | 2.95 |

**LOW PROFILE (TIN) SOCKETS**

| Part No. | 1-9 | 10-99 | 100-up |
|---|---|---|---|
| 8 pin LP | .13 | .12 | .11 |
| 14 pin LP | .15 | .13 | .11 |
| 16 pin LP | .17 | .15 | .13 |
| 24 pin LP | .31 | .30 | .29 |
| 28 pin LP | .39 | .37 | .35 |
| 40 pin LP | .49 | .46 | .43 |

**WIRE WRAP SOCKETS (GOLD) LEVEL #3**

| Part No. | 1-9 | 10-99 | 100-up |
|---|---|---|---|
| 8 pin WW | .55 | .49 | .45 |
| 14 pin WW | .69 | .65 | .59 |
| 16 pin WW | .75 | .69 | .65 |
| 24 pin WW | 1.19 | 1.09 | .99 |
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| FE0203D | 12.95 | 7211IPL (TTL) | 7.95 |
| 7106CPL | 8.95 | 7211MIPL(Micro) | 8.49 |
| 7106EV/Kit | 46.95 | 7217IJI | 10.95 |
| 7107CPL | 8.95 | 7217AIPI | 8.95 |
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| 74HC04 | .39 | 74HC240 | 1.39 |
| 74HC08 | .39 | 74HC244 | 1.49 |
| 74HC10 | .39 | 74HC245 | 1.59 |
| 74HC14 | .59 | 74HC253 | .79 |
| 74HC30 | .39 | 74HC259 | 1.19 |
| 74HC32 | .45 | 74HC273 | 1.79 |
| 74HC74 | .45 | 74HC373 | 1.49 |
| 74HC75 | .69 | 74HC374 | 1.49 |
| 74HC76 | .69 | 74HC393 | 1.19 |
| 74HC85 | 1.19 | 74HC595 | 1.95 |
| 74HC86 | .59 | 74HC688 | 1.95 |
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| 74HC125 | .99 | 74HC4049 | .79 |
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| 74HC138 | .79 | 74HC4060 | 1.19 |
| 74HC139 | .79 | 74HC4511 | 1.95 |
| 74HC154 | 1.95 | 74HC4514 | 2.95 |
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| 74C02 | .29 | 74C175 | .89 |
| 74C04 | .25 | 74C221 | 1.19 |
| 74C08 | .35 | 74C240 | 1.59 |
| 74C10 | .29 | 74C244 | 1.59 |
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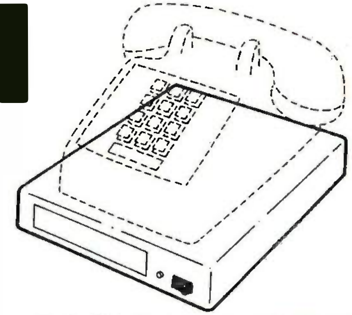

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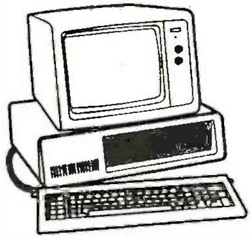

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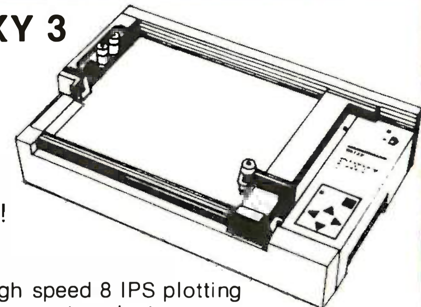

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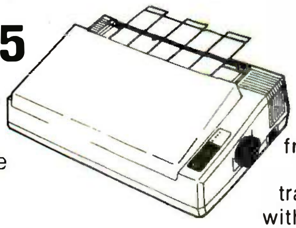

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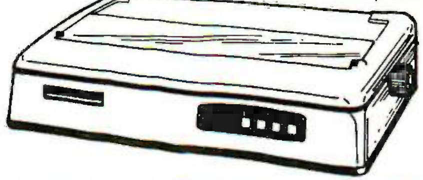

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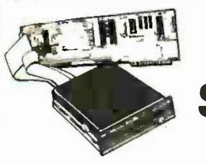

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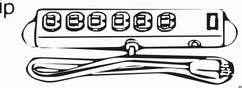

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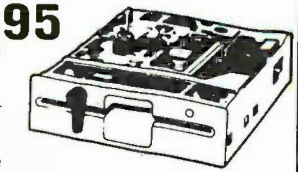

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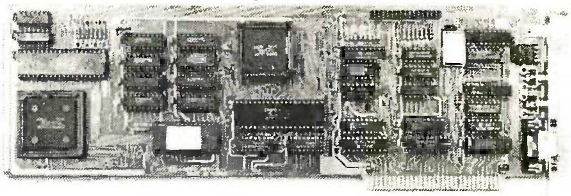

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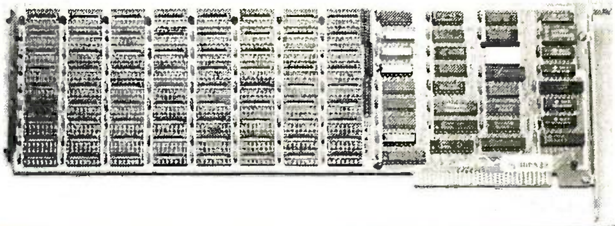

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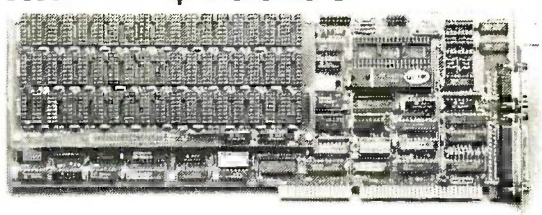

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## CLASSIC 286 SPEED PAK $795.00

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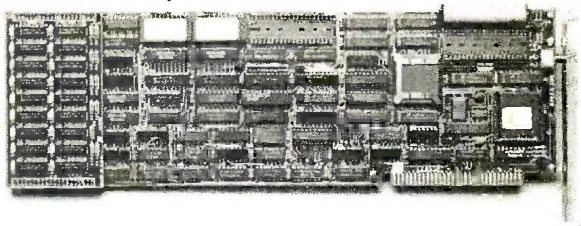

* 8MHz 80286 RUNS 33% FASTER THAN A STANDARD AT
* RUNS AT PROGRAMS—COMPATIBLE WITH DOS 2.1, 3.0 & 3.1
* COMPATIBLE WITH ALL PC/XT HARDWARE & SOFTWARE WITH NO PATCHES OR MODIFICATIONS NEEDED
* 1 MEGABYTE MEMORY ON BOARD, EXPANDABLE TO 16MB
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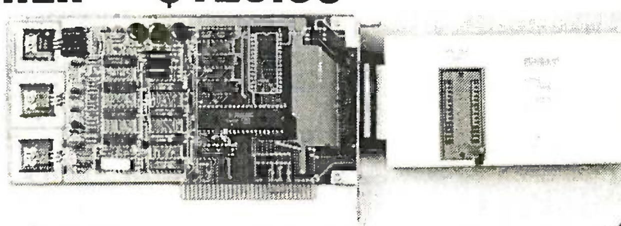
## EPROM PROGRAMMER $129.95

*FOR IBM PC/XT/AT AND COMPATIBLES*



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* MENU DRIVEN SOFTWARE PROVIDED ON DISKETTE
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## STATIC RAMS

| | | | |
|---|---|---|---|
| 2101 | 256x4 | (450ns) | 1.95 |
| 5101 | 256x4 | (450ns)(CMOS) | 3.95 |
| 2102L-4 | 1024x1 | (450ns)(LP) | .99 |
| 2112 | 256x4 | (450ns) | 2.99 |
| 2114 | 1024x4 | (450ns) | .99 |
| 2114L-4 | 1024x4 | (450ns)(LP) | 1.09 |
| 2114L-2 | 1024x4 | (200ns)(LP) | 1.49 |
| 2114L-15 | 1024x4 | (150ns)(LP) | 1.95 |
| TMS4044-4 | 4096x1 | (450ns) | 1.95 |
| TMM2016-150 | 2048x8 | (150ns) | 1.49 |
| TMM2016-100 | 2048x8 | (100ns) | 1.95 |
| HM6116-4 | 2048x8 | (200ns)(CMOS) | 1.39 |
| HM6116-3 | 2048x8 | (150ns)(CMOS) | 1.49 |
| HM6116LP-4 | 2048x8 | (200ns)(CMOS)(LP) | 1.49 |
| HM6116LP-3 | 2048x8 | (150ns)(CMOS)(LP) | 1.59 |
| HM6116LP-2 | 2048x8 | (120ns)(CMOS)(LP) | 2.95 |
| HM6264P-15 | 8192x8 | (150ns)(CMOS) | 3.89 |
| HM6264LP-15 | 8192x8 | (150ns)(CMOS)(LP) | 3.95 |
| HM6264LP-12 | 8192x8 | (120ns)(CMOS)(LP) | 4.49 |

LP=Low power

## DYNAMIC RAMS

| | | | |
|---|---|---|---|
| 4116-250 | 16384x1 | (250ns) | .49 |
| 4116-200 | 16384x1 | (200ns) | .69 |
| 4116-150 | 16384x1 | (150ns) | .89 |
| 4116-120 | 16384x1 | (120ns) | 1.49 |
| MK4332 | 32768x1 | (200ns) | 6.95 |
| 4164-200 | 65536x1 | (200ns)(5v) | 1.19 |
| 4164-150 | 65536x1 | (150ns)(5v) | 1.29 |
| 4164-120 | 65536x1 | (120ns)(5v) | 1.95 |
| MCM6665 | 65536x1 | (200ns)(5v) | 1.95 |
| TMS4164 | 65536x1 | (150ns)(5v) | 1.95 |
| 4164-REFRESH | 65536x1 | (150ns)(5V)(REFRESH) | 2.95 |
| TMS4416 | 16384x4 | (150ns)(5v) | 4.95 |
| 41128-150 | 131072x1 | (150ns)(5v) | 5.95 |
| TMS4464-15 | 65536x4 | (150ns)(5v) | 6.95 |
| 41256-200 | 262144x1 | (200ns)(5v) | 2.95 |
| 41256-150 | 262144x1 | (150ns)(5v) | 2.95 |

5v=Single 5 Volt Supply  REFRESH=Pin 1 Refresh

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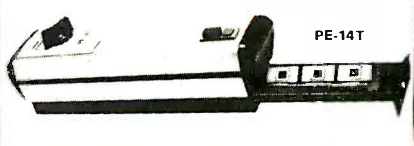
| | | | |
|---|---|---|---|
| 2708 | 1024x8 | (450ns) | 3.95 |
| 2716 | 2048x8 | (450ns)(5V) | 3.49 |
| 2716-1 | 2048x8 | (350ns)(5V) | 3.95 |
| TMS2532 | 4096x8 | (450ns)(5V) | 3.95 |
| 2732 | 4096x8 | (450ns)(5V) | 3.89 |
| 2732A | 4096x8 | (250ns)(5V)(21V PGM) | 3.95 |
| 2732A-2 | 4096x8 | (200ns)(5V)(21V PGM) | 4.25 |
| 27C64 | 8192x8 | (250ns)(5V)(CMOS) | 5.95 |
| 2764 | 8192x8 | (450ns)(5V) | 3.49 |
| 2764-250 | 8192x8 | (250ns)(5V) | 3.95 |
| 2764-200 | 8192x8 | (200ns)(5V) | 4.25 |
| MCM68766 | 8192x8 | (350ns)(5V)(24 PIN) | 17.95 |
| 27128 | 16384x8 | (250ns)(5V) | 4.25 |
| 27C256 | 32768x8 | (250ns)(5V)(CMOS) | 12.95 |
| 27256 | 32768x8 | (250ns)(5V) | 7.49 |

5V=Single 5 Volt Supply  21V PGM=Program at 21 Volts

## SPECTRONICS CORPORATION EPROM ERASERS




| Model | Timer | Capacity Chip | Intensity (uW/Cm²) | Unit Price |
|---|---|---|---|---|
| PE-14 | NO | 9 | 8,000 | $83.00 |
| PE-14T | YES | 9 | 8,000 | $119.00 |
| PE-24T | YES | 12 | 9,600 | $175.00 |

## 8000

| | |
|---|---|
| 8035 | 1.49 |
| 8039 | 1.95 |
| 8080 | 2.95 |
| 8085 | 2.49 |
| 8087-2 | 169.95 |
| 8087 | 129.00 |
| 8088 | 6.95 |
| 8088-2 | 9.95 |
| 8155 | 2.49 |
| 8155-2 | 3.95 |
| 8748 | 7.95 |
| 8755 | 19.95 |
| 80286 | 129.95 |
| 80287 | 199.95 |

## 8200

| | |
|---|---|
| 8203 | 29.95 |
| 8205 | 3.29 |
| 8212 | 1.49 |
| 8216 | 1.49 |
| 8224 | 2.25 |
| 8237 | 4.95 |
| 8237-5 | 5.49 |
| 8250 | 6.95 |
| 8251 | 1.69 |
| 8251A | 1.89 |
| 8253 | 1.89 |
| 8253-5 | 1.95 |
| 8255 | 1.69 |
| 8255-5 | 1.89 |
| 8259 | 1.95 |
| 8259-5 | 2.29 |
| 8272 | 4.95 |
| 8279 | 2.49 |
| 8279-5 | 2.95 |
| 8282 | 3.95 |
| 8284 | 2.95 |
| 8286 | 3.95 |
| 8288 | 4.95 |

## Z-80

| | |
|---|---|
| Z80-CPU 2.5 MHz | 1.69 |

### 4.0 MHz

| | |
|---|---|
| Z80A-CPU | 1.79 |
| Z80A-CTC | 1.89 |
| Z80A-DART | 5.95 |
| Z80A-DMA | 5.95 |
| Z80A-PIO | 1.89 |
| Z80A-SIO/0 | 5.95 |
| Z80A-SIO/1 | 5.95 |
| Z80A-SIO/2 | 5.95 |

### 6.0 MHz

| | |
|---|---|
| Z80B-CPU | 3.75 |
| Z80B-CTC | 4.25 |
| Z80B-PIO | 4.25 |
| Z80B-DART | 14.95 |
| Z80B-SIO/0 | 12.95 |
| Z80B-SIO/2 | 12.95 |
| Z8671 ZILOG | 19.95 |

## 6500

### 1.0 MHz

| | |
|---|---|
| 6502 | 2.79 |
| 65C02 (CMOS) | 12.95 |
| 6507 | 9.95 |
| 6520 | 1.95 |
| 6522 | 4.95 |
| 6526 | 26.95 |
| 6532 | 6.95 |
| 6545 | 6.95 |
| 6551 | 5.95 |
| 6561 | 19.95 |
| 6581 | 34.95 |

### 2.0 MHz

| | |
|---|---|
| 6502A | 2.95 |
| 6520A | 2.95 |
| 6522A | 5.95 |
| 6532A | 11.95 |
| 6545A | 7.95 |
| 6551A | 6.95 |

### 3.0 MHz

| | |
|---|---|
| 6502B | 6.95 |

## 6800

### 1.0 MHz

| | |
|---|---|
| 6800 | 1.95 |
| 6802 | 4.95 |
| 6803 | 9.95 |
| 6809 | 5.95 |
| 6809E | 5.95 |
| 6810 | 1.95 |
| 6820 | 2.95 |
| 6821 | 1.95 |
| 6840 | 6.95 |
| 6843 | 19.95 |
| 6844 | 12.95 |
| 6845 | 4.95 |
| 6847 | 11.95 |
| 6850 | 1.95 |
| 6883 | 22.95 |

### 2.0 MHz

| | |
|---|---|
| 68B00 | 4.95 |
| 68B02 | 5.95 |
| 68B09E | 6.95 |
| 68B09 | 6.45 |
| 68B21 | 3.50 |
| 68B45 | 6.75 |
| 68B50 | 3.95 |
| 68B54 | 7.95 |

## CLOCK CIRCUITS

| | |
|---|---|
| MM5369 | 1.95 |
| MM5369-EST | 1.95 |
| MM58167 | 12.95 |
| MM58174 | 11.95 |
| MSM5832 | 2.95 |

## CRT CONTROLLERS

| | |
|---|---|
| 6845 | 4.95 |
| 68B45 | 8.95 |
| 6847 | 11.95 |
| HD46505SP | 6.95 |
| MC1372 | 2.95 |
| 8275 | 26.95 |
| 7220 | 19.95 |
| CRT5027 | 12.95 |
| CRT5037 | 9.95 |
| TMS9918A | 19.95 |

## DISK CONTROLLERS

| | |
|---|---|
| 1771 | 4.95 |
| 1791 | 9.95 |
| 1793 | 9.95 |
| 1795 | 12.95 |
| 1797 | 12.95 |
| 2791 | 19.95 |
| 2793 | 19.95 |
| 2797 | 29.95 |
| 6843 | 19.95 |
| 8272 | 4.95 |
| UPD765 | 4.95 |
| MB8876 | 12.95 |
| MB8877 | 12.95 |
| 1691 | 6.95 |
| 2143 | 6.95 |

## BIT RATE GENERATORS

| | |
|---|---|
| MC14411 | 9.95 |
| BR1941 | 4.95 |
| 4702 | 9.95 |
| COM8116 | 8.95 |
| MM5307 | 4.95 |

## UARTS

| | |
|---|---|
| AY5-1013 | 3.95 |
| AY3-1015 | 4.95 |
| TR1602 | 3.95 |
| 2651 | 4.95 |
| IM6402 | 6.95 |
| IM6403 | 9.95 |
| INS8250 | 6.95 |

## SOUND CHIPS

| | |
|---|---|
| 76477 | 3.95 |
| 76489 | 8.95 |
| SSI-263 | 39.95 |
| AY3-8910 | 12.95 |
| AY3-8912 | 12.95 |
| SP1000 | 39.00 |

## CRYSTALS

| | |
|---|---|
| 32.768 KHz | .95 |
| 1.0 MHz | 2.95 |
| 1.8432 | 2.95 |
| 2.0 | 1.95 |
| 2.097152 | 1.95 |
| 2.4576 | 1.95 |
| 3.2768 | 1.95 |
| 3.579545 | 1.95 |
| 4.0 | 1.95 |
| 4.032 | 1.95 |
| 5.0 | 1.95 |
| 5.0688 | 1.95 |
| 6.0 | 1.95 |
| 6.144 | 1.95 |
| 6.5536 | 1.95 |
| 8.0 | 1.95 |
| 10.0 | 1.95 |
| 10.738635 | 1.95 |
| 12.0 | 1.95 |
| 14.31818 | 1.95 |
| 15.0 | 1.95 |
| 16.0 | 1.95 |
| 17.430 | 1.95 |
| 18.0 | 1.95 |
| 18.432 | 1.95 |
| 20.0 | 1.95 |
| 22.1184 | 1.95 |
| 24.0 | 1.95 |
| 32.0 | 1.95 |

## CRYSTAL OSCILLATORS

| | |
|---|---|
| 1.0MHz | 5.95 |
| 1.8432 | 5.95 |
| 2.0 | 5.95 |
| 2.4576 | 5.95 |
| 2.5 | 4.95 |
| 4.0 | 4.95 |
| 5.0688 | 4.95 |
| 6.0 | 4.95 |
| 6.144 | 4.95 |
| 8.0 | 4.95 |
| 10.0 | 4.95 |
| 12.0 | 4.95 |
| 12.480 | 4.95 |
| 15.0 | 4.95 |
| 16.0 | 4.95 |
| 18.432 | 4.95 |
| 20.0 | 4.95 |
| 24.0 | 4.95 |

## MISC.

| | |
|---|---|
| TMS99531 | 9.95 |
| TMS99532 | 19.95 |
| ULN2003 | .79 |
| 3242 | 7.95 |
| 3341 | 4.95 |
| MC3470 | 1.95 |
| MC3480 | 8.95 |
| MC3487 | 2.95 |
| 11C90 | 13.95 |
| 2513-001 UP | 6.95 |
| AY5-2376 | 11.95 |
| AY5-3600 PRO | 11.95 |

## 74LS00

| | | | |
|---|---|---|---|
| 74LS00 | .16 | 74LS165 | .65 |
| 74LS01 | .18 | 74LS166 | .95 |
| 74LS02 | .17 | 74LS169 | .95 |
| 74LS03 | .18 | 74LS173 | .49 |
| 74LS04 | .16 | 74LS174 | .39 |
| 74LS05 | .18 | 74LS175 | .39 |
| 74LS08 | .18 | 74LS191 | .49 |
| 74LS09 | .18 | 74LS192 | .69 |
| 74LS10 | .16 | 74LS193 | .69 |
| 74LS11 | .22 | 74LS194 | .69 |
| 74LS12 | .22 | 74LS195 | .69 |
| 74LS13 | .26 | 74LS196 | .59 |
| 74LS14 | .39 | 74LS197 | .59 |
| 74LS15 | .26 | 74LS221 | .59 |
| 74LS20 | .17 | 74LS240 | .69 |
| 74LS21 | .22 | 74LS241 | .69 |
| 74LS22 | .22 | 74LS242 | .69 |
| 74LS27 | .23 | 74LS243 | .69 |
| 74LS28 | .26 | 74LS244 | .69 |
| 74LS30 | .17 | 74LS245 | .79 |
| 74LS32 | .18 | 74LS251 | .49 |
| 74LS33 | .28 | 74LS253 | .49 |
| 74LS37 | .26 | 74LS256 | 1.79 |
| 74LS38 | .26 | 74LS257 | .39 |
| 74LS42 | .39 | 74LS258 | .49 |
| 74LS47 | .59 | 74LS259 | 1.29 |
| 74LS48 | .69 | 74LS260 | .49 |
| 74LS51 | .17 | 74LS266 | .39 |
| 74LS73 | .29 | 74LS273 | .79 |
| 74LS74 | .24 | 74LS279 | .39 |
| 74LS75 | .29 | 74LS280 | 1.98 |
| 74LS76 | .29 | 74LS283 | .59 |
| 74LS83 | .49 | 74LS290 | .89 |
| 74LS85 | .49 | 74LS293 | .89 |
| 74LS86 | .22 | 74LS299 | 1.49 |
| 74LS90 | .39 | 74LS322 | 3.95 |
| 74LS92 | .49 | 74LS323 | 2.49 |
| 74LS93 | .39 | 74LS364 | 1.95 |
| 74LS95 | .49 | 74LS365 | .39 |
| 74LS107 | .34 | 74LS367 | .39 |
| 74LS109 | .36 | 74LS368 | .39 |
| 74LS112 | .29 | 74LS373 | .79 |
| 74LS122 | .45 | 74LS374 | .79 |
| 74LS123 | .49 | 74LS375 | .95 |
| 74LS124 | 2.75 | 74LS377 | .79 |
| 74LS125 | .39 | 74LS378 | 1.18 |
| 74LS126 | .39 | 74LS390 | 1.19 |
| 74LS132 | .39 | 74LS393 | .79 |
| 74LS133 | .49 | 74LS541 | 1.49 |
| 74LS136 | .39 | 74LS624 | 1.95 |
| 74LS138 | .39 | 74LS640 | .99 |
| 74LS139 | .39 | 74LS645 | .99 |
| 74LS145 | .99 | 74LS669 | 1.29 |
| 74LS147 | .99 | 74LS670 | .89 |
| 74LS148 | .99 | 74LS682 | 3.20 |
| 74LS151 | .39 | 74LS683 | 3.20 |
| 74LS153 | .39 | 74LS684 | 3.20 |
| 74LS154 | 1.49 | 74LS688 | 2.40 |
| 74LS155 | .59 | 74LS783 | 22.95 |
| 74LS156 | .49 | 81LS95 | 1.49 |
| 74LS157 | .36 | 81LS96 | 1.49 |
| 74LS158 | .29 | 81LS97 | 1.49 |
| 74LS160 | .29 | 81LS98 | 1.49 |
| 74LS161 | .39 | 25LS2521 | 2.80 |
| 74LS162 | .49 | 25LS2569 | 2.80 |
| 74LS163 | .39 | 26LS31 | 1.95 |
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| | | | |
|---|---|---|---|
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| 74HC02 | .59 | 74HC151 | .89 |
| 74HC04 | .59 | 74HC154 | 2.49 |
| 74HC08 | .59 | 74HC157 | .89 |
| 74HC10 | .59 | 74HC158 | .95 |
| 74HC14 | .79 | 74HC163 | 1.15 |
| 74HC20 | .59 | 74HC175 | .99 |
| 74HC27 | .59 | 74HC240 | 1.89 |
| 74HC30 | .59 | 74HC244 | 1.89 |
| 74HC32 | .69 | 74HC245 | 1.89 |
| 74HC51 | .59 | 74HC257 | .85 |
| 74HC74 | .75 | 74HC259 | 1.39 |
| 74HC85 | 1.35 | 74HC273 | 1.89 |
| 74HC86 | .69 | 74HC299 | 4.99 |
| 74HC93 | 1.19 | 74HC368 | .99 |
| 74HC107 | .79 | 74HC373 | 2.29 |
| 74HC109 | .79 | 74HC374 | 2.29 |
| 74HC112 | .79 | 74HC390 | 1.39 |
| 74HC125 | 1.19 | 74HC393 | 1.39 |
| 74HC132 | 1.19 | 74HC4017 | 1.99 |
| 74HC133 | .69 | 74HC4020 | 1.39 |
| 74HC138 | .99 | 74HC4049 | .89 |
| 74HC139 | .99 | 74HC4050 | .89 |

### 74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

| | | | |
|---|---|---|---|
| 74HCT00 | .69 | 74HCT166 | 3.05 |
| 74HCT02 | .69 | 74HCT174 | 1.09 |
| 74HCT04 | .69 | 74HCT193 | 1.39 |
| 74HCT08 | .69 | 74HCT194 | 1.19 |
| 74HCT10 | .69 | 74HCT240 | 2.19 |
| 74HCT11 | .69 | 74HCT241 | 2.19 |
| 74HCT27 | .69 | 74HCT244 | 2.19 |
| 74HCT30 | .69 | 74HCT245 | 2.19 |
| 74HCT32 | .79 | 74HCT257 | .99 |
| 74HCT74 | .85 | 74HCT259 | 1.59 |
| 74HCT75 | .95 | 74HCT273 | 2.09 |
| 74HCT138 | 1.15 | 74HCT367 | 1.09 |
| 74HCT139 | 1.15 | 74HCT373 | 2.49 |
| 74HCT154 | 2.99 | 74HCT374 | 2.49 |
| 74HCT157 | .99 | 74HCT393 | 1.59 |
| 74HCT158 | .99 | 74HCT4017 | 2.19 |
| 74HCT161 | 1.29 | 74HCT4040 | 1.59 |
| 74HCT164 | 1.39 | 74HCT4060 | 1.49 |

## 74F00

| | | | | | |
|---|---|---|---|---|---|
| 74F00 | .69 | 74F74 | .79 | 74F251 | 1.69 |
| 74F02 | .69 | 74F86 | .99 | 74F253 | 1.69 |
| 74F04 | .79 | 74F138 | 1.69 | 74F257 | 1.69 |
| 74F08 | .69 | 74F139 | 1.69 | 74F280 | 1.79 |
| 74F10 | .69 | 74F157 | 1.69 | 74F283 | 3.95 |
| 74F32 | .69 | 74F240 | 3.29 | 74F373 | 4.29 |
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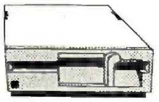

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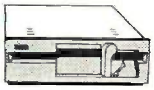
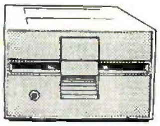
- 100% APPLE COMPATIBLE
- SIX MONTH WARRANTY

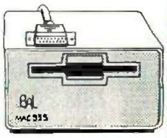


**BAL-500 $129.95**
- TEAC MECHANISM-DIRECT DRIVE
- 100% APPLE COMPATIBLE
- FULL ONE YEAR WARRANTY

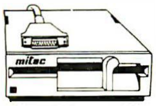


**AP-135 $129.95**
- FULL HT SHUGART MECHANISM
- DIRECT REPLACEMENT FOR APPLE DISK II
- SIX MONTH WARRANTY

DOUBLE SIDED!



**MAC535 $249.95**
- 3.5" ADD-ON DISK DRIVE
- 100% MACINTOSH COMPATABLE
- DOUBLE SIDED 800K BYTE STORAGE
- HIGH RELIABILITY DRIVE HAS AUTO-EJECT MECHANISM
- FULL ONE YEAR WARRANTY



**AD-3C $139.95**
- 100% APPLE IIc COMPATIBLE, READY TO PLUG IN, W/SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
- FAST, RELIABLE SLIMLINE DIRECT DRIVE
- SIX MONTH WARRANTY

### DISK DRIVE ACCESSORIES

FDD CONTROLLER CARD $49.95
IIc ADAPTOR CABLE $19.95
*ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE IIc*

## KB-1000 $79.95
*CASE WITH KEYBOARD FOR APPLE TYPE MOTHERBOARD*
- USER DEFINED FUNCTION KEYS
- NUMERIC KEYPAD WITH CURSOR CONTROL
- CAPS LOCK
- AUTO-REPEAT

## KEYBOARD-AP $49.95
- REPLACEMENT FOR APPLE II KEYBOARD
- CAPS LOCK KEY, AUTO-REPEAT
- ONE KEY ENTRY OF BASIC OR CP/M COMMANDS

## EXTENDER CARDS

| | |
|---|---|
| IBM-PC | $45.00 |
| IBM-AT | $68.00 |
| APPLE II | $45.00 |
| APPLE IIe | $45.00 |
| MULTIBUS | $86.00 |

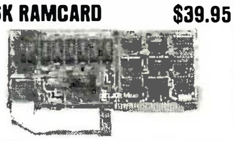
## APPLE COMPATIBLE INTERFACE CARDS

**EPROM PROGRAMMER $59.95**

**MODEL RP525**

- DUPLICATE OR BURN ANY STANDARD 27xx SERIES EPROM
- EASY TO USE MENU-DRIVEN SOFTWARE IS INCLUDED
- MENU SELECTION FOR 2716, 2732, 2732A, 2764 AND 27128
- HIGH SPEED WRITE ALGORITHM
- LED INDICATORS FOR ACTIVITY
- NO EXTERNAL POWER SUPPLY NEEDED
- ONE YEAR WARRANTY

**16K RAMCARD $39.95**



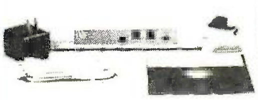
- FULL TWO YEAR WARRANTY
- EXPAND YOUR 48K APPLE TO 64K
- USE IN PLACE OF APPLE LANGUAGE CARD

BARE PC CARD W/INSTRUCTIONS $9.95

**IC TEST CARD $99.95**

- QUICKLY TESTS MANY COMMON ICs
- DISPLAYS PASS OR FAIL
- ONE YEAR WARRANTY
- TESTS: 4000 SERIES CMOS, 74HC SERIES CMOS, 7400, 74LS, 74L, 74H & 74S

## 300B MODEM $49.95
*FOR APPLE OR IBM*
*INCLUDES ASCII PRO-EZ SOFTWARE*



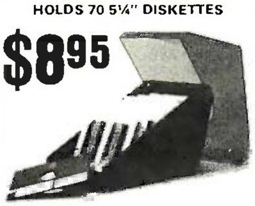
- FCC APPROVED
- BELL SYSTEMS 103 COMPATIBLE
- INCLUDES AC ADAPTOR
- AUTO-DIAL
- DIRECT CONNECT

CABLE FOR APPLE IIc $14.95

## JOYSTICK CR-401 $7.95
FOR ATARI 400, 800, 2600, VIC 20/64 AND APPLE IIe

## DISKFILE
HOLDS 70 5¼" DISKETTES

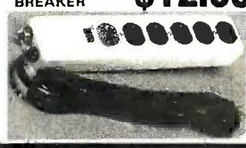
**$8.95**



3.5" DISKFILE HOLDS 40 $9.95

## POWER STRIP
- UL APPRDVED
- 15A CIRCUIT BREAKER

**$12.95**



## BAL 3-WAY SWITCH BOXES
- SERIAL OR PARALLEL
- CONNECTS 3 PRINTERS TO ONE COMPUTER OR VICE VERSA
- ALL LINES SWITCHES
- HIGH QUALITY ROTARY SWITCH MOUNTED ON PCB
- GOLD CONTACTS
- STURDY METAL ENCLOSURE

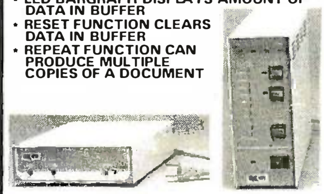
SWITCH-3P CENTRONICS PARALLEL $99.95
SWITCH-3S RS232 SERIAL $99.95

## BAL PRINTER BUFFERS
- FREES COMPUTER FOR OTHER TASKS WHILE PRINTING LONG DOCUMENTS
- STAND-ALONE DESIGN; WORKS WITH ANY COMPUTER OR PRINTER
- ALL MODELS FEATURE PRINT PAUSE MEMORY CHECK, GRAPHICS CAPABILITY

**SP120P PARALLEL $139.95**
- 64K UPGRADABLE TO 256K
- LED INDICATOR SHOWS VOLUME OF DATA IN BUFFER

**SP120S RS232 SERIAL $159.95**
- 64K UPGRADABLE TO 256K
- 6 SELECTBALE BAUD RATES, FROM 600B—19,200B

**SP110P PARALLEL $249.95**
- 64K UPGRADABLE TO 512K
- SPOOLS OUTPUT OF UP TO 3 COMPUTERS
- LED BARGRAPH DISPLAYS AMOUNT OF DATA IN BUFFER
- RESET FUNCTION CLEARS DATA IN BUFFER
- REPEAT FUNCTION CAN PRODUCE MULTIPLE COPIES OF A DOCUMENT



SP120 SP110

## NASHUA DISKETTES DEALS
5¼" SOFT SECTOR
DS/DD WITH HUB RINGS

**$9.90** BOX OF 10 — **69¢ea** BULK QTY 50 — **59¢ea** BULK QTY 250

NASHUA DISKETTES WERE JUDGED TO HAVE THE HIGHEST POLISH AND RECORDED AMPLITUDE OF ANY DISKETTES TESTED ACCORDING TO "COMPARING FLOPPY DISKS", BYTE 9/84

## DISKETTES

### NASHUA 5¼"

| | | |
|---|---|---|
| N-MD2D | DS/DD SOFT | $9.90 |
| N-MD2F | DS/QUAD SOFT | $34.95 |
| N-MD2H | DS/HD FOR AT | $49.95 |

### NASHUA 8"

| | | |
|---|---|---|
| N-FD1 | SS/DD SOFT | $27.95 |
| N-FD2D | DS/DD SOFT | $34.95 |

### NASHUA 3.5"

| | | |
|---|---|---|
| N-3.5SS | 3.5" SS/DD FOR MAC | $32.95 |

### VERBATIM 5¼"

| | | |
|---|---|---|
| V-MD1D | SS/DD SOFT | $23.95 |
| V-MD2D | DS/DD SOFT | $29.95 |
| V-MD110D | SS/DD 10 SECTOR HARD | $23.95 |

## Sakata
**120 CPS DOT MATRIX PRINTER**

**MODEL SP-1200 $169.95**
- EPSON/IBM COMPATIBLE
- 9-WIRE PRINTHEAD
- 120 CPS-BIDIRECTIONAL, 80 COL.
- FRICTION AND TRACTOR FEED
- PROPORTIONAL SPACING
- CENTRONICS PARALLEL INTERFACE
- 8 CHARACTER SETS AND GRAPHICS

*6 FOOT IBM PRINTER CABLE $9.95*
*REPLACEMENT RIBBON CARTRIDGE $11.95*

## 5¼" FLOPPY DISK DRIVES

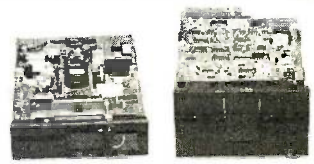
| | | |
|---|---|---|
| TEAC FD-55B | ½ HT DS/DD (FOR IBM) | $109.95 |
| TEAC FD-55F | ½ HT DS/QUAD (FOR IBM) | $124.95 |
| TEAC FD-55GFV | ½ HT DS/HD (FOR IBM AT) | $154.95 |
| TANDON TM100-2 | DS/DD (FOR IBM) | $129.95 |
| TANDON TM50-2 | ½ HT DS/DD (FOR IBM) | $89.95 |
| MPI-B52 | DS/DD (FOR IBM) | $89.95 |
| QUME QT-142 | ½ HT DS/DD (FOR IBM) | $79.95 |

## 8" FLOPPY DISK DRIVES

| | | |
|---|---|---|
| FD 100-8 | SS/DD (SA/801 EQUIV) | $119.00 |
| FD 200-8 | DS/DD (SA/851R EQUIV) | $159.00 |

## DISK DRIVE ACCESSORIES

| | |
|---|---|
| TEAC SPECIFICATION MANUAL | $5.00 |
| TEAC MAINTENANCE MANUAL | $25.00 |
| ½ HT MOUNTING HARDWARE | $2.95 |
| MOUNTING RAILS FOR IBM AT | $4.95 |
| "Y" POWER CABLE FOR 5¼" FDDs | $2.95 |
| 5¼" FDD POWER CONNECTORS | $1.19 |



TEAC FD-55 TANDON TM100-2

## DISK DRIVE ENCLOSURES

**CAB-APPLE $24.95**
APPLE TYPE CABINET W/OUT POWER SUPPLY

**CAB-1FH5 $69.95**
FULL HT 5¼" BEIGE CABINET W/POWER SUPPLY

**CAB-2SV5 $49.95**
DUAL SLIMLINE 5¼" CABINET W/POWER SUPPLY

**CAB-2SV8 VERTICAL $209.95**
DUAL SLIMLINE 8" CABINET W/POWER SUPPLY

**CAB-2FH8 HORIZINTAL $219.95**
DUAL FULL HT 8" CABINET W/POWER SUPPLY

CAB-2SV5 CAB-1FH5

## TEST EQUIPMENT FROM JDR INSTRUMENTS

**DIGITAL MULTIMETER PEN DPM-1000 $54.95**
AUTO RANGING, POLARITY AND DECIMAL!
- LARGE 3.5 DIGIT DISPLAY
- DATA HOLD SWITCH FREEZES READING
- FAST, AUDIBLE CONTINUITY TEST
- LOW BATTERY INDICATOR
- OVERLOAD PROTECTION

| | | |
|---|---|---|
| 20MHz DUAL TRACE OSCILLOSCOPE | MODEL 2000 | $389.00 |
| 35MHz DUAL TRACE OSCILLOSCOPE | MODEL 3500 | $549.00 |

FOR MORE INFORMATION ON THE OSCILLOSCOPES, CALL US FOR FREE PRODUCT BRIEFS.

**CALL FOR VOLUME QUOTES**

# BUILD A COMPLETE 256K XT SYSTEM—$717

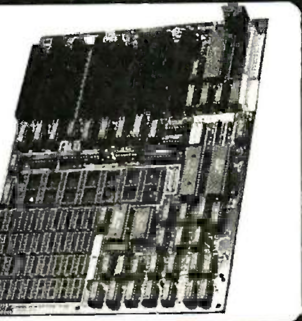
## SEAGATE ST-225 20MB HARD DISK SYSTEM

INCLUDES HALF LENGTH HD CONTROLLER, CABLES, MOUNTING HARDWARE AND INSTRUCTIONS. ALL DRIVES ARE PRETESTED AND COME WITH A ONE YEAR WARRANTY.

**$449.00**

## XT COMPATIBLE MOTHERBOARD

**$159.95**



- 4.77 MHz 8088 CPU, OPTIONAL 8087 CO-PROCESSOR
- 8 EXPANSION SLOTS
- 0K RAM INSTALLED, EXPANDABLE TO 640K ON-BOARD MEMORY
- ALL ICs SOCKETED-HIGHEST QUALITY PC BOARD
- ACCEPTS 2764 OR 27128 ROMS

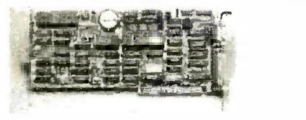
**PRO-BIOS $29.95**

## IBM COMPATIBLE INTERFACE CARDS

*ALL WITH A ONE YEAR WARRANTY*

### MULTI I/O FLOPPY CARD $129.95

*PERFECT FOR THE 640K MOTHERBOARD*

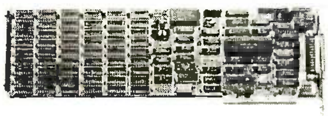


- 2 DRIVE FLOPPY DISK CONTROLLER
- 1 RS232 SERIAL PORT; OPTIONAL 2nd SERIAL PORT
- PARALLEL PRINTER PORT
- GAME PORT
- CLOCK/CALENDAR
- SOFTWARE: CLOCK UTILITIES, RAMDISK, SPOOLER

*OPTIONAL SERIAL PORT $15.95*

### MULTIFUNCTION CARD $119.95

*ALL THE FEATURES OF AST'S 6 PACK PLUS AT HALF THE PRICE*



- CLOCK/CALENDAR
- 0-384K RAM
- SERIAL PORT
- PARALLEL PORT
- GAME PORT
- SOFTWARE INCLUDED

*PRINTER CABLE $9.95*
*64K RAM UPGRADE 9/$10.71*

### COLOR GRAPHICS ADAPTOR $99.95

*FULLY COMPATIBLE WITH IBM COLOR CARD*

- 4 VIDEO INTERFACES: RGB, COMPOSITE COLOR, HI-RES COMPOSITE MONOCHROME, CONNECTOR FOR RF MODULATOR
- COLOR GRAPHICS MODE: 320 x 200
- MONO GRAPHICS MODE: 640 x 200
- LIGHT PEN INTERFACE

### MONOCHROME GRAPHICS CARD $119.95

*FULLY COMPATIBLE W/IBM MONOCHROME ADAPTOR & HERCULES GRAPHICS*

- LOTUS COMPATIBLE
- TEXT MODE: 80 x 25
- GRAPHICS MODE: 720 x 348
- PARALLEL PRINTER INTERFACE
- OPTIONAL SERIAL PORT $19.95

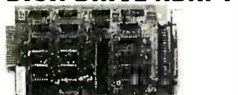
### MONOCHROME ADAPTOR $49.95

*ANOTHER FANTASTIC VALUE FROM JDR!*

- IBM COMPATIBLE TTL OUTPUT
- 720 x 350 PIXEL DIPLAY

PLEASE NOTE: THIS CARD WILL NOT RUN LOTUS GRAPHICS AND DOES NOT INCLUDE A PARALLEL PORT

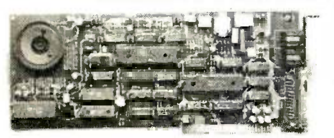
### FLOPPY DISK DRIVE ADAPTOR $49.95



- INTERFACES UP TO 4 STANDARD FDDs TO IBM PC OR COMPATIBLES
- INCLUDES CABLE FOR TWO INTERNAL DRIVES
- STANDARD DB37 FOR EXTERNAL DRIVES
- RUNS QUAD DENSITY DRIVES WHEN USED WITH JFORMAT

## EASYDATA 1200 BAUD MODEM FOR IBM

*INCLUDES PC TALK III COMMUNICATIONS SOFTWARE*



- NEW 10 INCH CARD
- HAYES COMPATIBLE
- AUTO DIAL/AUTO ANSWER
- AUTO RE-DIAL ON BUSY
- INCLUDES SERIAL PORT!
- ONE YEAR WARRANTY

**$169.95**

## CRT MONITORS FOR ALL APPLICATIONS

### LUXOR
HI-RES RGB MONITOR
*MODEL 190-9528*

- DIGITAL RGB IBM COMPATIBLE
- 14" SCREEN
- 16 TRUE COLORS
- 25 MHz BANDWIDTH
- RESOLUTION > 640 x 262
- .31mm DOT PITCH
- CABLE FOR IBM PC INCLUDED

**$299.95**

### SAKATA
COMPOSITE COLOR
*MODEL SC-100*

- TOP RATED FOR APPLE
- 13" COMPOSITE VIDEO
- RESOLUTION: 280H x 300V
- INTERNAL AUDIO AMP
- ONE YEAR WARRANTY

**$169.95**

### CENTER SYSTEMS
MONOCHROME
*MODEL KLM-1211*

- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE SCREEN
- P39 GREEN PHOSPHORUS
- VERY HIGH RESOLUTION: 25 MHz BANDWIDTH 1100 LINES (CENTER)

AMBER VERSION $109.95

**$99.95**

## BUILD YOUR OWN 256K XT COMPATIBLE SYSTEM

| | |
|---|---|
| XT MOTHERBOARD | $159.95 |
| PRO-BIOS | $29.95 |
| 256K RAM | $26.55 |
| 130 WATT POWER SUPPLY | $89.95 |
| FLIP-TOP CASE | $49.95 |
| DKM-2000 KEYBOARD | $79.95 |
| 1/2 HEIGHT QUME DRIVE | $79.95 |
| FLOPPY DISK CONTROLLER | $49.95 |
| MONOCHROME ADAPTOR | $49.95 |
| MONOCHROME MONITOR | $99.95 |
| TOTAL: | $716.10 |

## MONITOR STAND

TILTS AND SWIVELS

**ONLY $12.95**

## IBM PRINTER CABLE

- DB25 TO CENTRONICS
- SHIELDED CABLE

**$9.95**

## IBM STYLE COMPUTER CASE

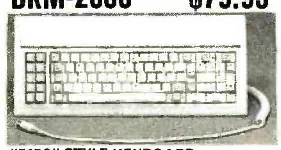
AN ATTRACTIVE STEEL CASE WITH A HINGED LID FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS

- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
- CUT-OUT FOR 8 EXPANSION SLOTS
- ALL HARDWARE INCLUDED

**$49.95**

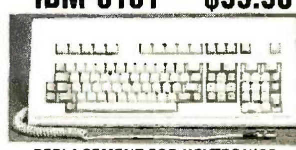
## IBM COMPATIBLE KEYBOARDS

### DKM-2000 $79.95



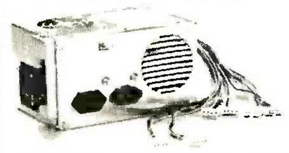
- "5150" STYLE KEYBOARD
- FULLY IBM COMPATIBLE
- LED STATUS INDICATORS FOR CAPS & NUMBER LOCK
- 83 KEY — SAME LAYOUT AS IBM PC/XT KEYBOARD

### IBM-5151 $99.95



- REPLACEMENT FOR KEYTRONICS KB-5151™
- SEPARATE CURSOR & NUMERIC KEYPAD
- CAPS LOCK & NUMBER LOCK INDICATORS
- IMPROVED KEYBOARD LAYOUT

## POWER SUPPLY



**NOW ONLY $89.95**

- FOR IBM PC-XT COMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A -5V @ .5A, -12V @ .5A

**150 WATT MODEL $99.95**

## DISK DRIVES

### TANDON TM50-2

**$89.95**

- 1/2 HT DS/DD
- IBM COMPATIBLE
- EXTREMELY QUIET!

| | | |
|---|---|---|
| TEAC FD-55B | DS/DD | $109.95 |
| TEAC FD-55F | DS/QUAD | $124.95 |
| TEAC FD-55G | DS/HD | $154.95 |
| QUME QT-142 | DS/DD | $79.95 |
| MOUNTING HARDWARE | | $2.95 |
| AT/RAILS | | $4.95 |

**JDR Microdevices** 1224 S. Bascom Avenue, San Jose, CA 95128
Toll Free 800-538-5000 • (408) 995-5430 • FAX (408) 275-8415 • Telex 171-110

# D·I·S·K·S A·N·D D·O·W·N·L·O·A·D·S

## Ordering Disks of BYTE Listings

Listings that accompany BYTE articles are available on disk in a variety of formats and in Cauzin Softstrip format. (For details on the Softstrip format, see page 460.) For each BYTE issue, beginning with December 1985, all the listings mentioned in that issue are on that month's disk. There's no need to request individual listings or to send additional fees; the cost per disk covers an entire month's listings. To order a disk of these listings for noncommercial purposes, indicate the issue and the kind of disk on the form below. Enclose a check or money order in the correct amount made out to BYTE Listings. We cannot accept credit card orders at this time. All prices include postage. Send requests to BYTE Listings, One Phoenix Mill Lane, Peterborough, NH 03458. Program Listings may also be downloaded via BYTEnet Listings at (617) 861-9764.

BYTE issue: ____________________

COMMON 5¼-INCH FORMATS
(All cost $5 per disk in North America, $6 in Europe and South America, $7 in Asia, Africa, and Australia.)

- ☐ Apple II 5¼-inch DOS 3.3 (5 disks)
- ☐ Apple II 5¼-inch ProDOS (5 disks)
- ☐ Hewlett-Packard 125 (2 disks)
- ☐ IBM PC (2 disks)
- ☐ Kaypro 2 CP/M (2 disks)
- ☐ Texas Instruments Professional (2 disks)
- ☐ TRS-80 Model III (4 disks)
- ☐ TRS-80 Model 4 (4 disks)
- ☐ Zenith Z-100 (2 disks)

COMMON 3½-INCH FORMATS
(All cost $6 per disk in North America, $7 in Europe and South America, $8 in Asia, Africa, and Australia.)

- ☐ Apple Macintosh (2 disks)
- ☐ Atari 520ST (2 disks)
- ☐ Commodore Amiga (1 disk)
- ☐ Data General/One (1 disk)
- ☐ Hewlett-Packard 150 (1 disk)

CP/M STANDARD 8-INCH FORMAT
($6 per disk in North America, $7 in Europe and South America, $8 in Asia, Africa, and Australia.)

- ☐ Single-sided single-density (2 disks)
- ☐ Double-sided double-density (1 disk)

OTHER FORMATS
Due to the diversity of requests and the custom work involved, there will be some delay in fulfilling these requests. (All cost $6 per disk in North America, $7 in Europe and South America, $8 in Asia, Africa, and Australia.)

Size ☐ 8-inch ☐ 5¼-inch ☐ 3½-inch
Machine ____________________

CAUZIN SOFTSTRIP
☐

SEND TO:

Name ____________________
Street ____________________
City__________ State or Province ________
Postal Code __________ Country __________
Check or money order enclosed for $__________

## Bulletin Boards in Canada

Listed below are some computer bulletin boards that carry program listings from BYTE. Programs are for noncommercial use in connection with BYTE articles only. Some BBSs may charge an annual maintenance fee, and you must pay your own telephone charges.

Western Canadian Distribution Center (3420 48th St., Edmonton, Alberta T6L 3R5) will be supplying listings to its member bulletin-board systems.

Edmonton, Alberta, (403) 454-6093

Meadowlark, Alberta, (403) 435-6579

Montreal, Quebec, PComm Systems, (514) 989-9450

Prince George, British Columbia, (604) 562-9519

Regina, Saskatchewan, (306) 586-5585

Toronto, Ontario, Epson Club of Toronto (EPCOT), (416) 635-9600

Winnipeg, Manitoba, (204) 452-5529

In addition, arrangements for BYTEnet Listings have been made with one or more system operators in the following nations: Australia, Brazil, Denmark, France, Hong Kong, Indonesia, Italy, Japan, Malaysia, The Netherlands, Nigeria, Norway, Saudi Arabia, Singapore, Sweden, Switzerland, United Kingdom, and West Germany. Contact us at (603) 924-9281 for an up-to-date list. ■

# THE CAUZIN SOFTSTRIP

Starting with this issue, BYTE will offer the text files of program listings from each issue in Cauzin Softstrip format. This new medium adds to the other ways you can get the full text of programs referred to in BYTE: the free BYTEnet Listings bulletin board, BIX (BYTE Information Exchange), and the disks of listings available through BYTE.

The Cauzin Softstrip was conceived by Robert Brass and implemented at Cauzin Systems Inc. It is a machine-readable form of printed software (see figure 1) that can be created on laser and dot-matrix printers and reproduced in magazines, newspapers, and other printed forms (including photocopies). Files in Softstrip format are highly reliable and resistant to errors. Softstrips can be folded, crumpled, smudged, or written over with most inks and still read correctly. (For a technical description of Softstrips, see Letters, January BYTE, page 24.)

We will offer the text-file content of the BYTE disks in Softstrip format as an experiment for the next 18 months; the price will be $2 per month for North America, $3 for Europe and South America, and $3.50 for Asia, Africa, and Australia. If the demand is sufficient at the end of this period, we will continue to offer software in Softstrip format. (We will supply only the text files associated with a given issue. Executable files are often too large to convert and are specific to one machine only; also, almost all the code associated with a given issue is source code.

The Cauzin Softstrip System Reader is a sound piece of technology that has the potential to be an economical way to distribute software, but it suffers from the chicken-and-egg problem that most new computers face: Users won't buy them until software exists, and software vendors won't support them until they have a large user base. Already several computer magazines are printing Softstrips. Although we currently do not have the space in BYTE to do this, we want to make them available at low cost to interested readers.

Currently, the Softstrip Reader works with the IBM PC, Apple II, and Macintosh families of computers (the Accessory Kit for each computer includes the appropriate computer-to-reader cable and the software for reading Softstrips). However, anyone with a computer capable of telecommunications and data capture at 4800 baud can read any text file in Softstrip format, including those supplied by BYTE (see "Reading Text Softstrips" at right for details). We feel that this capability makes Softstrip software available to a large segment of our audience, which contributed to our decision to offer this option.

This service is in no way an endorsement of Cauzin Systems or its product. We plan to publish a review of the Softstrip System Reader in an upcoming issue. For more information, contact Cauzin Systems, 835 South Main St., Waterbury, CT 06706, (203) 573-0150.

To order Softstrip versions of BYTE listings, see Disks and Downloads on page 459. ■

# Reading Text Softstrips

To read text-file Softstrips on an unsupported computer, you need the following:

- a computer that can connect to a modem through a male DB-25 connector (on the computer's side)
- a terminal program that has a data-capture mode and the ability to send and receive data at 4800 baud
- a Cauzin Softstrip System Reader package with the IBM PC Accessory Kit (includes the necessary cable that ends in a female DB-25 connector)

To read a text-file Softstrip, connect the Softstrip Reader to your computer as if it were a modem, turn on the Reader, position a Softstrip for reading, set your terminal program to capture incoming text at 4800 baud, 8 data bits, 1 stop bit, no parity bit, and type the letter "T." The reader reads the Softstrip and sends the information to your computer. Repeat this process for any additional Softstrips. (Note that if a file is distributed on multiple Softstrips, you may have to manually edit text broken by Softstrip boundaries.) After you have closed and edited the resulting file, you will have a text file that can be manipulated normally by your system.

In many cases, BASIC text files can be loaded and executed with little or no modification on your computer. For example, at BYTE we tested the above setup with an Amiga running the MaxiComm terminal program. We read in the Softstrip version of a short BASIC program (LCD.BAS from page 400 of the January Mathematical Recreations), loaded it into AmigaBASIC, and found that it ran without modification.

Figure 1: A *Softstrip containing two Turbo Pascal programs,* ANAGRAM.PAS *and* SETPROB.PAS, *from "Anagram Solving in Pascal" by Bob Keefer (page 113 of this issue).*

SET PROB.PAS
ANAGRAM.PAS

1 2 3 4 5

Softstrip

# B·O·M·B

## BYTE's Ongoing Monitor Box

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## BOMB *Results*

### POWER AND SECURITY

Steve Ciarcia's Circuit Cellar adventure in April, "Computer On Guard!" wins first place. In second is "Jerry's Best of 1985 Awards" from Dr. Pournelle's enviable vantage point at Chaos Manor. "A Micro-based Supercomputer" placed third, awarding its authors, Norman H. Christ and Anthony E. Terrano, the $100 bonus. Best of BIX wins fourth. And in fifth place is "Making UNIX Secure." Coauthors Alan Filipski and James Hanko will split the $50 prize.

The new $50 award for quality, which just began last month, goes to Norman H. Christ and Anthony E. Terrano for "A Micro-based Supercomputer." Congratulations one and all.

# R·E·A·D·E·R S·E·R·V·I·C·E



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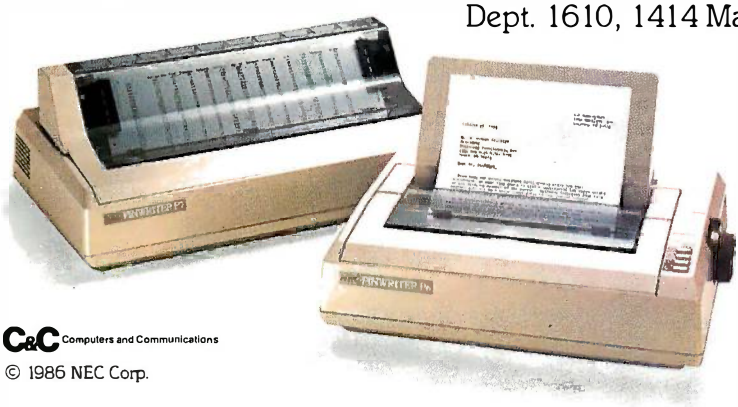


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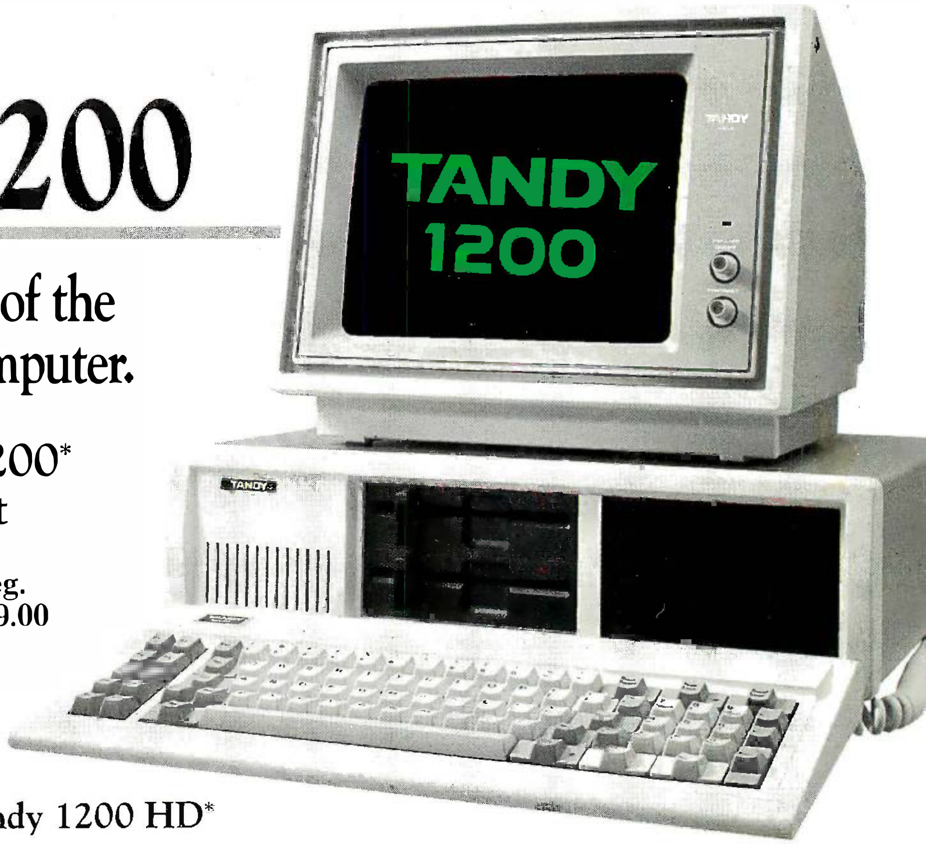


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Or for the ultimate in data-storage power, choose the Tandy 1200 HD (25-3000), with a 360K floppy drive, plus an internal 10-megabyte hard disk drive.

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### System Overview

**Microprocessor:** Intel 8088, 4.77 MHz.
**Memory:** 256K RAM, expandable to 640K.
**Storage:** Tandy 1200—two 360K floppy drives. Tandy 1200 HD—one 360K floppy and one 10-megabyte hard disk.
**Internal Expansion:** Seven card slots.

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