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FOR IBM PERSONAL COMPUTER USERS

TECH JOURNAL

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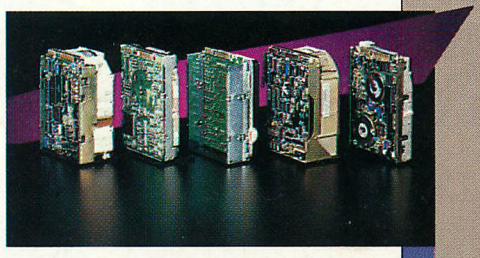

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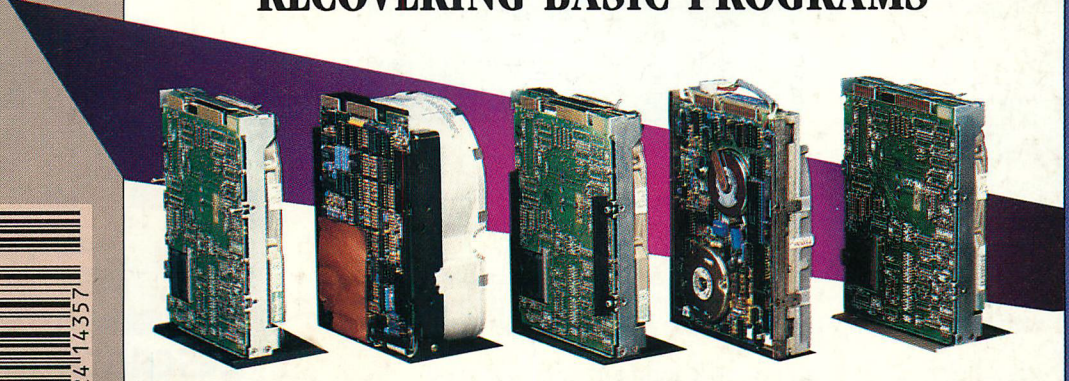

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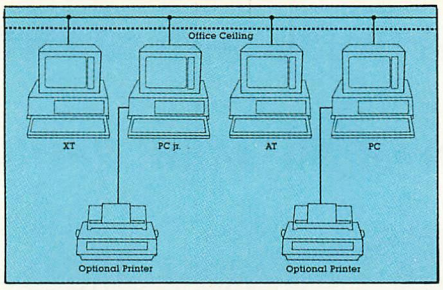

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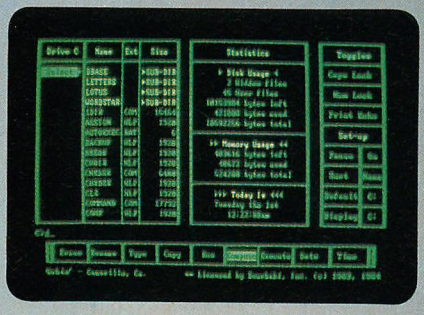

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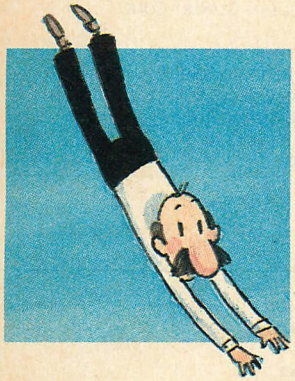

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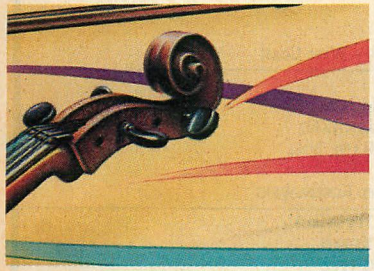

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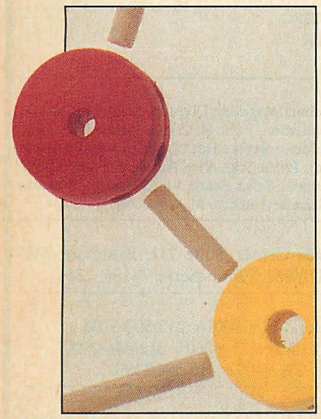

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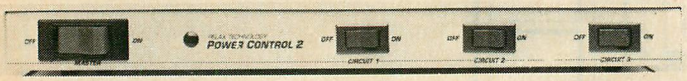

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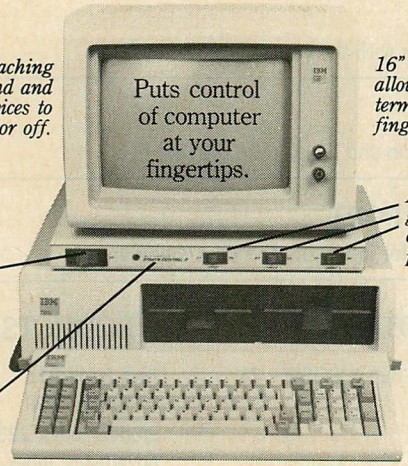

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BPA SELECTED MARKET AUDIT DIVISION

The Hard (or is it Fixed?) Disk Revolution

IBM continues to set de facto standards

DEFINITIONS

Hard disk: A device capable of storing and retrieving digital information on a rotating, rigid, metal disk coated with a magnetically sensitive substance. The disk (media) is usually sealed inside a chamber, along with the read/write mechanism, to protect it from contamination. Such a device is referred to as *hard* to distinguish it from a diskette, which is often referred to coloquially as *floppy*. A hard disk is sometimes called a Winchester.

Fixed disk: IBM's term for the same thing.

QUIZ

What is the real reason IBM refers to its mass-storage devices for the PC, XT, and AT as fixed disks? (*see answer box, next page*)

* * *

We are sitting on the brink of a big explosion in the market for hard disks. As it has for so many years past in its mainframe business, IBM is again setting standards. And while the standards themselves may not be particularly revolutionary, IBM's pricing is, to say the least, becoming very aggressive.

Let's examine IBM's push in this area, one standard at a time.

THE CAPACITY STANDARD

Before the PC, small, hard-disk drives were certainly available. The most widely used drives had a capacity of five megabytes, primarily because these were the least expensive units. Although higher capacities were also available, the incremental cost of 10 megabytes, for example, was almost as much as a second 5-Mbyte drive.

When IBM introduced the XT, in early 1983, 10 megabytes became the industry standard. This can clearly be seen in the raft of new products introduced over the last six months or so. Not only that, the prices for add-in or add-on subsystems with 10-Mbyte capacity have tumbled to incredible lows—they can be purchased for as little as $900 in some mail-order cases.

IBM being IBM, it allowed the user of a 10-Mbyte system, be it an XT or upgraded PC, room to grow. One expansion drive of 10 megabytes could bring the capacity of fixed-disk-equipped systems to 20 megabytes. Enough people must have built up systems with that kind of capacity, because by the time IBM introduced the PC/AT, it was again breaking new ground and establishing what will have to be a new standard. And if you think that capacity will *not* be standard, that's because you haven't considered fully the price of $1,595 for each 20-Mbyte add-in drive, of which the AT can support two. That's less than IBM was charging for a 10-Mbyte expansion for the PC!

Let's face it. IBM is not standing still on this point, as have some other vendors in the past.

THE PRICE STANDARD

In the past, IBM computers have been among the most expensive. Even the PC was richly priced, as demonstrated so conclusively by the considerably less costly clones.

IBM's fixed-disk storage for the PC was also expensive. The clearest indicator of this is the enormous size of the aftermarket in this segment alone. If all those folks were not selling any fixed-disk subsystems, then they wouldn't still be out there trying.

Here, however, it may be possible to see for the first time just how effectively IBM uses its sales history and the success of its aftermarket to tell it what to do next. A case in point is, again, the AT. I am in good company with my astonishment at how low the price of the new machine is. But, as I mentioned before, the price of the mass storage is more than just competitive, more than just aggressive. IBM has set a world-class pace, one that most companies will be hard-pressed to keep.

And those that do will find that they have to match IBM's standard in form (20-Mbyte) and function (high-performance) just to get in the race in the first place.

THE INTERFACE STANDARD

Third, and last, is the point that many past competitors of IBM have reached: the IBM interface.

In this issue, Tom Hoffmann reviews 10 add-in fixed-disk systems for the PC. These products were

selected because they all claim IBM compatibility. They live up to their promises because they all run in DOS versions from 2.0 up. But not all of them run PC/IX, and some probably will find difficulty with other operating systems. Why? While they are able to make themselves emulate the behavior of a fixed-disk subsystem under DOS, they cannot make themselves identical to the IBM interface.

You might well ask, "Why not?" At one time, I would have said, "No reason." Now, however, the controller boards, the adapter cards are not just hardware designs that can be reverse-engineered. Now they include sophisticated, special-purpose microprocessors and—herein lies the rub—software.

If you have been reading Max Oppenheimer in these pages, you know that copyrights might be applicable to software. Both IBM and Apple have been successful in their efforts to protect the software embedded in their systems. What this means is that a third-party vendor is limited to building a system that *emulates* the IBM system, but may never be able to match it exactly without infringing.

That is a standard, therefore, that cannot be violated.

What's it Mean?

1. IBM has put the competition on record. Twenty megabytes is the capacity, $1,600 is the price, and the I/O channel is fast. If you are going to build a competing system, it has to be like or better.
2. The aftermarket may not be able to match the IBM standard. Therefore, it will have to find some other way to be aggressive. A good cost-per-megabyte ratio may be the only way.
3. While IBM has been aggressive about setting the standard, it has not been innovative about the technology. I would seriously consider products that take the next step and offer some significant extra value.

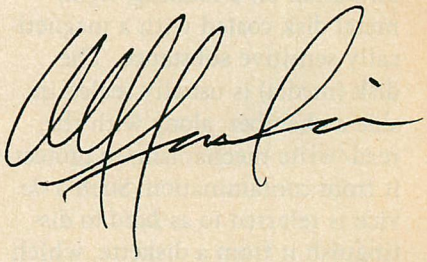
And given all that, what I predict now is a new, heated competition for that mass-storage dollar—one that shows innovation in capacity, technology, and price to be the main points of battle.

AT Review

Our December issue will feature a complete review of the new IBM PC/AT, its operating software, the network, and other associated IBM announcements. These products represent new directions and strategies for the company that now commands the largest share of the desktop computer market.

We will assess for you what these announcements mean, and we will pass along our opinions. Depend on us, though, for what you have come to expect from *PC Tech Journal*: thorough, insightful, and exacting descriptions of these complicated products. We are doubly proud to say that you will have this information faster than we have ever brought a major review of a new product to you before.

So polish up your critical eyeball, and let us know how we do.



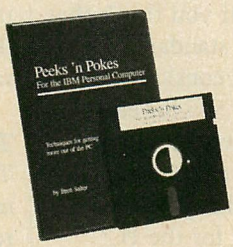
Answer Box

IBM calls its hard-disk systems *fixed* because the media cannot be removed from the drive.

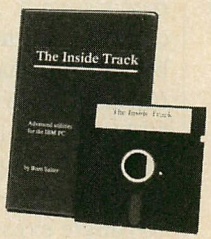
Know Thy PC!

Are you writing programs in BASIC or Pascal? The popular **Peeks 'n Pokes** has a disk with 58 programs and a 38-page manual that helps you get 'underneath the covers' of the PC. Learn how to use PEEK, POKE, INP, OUT, and DOS/BIOS function calls to do what you want, fast! Do you want to perform functions not available from BASIC or Pascal? It's all explained in the manual and demonstrated in the sample programs. Source code included!

Peeks 'n Pokes shows you how to:
- Access the system's configuration
- Unprotect BASIC programs
- Scroll part or all of the screen
- Access the file directory
- Logically swap printers
- Read and change the keyboard
- Find more Peeks and Pokes
- And much more...for only $30.00



Want to know more? **The Inside Track!** is a collection of advanced utilities for the PC programmer. It contains a disk with 61 programs, a 42-page manual, and a fold-out memory map that helps you get better performance from the PC. With this package you can give your programs assembler-assisted speed from high-level languages, get control over memory, customize and control the PC, and more. Some programs require DOS 2.00. Source code included!



The Inside Track! shows you how to:
- Read/write files as fast as DOS
- Display data on the screen faster
- Reserve memory for your use
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CIRCLE NO. 137 ON READER SERVICE CARD

WHY DEBUG YOUR PROGRAM IN ASSEMBLY LANGUAGE WHEN YOU WROTE IT IN ONE OF THESE...

ATRON Announces Source Level Software Debugging

Without source level debugging, the programmer must spend time mentally making translations between assembly language and the C, PASCAL, or FORTRAN source code in which the program was written. These tedious translations burn up valuable time which should be spent making critical product schedules. The low level hex and symbolic debuggers available today are superceded by ATRON'S solution — Source Probe.

HOW TO SINGLE STEP YOUR SOURCE CODE AND KEEP CRITICAL DATA IN VIEW

With Source Probe, you can step your program by source code statements. While stepping, a window which you define can display critical high level data structures in your program. The next several source code statements are also displayed to give you a preview of what the program will do

HOW TO DISPLAY DATA IN MEANINGFUL FORMATS

Why look at program data in hex when you defined it to be another data type in your program. Source Probe provides a formated print statement to make the display of your variables look like something you would recognize. You can specify data symbolically too.

FIND A BUG — FIX IT RIGHT NOW

Source Probe provides an on-line text editor to allow you to log program corrections as you find them while debugging. With on-line display and editing of source files, the time lost printing and looking through program listings can be eliminated.

A SNAP SHOT OF REAL TIME PROGRAM EXECUTION — BY SOURCE CODE !

When Source Probe is running on ATRON'S PC PROBE hardware, the real time execution of the program is saved. You can then view your source code as it executed in real time — including all the changes the program made to your data variables.

HOW TO FIND A BUG WHICH OVERWRITES MEMORY

When running on PC PROBE, the Source Probe can trap a bug which overwrites a memory location. Because complex pointers are normally used in high level language programming, this bug occurs frequently and is very difficult to find.

A BULLET PROOF DEBUGGER

What good is a debugger that can be wiped out by an undebugged program? With Source Probe running on PC PROBE, the software is write protected and cannot be changed.

ATRON PROVIDES THE DEBUGGING TOOLS WHICH FIT YOUR PROBLEM

PC PROBE — A hardware aid to symbolic software debugging

SOFTWARE PROBE — A symbolic debugger, runs without PC PROBE

SOURCE PROBE — A source level debugger, versions run with or without PC PROBE

PERFORMANCE AND TIMING ANALYZER — For finding where your program spends its time

WE HAVE HUNDREDS OF HAPPY CUSTOMERS

ATRON produced the first symbolic debugger for the PC and the first hardware aided debugging tool — PC PROBE. We have hundreds of happy customers who have made their schedules because of ATRON debugging tools. Why waste more time — call us today!

atron
a debugging company

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CIRCLE NO. 107 ON READER SERVICE CARD

What do you get when you cross 1200 baud, free on-line time, and extra features at a price Hayes can't match?

Shopping for a modem doesn't have to be a riddle. A tedious sifting through claims and counterclaims. A quest for the best that raises more questions than it answers.

The new MultiModem, from Multi-Tech Systems, gives you the right answers from the start. The answers to all your questions about what a first-rate intelligent modem should do for you.

Data Transmission Speed?

The MultiModem gives you a choice—either 1200 or 300 bits per second. 1200 for fast, efficient communications and lower long-distance charges. Like when you're downloading data from the corporate computer, or swapping files with a friend across the country. 300 bps for your less demanding applications, like checking out bulletin boards, playing games, or having on-line keyboard conversations.

Free On-Line Time?

With the MultiModem you get CompuServe's DemoPak—a free two-hour demonstration of their service, and up to seven more free hours of on-line time if you subscribe. You also get a $50 usage credit from NewsNet, a service which lets you tap into 150 different specialized business newsletters.

Intelligence? Extra Features?

Of course, the MultiModem automatically dials, answers, and disconnects. But it does a few extra things too, things the Hayes Smartmodem 1200™ doesn't. Like recognize dial tones and busy signals, so the MultiModem will automatically redial, or automatically try a different number. And it remembers phone numbers too, up to six of them, in its battery-backed memory.

Trademarks—*MultiModem, MultiCom PC: Multi-Tech Systems, Inc.—CompuServe: CompuServe Information Services, an H & R Block company—NewsNet: NewsNet, Inc.—Smartmodem: Hayes Microcomputer Products, Inc.—Crosstalk: Microstuf, Inc.—Data Capture: Southeastern Software—PC-Talk III: Freeware/The Headlands Press.*

Hayes-compatibility?

Yes, the MultiModem is Hayes-compatible. (Most software requires modems that are.) That means the MultiModem will run with popular communications programs like Crosstalk XVI, Data Capture, PC-Talk III, our own MultiCom PC, and dozens of others.

What About Price?

At $549, the MultiModem retails for $150 less than the Smartmodem™. You get Hayes-compatibility and so much more—for so much less.

What do you get when you cross all these things? The MultiModem. From Multi-Tech Systems—a company that's been making top-quality modems for over thirteen years.

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CIRCLE NO. 204 ON READER SERVICE CARD

"Mr. Chips™ Brings Our IBM® PC To Life"

Jim Reedy, Vice President
Reedy Robotronic Productions, Inc.
Van Nuys, California

The First Multi-function Card for the Real World

At Reedy Robotronic Productions, bringing ideas to life is a way of business. With an IBM PC and Mr. Chips, the new multi-function card from Orange Micro, complex robotic machines virtually come alive.

"Mr. Chips provides the link between our IBM PC and the devices we use to develop our applications," says Jim Reedy, Vice President. "With an on-board interface that accepts direct digital timing data and a port for the measurement of variable resistive inputs, Mr. Chips allows us to program our robots to become top performers—animated characters that sing and dance in precisely synchronized sound and motion."

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- Dual Game Port*: Besides serving as a standard game paddle interface, this unique port also permits monitoring of four variable resistive inputs (up to 100K Ohms each) and four digital inputs. Combined with the Real World features, you can also interface your PC to many popular general purpose instruments.
- BSR™ AC Line Controller*: This interface will send coded ultrasonic signals to your BSR X-10 unit, allowing control of up to 16 AC devices. It can also be set up for responses to Real World Interface input or data from the clock/calendar to provide a complete control system.

And of course Mr. Chips also provides the features you expect on any quality multi-function card. Like memory expandable from 64K to 256K, a clock/calendar to keep track of time and date, and a parallel and serial port for communication with peripheral devices. Also included is Chipdisk™ software for configuring your PC's memory into a RAM Disk for efficient program execution and a Print Spooler for printer buffering.

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*Cables available separately.

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Before IRMA™
PC-to-mainframe
communications
had advanced just
about this far.
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Until just two years ago, communications between big IBM® mainframes and individual PCs was all smoke, without a bit of substance.

But two years ago, the smoke lifted.

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All completely integrated. So you can do just about anything you wish. Like financial modeling, order entry, job costing or decision support.

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Operating Systems: PCDOS, MSDOS, CP/M-86. Requirements: 192K RAM
Text processing, forms painting and color graphics are optional integrated KnowledgeMan components.

KnowledgeMan is a trademark of Micro Data Base Systems, Inc., dBASE II of Ashton-Tate, SQL/DS of IBM. Current release is 1.06 as of 4/1/84. Color graphics requires PCDOS and IBM color graphics card or equivalent.

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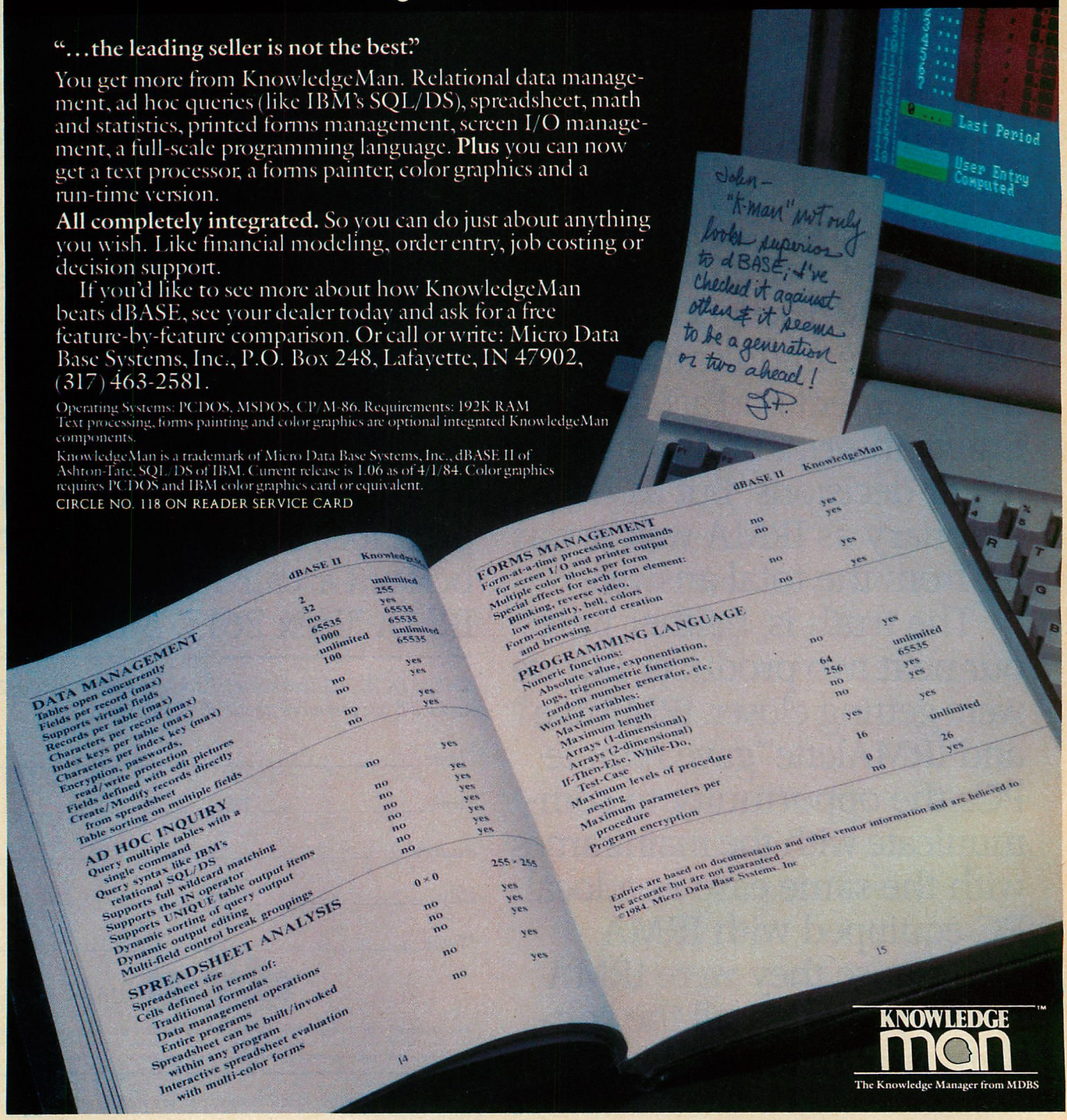

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PC Paintbrush is available NOW for the IBM PC and compatibles, with 192K of memory and DOS 2.0 or above. We support an astonishing variety of hardware; check the lists below. Soon: HP150 and Corona 640x325 versions.

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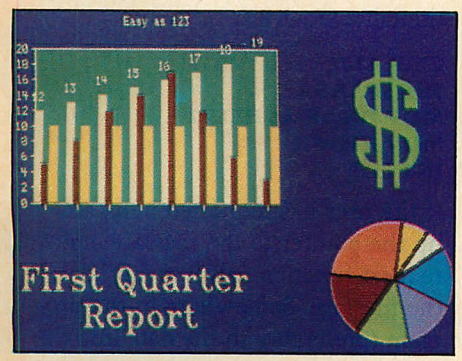

Want to improve humdrum bar graphs? With PC Paintbrush, you can grab a chart or graph from another program (such as Lotus' 1-2-3 or Soreim's SuperCalc3), then embellish it with PC Paintbrush. Take a plain 2 or 4 color bar graph and produce a stunning 16 color slide or printout (requires appropriate display adapter).

We offer special group licensing agreements, as well as inexpensive customization services for your business' special requirements.

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No need to buy additional hardware. We've made sure that PC Paintbrush will work with your printer, your display, and your application.

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You hate waiting and so do we. All of our graphics are written entirely in assembler, for the fastest possible results.

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No promises, just fact: we are currently shipping PC Paintbrush.

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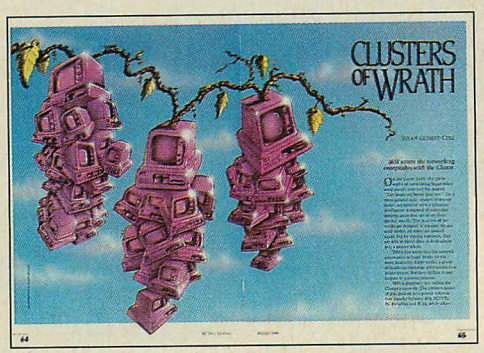

Credibility Gap

My topic today is credibility. I think many people judge the credibility of a technical (or even not-so-technical) publication the same way I do: if the facts and opinions in the areas with which I am familiar are well-founded, then I am willing to assume that the information is equally sound in the areas with which I am not familiar. On the other hand, if I find lots of factual errors or unfounded opinions, then I lose confidence in the rest of the information presented there.

Let's take the August 1984 issue of *PC Tech Journal*. I have only skimmed through it lightly, and already I have seen two ridiculous errors. The first occurred in "Clusters of Wrath" (Susan Glinert-Cole, page 64). In discussing the BUFFERS command on page 71, she says that each buffer takes 128 bytes; 90 buffers use 11,520 bytes. Actually, each buffer takes 528 bytes; this is clearly indicated in the DOS manual. Three things bother me about this error. First, Glinert-Cole must never have checked her available memory before and after changing the BUFFERS setting—that's sloppy to begin with. Second, she did a sloppy job of looking up the information in the DOS manual—she obviously must have skimmed it, picking up the first number she saw that happened to be 128 in reference to 128-byte records. Third, this is not a very obscure piece of information—doesn't anyone read these articles for technical accuracy before they get printed in the magazine?

The second error I noticed was in "Managing Memory" (William J. Redmond, page 43). The article states that on the newer PC, 256K memory chips are used in place of the 16K chips. We all know that 64K chips are used. Where are the editors? If *PC Tech Journal* cannot even get the trivial facts right, how in the world can we have any confidence when you tell us something we don't already know?

I think the technical credibility of *PC Tech Journal* is being seriously compromised by errors that slip through because of inadequate editing for technical accuracy.

Robert E. Brown
Landmark Software
Sunnyvale, CA

Let me begin my reply by flatly stating that you are right. We know the problem exists, and we are doing everything we can to prevent similar occurrences in the future. We have recently made an important internal adjustment to the flow of manuscripts through our office to give us an additional opportunity to catch errors of this kind. We already make multiple editorial passes over the material and do our best to cross-check by using different editors on different passes. We also take pride in our choice of staff and contributing authors. Even so, no one has been error-free. The amount of detail involved, as I am sure you will agree, is mind-boggling. We rely on our sophisticated readers to spot the errors and let us know, and we have been unbashed in publishing these corrections.

—WF

Prompting Users

Many authors of .COM routines try to minimize the number of bytes used. This is laudable, but it should be remembered that disk blocks are 512 bytes long. If the .COM file does not use an entire block, it is worth using the available space to add help for the user.

Douglas Ritari's EPSON.COM program in the September issue of *PC Tech Journal* ("The DOS Command IBM Forgot," page 79) is a good example. His 281-byte program provides a useful means for setting various modes (emphasized, double-strike, compressed, wide, italics, top-of-form, unidirectional, reset, and hex input) of an Epson printer. However, the occasional user is unlikely to remember all the various switches. One possible solution is to add the following code just above the label SEARBK:

```
CMP AL,'?'
JNE SEARBK
MOV DX,offset HELP2
MOV AH,09H
INT 21H
```

If the user has requested help, set up the pointer to the message and request function call 9 to display the message. Somewhere in the program (preferably in the data initiali-

A BUREAUCRAT'S GUIDE TO WORD PROCESSING

Now, if it were you or I and we wanted a word processing program for our IBM-type PC, we'd probably stop off at our local computer store and simply diddle with a few.

You and I, however, are not the U.S. Department of Agriculture.

(Nor any of its permutations of subsystems like the Economic Research Service, National Resources Economics Division, Data Services Center, etc., etc.)

So when the USDA told ERS to tell NRED and DSC to look into a truckload of w.p. programs for all their PCs, the last thing they wanted was simple diddling. Their dedicated Wangs and Lexitrons were far too few to handle their needs, their IBM® PCs weren't compatible with them anyway, and nobody really, quantifiably, knew from word processing with a personal computer.

Definitely not a diddling-mode condition.

As they put it in The Exchange, an internally distributed publication of the Department of Agriculture: "A needs assessment showed that, in the long-term, a word processing system is needed that can increase word processing capability and also be compatible with ERS' Long Range Information Management goals."

Well. "Needs assessment" led swiftly to "procurement action," which galloped into an "objective review" of the eight top-rated PC programs on the market (as compiled by The Ratings Book published by Software Digest), along with Wordstar® and Display Write 2, because they had some around.

Thus armed with the names, the final evaluators (a team of secretaries from NRED who would be the primary users of the PC software) became armed with each of the programs, along with checklists to record such things as ease of use, advanced features, and similarity to their existing dedicated equipment.

The first to be eliminated from the prospect list were Office Writer™ and Samna,™ since they're copy-protected and couldn't be transferred to hard disks.

Next, IBM's Display Write 2: because it's "not compatible with other software used in ERS (like Lotus 1-2-3,™ dBASE II,® etc.)," and it's "full of confusing menu options and cryptic error messages." Au revoir IBM.

Then, three more, for a variety of reasons.

Which left the following:

Volkswriter® Deluxe™
MultiMate™
Leading Edge™

Volkswriter Deluxe? "Too complicated and confusing." Not "easy to learn or use."

MultiMate? Not bad. It actually tied the winner in a few categories.

The winner being the one that won 82% of the votes in the Ease of Use/Ease of Learning categories. The one about which they said, "The ability to store deleted text and automatic document backup features were both highly desirable." The one they thought they'd quickly "be able to use . . . for their day-to-day word processing tasks."

The whole process took some three months of work by people in DSC to support the NRED in its work with the ERS and DSC to make the world a better place for the USDA.

But the results were well worth the wait. Because at last they've solved their word-processing problems . . .

"With Leading Edge!"

THESE ARE THE PACKAGES THE COMMITTEE EVALUATED:

THESE WERE THE FINALISTS:

THIS WAS THE WINNER:
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LEADING EDGE WORD PROCESSING

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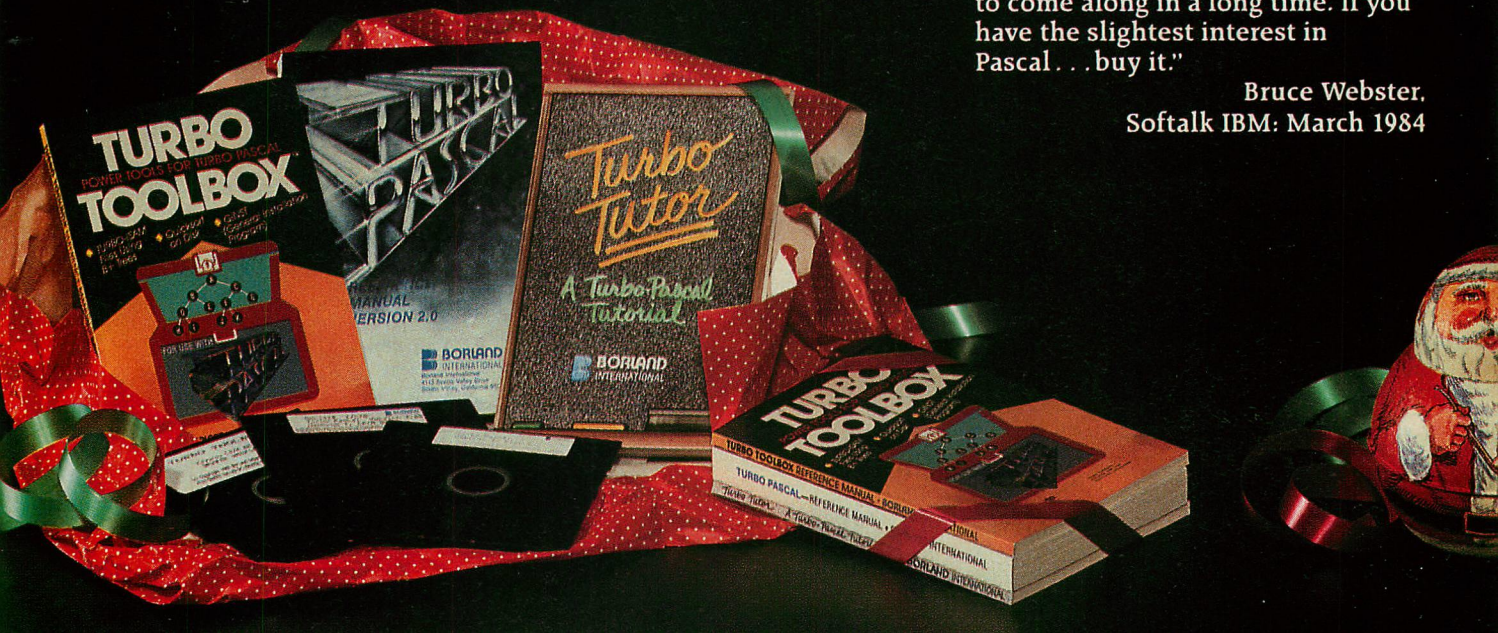
Jerry Pournelle,
Byte, July 1984

"TURBO PASCAL appears to violate the laws of thermodynamics.

You won't find a comparable price/performance package anywhere. It is simply put, the best software deal to come along in a long time. If you have the slightest interest in Pascal . . . buy it."

Bruce Webster,
Softalk IBM: March 1984



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TURBO PASCAL Version 2.0 (reg. $49.95). The now classic program development environment still includes the FREE MICROCALC SPREAD SHEET. Commented source code on disk

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NEW! TURBO TOOLBOX (reg. $49.95). A set of three fundamental utilities that work in conjunction with TURBO PASCAL. Includes:

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- GINST (General Installation Program)

Provides those programs written in TURBO PASCAL with a terminal installation module just like TURBO'S!

- NOW INCLUDES FREE SAMPLE DATABASE . . . right on the disk! Just compile it, and it's ready to go to work for you. It's a great example of how to use TURBO TOOLBOX and, at the same time, it's a working piece of software you can use right away!

NEW! TURBO TUTOR (reg. $29.95). Teaches step by step how to use the TURBO PASCAL development environment—an ideal introduction for basic programmers. Commented source code for all program examples on disk.

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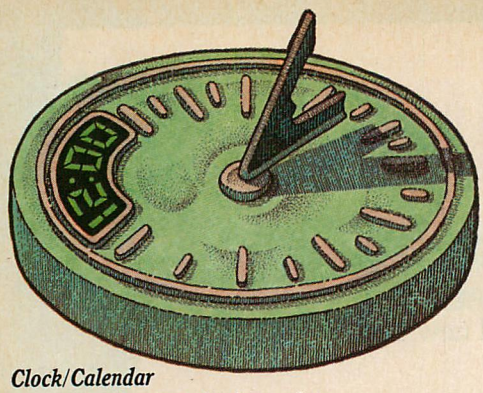

Clock/Calendar
Automatically inserts the date and time when you turn on your computer.

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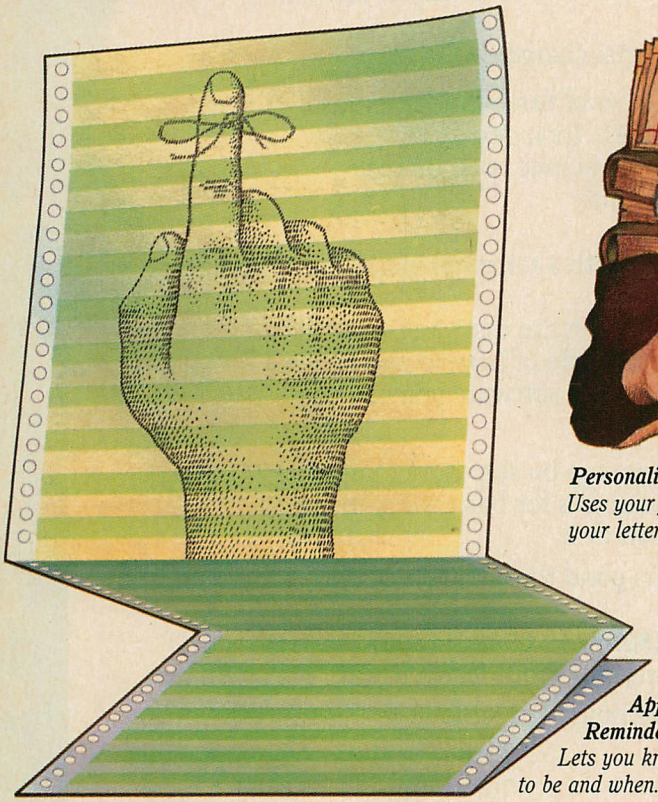

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Uses your file to personalize your letters and make labels.

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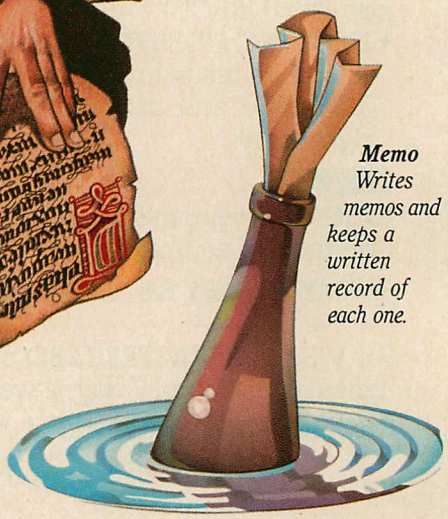


Memo
Writes memos and keeps a written record of each one.

Tecmar thinks your PC

As your business grows, so should your computer. Only Tecmar offers you this unique package of hardware and free software. With it your PC can grow to its full potential.

Tecmar Multifunction Boards...

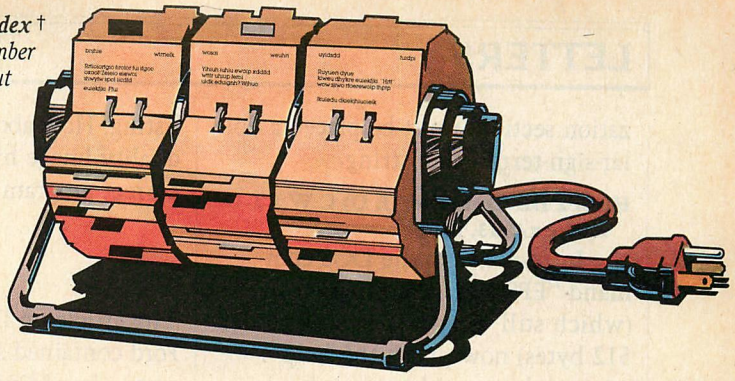
"extremely powerful."—PC World

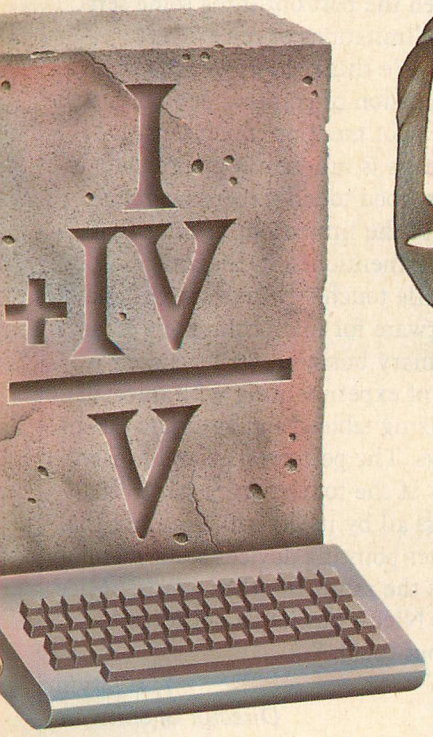
A Tecmar board will expand your computer's memory and increase its speed and efficiency. It will give you additional ports to accommodate a wide range of peripherals from modems and plotters to dot matrix and letter quality printers. With a Tecmar board you can run powerful programs like Lotus 1-2-3™* and WordStar®†† on a PCjr. The RamSpooler makes printing a background task and frees your PC for other jobs. A built-in clock/calendar automatically inserts the date and time at power on and is independently powered by an easily replaced battery.

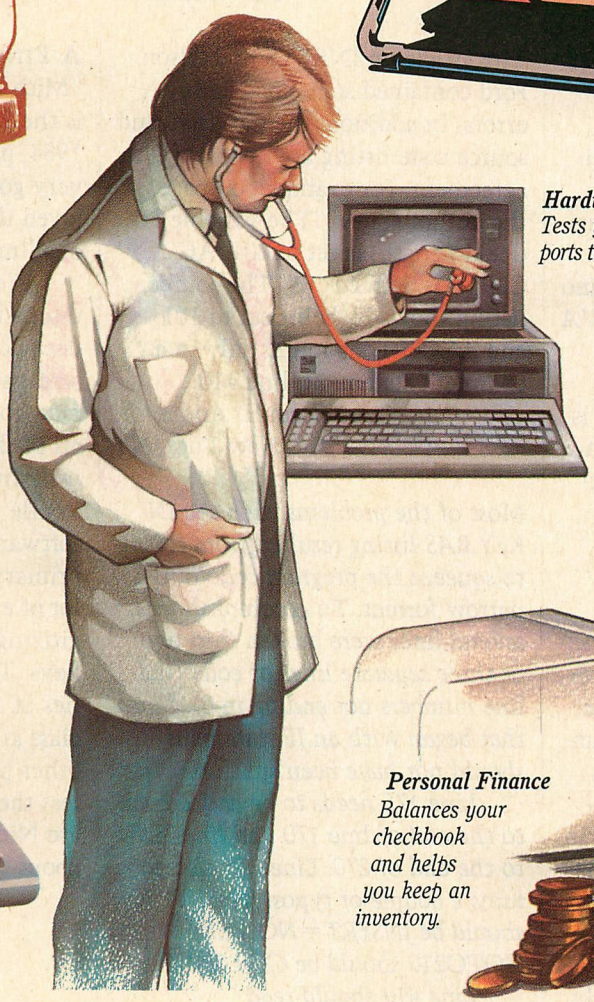
Every Tecmar multifunction board is run through a series of rigorous tests to ensure quality. Our incredibly low failure rate (0.4%) is unparalleled. All boards are additionally backed by a full one-year warranty.

Banner
Allows you to print in a variety of type sizes. Even large banners!

Rolodex†
Finds the name and number you need instantly without changing programs.







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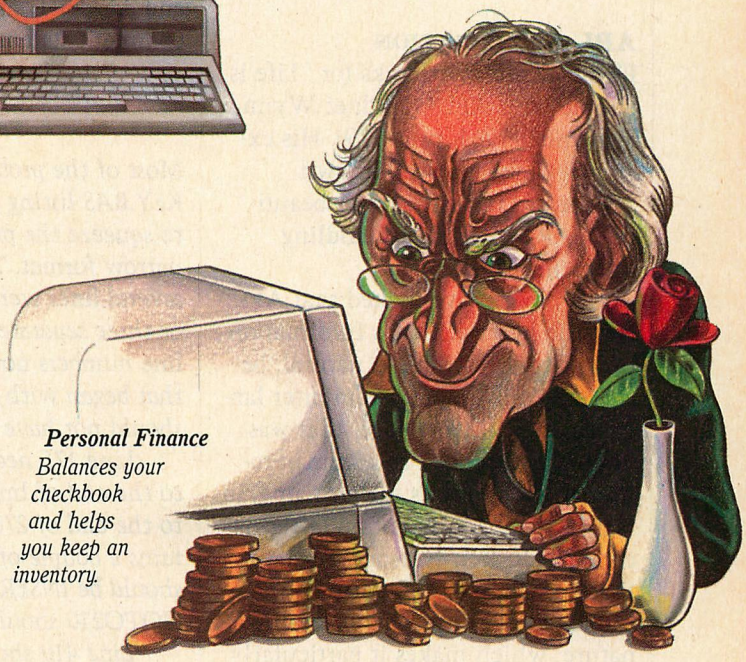

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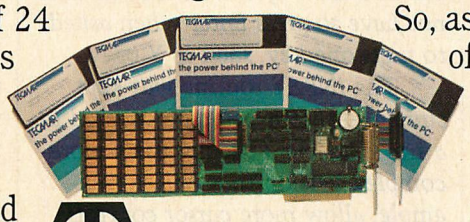

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CIRCLE NO. 195 ON READER SERVICE CARD

zation section) must be placed a dollar-sign-terminated string:

```
HELP2 DB 'Options: (E D) C W I T U R /hex/', 13, 10, '$'
```

In response to the DOS command "EPSON?" the program (which still weighs in at well under 512 bytes) now prints the help prompt shown. (Note that the default parameters, E D, also are indicated.) I urge all programmers to adopt this policy of prompting users in response to the parameter "?".

Alan Aqualino
Charlottesville, VA

APL Appreciation

Please accept my thanks for "Life is Simple with APL" (Pardner Wynn, September 1984, page 129). His example, Conway's well-known "Game of Life," illustrates beautifully APL's facility at handling arrays in real life.

It is often overlooked that APL is at the heart of IBM's Information Center concept. This is natural, because APL is the only computer language, to my knowledge, that was originally intended as a human-to-human notation; its earlier name, in fact, was Iverson Notation (after its creator, Dr. Ken Iverson). Perhaps that may help to explain APL's "concise, expressive, and versatile" nature, which makes it particularly appropriate in the business world where another game of life is played: making money.

Jim Fiegenschue
PCResults
Carrollton, TX

Wrong Listing?

I am appalled at the program listing INKEY.BAS that was published in the August 1984 issue of *PC Tech Journal* ("Controlling Input Using INKEY$," Nelson Ford, page 32). Besides lack of correlation with the text of the article, the listing contains many syntactic errors, logical errors, and much superfluous code.

I have to believe someone made an error, and you printed the wrong listing. How about repairing your quality image by publishing the correct program?

Hugh S. Jackson
New York, NY

The article on INKEY$ by Nelson Ford contained some maddening errors. In addition, the narrative and source code listing are not always in agreement. For example, on page 34 the author states: "The variable FL (Field Length) is set to 301, ACCEPT$ is defined . . ." The source listing shows FL being set to 101, and ACCEPT$ is found only in a comment statement, line 410.

John H. Andren Jr.
New York, NY

Most of the problems with the INKEY.BAS listing resulted from trying to squeeze the program code into a narrow format. To accomplish this, several lines were broken into two or three separate lines of code (the line numbers not ending in 0). Lines that began with an IF statement should not have been split up.

Line 175 needs to be added back to the end of line 170 and line 275 to the end of 270. Line 275 also contains a couple of typos: INSERT-NO should be INSERT=NO, and GOTO210 should be GOTO 210.

Line 410 should read

```
IF CHAR.ACCEPT.CODE=3 THEN IF INSTR (ACCEPT$, N$) >0 THEN 500
```

and line 760 should read

```
ACCEPT$="123": LOCATE 14,33: FL=301: GOSUB 100
```

Line 590 should read GOTO 190 to be consistent with the text. In practice, the reader might want to leave the line the way it is so that he does not have to press Enter when asked to press one key, such as Y or N.

The INKEY routine was kept simple so that it could be covered in a single article. I usually use a more complex version that will, for example, allow more cursor controls (word right, word left) and constants in the input field (the slashes in a date field) and that constantly monitors and displays the status of the NumLock and CapsLock keys.

—Nelson Ford

A Finishing Touch

"Mice are Nice . . . but performance is the key" (Will Fastie, August 1984, page 5) makes a number of very good points. We especially enjoyed the part outlining some serious limitations of mice.

We think, however, that any discussion of pointing devices that does not mention touch-sensitive screens is inherently incomplete. In fact, good touch screens overcome all of the limitations of mice that were mentioned in the article. While touch-sensitive screens and software for microcomputers is our primary business, we have done a lot of experimenting with mice, digitizing tablets, and keyboard cursor keys. The performance and capabilities of the touch screen put it in a class all by itself, while most of the other pointing devices seem more or less the same. In other words, "Mice are Nice—but let us not forget about touch."

Yuri Litvin
Director of Software
MicroTouch Systems
Woburn, MA

Looking for .OBJ

I bought my first copy of your magazine in a computer store last year because of the article on .EXE and .COM file formats ("Load and Go: .COM and .EXE Files Explained," Tom Carter, September/October 1983, page 136). Although it turned out that this article had some inaccuracies, it gave me enough correct information that I was able to fill in the rest of the details myself. On the strength of that first issue, I subscribed to your magazine. On the whole, I have been pleased.

I have been hoping to see a subsequent article on the format of .OBJ files. Several books on assem-

bly language programming refer to .OBJ files as if their structure were well known, but where is this well-known information?

John Blattner
Santa Monica, CA

An article on .OBJ files has been assigned and should appear in the next several months.

—WF

A *Much* Easier Way

Your typo, leaving out a phrase from my program (learned from National CSS timesharing) submitted as a letter to the editor in the September 1984 issue ("An Easier Way," page 20), makes my contribution meaningless. Please consider printing a correct version.

James M. Detmer
Detmer Systems Co.
New Canaan, CT

We considered it, and below is printed the corrected program. We are sorry for the mistake.

—WF

```
ECHO OFF
REM (((FORMAT.BAT)))
REM PREVENTS USE OF
  FORMAT COMMAND
  LACKING DRIVE
  SPECIFICATION
REM REQUIRES
  FORMAT.COM
  TO BE RENAMED
  FORMATJD.COM
IF NOT "%1"=="" FOR-
  MATJD %1 %2 %3 %4 %5 %6 %7
  %8 %9
IF "%1"=="" ECHO DRIVE
  SPECIFICATION MISS-
  ING—PLEASE TRY AGAIN
```

A Safer Way

I was pleased to see Tech Notebook 20 for "Disarming DOS FORMAT" (James A. Folts, July 1984, page 32). I believe the safety could be improved for those persons using multiple memory disks. For instance, the Quadram version of these programs bumps the hard disk up to the next available letter. In the case of the XT, the first memory disk is

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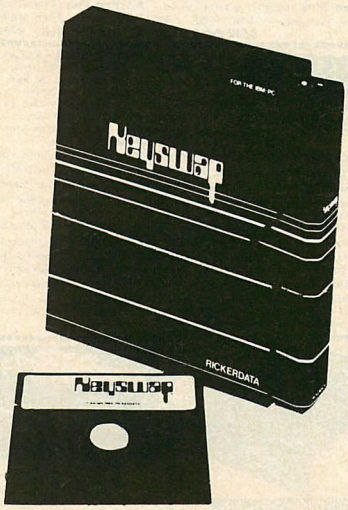

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LETTERS

assigned to B, the next memory disk to C, and the hard disk is then assigned to D. Thus, protection for the hard disk can be lost.

If the instruction located at 1862 in the listing, namely JZ 1868, is changed to JNB 1868, then all drive designations of C, D, or above will give the "Invalid drive parameter" error message.

A.M. Foley
Tokyo, Japan

Erratum: *Our attention has been called to a copy editing error made in "Random Number Generators" (Paul Hultquist, August 1984, page 86). A sentence on page 97 stating that "chi square is distributed uniformly" should have read, "RND is distributed uniformly."*

—WF

Thank you for all your questions and comments. We appreciate all of them—complimentary and critical. Please address editorial correspondence to PC Tech Journal, *Suite 211, World Trade Center, Baltimore, MD 21202, or contact us through CompuServe 74156,2365 or the Source, STY682. Be sure to include your name and address.*

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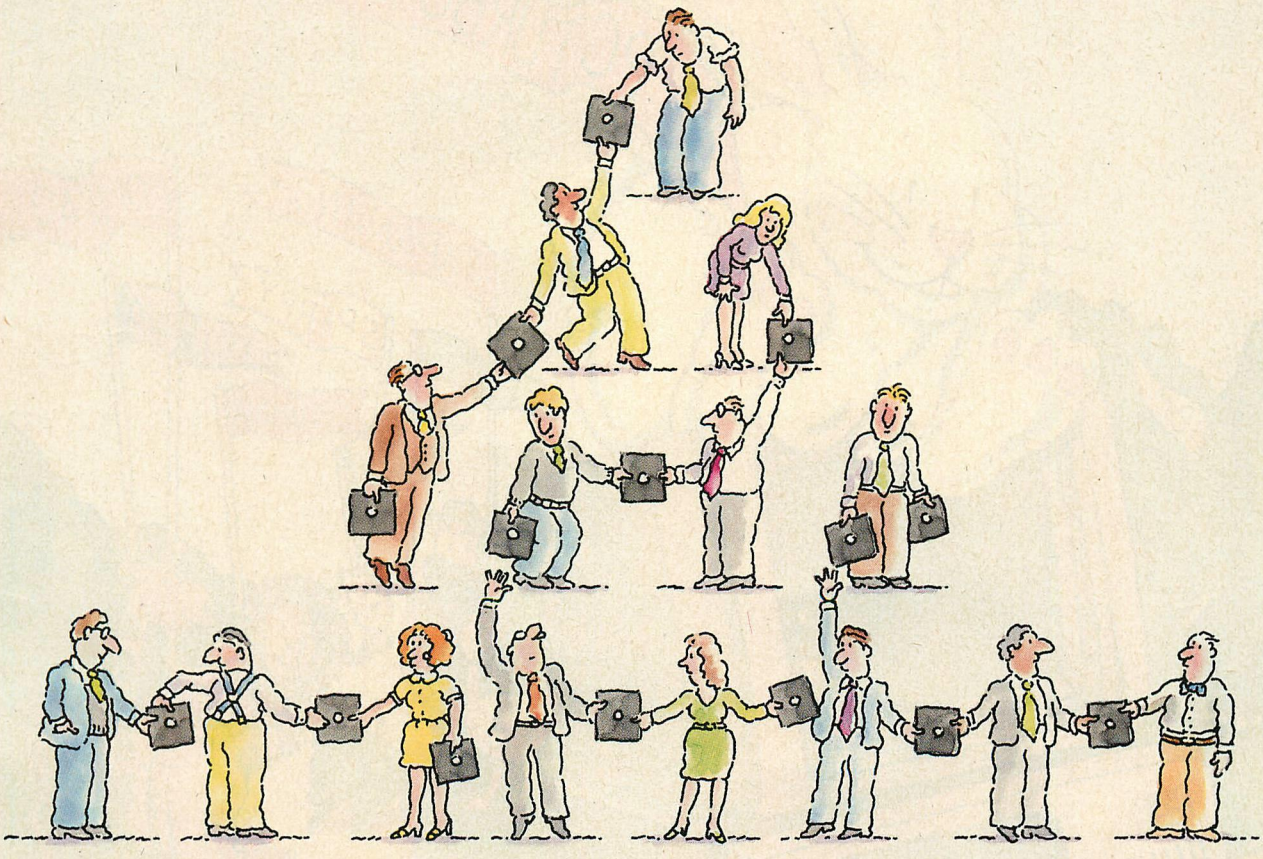

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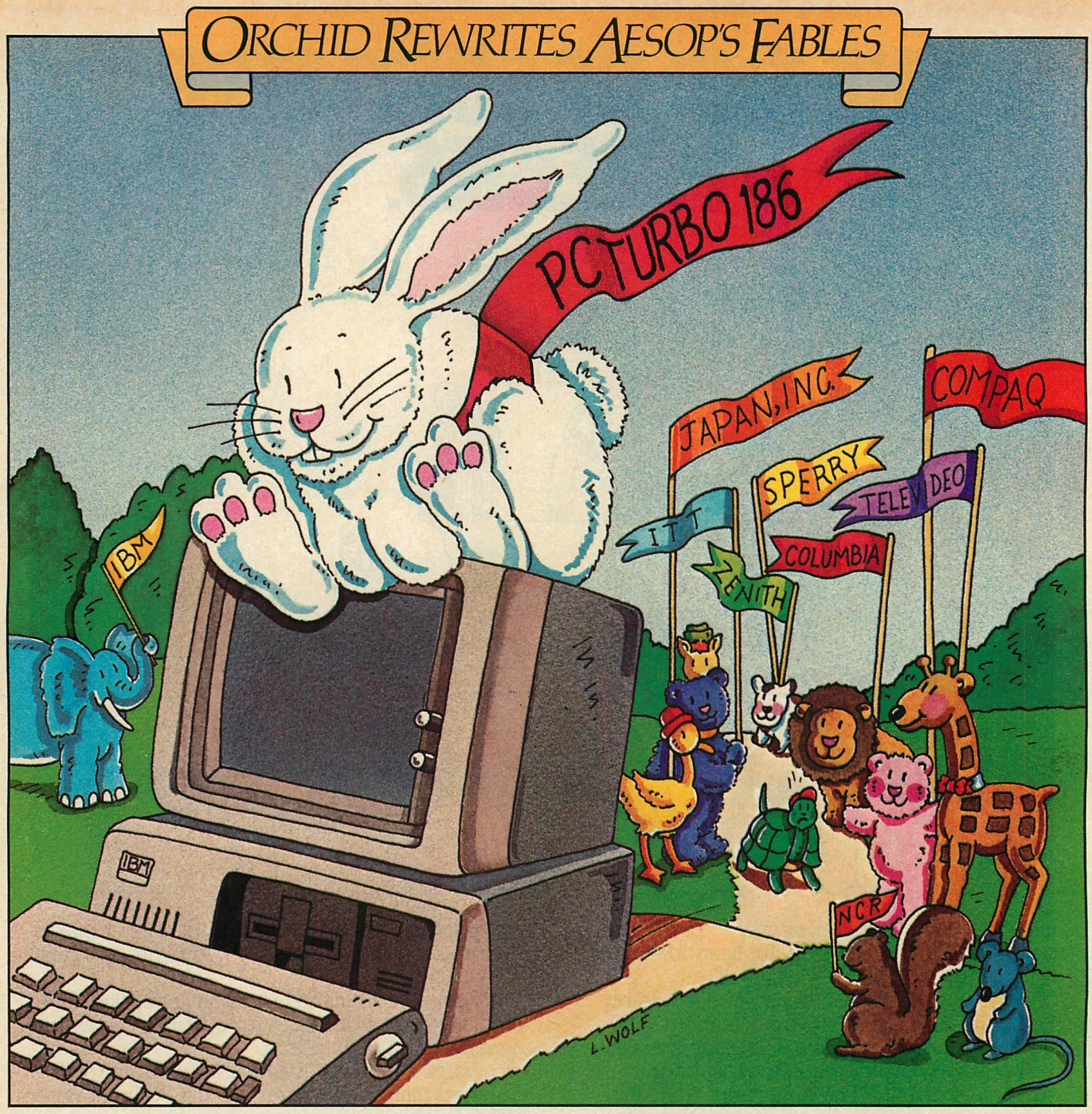

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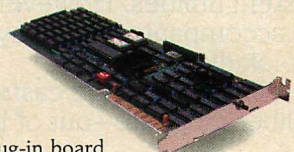

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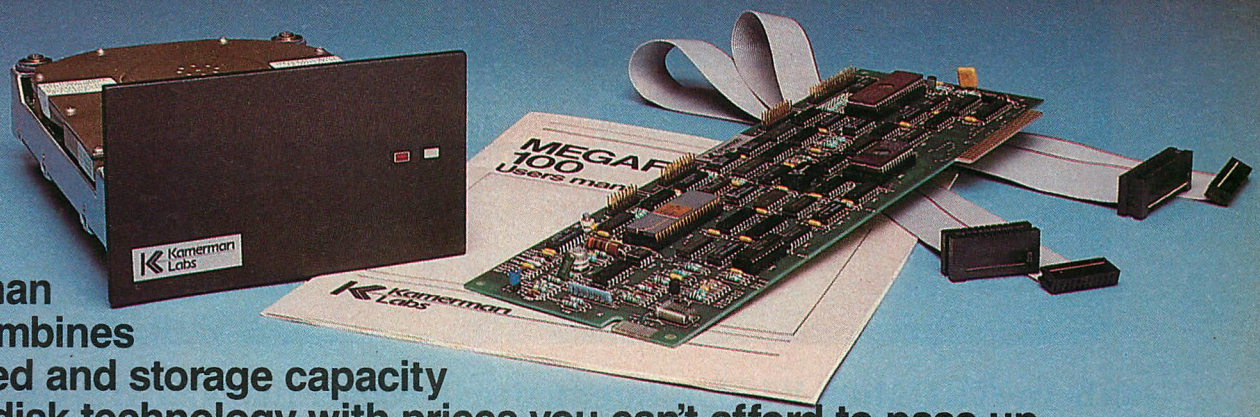

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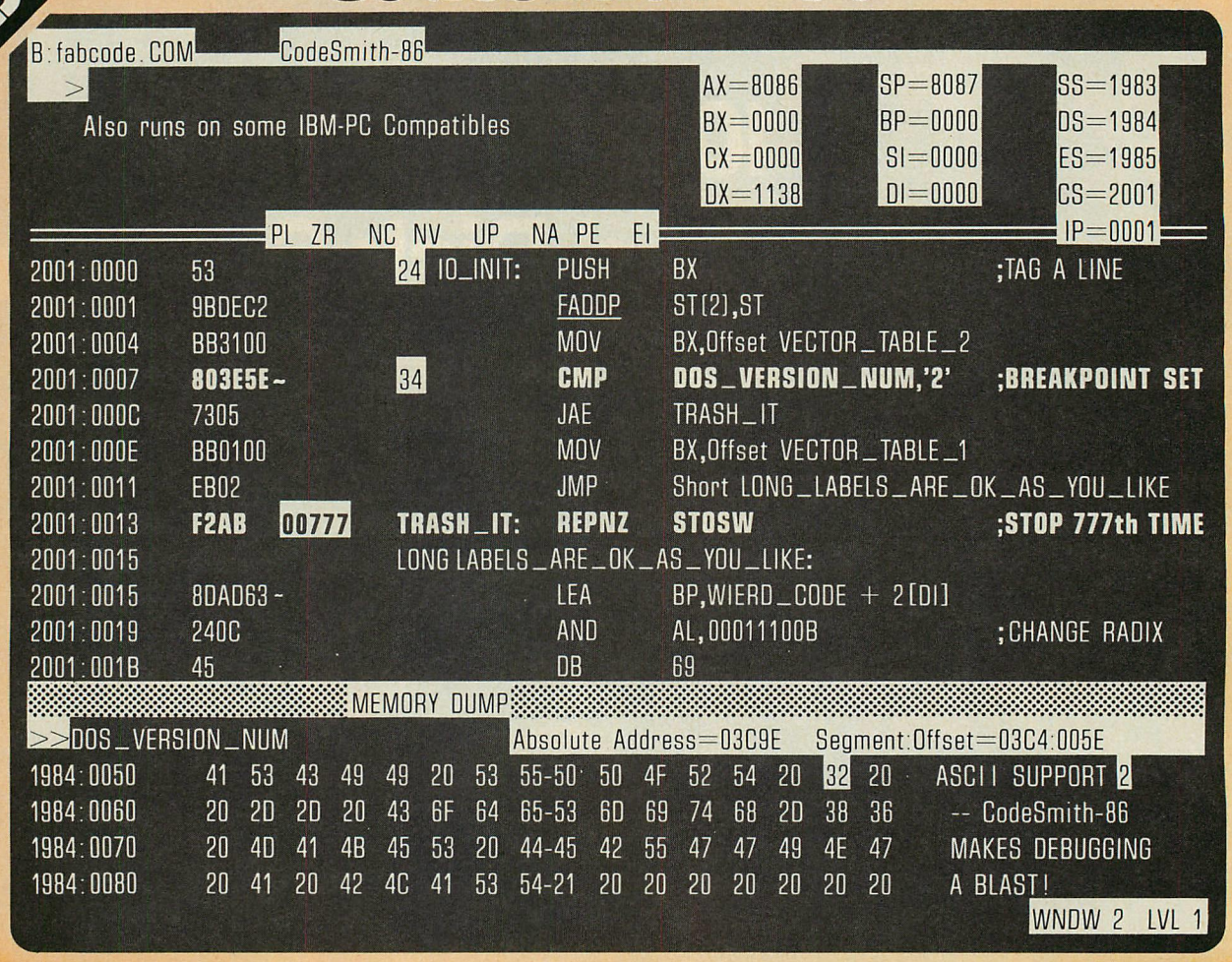

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PROGRAM ORCHESTRATION

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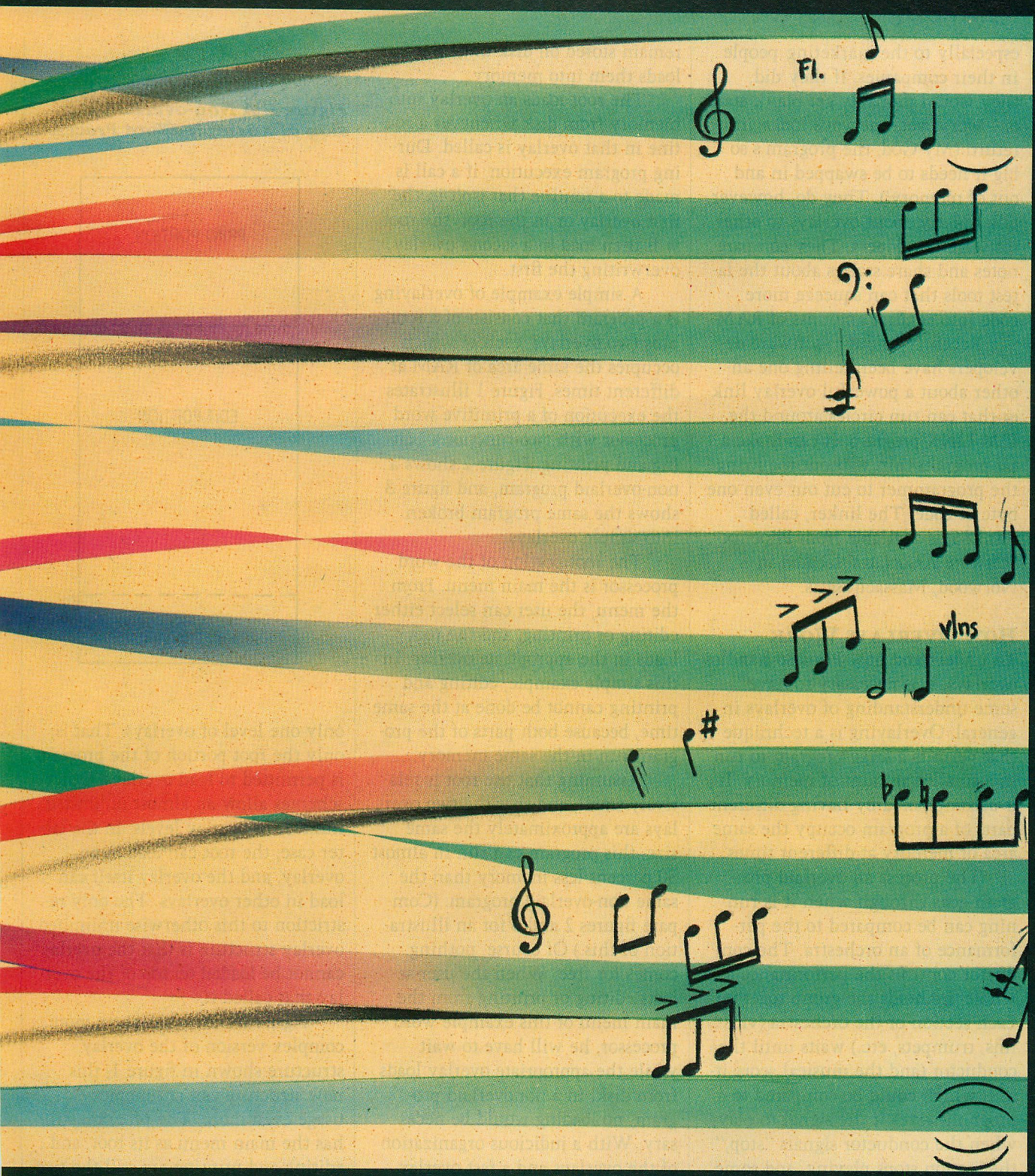


ILLUSTRATION • AKIO MATSUYOSHI

Plink86 arranges a large program to fit into less memory.

Professional software developers have a secret tool that they can pull out whenever a Pascal, FORTRAN, C, or any other compiled program grows too far beyond its intended size. This secret tool is called *program overlays*, or just *overlays* for short. Software developers don't talk much about overlays,

Steven Armbrust is working as a senior documentation engineer at Multisoft Corporation.
Ted Forgeron is vice president of systems software engineering, also at Multisoft Corporation.

especially to the marketing people in their companies. If they did, they would probably get blank stares or—worse yet—nervous looks in return (My God, the program's so big it needs to be swapped in and out of memory!). They do, however, talk quietly about overlays to other software developers. They compare notes and share stories about the latest tools that can squeeze more code into smaller amounts of RAM.

Recently, though, software developers have been telling one another about a powerful overlay linker that can run circles around the IBM LINK program. It can make a fat program thin without requiring the programmer to cut out even one byte of code. The linker, called Plink86, is available from Phoenix Software Associates, located in Norwood, Massachusetts.

How Overlays Work

To understand how Plink86 handles overlays, it is necessary to have some understanding of overlays in general. Overlaying is a technique that permits a large program to run in a smaller amount of memory. It is accomplished by having different parts of a program occupy the same area of memory at different times.

The process an overlaid program goes through when it is running can be compared to the performance of an orchestra. The conductor controls the performance as a whole; he holds the group together. Each section of the orchestra (violins, trumpets, etc.) waits until the conductor (and the musical score itself, which could be compared to a program) gives it the signal to play; when the conductor signals "stop," the section stops playing, and some other section takes over.

In an overlaid program, the part of the conductor is played by one portion of the program—called the *root*—that is always resident in memory. The branches of the program—called overlays—function as the sections of an orchestra do; they remain stored on disk until the root loads them into memory.

The root loads an overlay into memory from disk whenever a routine in that overlay is called. During program execution, if a call is made to a routine that isn't in the first overlay or in the root, the root will then load in a second overlay, overwriting the first.

A simple example of overlaying is a program that consists of a root plus two overlays, each of which occupies the same area of RAM at different times. Figure 1 illustrates the execution of a primitive word processor with two functions: editing and printing. Figure 2 shows a non-overlaid program, and figure 3 shows the same program broken into simple overlays.

The root portion of the word processor is the main menu. From the menu, the user can select either editing or printing, and the root loads in the appropriate overlay. In this simple example, editing and printing cannot be done at the same time, because both parts of the program run in the same memory.

Assuming that the root is relatively small, and that the two overlays are approximately the same size, this program can run in almost 50 percent less memory than the same non-overlaid program. (Compare figures 2 and 3 for an illustration of this.) Of course, nothing comes for free. When the user selects editing or printing from the main menu of this example word processor, he will have to wait while the appropriate overlay loads from disk. In a nonoverlaid program, no loading would be necessary. With a judicious organization of the overlays and a fast overlay loader, however, the wait will be relatively painless, and the inconvenience will be more than offset by the great savings in memory.

Overlaying schemes can be simple or complex, depending on the design of the overlay structure. Some overlaying schemes permit only one level of overlays. That is, only the root portion of the program is permitted to load overlays. Other schemes allow an almost unlimited number of overlay levels. In the latter case, the root can load in an overlay, and the overlay itself can load in other overlays. The only restriction to this otherwise unlimited overlay structure is that the overlay cannot be loaded on top of the overlay that called it.

Figure 1: A Non-overlaid Version of a Sample Word Processor

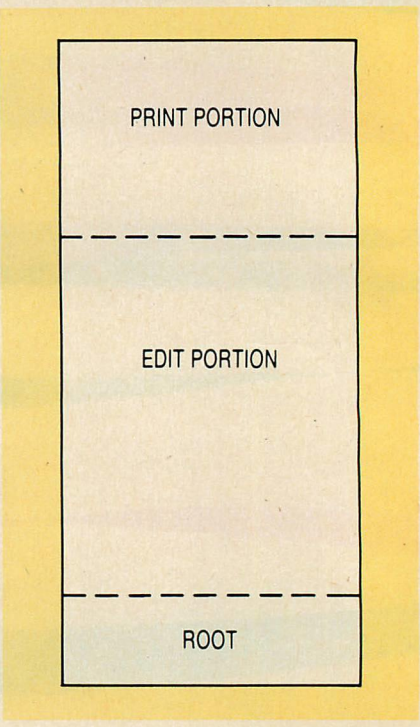


Figure 3 shows a slightly more complex version of the overlay structure shown in figure 1; this new structure can cut memory usage even more. The program still has the main menu as its root, and editing and printing are still the two main overlays. This version of the program can run in less memory, however, because the editing and printing portions have been broken up into more overlays.

The editing portion has a primary module that handles keyboard I/O, word wrap, and other opera-

Figure 2: A One-level Overlay Scheme for a Word Processor

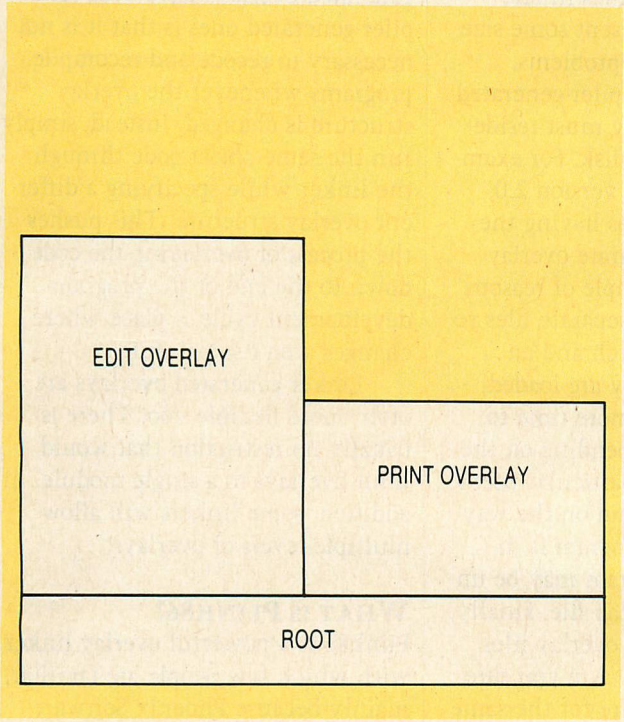
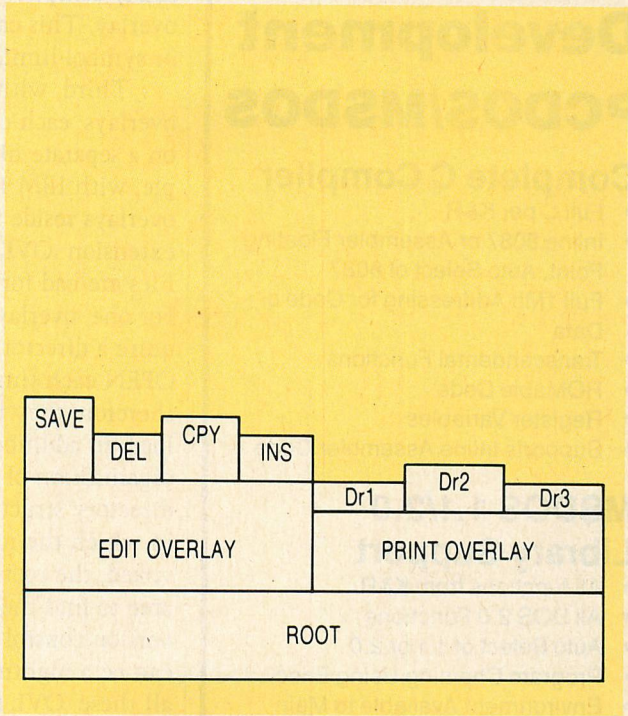


Figure 3: A Multi-level Overlay Scheme for a Word Processor



tions that are always required while editing a document. The overlays handle inserting, deleting, copying, and saving (it's still a simple word processor; those are all the operations it can handle).

With this structure, the program is a little slower than it was before (if the user tries to delete something, he has to wait while the program loads in the delete overlay, for example), but the editing part of the word processor now requires less memory than it did before.

The printing portion of the word processor is similarly divided: the individual printer drivers are broken out as overlays. To print something, the user selects a document to print and a printer driver. The program will then load the correct driver (if it isn't loaded already) and print the document. Like editing, printing is slower than it was before (because the user has to wait while the printer driver loads), but memory is saved by keeping the unused printer drivers on disk instead of in RAM. And if the program is set up correctly, performance loss can be minimized by always loading in a default printer driver—one that the user chooses.

Putting Overlays into a Program

There are two ways in which programmers can turn code into overlaid code: they can use either compiler-generated overlays or linker-generated overlays.

Some compilers support overlays directly. IBM Pascal version 2.0, SBB Pascal, and Turbo Pascal all support their own versions of overlays. To use these compiler-generated overlays, programmers should include statements in their source code to inform the compiler which pieces of code reside in which overlays and when the overlays should be loaded. Calls to the compiler's overlay loader should be included as part of the program's root module.

There are some disadvantages to using compiler-generated overlays. First, setting up any overlay structure involves a lot of trial and error. It may be necessary to set up the overlay structure several different ways, testing the program each time to see which set-up produces the best performance. It's easy to slip up and include a call to an overlaid subroutine inside a program loop that executes several hundred times. This might slow the program to a crawl. Only by testing can programmers find all these situations.

With compiler-generated overlays, it's relatively difficult to experiment with overlay structure. To change this structure, programmers have to go back to their source code, change some of the statements, and recompile the code. Some compilers are fairly fast, but recompiling programs that are large enough to need overlays can take an annoying amount of time. Certainly, no one wants to recompile on a whim.

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Additionally, using compiler-generated overlays requires each overlay to be a single module. It is not possible to include several separately compiled modules in one overlay. This can present some size- or symbol-limitation problems.

Third, with compiler-generated overlays, each overlay must reside on a separate file on disk. For example, with IBM Pascal version 2.0, overlays reside in files having the extension .OVL. Separate overlay files are bad for a couple of reasons. For one, overlays in separate files require a directory search and an OPEN each time they are loaded; therefore they take more time to load. In addition, depending on the organization of the particular user's directory structure and on the way in which the root program is invoked, the root program may be unable to find the overlay file. Finally, version control with overlay files can be a nightmare ("Are you *sure* all these .OVL files are for the same version of the program?").

One final disadvantage of compiler-generated overlays is that compilers usually support only a single level of overlays. That is, the root portion of the program is the only portion that can load overlays. A compiler could support the overlay structure outlined in figure 2, but not the one shown in figure 3.

The second way to get overlays into a program is to use a linker that supports overlays directly. Linker-generated overlays correct many of the disadvantages of compiler-generated overlays. To use linker-generated overlays, simply code and compile the program as if it had no overlays at all. Then, when the separate modules of the program are linked together, tell the linker how the overlays should be set up and which modules reside in which overlays. When the program runs, the overlay manager (which is contained in a library that should also be linked to the program) intercepts the calls to the overlaid routines and loads the overlays when needed. With linker-generated overlays, overlay loading is automatic.

Another advantage that linker-generated overlays have over compiler-generated ones is that it is not necessary to recode and recompile programs whenever the overlay structure is changed. Instead, simply run the same object code through the linker while specifying a different overlay structure. This pushes the process of overlaying the code down to the end of the program-development cycle, a place where changes aren't so painful.

Linker-generated overlays are often more flexible, too. There is usually no restriction that would limit overlays to a single module. In addition, some linkers will allow multiple levels of overlays.

WHAT IS PLINK86?

Plink86 is a powerful overlay linker with which few people are familiar, mainly because Phoenix Software Associates, its creator, hasn't spent much money to advertise the product. Even so, Plink86's fame is spreading by word of mouth, and it's becoming a cult favorite.

Plink86 is used as a substitute for IBM LINK, MS-LINK, or any other linker that would normally be used with compiled or assembled code. It can link any object modules that adhere to the Microsoft or Intel relocatable object-module formats. For example, Plink86 version 1.4 can handle object modules produced by the following compilers: Lattice C, Microsoft C, Mark Williams' C, Computer Innovations' C86, Microsoft FORTRAN, Microsoft Pascal, Microsoft BASIC, Microsoft COBOL, mbp COBOL, Microsoft Macro Assembler, and most Intel languages. As new compilers, or new versions of compilers, become available, Phoenix Software Associates usually updates Plink86 to support them.

The primary strengths of Plink86 are its ability to handle overlays, its debugging features, its

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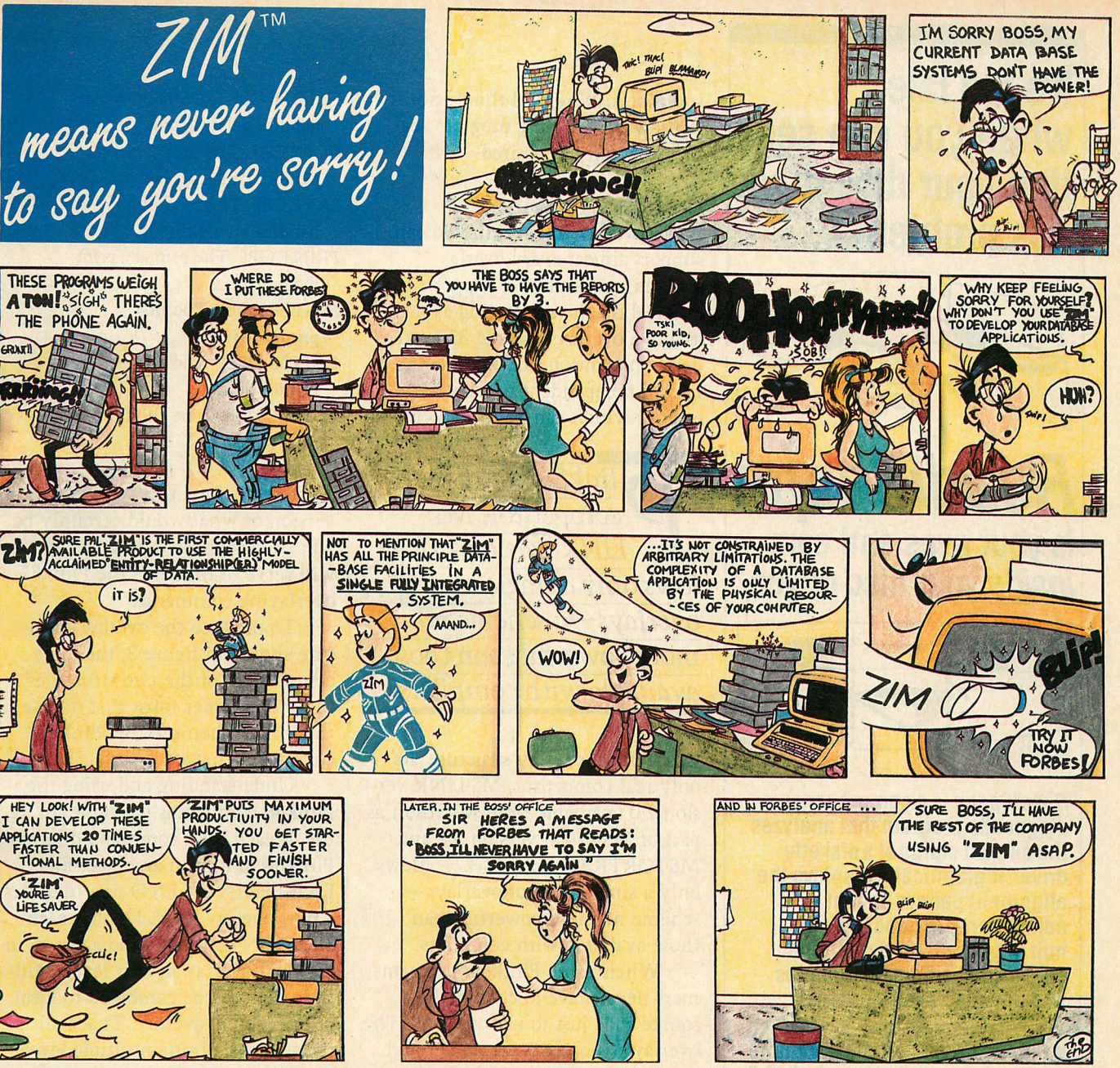

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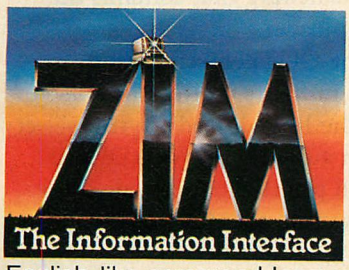

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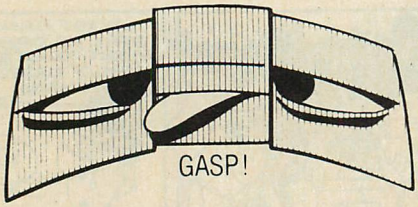

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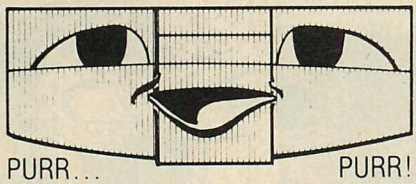

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OVERLAY FEATURES

As an overlay linker, Plink86 can support almost every overlay scheme imaginable. It supports hierarchical overlays, allowing as many as 4,095 overlays stacked 32 levels deep. In addition, it allows definition of independent overlay areas, each of which can have its own hierarchical overlay structure. Its only real competitor, MS-LINK version 2.0 (available from Microsoft as part of MS-Pascal version 3.2 and MS-FORTRAN version 3.2), allows only a single level of overlays—a scheme no more powerful than those available with compilers.

Plink86's only real competitor, MS-LINK version 2.0, allows only a single level of overlays—a scheme no more powerful than those available with compilers.

When using Plink86, programmers never have to change their source code just to use overlays. The overlay structure is set up through the link commands entered when the modules are linked together.

The example of the word processor can be used one more time to illustrate the Plink86 commands that would be used to link the program together and to obtain the desired overlay structure.

First, suppose that the word processor has been written in MS-Pascal, all its program modules have been compiled, and object files with names like these have been set up:

ROOT.OBJ The main menu
EDIT.OBJ The primary edit module
INSERT.OBJ The module that handles inserting text
DELETE.OBJ The module that handles deleting text
COPY.OBJ The module that handles copying text
SAVE.OBJ The module that handles saving files
PRINT.OBJ The primary print module
DRIVER1.OBJ The first printer driver
DRIVER2.OBJ The second printer driver
DRIVER3.OBJ The third printer driver

As stated before, this is a simplified version of what would certainly be a more complicated program, but it will serve to illustrate the Plink86 overlaying commands.

To produce the overlay structure shown in figure 3, the more complicated of the two structures, the programmer must first invoke the linker, then use the Plink86 commands that are shown in figure 4.

Understanding and using the Plink86 commands is simple. In figure 4, each FILE command directs Plink86 to link in an object file. Each BEGIN . . . END pair indicates a new overlay level. Finally, each SECTION command indicates an individual overlay in that level. Multiple files can be combined to form an individual overlay. That's all there is to defining multiple levels of overlays. The overlay manager, which is located in a file called OVERLAY.LIB, gets linked in automatically, so it does not need a command. No license fee is charged for selling software that contains the overlay loader.

The OUTPUT command shown in figure 4 directs Plink86 to place the linked, ready-to-run object code in a file called WORDP.EXE. Plink86 places the root and all the overlays into a single file, thereby avoiding the problems with multiple-file overlays, which were discussed earlier. Plink86 will store overlays in separate files if desired, however. This allows programmers

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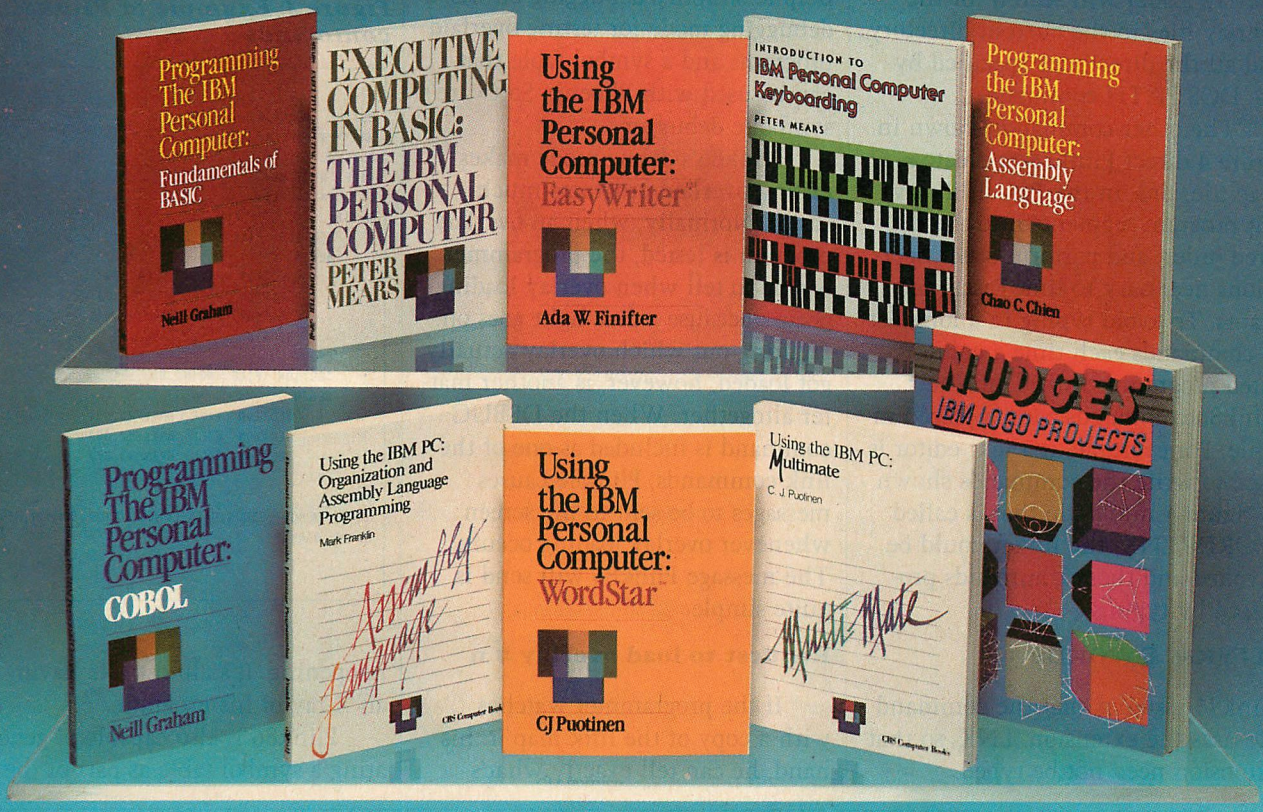

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to break up programs that are too large to fit on one diskette. The overlay loader will search for the overlay files in the current directory and all the directories specified by the DOS PATH command.

The other commands shown in figure 4 direct Plink86 to create a map file, link in the Pascal library, put program segments into the desired order, and perform other operations necessary to link Pascal programs. To avoid typing in a long list of commands each time a complicated program is linked, all the Plink86 commands can be placed in a file. For example, if a text editor is used to write the commands shown in figure 4 into a file that is called WORDP.LNK, the linker could be invoked and those commands processed by typing:

PLINK86 @WORDP

Plink86 assumes that the command file uses the extension .LNK, so that extension need not be typed.

DEBUGGING FEATURES

Plink86 offers two features that can help to simplify debugging efforts: a debugging mode for testing overlaid programs and a symbol table that can be used with Phoenix Software's symbolic debugger.

Plink86's debug mode makes testing overlaid programs much easier. Normally, when an overlaid program is tested, the programmer is able to tell when overlay loading occurs because a disk light goes on. Figuring out which overlay actually got loaded, however, is another matter altogether. When the DEBUG command is included as one of the link commands, Plink86 causes messages to be sent to the screen whenever overlay loading occurs. The message Plink86 will send is quite simple:

Request to load overlay # n

If the programmer watches with a copy of the link map in his hand, he can tell exactly what's happening. It's almost like having an X-ray of his program.

Plink86 is also capable of generating a symbol table as part of the

Figure 4: Example of Plink86 commands

```
OUTPUT  WORDP.EXE
MAP = WORDP.MAP A
DSALLOC
FILE  ROOT.OBJ
LIB  PASCAL.LIB
BEGIN
     SECTION  FILE  EDIT.OBJ
     BEGIN
          SECTION  FILE  INSERT.OBJ
          SECTION  FILE  DELETE.OBJ
          SECTION  FILE  COPY.OBJ
          SECTION  FILE  SAVE.OBJ
     END
     SECTION  FILE  PRINT.OBJ
     BEGIN
          SECTION  FILE  DRIVER1.OBJ
          SECTION  FILE  DRIVER2.OBJ
          SECTION  FILE  DRIVER3.OBJ
     END
END
CLASS  MEMORY,STACK,DATA,COMADS,CONST,COMMON,HIMEM
GROUP  DGROUP
```


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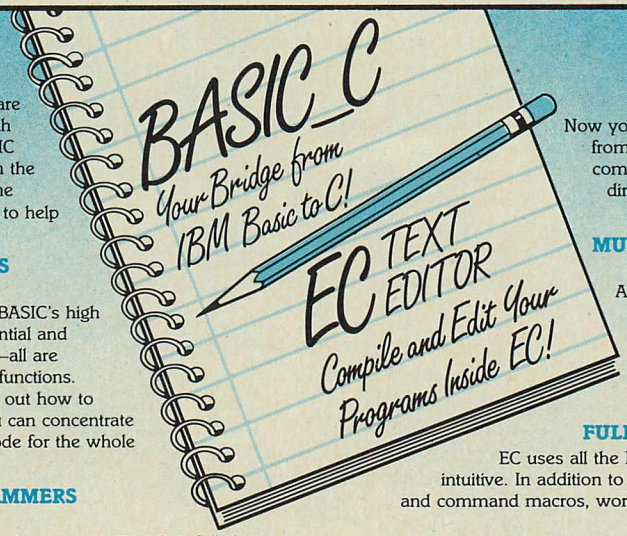

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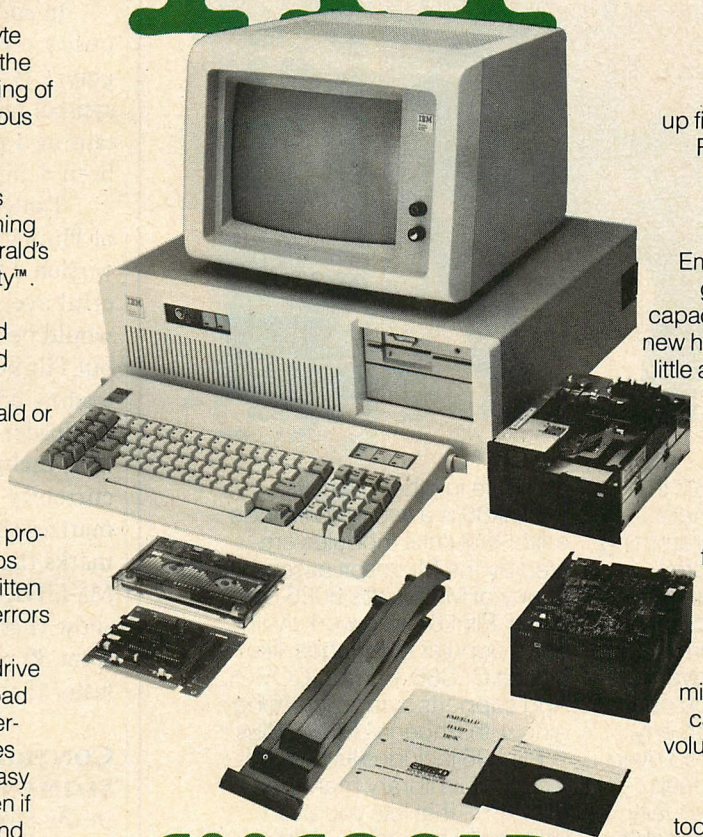

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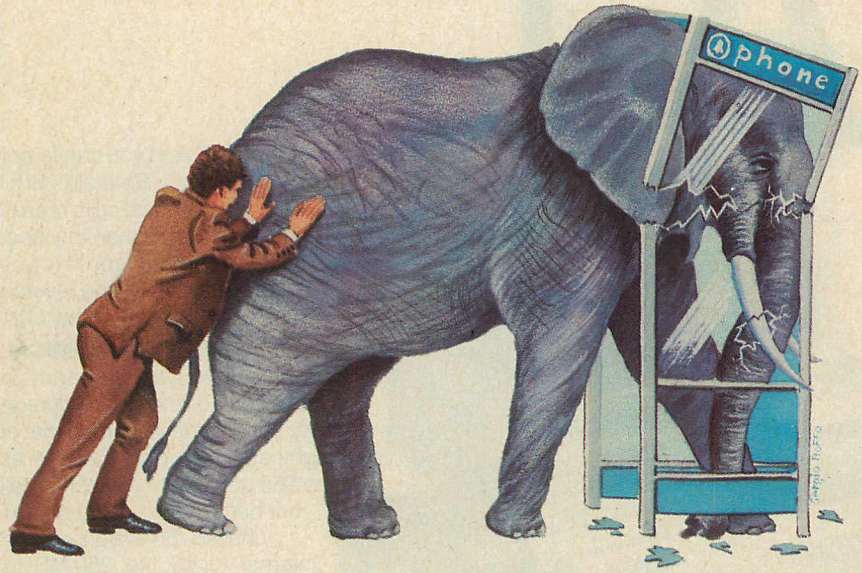

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.EXE file it produces. The symbol table allows Phoenix Software's new debugger, PFIX86-Plus, to perform symbolic debugging, which means that the programmer can refer to his program's procedures and global symbols by name instead of by absolute address. This reduces the need to search through link maps and calculate absolute addresses during the debugging process.

In addition, Plink86 contains a utility program that can list a program's symbol table and delete the symbol table from an .EXE file containing a program that has already been debugged.

Table 1 compares the features of Plink86 with those of MS-LINK version 2.0. Of course, all the powerful overlay features in the world would be worthless without speed, but Plink86 has that, too. Overlay loading occurs instantly. The overlay loader maintains a table of overlays, including which overlays are currently in memory. Table 2 summarizes the results of some benchmarks that compare Plink86 with MS-LINK version 2.0. These results show that Plink86 loads overlays from 30 percent to 55 percent faster than MS-LINK.

CONTROL OF PROGRAM SEGMENTS

In the 8088 architecture, a segment is an area of memory that can be accessed with a 16-bit address. Thus, each segment can have a length of 64K. A segment is the smallest entity a linker can manipulate.

The 8088 provides four segment registers (CS—code segment, DS—data segment, SS—stack segment, and ES—extra segment) to store the starting address of a segment. (Because registers are 16 bits long, they can directly address only 64K bytes. To allow segments over the full megabyte of address space, however, the 8088 assumes that the segment registers contain the high-order 16 bits of a 20-bit address. The four low-order bits are assumed to be

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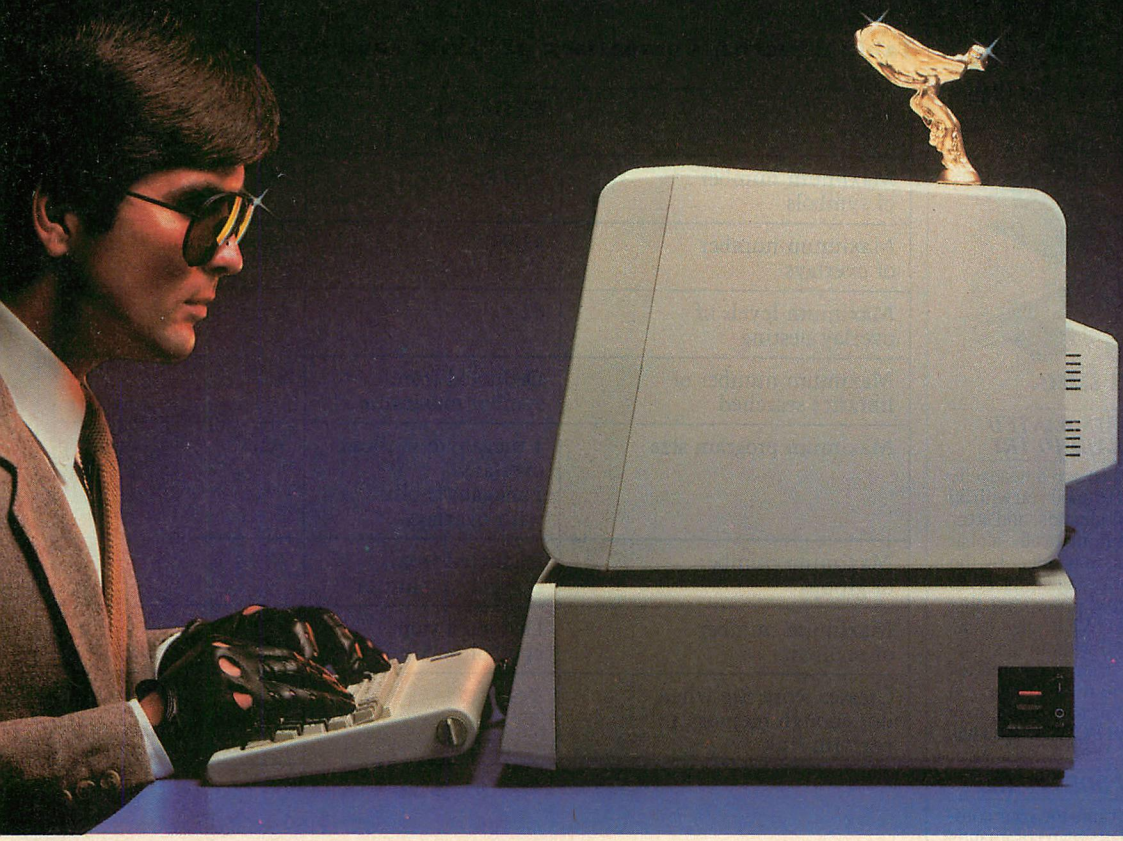

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Table 1: Feature Comparison of Plink86 and MS-LINK

	PLINK86 VERSION 1.4	MS-LINK VERSION 2.4
Maximum number of symbols	35,000	511 per module
Maximum number of overlays	4,095	Not available
Maximum levels of overlay nesting	32	1
Maximum number of libraries searched	Deducted from symbol maximum	8
Maximum program size	1 megabyte without overlays 1 megabyte-plus with overlays	900K
Maximum number of groups	Deducted from symbol maximum	10
Maximum number of segments	Deducted from symbol maximum	255
Creates work file when not enough memory to perform link	Yes	Yes

Table 2: Benchmark Results Using a 250K Program

	PLINK86 VERSION 1.4	MS-LINK VERSION 2.4
Time to link 250K program with PC/XT and hard disk	7 min. 50 sec. (30% slower)	6 min.
Time to load 20K overlay from hard disk	.9 sec. (55% faster)	2 sec.
Time to load 20K overlay from diskette	2.2 sec. (31% faster)	3.2 sec.
Size of .EXE file on disk	267,262 bytes (9.6% smaller)	295,584 bytes
Overlay manager overhead	1,326 bytes (52% smaller)	2,772 bytes

zero. Therefore, every segment starts on a 16-byte boundary.)

When a program starts running, values are loaded into some or all of the four segment registers to indicate the segments that the program can access. Then the program uses the 16-bit offset addresses (short addresses) to access all of the data (program code, date, stack, constants, etc.) in the segments. Each short address is relative to an address in one of the segment registers—which address depends upon the kind of segment that is being accessed.

If the program wants to access other memory segments, it must use long addresses; that is, it must do so by loading a new value into one of the segment registers.

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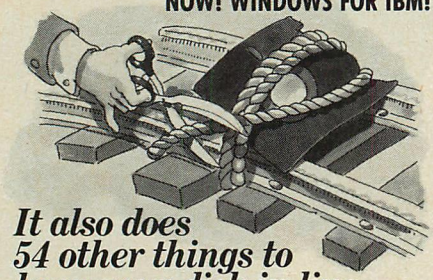

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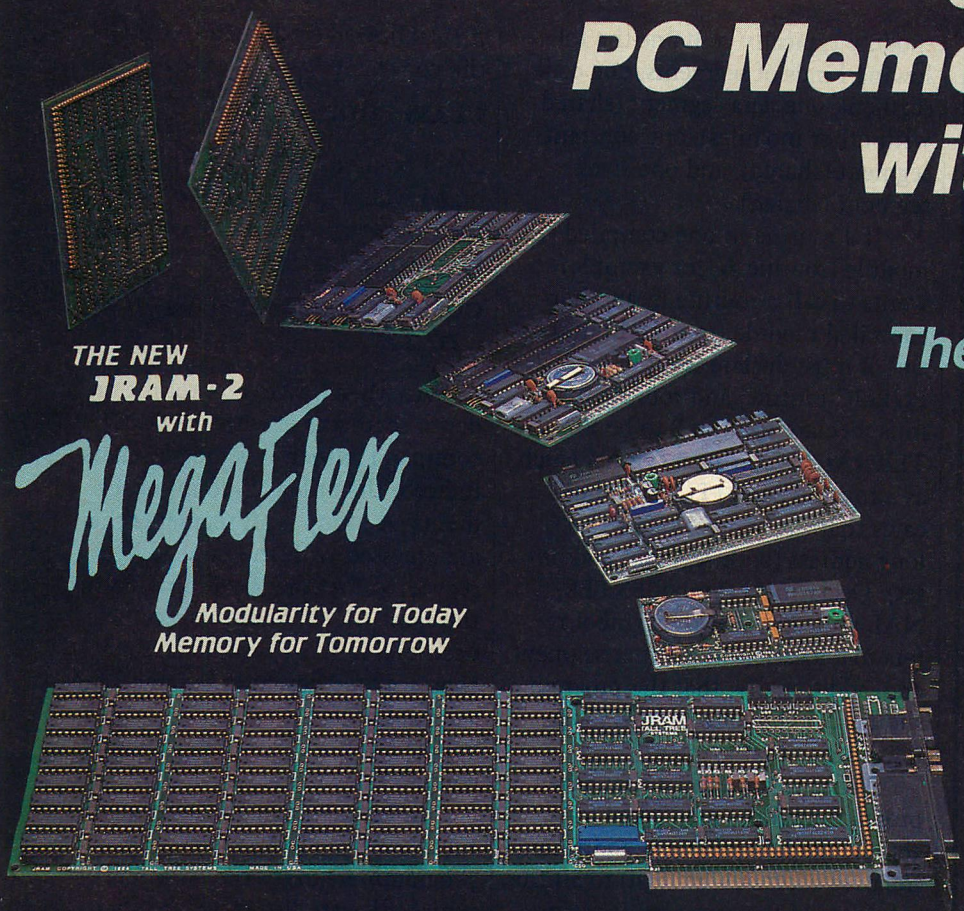

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module typically contains the following kinds of segments: one code segment, one data segment (shared with other modules), one constant segment (shared), and one stack segment (shared).

If a routine in one compiled module (routine A, for example) wants to call a routine in another compiled module (routine B), routine B must declare itself to be a PUBLIC routine, and routine A must declare routine B to be EXTERNAL. Declaring a symbol (such as a routine name) PUBLIC indicates that the symbol refers to a long address (both segment and offset). Declaring a symbol EXTERNAL indicates that the symbol refers to a location in another segment and, additionally, that the program should use the long address when referring to that symbol.

What this means is that when program modules are linked together, the linker assigns addresses (relative addresses, at least) to all the segments of the program. It makes sure that none of the code overlaps (unless overlays exist), and it makes sure that routines that call other routines know the correct relative addresses of the routines they call.

Most linkers provide little or no control over the order of the segments in memory. They simply assign segments to memory on a first-come, first-served basis. Sophisticated programmers, however, often need to be able to rearrange the segments exactly as they want them. Plink86 gives them that control.

One way it gives control is with the CLASS command. Programmers who work in assembly language can create any classes they like and can assign segments to them arbitrarily. Most compilers, however, choose class names such as CODE, DATA, STACK, and CONST, and assign segments to these classes based on their functions. The CLASS command makes it possible to indicate the order of all classes of segments.

To locate all code segments first, followed by all data segments, the command

CLASS CODE, DATA

could be used. The following command would ensure that, within the code class segment, code2 came before segment code1:

CLASS CODE(code2,code1), DATA

Another way to control the order of segments is with the GROUP command, which lets programmers indicate the order of groups of segments. A group is all segments that are accessed with the same segment register value (that is, all that lie in the same 64K of address space). For example, in MS-Pascal, data, stack, constant, and common segments are accessed with the same DS register value. They are part of a group the compiler has named DGROUP.

In addition to these ordering mechanisms, Plink86 also enables programmers to set the order in which files are linked. If no other ordering commands are in effect, the segments will be linked in the order in which they are read.

EXTRAS

Besides the powerful linker, the Plink86 package contains a few extras that make owning it more worthwhile. One of these extras is a program called CHECKSUM that validates the checksum of any .EXE file. This program can determine if object files have become damaged.

Another program, called COMPARE, performs a byte-by-byte comparison of two files and reports the differences. DUMP is a program that dumps an object file—in readable form—to the monitor or to disk. Finally, there's PLIB86, a full-featured object-library manager that can be invaluable for creating libraries of often-used utility routines.

LIMITATIONS

Plink86 is not perfect. For one thing, it is a two-pass linker, which

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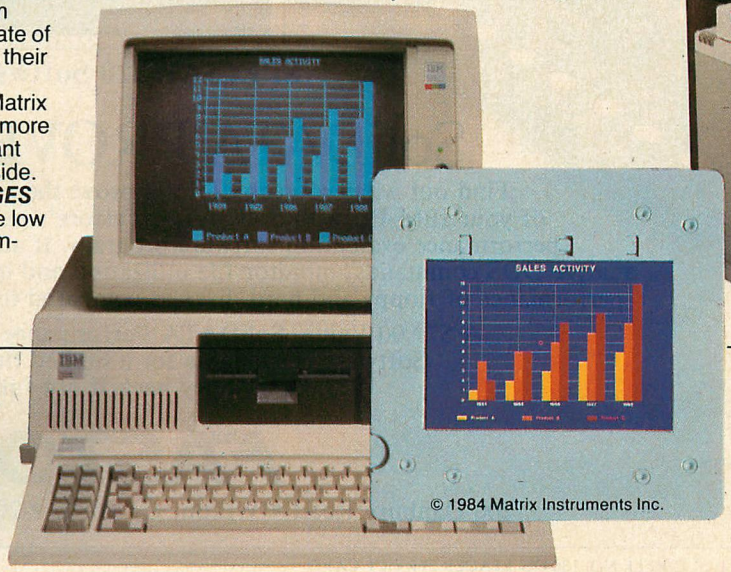

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means that it takes longer to link a program than any other linker we have used. Table 2 compares the execution time of Plink86 with that of MS-LINK version 2.0—there's no speed improvement there. (At our office, we get around this problem by using MS-LINK during most of our development cycle. Then, at the end, when we want to start overlaying, we switch over to Plink86.)

Another problem is that the manual is a little crude when compared to its IBM and Microsoft counterparts. Most of the information is there, and it includes some good instructional material about general linker concepts and 8088 architecture, but overall it reads as though it were written by a programmer instead of by a talented technical writer. It has no index, and it gets a little confusing because it serves both the MS-DOS and the CP/M-86 versions of Plink86.

Finally, Phoenix Software Associates is not Microsoft. This means that Plink86 won't support new versions of Microsoft's or IBM's compilers instantaneously. The people at Phoenix promise timely updates to their product, and so far they have been very punctual. Certain delays are inevitable, however.

Plink86 is extremely powerful, it loads overlays as quickly as any overlay loader now on the market, and it makes adding or experimenting with overlays easy.

Articles such as this usually include a sample of program code to illustrate the points made. In this case, however, such a sample is unnecessary, because the source code is unimportant. Almost any well-structured program can be transformed into an overlaid program simply by using linker commands to set up an overlay structure.

For seasoned programmers and novices alike, Plink86 is valuable for enabling large programs to run in small amounts of memory. It's extremely powerful, it loads overlays as quickly as any overlay loader currently on the market, and it makes adding or experimenting with overlays easy. Plink86 may not have a familiar name, but because of its strengths it is quietly taking over at many of the programming shops around the country.

Plink86
Phoenix Software Associates
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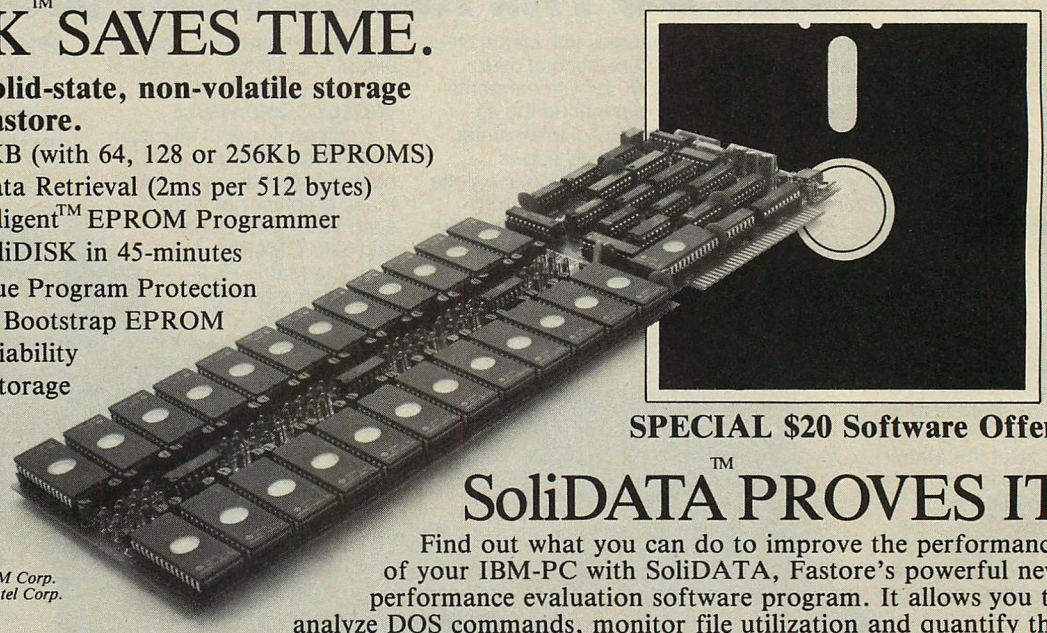

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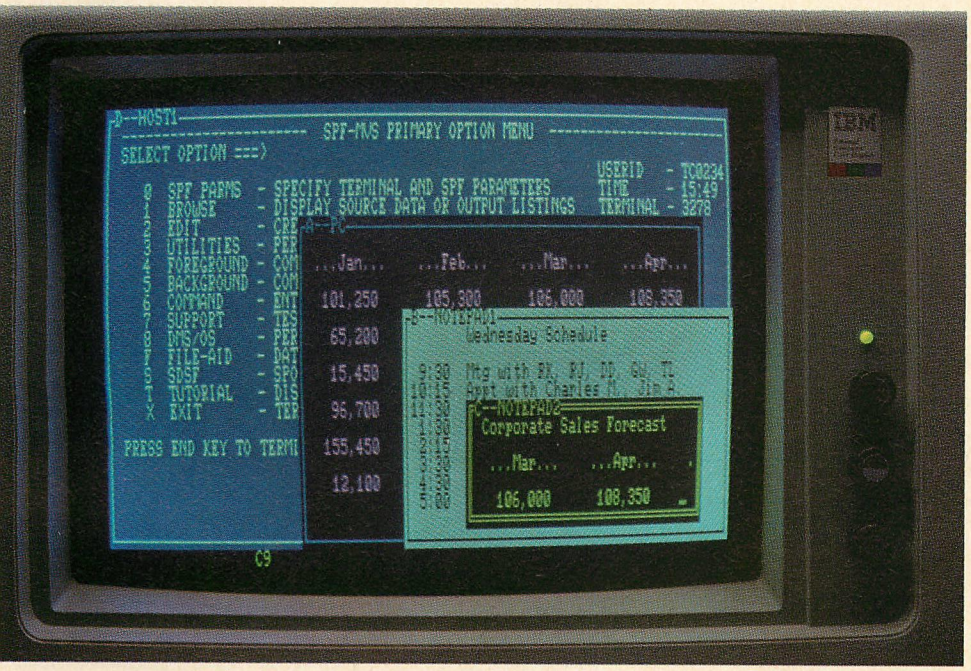
Compared to this, other 3278/79 emulators aren't much to look at.



Look closely.

This isn't your everyday 3278/79 emulator. Ours gives you much more to work with. Namely, a host session, a PC DOS session and two notepads. All on the same screen. At the same time.

We call it the CXI 3278/79 PLUS PC connection.

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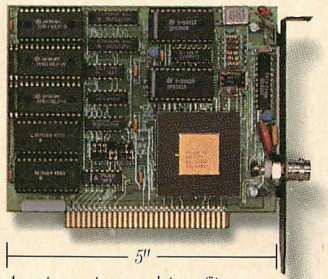

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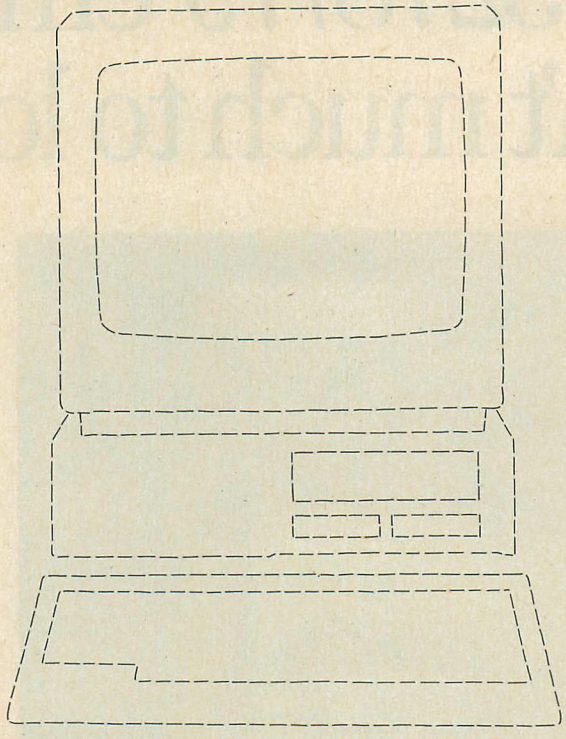

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A new typewriter-style keyboard.

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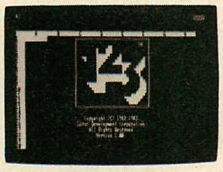
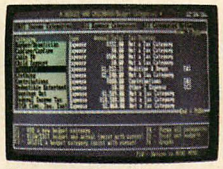
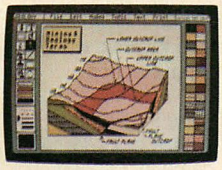


Right now, PC*jr* can run the powerful Lotus 1-2-3™ on diskette (with Lotus 1-2-3 PC*jr* Installation Kit and additional memory). The new cartridge version, requiring no additional memory, will be available this fall.



Managing Your Money™ by Andrew Tobias, new on cartridge for PC*jr*, is a comprehensive personal financial advisor and manager.



Turn your screen into a canvas. The new cartridge program. PC*jr* ColorPaint, lets you create with the added dimension of color.

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*Weight does not include power pack and monitor.
†IBM Product Center price.

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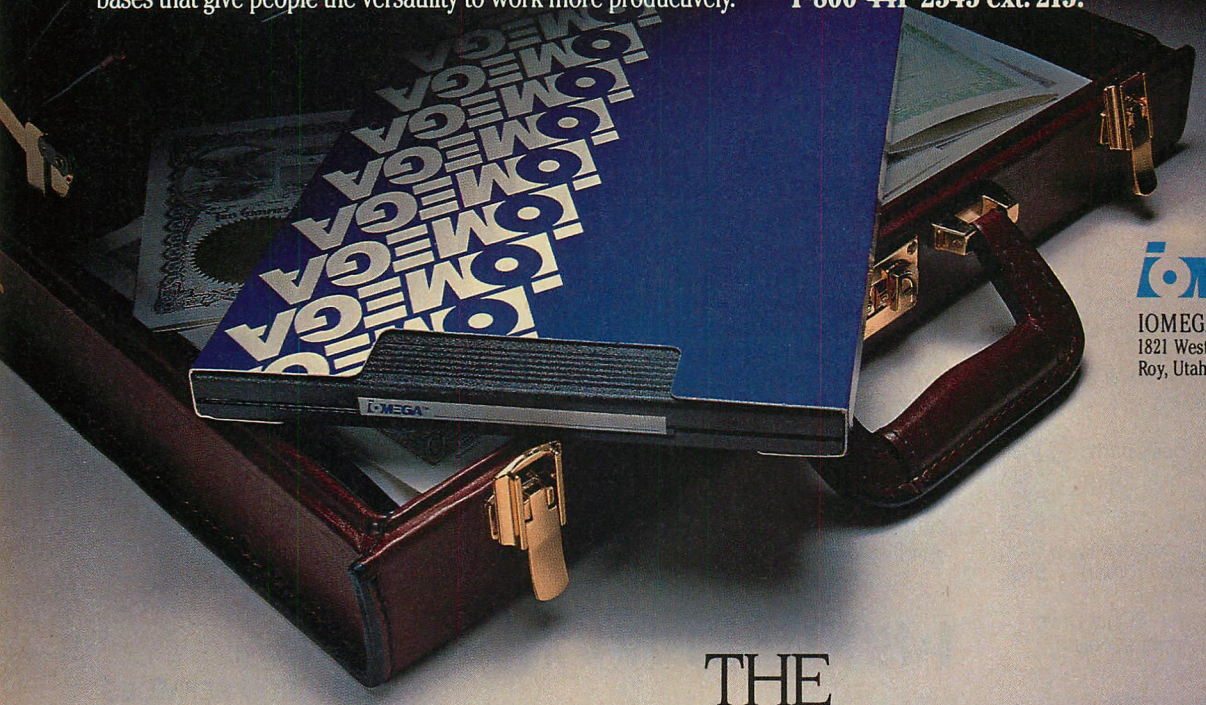

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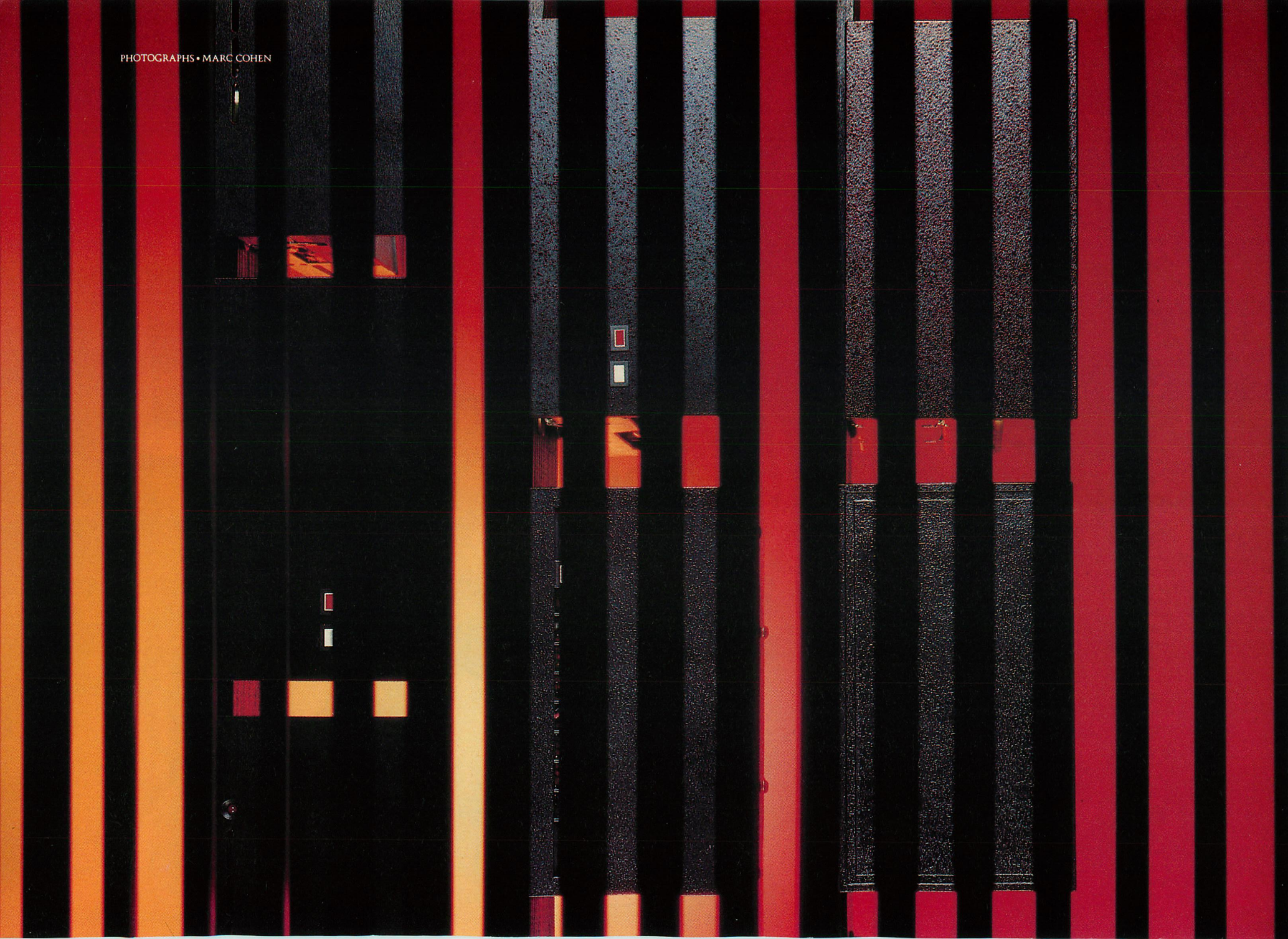
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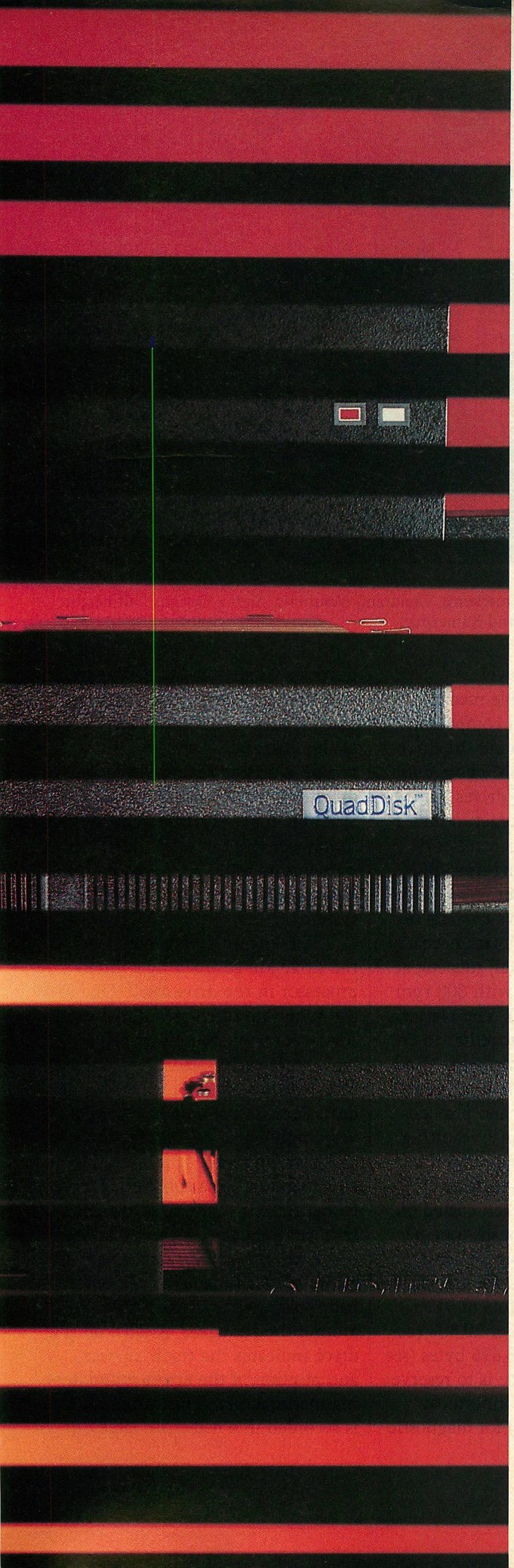


TEN BY TEN

A comparative review of ten 10-Mbyte internal fixed-disk systems for the PC

THOMAS V. HOFFMANN

OK, I admit it: I covet my neighbor's disk. Well, not my neighbor's exactly—he doesn't have a computer. I mean it more in the Biblical sense, where everybody is your neighbor. I don't mean I want everybody's disk, just somebody's. No, that's not it either. I don't want somebody's in particular, just anybody's. Well not just *anybody's*, you understand. I do have some standards.

It wasn't always like this. It began nearly three years ago when my PC pioneer friends and I were getting our systems together. One of my coworkers bought a hard-disk system for his PC. Ten megabytes for $3,600. We weren't impressed. Who needed it? Who could afford it? Eventually it broke, and he was heard to say, "Can anyone get this hard disk fixed?" IBM heard him, so it invented the PC/XT, which had a hard disk. IBM called it a fixed disk.

Anyway, to get rapidly to the present, soon there were XTs in the *accountants'* offices. That can really get to a programmer, you know, when the accountants have fancier technology than the technology guys. How would *they* like it if *we* had better income tax returns than they did? See how covetousness starts?

About this time fixed disks started getting cheaper and smaller, and seemed to be proliferating. Suddenly I knew at least six people with 10-megabyte Maynard

Thomas Hoffmann is director of advanced systems development for General Instrument Corporation. He is a contributing editor. His last major article for PC Tech Journal *was a technical review of PCjr.*

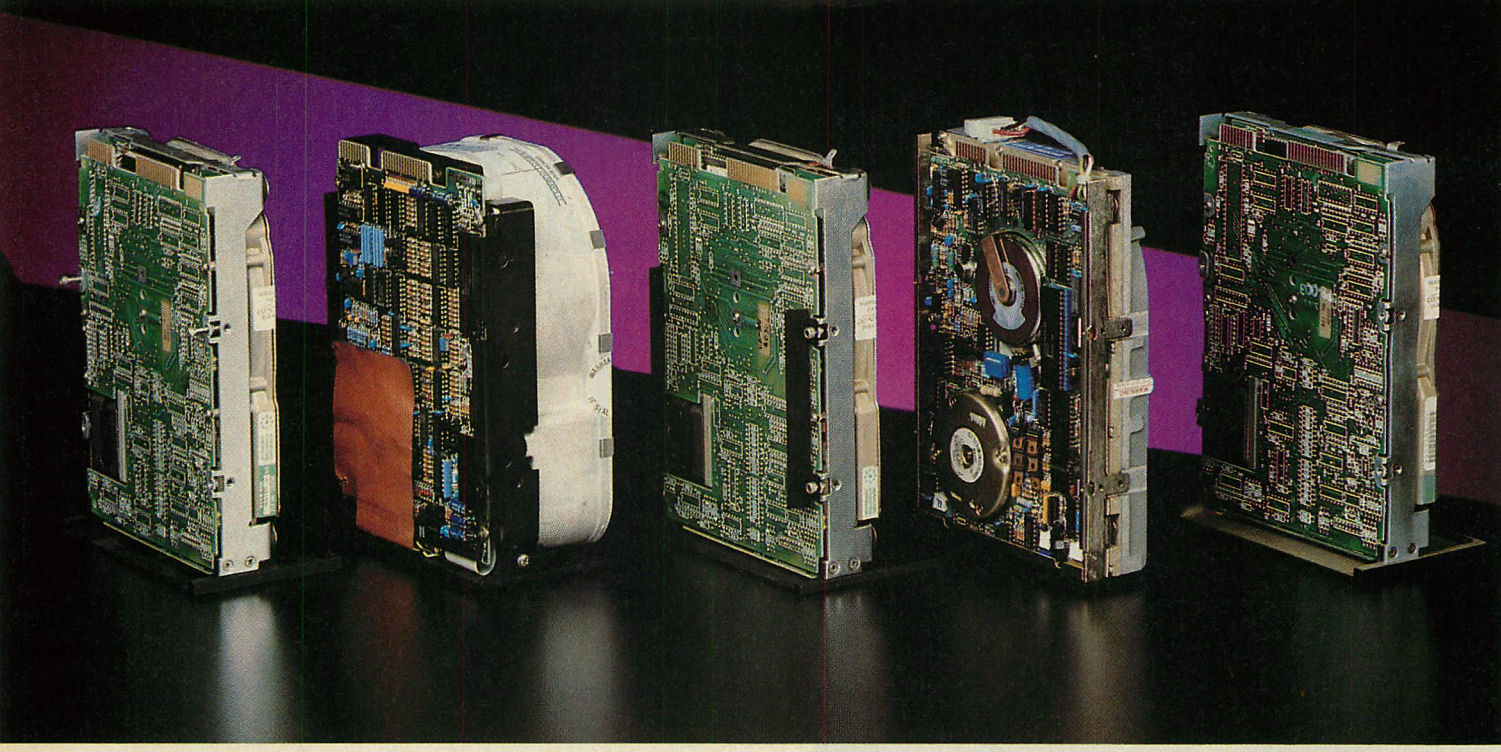


Photo 1: Inside the ten fixed-disk drives. From left, Maynard Microscience, Quadram, Mountain, Sigma Designs half-height, Qubie', Sigma Designs full-height, DSS, Maynard Shugart, Falcon, and Kamerman.

disk systems in their PCs at *home*; one guy already has his filled up and wants another one.

Overview of Fixed Disks

Fixed-disk systems provide a significant improvement in both capacity and performance over diskette storage. A typical 10-Mbyte fixed, or hard, disk is roughly 30 times faster and more capacious than a standard double-sided floppy diskette.

This review examines 10 internally mounted, 10-Mbyte fixed-disk subsystems for the IBM PC. When one of these systems is added to a PC, it results in the functional equivalent—at least insofar as storage is concerned—of the PC/XT.

Each drive system reviewed here has the following features:

1. A disk drive that mounts inside the PC system unit in place of the second diskette drive
2. A nominal storage capacity of 10 megabytes (actual usable capacity ranged from 10.5 to 11.1 megabytes)
3. A full-length controller card that fits in one of the expansion slots on the system board and is compatible with DOS 2.0 and 2.1—at least at the BIOS level
4. Fixed, nonremovable media.

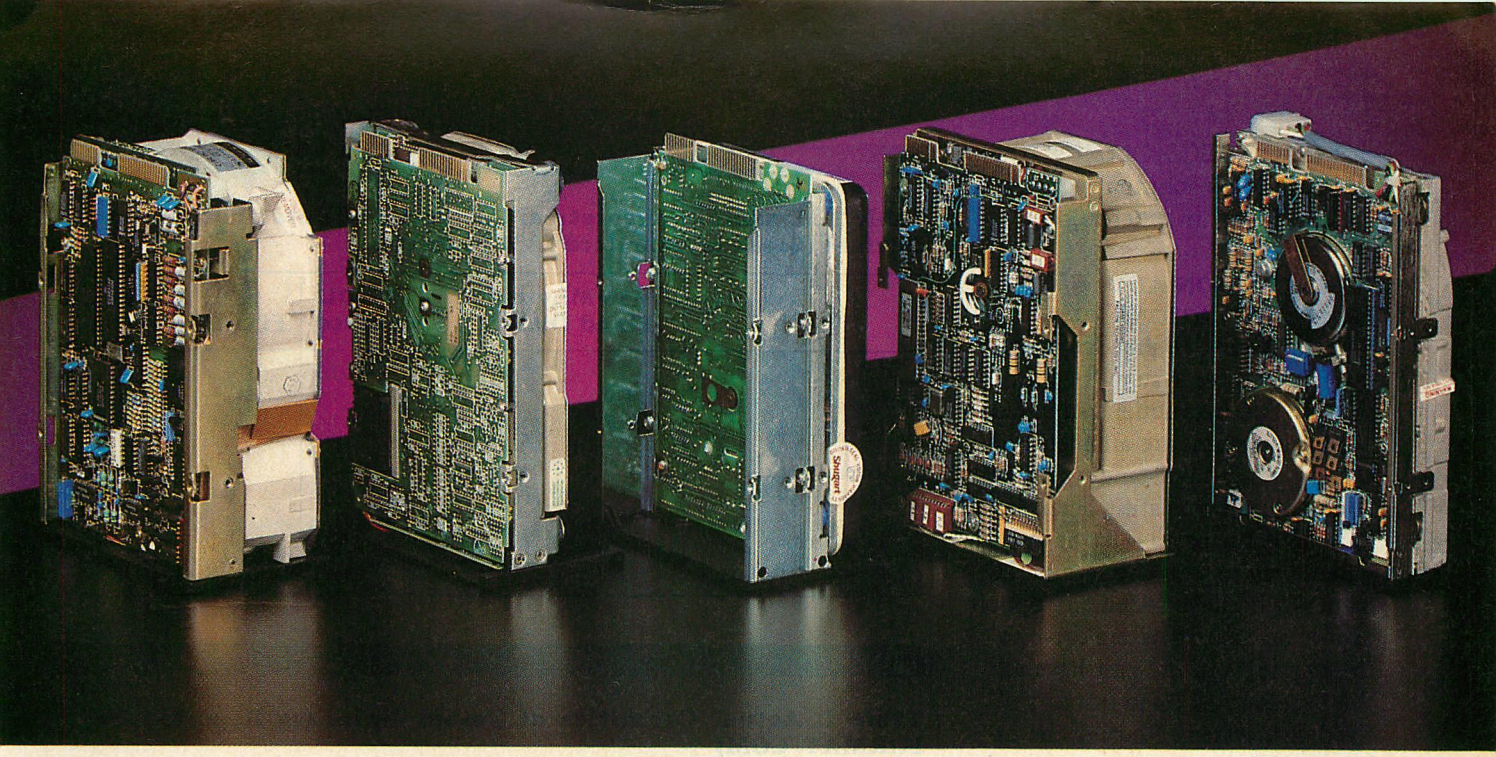
The two essential components of a fixed-disk system are the drive and the controller. IBM chose existing industry-standard drives (supplied by several manufacturers) for the XT and had the controller designed by Xebec, a long-time OEM disk-controller supplier.

The standard drive consists of one or more 5¼-inch platters coated with magnetic material, rotating at 3600 rpm (compared with 300 rpm for 5¼-inch diskettes). The platter and heads are sealed together in an airtight enclosure. This helps eliminate airborne contaminants from the recording surface and provides greater thermal stability, resulting in greater accuracy and reliability.

A typical 10-Mbyte drive consists of two platters, each coated on both sides, and four heads (one per surface) moved by a single actuator arm. Each surface has 306 tracks, formatted into 17 sectors of 512 bytes each, for a total of 20,808 sectors containing 10,653,696 bytes (see table 1). IBM's practice is to reserve the last cylinder (the innermost track on each surface) for diagnostic purposes, slighty reducing the available storage. Some of the remaining space is used by DOS to keep track of the logical disk structure (boot record, partition record, FAT, and directory), so the actual capacity available for user file storage is somewhat less than the theoretical maximum. Table 2 shows the usable storage capacity of each of the systems tested.

The lowest level functions of the drive are govened by a microprocessor in the drive itself. One of the functions often performed is to store—somewhere on the disk—a table of defective areas so that these areas will not be used for recording data. Because these disks record at very high densities (relative to diskettes, anyway), it is often difficult to guarantee a completely error-free surface; the slightest imperfection can impede reliable recording.

Rather than throwing away an entire platter because of one or two bad spots, these systems work around the bad areas. A label on the drive indicates the track, surface, and position of the errors found during manufacture. This information is recorded in a bad-track table dur-



ing formatting. Two of the ten drives tested had one bad spot each. The others were error-free.

The drive controllers are responsible for issuing the seek, read, write, and format commands to the disk drive, performing error-detection and correction algorithms on the data, and transferring the data between the PC's memory and the disk drive. The transfer rate is five megabits per second. Most of the controllers transfer data to an intermediate buffer on the controller, then to the drive or host memory.

FIXED-DISK BIOS

Just as the PC's low-level device I/O functions are placed in standardized ROM subroutines, the fixed-disk functions are defined in routines called the fixed-disk BIOS. IBM's controller, as well as the seven that are compatible with it, contain the fixed-disk BIOS on the controller card at segment C800h in the 8088 memory address space. As with the standard BIOS, the purpose of fixed-disk BIOS is to provide a standard, high-level interface to device functions in order to shield calling programs from the hardware details.

Falcon and Maynard supply their fixed-disk BIOS as a PROM chip that must be installed in the extra ROM socket on the system board (just under expansion slot 1), which places it at segment F000h. Either place works equally well from the IBM PC's point of view, although some may prefer to keep the spare socket available for future use.

In the PC/XT and all new PCs manufactured since October 1982, the standard BIOS scans memory for device control ROMs such as the fixed-disk BIOS. When one is found, it is checked, then called to initialize the functions it contains. The fixed-disk BIOS initialization modifies the standard BIOS diskette function vector to point to a routine that can handle either diskette or fixed-disk I/O requests. These are purposely similar so DOS does not need any special knowledge of the disk device type. The fixed-disk BIOS also provides for booting the system directly from the fixed disk if no diskette is found in drive A:.

Earlier PCs (called PC1, with 64K system boards) do not perform the ROM scan, and so they will not automatically integrate the fixed-disk BIOS or boot from the fixed disk. There are two solutions to the problem. The best one is to replace the old BIOS with the new one. IBM now sells a ROM BIOS Upgrade Kit for about $30, which consists of a replacement ROM, an extraction tool, and an instruction booklet. A BIOS that is dated 10/27/82 or later is the new one (see Tech Notebook 17, "Name, Rank, and Serial Number," Susan Glinert-Cole, May 1984, page 192).

[PC Tech Journal *strongly encourages the acquisition of the new IBM BIOS. In addition to the ROM scan feature, a number of bugs have been fixed. The ROM scan feature is more likely to be used by future builders of add-in boards.* —*WF*]

Another solution for older PCs is to boot from a specially configured floppy disk, which will integrate the fixed-disk BIOS and then reboot from the fixed disk. With the exception of Falcon, all of the vendors provide software to do this.

The problem of automatically integrating the fixed-disk BIOS can be avoided altogether. Since DOS 2.0 and 2.1 provide for loadable device drivers adding a fixed-disk driver to the system disk and loading it with the proper assignment in the CONFIG.SYS file is a reasonable alternative. Maynard and Falcon supply software drivers for this purpose, which can be used instead of the fixed-disk BIOS chip. Falcon's software driver actually performs better than the built-in DOS driver

that uses the BIOS. Of course, the software driver solution requires the use of a floppy in order to boot.

INSTALLATION AND DOCUMENTATION

Enough theory. In practice, installing any of these systems is quite simple. The instructions supplied with the systems are all adequate, though none is outstanding. Some describe in excruciating detail how to remove the cover—down to which way to turn the screws. PC owners who have added any option card or a second diskette drive to their systems in the past have all the necessary skills to install a fixed-disk system. Routing the cables can be a little tricky, and negotiating the cover past them can be frustrating, but the average installation takes less than 30 minutes.

The basic installation steps are: (1) plug the controller into an empty slot (sometimes cables have to be attached to the controller, sometimes it's already done); (2) slide the drive into the right-hand disk drive space; (3) attach the power cable (probably the hardest part); (4) attach the control and data cables (be careful about the orientation—Quadram and Sigma are alone in using keyed cables that can be installed only one way); and (5) secure the drive with screws. One caution: use the screws that come with the fixed-disk drive to mount it to the system unit. The screws that hold the diskette drive in place may be long enough to interfere with the head positioning mechanism on some of the half-height drives.

Once the hardware is installed, a few software steps are required. First, the low-level hardware formatting must be done. This consists of writing a header, which contains the sector number, for each sector on the disk. Sometimes this step is done prior to shipment. All vendors except Sigma supply a hardware formatting program. It is best to have the capability to reformat the disk

Table 1: Maximum Theoretical Capacities of Rotating Memory Devices (Based on Standard IBM Formats)

	10-Mbyte Fixed Disk	DS/DD Diskette	Ratio Fixed/Floppy
Cylinders	306	40	7.65
Heads	4	2	2.00
Total Tracks	1,224	80	15.30
Sectors/Track	17	9	1.89
Total Sectors	20,808	720	28.90
Bytes/Sector	512	512	1.00
Total Bytes	10,653,696	368,640	28.90

Table 2: Actual Capacities of Tested Units (as Reported by FORMAT. COM)

IBM reserves the last cylinder for diagnostic purposes, leaving 305 usable cylinders. Since the Falcon and Maynard controllers are not IBM-compatible (at the hardware level), and thus do not support the IBM diagnostics, they make the last cylinder available for normal use.

PC-DOS reserves certain sectors on each fixed disk drive as follows:

Boot block	1 sector
Partition table	1 sector
FAT (2 copies)	16 sectors
Root directory	32 sectors
Total reserved	50 sectors

The remaining space is divided into clusters of 8 sectors (4,096 bytes); any remaining sectors are not available for DOS file storage.

	Cyl Used	Available Sectors	Available Bytes	Bad Bytes	Usable Bytes
IBM	305	20,688	10,592,256		10,592,256
DSS	305	20,688	10,592,256		10,592,256
Falcon	306	20,752	10,625,024		10,625,024
Kamerman	305	20,688	10,592,256		10,592,256
Maynard-M	306	20,752	10,625,024	12,288	10,612,736
Maynard-S	320	21,704	11,112,448		11,112,448
Mountain	305	20,688	10,592,256		10,592,256
Quadram	305	20,688	10,592,256	12,288	10,579,968
Qubie'	305	20,688	10,592,256		10,592,256
Sigma (half)	305	20,688	10,592,256		10,592,256
Sigma (full)	305	20,688	10,592,256		10,592,256

For 305 cylinders, 20,740 sectors minus 50 gives 20,690, of which 20,688 (8 × 2,586) are available for files and 2 are wasted.

For 306 cylinders, 20,808 sectors minus 50 gives 20,758, of which 20,752 (8 × 2,594) are available for files and 6 are wasted.

For 320 cylinders, 21,760 sectors minus 50 gives 21,710, of which 21,704 (8 × 2,713) are available for files and 6 are wasted.

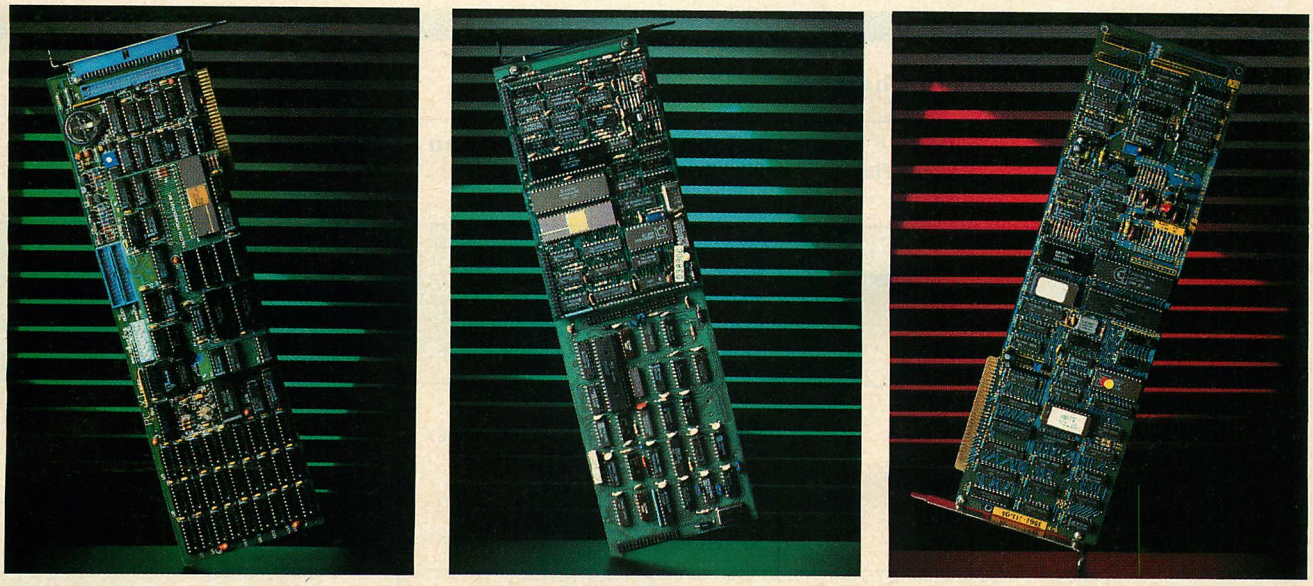


Photo 2: Controller cards (left to right) from Falcon, Maynard, and Mountain. Falcon's is a multifunction card with a serial port, clock/calendar, and sockets for 192K in addition to the fixed-disk controller. It is not IBM-compatible. The Maynard is used by both Maynard drives (Microscience and Shugart). The fixed-disk controller is a piggyback module that plugs into Maynard's Sandstar modular cards. Pictured here is the piggyback module for the diskette controller. It is not IBM-compatible. The Mountain controller is IBM-compatible.

in case some catastrophic event leaves the sector headers damaged and in need of reconstruction.

After physical formatting, the DOS program FDISK must be run to allocate the disk into partitions. A partition is a contiguous set of cylinders that are treated logically as one disk. Most users will have just one partition, consisting of the entire disk, which contains DOS. However, as many as four partitions, each with a different operating system installed, are possible.

Once the partitions are established, the DOS partition must be formatted with the FORMAT program (also used for diskettes). FORMAT writes the boot block and operating system (if the /S option is used), the file allocation table, and the initial file directory. The system is now ready for use, with the fixed disk appearing as drive C:.

Installing the software should be easier than installing the hardware, but inadequate documentation and user-hostile programs can get in the way of progress. Sometimes the manuals refer to programs that are not provided; sometimes programs are provided with no explanation. In no case during testing was the situation so bad that the system could not be started quickly, but these lapses are annoying all the same. User hostility most often took the form of hardware formatters or diagnostics with hidden features and a tendency to lock up if invalid input was provided.

Maynard's formatter is one of the nicer ones to use, since it provides a continuous display of the track number currently being formatted (most others just format for a few minutes, then say they are done). Maynard's "change parameters" menu, however, asks questions such as, "Which cylinder starts write precompensation?" and insists on an answer. This aspect of the program isn't discussed at all in the manual. After fooling around with it for awhile, I eventually got to the point at which even Ctrl-Alt-Del wouldn't get me out. Fortunately, no damage had been done, and cycling the power off and on brought the system back to life.

For users who feel adventurous or have special needs (such as wanting to attach two drives to one controller), all of the vendors provide technical assistance via telephone.

SPECIFICATIONS

Table 3 lists the 10 systems tested, alphabetically by vendor, and compares the features and prices of each. A brief description of each category with commentary follows:

Vendor/Product: This identifies the vendor and product.

Drive: The Microscience HH-612 appeared in four of the ten packages. Only three systems offered full-height drives. Thin-film plated media is said to be more durable than standard oxide, but not all of the manufacturers agree on the need for it. It's touted as a plus by those that offer it. Some vendors may ship different drives depending on current supplies; they will accept orders for specific drives if the buyer has a preference.

Controller: Only the IBM fixed-disk controller is undeniably 100-

Table 3: Feature Comparison Chart

Vendor **Product**	**DSS** StoragePlus	**Falcon** PCeXTender	**Kamerman** Megaflight	**Maynard** WS-2	**Maynard** WS-2
Drive					
Mfgr	Microscience	Tandon	Cogito	Microscience	Shugart
Model	HH-612	TM-502	CG-912	HH-612 PSaver	SA-712
Height	Half	Full	Half	Half	Half
Media	Plated	Plated	Standard	Plated	Standard
Controller					
Mfgr	A.D.E.S	Falcon	DataTechnology	Maynard	Maynard
Model	—	—	DTC 5150-BX	—	—
IBM Compatible	Yes	No	Yes	No	No
Extra Functions	No	Serial, Clock, Sockets for 192K	No	Diskette Ctrlr (5¼" and 8")	Diskette Ctrlr (5¼" and 8")
Fixed-disk BIOS	Controller	System Board	Controller	System Board	System Board
Interleave Factor	3	1	4	5	5
User Choice	Yes	Yes	No	No	No
Software					
H/W Formatter	Yes	Yes	Yes	Yes	Yes
DOS Dvc. Driver	No	Yes	No	Yes	Yes
Diagnostics	No	No	No	Yes	Yes
Shipper	No	Yes	Yes	No	Yes
Other	—	Back-up	—	—	—
Power Consumed (amps)					
+5VDC Drive	0.9	0.5 (0.8 max)	0.8 (1.0 max)	0.9	1.4
Ctrlr	2.0	1.3	2.5	2.1	2.1
+12VDC Drive	0.9 (2.5 max)	1.4 (2.4 max)	0.8 (2.2 max)	0.9 (1.6 max)	1.1 (1.7 max)
Ctrlr	—	1.0	—	—	—
Auxiliary Power	Optional	Optional	Optional	Optional	Optional
Required	Yes	Yes	No	No	Yes
Pricing					
System	$ 895	$1,895	$ 895	$1,595	$1,595
Aux Power	$ 175	$ 225	$ 285	$ 156	$ 156
Total	$1,070	$2,120	$1,180	$1,751	$1,751

All systems include one 10-Mbyte fixed-disk drive, controller, cables, mounting hardware, software, and installation instructions. All are compatible with IBM software at the BIOS level (fixed-disk BIOS supplied on controller or as a ROM module for the spare slot on the system board). Most are compatible with the IBM fixed-disk controller at the I/O register level.

percent *IBM-compatible*. The controllers marked "Yes" in the compatibility row in table 3 claim hardware compatibility such that they will pass the IBM diagnostics. The Maynard and Falcon controllers make no claim to IBM-hardware-compatibility. All the controllers are compatible with DOS, which means that they come with a DOS 2.0 device driver or a fixed-disk BIOS that supports the functions required by DOS. I did not try any non-DOS software to verify these claims. Several attempts have been made to run PC/IX (IBM's UNIX trademark for the PC) with third-party controllers; none has been successful. *Extra functions*, listed in the chart under controller, are anything unrelated to operating the fixed disk.

Fixed-disk BIOS: This indicates whether the BIOS is part of the fixed-disk controller (as it is on the IBM controller), or a ROM to be inserted in the spare socket on the system board.

Interleave factor: This is logical to physical interleaving (see "Performance" section in this

	Mountain 10-Mbyte Internal	**Quadram** QuadDisk	**Qubie'** PC10	**Sigma** HHK-10	**Sigma** HDK-10
	Microscience HH-612 Half Plated	Disctron D-514 Full Plated	Microscience HH-612 PSaver Half Plated	Cogito CG-912 Half Oxide	CMI CM-5412 Full Plated
	Mountain – Yes No	DataTechnology DTC 5150-BX Yes No	Western Digital WD 1002-WX2 Yes No	DataTechnology DTC 5150-BX Yes No	DataTechnology DTC 5150-BX Yes No
	Controller	Controller	Controller	Controller	Controller
	6 Yes	6 No	3 Undocumented	6 No	6 No
	Yes No No Yes –	Yes No No No 1DIR MultiTask OS	Yes No No No 1DIR Help Files	No No No Yes –	No No No Yes –
	0.9 1.0 0.9 (2.5 max) 1.2	1.1 (1.5 max) 1.9 0.6 (1.3 max) –	0.9 2.0 0.9 (1.6 max) 0.2	0.7 1.9 0.7 –	1.9 1.9 2.5 –
	Not Available Yes	Included –	Optional No	Optional Yes	Included –
	$1,695 – $1,695	$2,250 Included $2,250	$888 $ 88 $976	$1,295 $ 150 $1,445	$1,495 Included $1,495

article). A yes in the *user choice* row means that the user can select the interleave factor during the physical formatting step. Qubie's formatter also has the feature, but it is undocumented, and its operation could not be verified.

Software: This category indicates the presence or absence of various programs in the vendor's package. The absence of a *DOS device driver* is not necessarily bad. A *shipper* program moves the heads to a "safe" area, as a prelude to shipment. Some vendors with plated media drives claim this is unnecessary. Vendors that use all available physical cylinders for data do not have a "safe" cylinder.

Power consumed: Data in this category were provided for reference only by vendors or other available specifications. They were not tested for accuracy.

Auxiliary power: Under this category, *required* means required for successful operation in Tom Hoffmann's IBM PC1 configuration. Results may be different on other machines.

Pricing: This is the vendor's suggested retail price. Shipping charges may be extra.

Notable Differences

Most of the systems tested for this article are functionally identical: an IBM-compatible controller and a 306-cylinder, four-head fixed-disk drive. Once installed, they are nearly indistinguishable.

The Microscience HH-612 half-height drive seems to be the most popular with the vendors, appearing in four of the ten systems and available from at least one other vendor in the group. Careful inspection of table 3 shows two different models. The HH-612 PSaver (power saver) is the newer model and apparently the only one currently manufactured that draws slightly less power at start-up. This makes it a better choice for marginal power situations than the older HH-612 model. The distinction is not so important with an auxiliary power supply.

The Microscience drive uses a servo wedge in its positioning system. The wedge is simply an extra sector on each track and has the track number recorded in it. When the head seeks to a new track, the drive's microprocessor reads the wedge to verify that it is correctly positioned. To maintain compatibility with the timing characteristics of standard wedgeless drives, the Microscience rotates at 3550 rpm instead of 3600 rpm. This slightly lower rotational speed is barely significant, but another effect of the wedge technique is noticeable. A standard drive can seek from track to track in 3 milliseconds, plus 15 milliseconds for head settling. The Microscience drive has similar timings, but must also wait for the wedge to come around to verify the track position, adding another 8 to 17 milliseconds to each seek time.

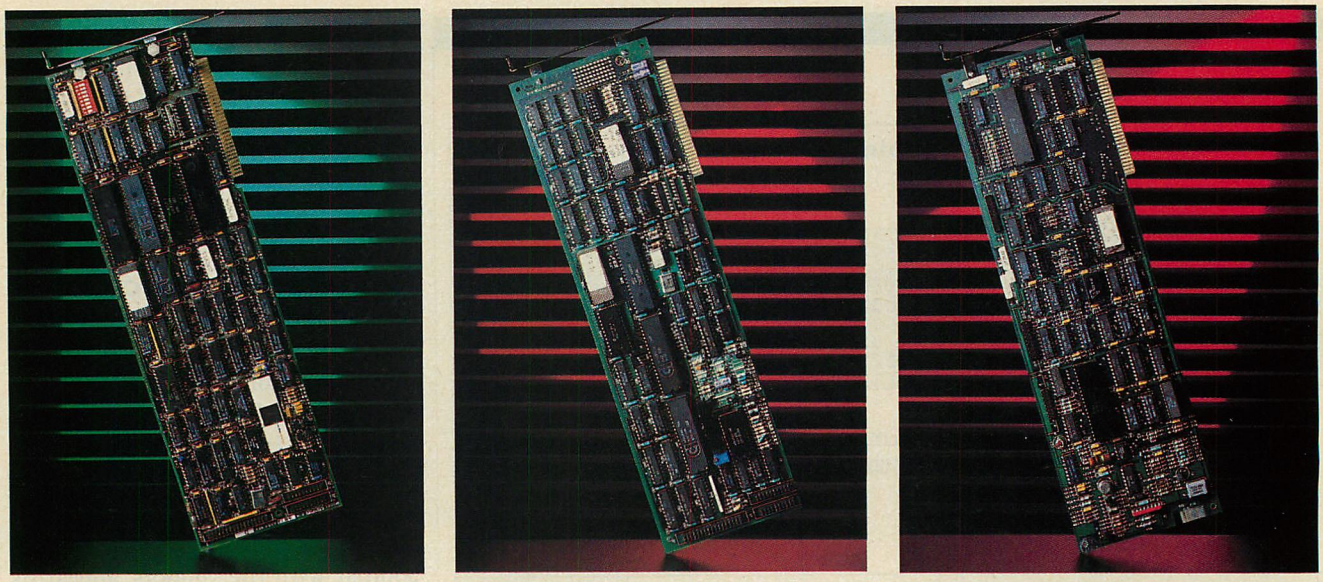


Photo 3: Controllers from Kamerman, DSS, and Qubie'. The Kamerman version is the 5150-BX from Data Technology Corporation (DTC). Sigma's half- and full-height cards and the Quadram board also use the DTC controller. DSS is made by A.D.E.S., and the Qubie' uses a card from Western Digital, model 1002-WX2.

The benchmark results in table 4 demonstrate this effect.

The new Shugart SA-712 drive has 320 cylinders, 14 more than the usual standard. This results in about 500,000 more bytes of usable capacity. The drive soon will be available from several vendors.

STAYING IN CONTROL

In the controller department, the two non-IBM-compatible controllers have some very interesting additional properties. The Falcon controller is a complete multifunction board with serial port, clock/calendar, and room for 192K expansion memory in addition to the fixed-disk controller; it also offers significantly faster performance than the other controllers. This is because Falcon's controller (designed by Tim Paterson, original author of PC-DOS) is able to transfer multiple sectors to memory as fast as the data arrive from the disk drive. All the other controllers need some breathing room between sectors, as illustrated in the benchmark results.

Maynard Electronics offers several different options in its fixed-disk controller, which is a piggyback module that plugs into Maynard's Sandstar modular cards. The Sandstar floppy-disk controller comes with cables for two 5¼-inch floppies, and a connector for attaching two external drives, either 5¼-inch or industry-standard 8-inch floppies. The Sandstar multifunction card has six identical sets of connectors: the fixed-disk controller covers three sets, leaving three for a variety of add-on modules, such as serial and parallel ports, a clock/calendar, and a game control adapter. The WS-1 system from Maynard consists of the multifunction card with fixed-disk controller and a 10-Mbyte drive. It lists for $1,195 ($200 less than the WS-2).

DUBIOUS EXTRAS

The extra features offered on the Falcon and Maynard controllers have obvious purpose and benefit. It's nice to be able to save a slot or increase performance.

Two vendors include with their disk systems additional software packages that are largely unrelated to the business of running the disk and that are of dubious interest or value to potential users.

Qubie' includes a program called 1DIR (pronounced "wonder"), which is a menu shell for DOS written by Bourbaki Inc. of Boise, Idaho. The reference card claims that 1DIR "reduces computer-phobia." Like so many menu systems, 1DIR seems harder to use (though prettier to look at) than the human interface it replaces—the DOS command interpreter. Common operations, such as TYPEing a file, sometimes take more keystrokes and time using 1DIR than by typing the DOS command.

Qubie's 1DIR comes with 30 help files—full-screen images that give reminders on the format and purpose of 30 different DOS commands. This is a nice touch; they are just the kind of on-line reference that's nice to have, and a fixed-disk system is a good environment to support them. The fixed-disk system has plenty of space, and loading the help files to the screen is very quick. People who don't mind menus may like 1DIR. In any case, Qubie's version may be worth trying: at $888 for the package, this is the least expensive of the 10 fixed-disk systems in this review.

Quadram's QuadDisk package also includes 1DIR, plus a set of programs purporting to be a multitasking operating system. This version of 1DIR does not include the help files, but otherwise seems to be basically the same as Qubie's. Unfortunately, Quadram's documentation is nearly incomprehensible. Curiously deficient in pronouns and unforgiveably sloppy about punctuation and spacing in DOS commands, it will lead to certain frustration for the majority of new users.

Quadram's Multi-tasking Operating System (QMOS) is embodied in a program called QLINK.COM, which interposes itself between DOS and user programs. QMOS supports one foreground memory partition and up to nine background partitions. Each partition appears as a separate DOS system—the user switches from one to another by pressing Alt and one of the 10 function keys. QMOS is "described" in 5½ pages of impossible-to-understand gibberish. Example: "If you have any problems with QMOS, you may need to consider: . . . DOS compatibility: does the program modify DOS enough? Some programs may not work with QMOS."

I managed to get QMOS to stop dead in its tracks by trying to type a file in a background partition while VisiCalc was idling in the foreground (the simplest thing I could think of). Ctl-Alt-Del didn't even work. Something apparently didn't "modify DOS enough."

Adding insult to injury, Quadram's package at $2,250 is the most expensive one reviewed. Nothing is wrong with the hardware: it uses a good quality, full-height disk and the same Data Technology controller as Kamerman and Sigma; it includes an auxiliary power supply; and Quadram is one of only two vendors that supplied keyed connectors on the disk cables to guard against incorrect installation. But QMOS still is no bargain.

Performance

To gauge the relative performance of the 10 systems, Bill Hunt's automatic benchmark test was pressed into service (see "Benchmarks for Fixed Disks" on page 64 in this issue). The benchmark measures both sequential and random access. The results are shown in table 4. As might be expected, short sequential reads take nearly the same time on any system. This is because all the drives have essentially the same rotational speed.

Longer sequential reads show the effect of interleaving. Falcon is clearly the fastest here, with an interleaving factor of 1 to 1. The systems with 3 to 1 interleaving come next, and the 6 to 1, totally IBM-compatible systems are the slowest.

Random read performance depends most heavily on the seek times of the drive. Again, since most drives have similar performance, the results are not far apart. The medium length random reads show the combined effects of rotation and seek times.

Power: How to Get It, How to Use It

The major electrical difference between the PC and the PC/XT is in the power supply (63.5 watts for the PC vs. 130 for the XT). The motors used in both diskette and fixed-disk drives use +12 volts DC. Serial ports and modems also consume significant amounts of 12-volt power.

Diskette-drive motors consume about 0.9 amps of 12-volt power on the average, while fixed-disk drive motors typically consume from 2.5

Photo 4: The Maynard optional clip-on power supply and the Quadram power supply, which is included with the drive.

Photo 5: Power supplies from Sigma and Falcon.

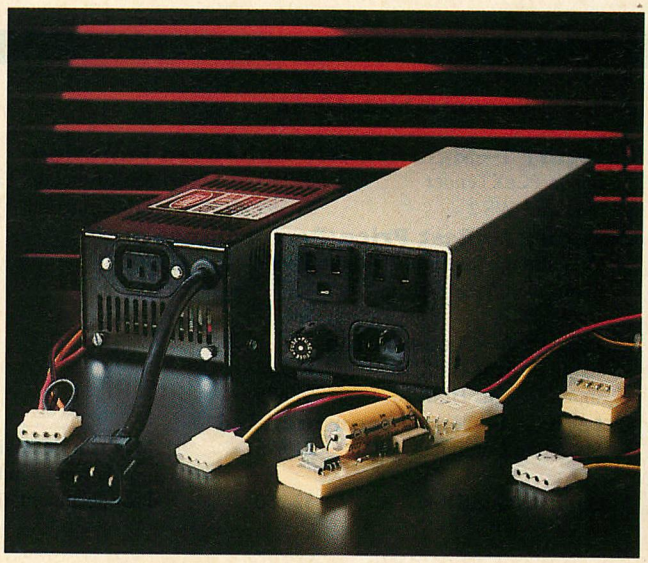


Table 4: Benchmark Performance Data

System Vendor	Sequential (Number of Sectors) 1	8	16	24	Random 1 Sector (Fraction of Disk) .10	.33	.50	.90	Random 8 Sector (Fraction of Disk) .10	.33	.50	.90
[1]*Floppy	203	354	533	670	111	212	235	310	288	390	412	489
MS[1] DSS	16	88	162	242	74	113	141	210	137	184	214	277
MS[1] Mountain	16	146	294	442	73	118	147	221	203	250	280	349
TN[1]*Falcon BIOS	18	33	49	69	59	99	133	208	77	119	146	218
TN[1]*Falcon S/W	17	26	37	49	51	100	133	207	68	114	139	212
TN[3] Falcon BIOS	16	39	64	91	59	101	134	203	87	121	154	226
MS[3] Mountain	21	108	199	307	72	116	147	221	158	208	233	299
MS[3]*DSS	21	51	88	129	73	112	142	210	107	146	180	246
MS[3]*Qubie'	19	50	85	122	74	114	144	215	104	143	176	246
MS[4] DSS	21	59	96	143	73	112	141	213	112	150	184	253
MS[4] Mountain	22	55	91	129	71	115	146	221	110	148	181	253
CG[4]*Kamerman	22	71	126	186	62	111	137	220	106	156	189	266
MS[5]*Maynard	19	46	75	107	72	109	139	204	94	136	163	233
SH [5]*Maynard	19	44	66	93	77	110	136	185	96	132	157	206
MS[6] DSS	22	72	124	184	73	112	142	212	123	167	197	264
SG [6]*IBM PC/XT	22	71	126	187	70	120	160	240	120	160	210	300
MS[6]*Mountain	16	64	118	171	71	116	146	221	121	170	197	267
DT[6]*Quadram	22	71	127	185	61	111	145	236	107	164	190	280
CM[6]*Sigma (Full)	22	71	126	187	71	111	136	195	123	161	189	249
CG[6]*Sigma (Half)	22	70	127	187	61	111	144	220	107	156	190	265

Drive designators:

CG Cogito CG-912
DT Disctron D-514
MS Microscience HH-612
SH Shugart SA-712
TN Tandon TM-502

The interleave factors for the disks are shown in brackets [ ]. An asterisk (*) indicates that the interleave factor is recommended or shipped by the vendor.

Table 5: Recommendations

Category 1—Significantly Enhanced Function		
Falcon PCeXTender	$1,895	Multifunction, Fastest
Maynard WS-2	$1,595	Multifunction
Category 2—Best Price/Performance		
Data Storage Solutions (DSS)	$895	
Kamerman Megaflight	$895	
Qubie' PC10	$888	
Category 3—Acceptable		
Sigma Designs HHK-10	$1,295	
Sigma Designs HDK-10	$1,495	
Category 4—Not Recommended		
Mountain Computer	$1,695	May require auxiliary power not available from vendor
Quadram QuadDisk	$2,250	Poor documentation, overpriced

to 4.5 amps while starting, and .7 to 2.5 amps thereafter. The PC power supply only has 2.0 amps of 12-volt power allocated for diskette drives and further assumes that only one drive at a time is operating.

Successful operation of a fixed-disk motor in a fully loaded PC without auxiliary power is a marginal proposition. It's almost surprising that any of them work. That they do is a result of IBM's conservative engineering. The PC power supply shuts down when any voltage is overdrawn by 30 percent. That's just enough for some of the low-power, half-height disks to squeak by.

What happens if there is not enough power? It's simple: the PC shuts off. Nothing breaks (at least not in the 20 or more instances I witnessed), but everything stops.

The system used for this evaluation is an original PC1 (manufactured in October 1981), with 64K on the system board; a Persyst Spectrum multifunction card with 256K, one serial and one printer port (slot 1); both IBM Color Graphics (slot 2) and Monochrome Display (slot 3) adapters; the IBM diskette adapter (slot 5); and two Tandon TM100-2 double-sided diskette drives. The second floppy drive was removed to make room for the fixed disk, and the fixed-disk controller was always mounted in slot 4. (The Maynard card, with a floppy-disk controller, replaced the IBM controller in slot 5, freeing slot 4.)

The only sure way to know if the power supply is sufficient is to try the system in the PC. Auxiliary power is simple insurance, but can add significant expense, pushing the system cost close to that of external units. The vendors uniformly agree that power problems with their 10-Mbyte systems are extremely rare, and that larger systems (15-Mbyte and up) definitely require external assistance.

The full-height drive systems supplied by Quadram and Sigma in-

clude auxiliary power supplies. The Sigma half-height system would not start up in the test system without an auxiliary supply, which Sigma sells for $150. Its full-height system (with auxiliary supply included) costs $50 less than the half-height plus auxiliary supply.

The Kamerman and Qubie' systems use low-power, half-height drives, and both of them work very well using only the PC's internal supply. These are the only two systems that function well solely on internal power (and they are two of the least expensive systems). Optional auxiliary supplies are available from both vendors.

Falcon includes a current limiter that goes between the power supply and the disk drive. Its job is to smooth out the start-up surge with a capacitor and resistor, so the PC's own power supply can handle the start-up without shutting down. That worked fine, but after several hours of operation there was a tendency for a spontaneous shutdown if I tried to access a floppy drive. Falcon's Power Booster auxiliary supply solved the problem.

The Mountain system also needed an auxiliary supply to get going, but Mountain does not offer one. A supply from any manufacturer should work (I used the Falcon Power Booster), but the result would be to push the already high cost even higher.

The Maynard systems did not seem to require auxiliary power supplies, but they each had another problem: heat. After a few minutes of operation, the system unit became very hot, and the disk unit became unreliable. The system would lock up, and Ctl-Alt-Del did not reboot. Turning the system off and on did not eliminate 1701 error on disk diagnostics. The problem was solved by removing the cover and blowing an electric fan across the system. It wasn't pretty, but it worked.

I know at least five people with Maynard systems using the multifunction controller (*not* the floppy controller) who have had no problems of any kind with their systems. Maynard's customer service representative believed the trouble to be a faulty component on the controller board (because of the heat-related nature of the problem), so he sent another complete system, and included the optional clip-on power supply ($156). It worked fine for about 15 minutes on PC power alone; then the power supply shut down. With the auxiliary supply, it has been going strong for more than 18 hours of continuous operation. The Maynard systems do seem to run hotter than the other fixed disks but they are reliable.

An auxiliary supply may not be necessary with the addition of a single, 10-Mbyte, low-power fixed disk. But with a second drive, which can be added with the half-height drives, or one of the new tape back-up units, the power situation will have to be addressed.

The best bargain in power supplies seems to be Qubie's at $88 (it was unavailable for review). Falcon's Power Booster at $225 is the nicest auxiliary supply. It stands alone, much like the PC*jr* supply, so it is out of the way (most of the others must be bolted to the back of the PC, adding a sizable, black lump). The Booster has two automatically switched convenience outlets, suitable for plugging in a printer, color monitor, or other peripherals. The Booster senses when the PC is turned on, then turns on its DC output and the convenience outlets. Thus, the whole system can be turned on with the PC's red on/off switch—a very nice feature.

The most novel approach is Kamerman's $285 PC/XT-alike supply, which replaces the one inside the system unit. It's simple and direct, but because IBM will not service systems with "foreign" equipment installed, the IBM supply will probably have to be re-installed if the machine requires repair.

Recommendations

Table 5 divides the 10 fixed-disk systems into four categories. At the top are the three that offer significantly more hardware function, albeit at a higher price. The Falcon system offers the best performance by a significant margin. The two Maynard systems have more combinations and a slightly lower cost.

The next group offers the best price/performance ratio. The products are nearly identical, as are the prices. Qubie' has a slight edge in price, and throws in the 1DIR visual shell package, but the bezel and feet have to be mounted on the drive by the user. The Kamerman system ran the coolest and quietest of any of the systems—and on the original internal power supply.

Category 3, "Acceptable," contains the two Sigma Designs systems. They are essentially the same price, considering that the full-height system includes the external power supply and the half-height does not. Buying from a dealer who offers installation and support may be worth the premium.

The final "Not Recommended" category does not mean that the systems are bad, rather that the other eight are just as good or better—and at a lower cost. The Mountain system would have been in the "Acceptable" category except that it does not offer auxiliary power, and the system needs it. Mountain seems to concentrate on the higher capacity 20- and 30-Mbyte systems with tape back-up; the 10-Mbyte product may be in the catalog only for completeness.

The big disappointment is Quadram. Its hardware is just as good as the others, but it is overpriced and accompanied by surprisingly poor documentation, completely negating any possible attraction the extra software offered.

I would highly recommend six of the ten products reviewed here; all in all that's not a bad average.

Evaluating fixed-disk performance with some simple tests for disk I/O

FIXED-DISK BENCHMARKS

Good measurements of fixed-disk performance are scarce; the usual specifications are vague and incomplete. Product reviews provide little help; if any benchmarks are used, they consist of a few BASIC programs that are limited by BASIC's I/O facilities and are affected by the placement of files on each disk.

Recently, I investigated using an IBM PC for a very disk-intensive application. Having a reliable estimate of the potential performance of an IBM PC with a fixed disk was the key to evaluating the feasibility of the application. Since accurate results for fixed-disk performance were crucial, I developed some simple, practical benchmarks for disk I/O. These benchmarks then allowed me to evaluate the level of performance attainable with a PC/XT and to compare it to available add-on fixed disks.

First, several criteria for good benchmarks had to be defined. They had to be simple enough to run on any PC with a fixed disk. Tests that required careful set-up of each system were out of the question. What was needed was a program file that could be copied onto a floppy disk and carried into a store. There, the disk could be inserted and the test run without concern for the operating system parameters or the layout of files on the disk. In addition, the program could be sent on a floppy disk to colleagues to run on their systems.

If the benchmarks were to be run on systems performing real work, then the second criterion was that they had to be absolutely safe and nondestructive. Any problems in this area could result in loss of friends, limbs, or life.

Requiring that the benchmarks be simple to run led to a third criterion. The benchmark program had to be portable. Modifying it for each model of fixed disk was simply not practical. It had to use standard PC-DOS and BIOS calls supported on any IBM PC or compatible computer. The benchmarks should work with any fixed disk that is interfaced to PC-DOS.

Finally, benchmarks are of absolutely no use unless their measurements are reliable and lead to accurate comparisons. Good benchmarks must produce reliable results independent of the layout of files on the disk or operating system parameters (such as the number of buffers).

WILLIAM HUNT

William Hunt is writing a book on software tools and C programs that illustrate real world functions, and he has reviewed several C compilers in past issues of PC Tech Journal. *He holds a Ph.D in chemistry from the California Institute of Technology.*

Figure 1: Top View of Fixed Disk

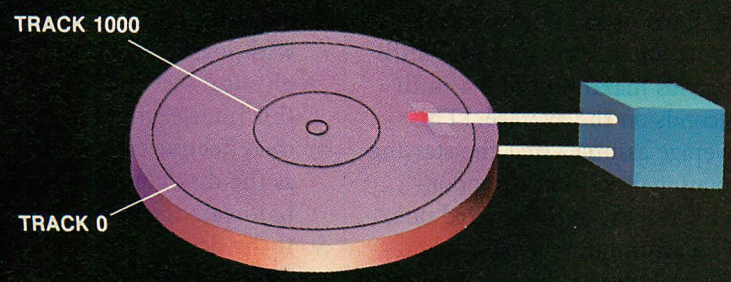


Figure 2: Formatting in Sectors

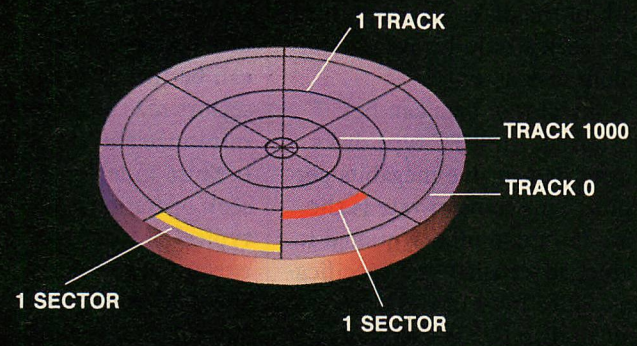
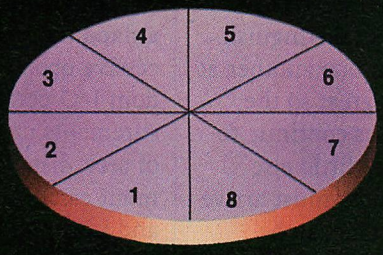
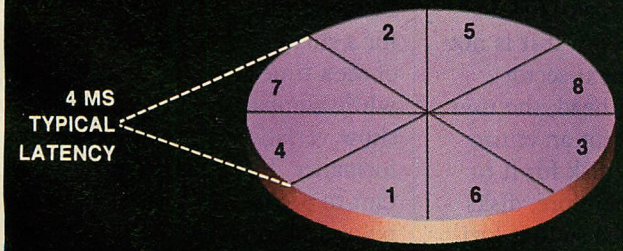


Figure 3: Location of Sectors with and without Interleaving



No interleaving (latency): *Sectors run consecutively one right after another. After reading sector 1, if the disk controller is not immediately ready for sector 2, the disk will make another complete revolution (17 milliseconds).*



Interleave factor of three: *Consecutive sectors are separated by three physical sectors to allow time for the disk controller to get ready between reading sectors (4 milliseconds).*

THE SOLUTION

The usual approach to measuring fixed-disk performance is to write a few BASIC programs to read and write files. This has several major drawbacks. Interpreted BASIC is slow and its file I/O facilities are a poor basis for disk benchmarks. In addition, any file I/O results are highly dependent on the layout of files and free space on the disk. File reads and writes sometimes cause extra physical reads or writes for directory and File Allocation Table data. The cache buffering that DOS supplies may further affect the number of physical operations. The contents of these cache buffers at the beginning of a test may make the test results vary.

Using file I/O for disk benchmarks has some advantages. Such tests are safe since DOS keeps track of the space allocated to files. They are also portable—any fixed disk interfaced to DOS can be tested.

Another approach is to use BIOS-level functions for reading and writing sectors. Because this is below the level of the file system, it is independent of the layout of files and free space on the disk; and, furthermore, because it performs physical operations directly, it avoids the problems of DOS cache buffers and overhead operations.

This approach has serious problems, however. Some fixed disks are not compatible with the PC/XT disk at the BIOS level. Therefore, the benchmarks would have to be rewritten for some disks. In addition, writing directly to the disk is a very dangerous practice.

Fortunately, PC-DOS provides the features needed to solve the problem. The Absolute Disk Read function reads absolute disk sectors. It operates below the level of disk files and disk space management. The logical sector number of one or more disk sectors to be read must be specified. The level of this function is too low to be useful in applications programs, but it is perfect for

my uses. This function is referred to as RAWREAD.

Because the RAWREAD function operates on absolute disk sectors, the differences in file layouts on different systems can be ignored. The same sectors are always read—regardless of their uses in a particular system. A casual disassembly of the PC-DOS code suggests that this function does not use DOS buffers for caching or perform retries after disk errors. However, the sequence of RAWREAD operations in the benchmark program avoids the effects of caching.

Writing absolute disk sectors is just as dangerous with DOS functions as it is with BIOS functions. That problem can be avoided by restricting the benchmark program to reading the disk. While this does not directly measure disk writing performance, most of the effects are also present in disk reads.

A Little Theory

The benchmark program is a practical, down-to-earth tool. But a little explanation about how disk I/O works will help in selecting appropriate tests. Figure 1 shows a top view of the kind of fixed disk used in the IBM PC. The figure shows the moveable read/write head and the tracks of data recorded on the disk. Figure 2 shows how each track is formatted in sectors (normally 512 bytes long for a PC disk).

In general, a disk read or write requires the following steps:

1. First, the head must be moved to the right track. This seek operation may require a few milliseconds for a single track movement or 50 to 100 milliseconds for moving the width of the disk. When the movement is completed, a small amount of additional time is required for the head to settle down. (If the head was already positioned on the right track, this step is skipped.)
2. Next, the first sector to read or write must pass under the head as the disk rotates. Fixed disks rotate at 2400 to 3600 rotations per minute with 3600 rpm usual for PC fixed disks. This translates to a rotational latency of 16.7 milliseconds maximum or 8.4 milliseconds on the average. (This average assumes that the starting rotational position is random with respect to the desired one. The assumption is valid when the seek time is larger than the rotational latency time.) A single specification—average access time—is often quoted for the disk drives. This definition is not precise but it usually refers to a seek across one-third of the width of the disk. This one-third-width seek would be average for random disk activity.
3. Now a sector of data can be transferred. Most PC-type disks transfer data at five megabits per second. This transfer rate is the figure most commonly quoted in product advertising and specifications. Since most of the time spent in disk I/O is used for getting the right sectors under the head, this figure has little to do with actual performance. Furthermore, the transfer rate is the same for almost all PC fixed disks, so it does not distinguish the products from one another at all. But it sounds great so the marketing geniuses continue to feature it and very little else.
4. The next sector now must arrive under the head. The gap between sectors is small, so the next sector will arrive quickly. The disk controller may require some time to get ready for the next sector, however. If it is not ready when the next sector arrives under the head, the user will have to wait for an entire revolution of the disk for it to pass by again. Therefore, disks are often formatted so that logically consecutive sectors are separated by several physical sectors to give the controller more breathing room. This arrangement is called *interleaving*. Figure 3 shows two disk formats: one with no interleaving and one with logical sectors spaced three physical sectors apart. Reducing this interleaving factor improves the effective transfer rate as long as the disk controller and the PC hardware itself can keep up.
5. If the desired data are on several different tracks, separate I/O operations will have to be set up for each track. This is a restriction imposed by the disk controllers used with the PC fixed disks.

Designing Good Tests

One series of tests involves reading disk sectors sequentially. The tests can be run varying the number of sectors read each time. These tests minimize the effect of seek time, because much data are read between seek operations. Such operations are typical of loading large programs for execution or for saving large spreadsheet or word processing files (assuming that the disk layout is not very fragmented). The measurements show the effective data transfer rate, which is mostly determined by the interleave factor.

Testing reading operations with a fixed track distance between successive operations measures the random I/O performance. These measurements can be used for a variety of seek distances. Each measurement can also be taken for single- and multi-sector reads. The random read operations are characteristic of retrieving or updating single records in a data management application or in accessing small files. The results for a single disk show the variation of seek time with the seek distance, while comparisons of different disks show variations in seek time performance. In each case, it is important to provide a consistent starting point and to repeat the test enough times to give reliable timing. A PC BIOS function is used to time these results automatically.

Table 1: Disk I/O Results

TEST		TYPE OF DISK			
		Floppy Disk	RAM Disk	IBM PC/XT Fixed Disk	Compaq Plus Fixed Disk
Sequential Read					
1 sector		0.20*	0.003	0.022	0.022
8 sectors		0.35	0.011	0.071	0.047
16 sectors		0.53	0.025	0.126	0.080
24 sectors		0.67	0.036	0.187	0.120
Random Read					
1 sector					
Seek distance (for width of disk traveled)	0.1	0.11	0.001	0.070	0.077
	0.33	0.21	0.003	0.120	0.110
	0.5	0.23	0.004	0.160	0.140
	0.9	0.31	0.003	0.240	0.180
8 sectors					
Seek distance (for width of disk traveled)	0.1	0.29	0.014	0.120	0.110
	0.33	0.39	0.014	0.160	0.140
	0.5	0.41	0.011	0.210	0.160
	0.9	0.49	0.011	0.300	0.212

**Times (all times are in seconds per read)*

PROGRAM LISTINGS

Listings 1 through 5 are written in the C language with low-level functions coded in assembly language. Pascal, FORTRAN, COBOL, or compiled BASIC could be used instead, but interpreted BASIC would be too slow to give valid results.

Two versions of the program are provided: the disktest.c file in listing 1 prompts for the major parameters for the test and can be used to design the user's own test. The autotest.c file in listing 2 runs a fixed series of measurements.

The autotest function runs random I/O tests for seek distances that are fixed fractions of the disk's capacity. It uses the getspac function to calculate the disk's total size. This lets it adjust automatically to disks of various sizes.

The align function in listing 3 works around a hardware limitation. The DMA hardware, used to transfer data between the disk controller and RAM memory, requires that the entire data transfer buffer lie within a 64K physical page. (It must not cross a 64K address boundary.) If the specified buffer does cross such a boundary, DOS may divide the actual I/O operation into several operations. For consistent results the buffer must be aligned. The align function is given the address of a large memory area and returns a properly aligned address. This requires that the area supplied be twice as large as the buffer that will actually be used.

The functions in listings 4 and 5 perform single sequential or random I/O tests. They perform a dummy operation to give a consistent starting point and then time a number of read operations (using RAWREAD). The starting sector to be read is advanced after each read so that logically sequential sectors are read. The randio function alternates reads between two areas of the disk separated by a fixed offset.

Both seqio and randio check for errors in performing read operations. If any errors are detected, a message is displayed. Trying to read past the end of a disk is a possible source of errors. Reading a bad sector may also cause an error. If such an error is encountered, disktest can be used to avoid the bad sector.

The assembly language source file in listing 6 provides low-level support. The RAWREAD function implements use of the DOS INT 25H service. This DOS function destroys a number of register values, so RAWREAD saves them before calling DOS and restores them afterward. (Particular compilers may not require this saving or restoring activity, but the program is written to adapt easily to any C compiler.) The DOS INT 25H function also leaves the stack partially restored—the unused flag values are popped from the stack to restore it properly.

The get__ds function supplies the data segment value that the align function needs for aligning the transfer buffer. The gettime function returns the time of day as a number of ticks (18.2 ticks per second). The time-of-day BIOS function is used for timing. Using a DOS function (2CH) instead would make the program compatible with MS-DOS as well as PC-DOS.

The getspac function supplies information on the size of the disk. Autotest uses this data to calculate seek offsets for random read tests.

The assembly language functions are written for the Lattice C compiler and assume that the small memory model is used. The syntax for the statements is correct for the IBM/Microsoft Macro Assembler. The compiler-dependent definitions should be modified for other C compilers such as the Computer Innovations C86, Manx Aztec C, and C-Systems compilers. For C compilers that work with a different

assembler, changes to statement syntax may also be needed.

The following examples show how to link the two versions of the program. The locations of files and, thus, the device names may vary from system to system. The examples are specific to the Lattice C compiler (version 2+), but they should provide some guidance for other compilers.

link cs disktest align seqio randio disk2,disktest,,lcs

and

link cs autotest align seqio randio disk2,autotest,,lcs.

Executing the programs is shown in the next examples. The programs are assumed to be on drive A:. The drive to be tested is C: in both cases.

```
>a:disktest
drive number . . .
2
```

(Program prompts for and accepts rest of test parameters)

```
>a:autotest
drive number . . .
2
```

RESULTS

The accompanying article, "Ten by Ten," (page 52) applies these benchmarks to several add-on fixed disks. Therefore, I will use the benchmarks for other comparisons. Since the benchmarks use standard PC-DOS services, they can be used to compare the speeds of floppy disks, RAM disks, and fixed disks. Table 1 lists some striking results for the autotest program for these devices. RAM disk operations are from 20 to 100 times as fast as floppy disks. The times for the XT fixed disk are from 1.3 to 9 times as fast as those for floppy disks. While the fixed disk does improve performance over the floppy disk, the improvement seems a bit disappointing.

Floppy disk drives are turned off when they have not been used for a few seconds. Thus, single reads to floppy disks require an extra delay (0.2-0.5 seconds) for the disk to get up to its normal speed. Since the benchmark measures a series of operations with a dummy operation before the start, our results are too optimistic for single floppy disk reads. The random-read test measures seek times in terms of fixed fractions of the disk's capacity. The capacity of the floppy disk is 360 Kbytes compared to 10 Mbytes for the fixed disk. So the figures for the fixed disk represent seek distances of 1 to 9 Mbytes instead of 36 to 324 Kbytes for the floppy disk. In some cases, comparing seek times with similar fractions of the disk capacity are appropriate, while in other cases comparing seek times with the same amount of data between the two areas is appropriate.

The table also shows a comparison between a fixed disk in the PC/XT and one in a Compaq Plus. Most times for the Compaq fixed disk are 60 to 70 percent of those for the XT. The improvements in multi-sector sequential reads show that the Compaq disk has less interleaving, while the single-sector random read times show faster seek times. Both effects are present for random eight-sector reads.

The differences between the two fixed disks are impressive on a percentage basis, but are they really noticeable in practice? The numbers in the table measure one physical read operation. An applications-level I/O operation may require a number of these operations. Differences of one or two seconds in saving a source file and exiting an editor or three to five seconds in a compile time are consistent with the table's results. A long I/O limited operation (such as sorting data files) might take 70 percent less time.

All fixed-disk benchmark programs are available from PC Tech Journal's *Listing Diskette Service. See the ad on page 116 for information on ordering listing diskettes.* —*WF*

LISTING 1 DISKTEST.C

```
/* disktest.c - test raw disk i/O */
#include "stdio.h"
#include "ctype.h"

#define ASIZE  25000                /* size of area for a buffer */

long seqio() , randio() ;
char *align() ;

main(argc,argv)
 int argc ;
 char *argv[] ;
 {
    int dno , nstart , nseg , i , nit ;
    int offset ;
    char area[ ASIZE ] ;
    float t ;
    char *pbuf ;

    /* ensure that the buffer does not cross a 64K address boundary */
    pbuf = align(area,ASIZE/2) ;

    printf(" max. no. of sectors per read = %d \n",ASIZE/(2*512));

    printf(" drive number (0=a , 1=b ...) \n") ;
    scanf("%d",&dno) ;
    printf(" number of sectors per read: \n");
    scanf("%d",&nseg) ;
    printf(" starting sector number (0 = beginning of disk: \n");
    scanf("%d",&nstart) ;
    printf(" offset between reads (0=sequential I/O) \n");
    scanf("%d",&offset) ;
    printf(" number of iterations: \n");
    scanf("%d",&nit) ;
    if( nseg > 24 )
      { printf(" too many sectors per read \n");
        exit(10) ;
      }
                          /* now do the operation */
    if( offset == 0 )
        t = seqio(dno,nseg,nstart,pbuf,nit) ;
    else t = randio(dno,nseg,nstart,pbuf,nit,offset) ;


  printf(" %4.2f  Seconds \n", t /18.2 ) ;
  printf(" %4.3f Seconds per read operation \n",  t / (18.2*nit) ) ;
}
```

LISTING 2 AUTOTEST.C

```
/* disktest.c - test raw disk i/O */
#include "stdio.h"
#include "ctype.h"

#define ASIZE  25000                /* size of area for a buffer */

long seqio() , randio() ;
char *align() ;
int dno , nstart , i , nit ;
char *pbuf ;

int clu , free , tot , bps ;        /* disk space variables */
long totsec ;                       /* put total sectors here */

main(argc,argv)
 int argc ;
 char *argv[] ;
 {
    char area[ ASIZE ] ;

    /* ensure that the buffer does not cross a 64K address boundary */
    pbuf = align(area,ASIZE/2) ;

    printf(" drive number (0=a , 1=b ...) \n") ;
    scanf("%d",&dno) ;

    clu = getspac(dno+1,&free,&tot,&bps) ;
    if( clu == 0xffff )
      { printf(" invalid drive number \n");
        exit(10) ;
      }
    totsec = clu * (long) tot ;
    printf(" total number of sectors = %ld \n",totsec) ;

    nstart = 0 ;  nit = 20 ;
    printf(" Sequential Reads \n");
    doseq(1) ;                      /* run some Sequential Read tests*/
    doseq(8) ;
    doseq(16) ;
    doseq(24) ;
                          /* now run some random read tests */
    nit = 40 ;
    printf(" Random Reads - %2d sector \n",1);
    dorand(1, 0.1 ) ;
    dorand(1, 0.33 ) ;
    dorand(1, 0.5 ) ;
    dorand(1, 0.9 ) ;
    printf(" Random Reads - %2d sector \n",8);
    nit = 20 ;
    dorand(8, 0.1 ) ;
    dorand(8, 0.33 ) ;
    dorand(8, 0.5 ) ;
    dorand(8, 0.9 ) ;
 }


int doseq(nseg)
 int nseg ;
 {
   long t ;

   t = seqio(dno,nseg,nstart,pbuf,nit) ;
   printf(" %2d sectors          - ", nseg ) ;
   printf("  %4.3f Sec/read \n",  t / (18.2*nit) ) ;
 }


int dorand(nseg,frac)
 int nseg ;
 float frac ;
 {
   long t ;
   int offset ;

   offset = totsec * frac ;
   t = randio(dno,nseg,nstart,pbuf,nit,offset) ;
   printf(" %5.2f width seeks    - ", frac) ;
   printf("  %4.3f Sec/read \n",  t / (18.2*nit) ) ;
 }
```

LISTING 3 ALIGN.C

```
/* align.c - align a buffer so that it does not cross */
/* a 64K physical address boundary */
/* We give it the address of a buffer area */
/* It returns a starting address such that the following (size) bytes */
/* do not cross a 64K byte address boundary. */
#include "stdio.h"

unsigned get_ds() ;

char *align(area,size)              /* align buffer address */
 char *area ;                       /* start of buffer area */
 int size ;                 /* size required for buffer */
 {                          /* returns an aligned address */
    long begin ;            /* flat address for area */
    unsigned room ;         /* number of bytes to boundary */

                            /* build flat address */
    begin = ((long) get_ds() ) * 16L + (long) area ;
    room = 0x10000 - (begin & 0xffff) ; /* get distance to boundary */
    if( room >= size )
        return( area ) ;
    else return( area + room ) ;
 }
```

LISTING 4 SEQIO.C.

```
/* seqio.c - do a sequential I/O test */
#include "stdio.h"

long gettime() ;

long seqio(dno,nseg,nstart,buffer,nit)
 int dno , nstart , nseg , nit ;
 char *buffer ;
 {
    int i , nerror ;
    long t ;

    nerror =0 ;
                            /* do one read to fix starting point */
    if( rawread(dno,1,nstart,buffer) != 0 )
            nerror = nerror + 1 ;
                            /* now do a series of reads */
    t = gettime() ;         /* start timing */
    for(i=0 ; i<nit ; i=i+1)
      {                             /* do a read and check for errors */
        if( rawread(dno,nseg,nstart,buffer) != 0 )
            nerror = nerror + 1 ;
        nstart = nstart + nseg ; /* move past area read */
      }
   t = gettime() - t ;              /* get elapsed time */
   if( t < 0L )
      t = t + 0x1800B0 ;

   if( nerror > 0 )
      printf(" %d errors \n",nerror) ;

   return( t ) ;            /* return elapsed time in ticks */
 }
```

LISTING 5 RANDIO.C

```
/* randio.c - test random raw disk i/O */
#include "stdio.h"

long gettime() ;

long randio(dno,nseg,nstart,buffer,nit,offset)
 int dno , nstart , nseg , nit ;
 char *buffer ;
 int offset ;
 {
    int i  , nerror ;
    long t ;

    nerror =0 ;
                            /* do a read in second area to start */
    if( rawread(dno,nseg,nstart+offset,buffer) != 0 )
```

```
        nerror = nerror + 1 ;
    t = gettime() ;         /* now start timing */

    for(i=0 ; i< (nit/2) ; i=i+1)
      {                             /* read first area */
        if( rawread(dno,nseg,nstart,buffer) != 0 )
            nerror = nerror + 1 ;
                          /* read second area */
        if( rawread(dno,nseg,nstart+offset,buffer) != 0 )
            nerror = nerror + 1 ;
        nstart = nstart + nseg ;
      }
    t = gettime() - t ;
    if( t < 0L )
        t = t + 0x1800B0 ;
    if( nerror > 0 )
        printf(" %d errors \n",nerror) ;
    return( t ) ;
}
```

LISTING 6 DISK2.ASM

```
;  disktest.asm - assembler functions for
;  disk I/O performance benchmark
;  assumes the small memory model is used

;  compiler-dependent definitions
;  Lattice C version
Pgroup      group   prog
Dgroup      group   data
    assume  cs:pgroup,ds:dgroup
dstart      equ     dgroup
Data        segment word public 'DATA'
Data        ends
Prog        segment byte public 'PROG'
;  end of Lattice C version


;  rawread(drive,nsec,begin_sec,buffer) - reads raw disk sectors
;           drive     = drive number 0=A  , 1=B ...
;           nsec      = number of sectors (512 bytes) to read
;           begin_sec = number of first logical sector to read
;           buffer    = store the data read here
;                       (relative to DS)

;  define the argument offsets relative to BP
;  old BP value is at zero
;  return address is at 2
drive       equ     4
nsec        equ     6
begsec      equ     8
buffer      equ    10

    public  rawread,rawread_,_rawread
rawread:
rawread_:
_rawread:   push    bp
    mov     bp,sp
    push    bx
    push    cx
    push    dx
    push    si
    push    di
    mov     ax,word ptr [bp+drive]
    mov     cx,word ptr [bp+nsec]
    mov     dx,word ptr [bp+begsec]
    mov     bx,word ptr [bp+buffer]
    int     25H             ; absolute disk read
    pop     cx              ; discard original flags
    pop     di
    pop     si
    pop     dx
    pop     cx
    pop     bx
    jc      raw1            ; did the operation succeed ?
    mov     ax,0            ;    yes - set ax=0
    jmp     raw2
                            ;    no  - force ax to be non-zero.
raw1:
    or      ax,ax           ; is AX already non-zero ?
    jnz     raw2            ;    yes - just use it as an error return
    mov     ax,255          ;    no  - fake a non-zero error return.
raw2:
    pop     bp
    ret


;  get_ds()  - returns the data segment address
    public get_ds,get_ds_
get_ds:
get_ds_:
_get_ds:
    mov     ax,ds
    ret


;  long gettime() - returns time
    public  gettime,gettime_,_gettime
gettime:
gettime_:
_gettime:
    push    cx
    push    dx
    mov     ax,0            ; read clock function
    int     1AH             ; time of day BIOS call
;  now set up the return value
;  Lattice C version - long return = (AX-high , BX-low)
    mov     ax,cx           ; move high order word to AX
    mov     bx,dx           ; move low order word to BX
;  for C.I. C86 and others - long return = (DX-high , AX-low)
;  mov     ax,dx
;  mov     dx,cx
    pop     dx
    pop     cx
    ret


;  getspac(ddrive,pfree,ptot,pbytes) - get disk free space info
;  ddrive - drive number ( 0=A , 1=B ... )
;  pfree - store no. free clusters here
;  ptot  - store no. clusters total here
;  pbytes- store number of bytes per sector here
;  returns no. sectors per cluster (or 0xFFFF for invalid drive)

;  define argument offsets
;  old BP = 0
;  return address = 2
ddrive      equ     4
pfree       equ     6
ptot        equ     8
pbytes      equ    10

    public  getspac,getspac_,_getspac
getspac:
getspac_:
_getspac:
    push    bp
    mov     bp,sp
    push    bx
    push    cx
    push    dx
    push    si
    mov     dx,word ptr [bp+ddrive]
    mov     ah,36H          ; PC-DOS get free space call
    int     21H
    mov     si,word ptr [bp+pfree] ; store free clusters value
    mov     word ptr [si],bx
    mov     si,word ptr [bp+ptot]  ; store total clusters value
    mov     word ptr [si],dx
    mov     si,word ptr [bp+pbytes] ; store bytes/sector value
    mov     word ptr [si],cx
                                    ; sectors/cluster already in AX
    pop     si              ; restore registers
    pop     dx
    pop     cx
    pop     bx
    pop     bp
    ret

;  compiler dependent stuff for end of code segment
;  Lattice C version
Prog        ends
;  end of Lattice C version

    end
```

Patching a Bug In DOS 2.1

The use of NMIs can cause a problem in DOS.

TECH NOTEBOOK 27

DON AWALT

Improper handling of the segment register and stack pointer in DOS 2.1 can cause an unpredictable and rather severe problem to occur on the PC*jr*: it may "hang" after any key is pressed, with rebooting the only possible recovery.

The use of non-maskable interrupts in the PC*jr* is a key to understanding this bug. NMIs are high-priority interrupts that cannot be disabled by the interrupt disable instruction on the Intel 8088. They permit immediate execution of an important operation. In the PC*jr*, NMIs are used for keyboard interrupts so the BIOS can perform deserializing of keyboard data.

The specific problem in DOS is easy to cure. Whenever the stack segment register (SS) and the stack pointer (SP) are changed to define a new stack location in memory, the order in which the two registers are modified is significant. The 8088 chip does not allow an interrupt to occur until one instruction after any MOVe to a segment register. If the stack segment register is changed before the stack pointer, no damage occurs. However, if the stack pointer is changed before the stack segment register, an interrupt can occur between the two instructions. Then the integrity of the stack is destroyed; the CPU flags, CS, and IP registers are pushed into the wrong locations in memory; and the system quickly dies.

IBM is aware of the problem and has supplied the patch for DOS 2.1, as shown in figure 1. Although the problem also exists in DOS 2.0, IBM has not supplied a patch for it. The solution is to change the six instances in IBMDOS.COM in which the two stack registers are modified incorrectly. First, the read-only, hidden file, and system file attributes of IBMDOS.COM must be removed; they are restored after the patches have been applied.

This problem can occur on *any* IBM PC model—if special hardware is installed that uses the NMI—with either DOS 2.1 or 2.0.

Figure 1: Procedure for Patching DOS 2.1

This procedure assumes that a DOS 2.1 system diskette is in drive A:. Enter the following commands; computer responses are in bold type:

```
A> DEBUG
—L 100 0 5 1
—D 12B L4
XXXX:012B 27 00 00 00
—E 12B
XXXX:012B 27.20
—W 100 0 5 1
—Q

A>DEBUG IBMDOS.COM
—U3AC L A
XXXX:03AC      CS:
XXXX:03AD      MOV SP, [02A6]
XXXX:03B1      CS:
XXXX:03B2      MOV SS,[02A8]
—A3AC
XXXX:03AC      CS:MOV SS,[02A8]
XXXX:03B1      CS:MOV SP,[02A6]
XXXX:03B6      [ENTER]
—UCD1 L A
XXXX:0CD1      CS:
XXXX:0CD2      MOV SP, [02D1]
XXXX:0CD6      CS:
XXXX:0CD7      MOV SS,[02D3]
—ACD1
XXXX:0CD1      CS: MOV SS,[02D3]
XXXX:0CD6      CS: MOV SP, [02D1]
XXXX:0CDB      [ENTER]
—U1522 L A
XXXX:1522      SS:
XXXX:1523      MOV SP,[02D1]
XXXX:1527      SS:
XXXX:1528      MOV SS,[02D3]
—A1522
XXXX:1522      CS: MOV SS,[02D3]
XXXX:1527      CS: MOV SP, [02D1]
XXXX:152C      [ENTER]
—U311D L 8
XXXX:311D      MOV SP,[02D1]
XXXX:3121      MOV SS,[02D3]
—A311D
XXXX:311D      MOV SS,[02D3]
XXXX:3121      MOV SP,[02D1]
XXXX:3125      [ENTER]
—U325F L 4
XXXX:325F      MOV SP,ES
XXXX:3261      MOV SS,SP
—A325F
XXXX:325F      MOV BP,ES
XXXX:3261      MOV SS,BP
XXXX:3263      [ENTER]
—U409B L 7
XXXX:409B      MOV SP,4235
XXXX:409E      MOV AX,CS
XXXX:40A0      MOV SS,AX
—A409B
XXXX:409B      MOV AX,CS
XXXX:409D      MOV SS,AX
XXXX:40A2      MOV SP,4235
XXXX:40A5      [ENTER]
—W
WRITING 4280 BYTES
—Q
A>DEBUG
—L 100 0 5 1
—D 12B L 4
XXXX:012B 20 00 00 00
—E 12B
XXXX:012B      20.27
—W100 0 5 1
—Q
```

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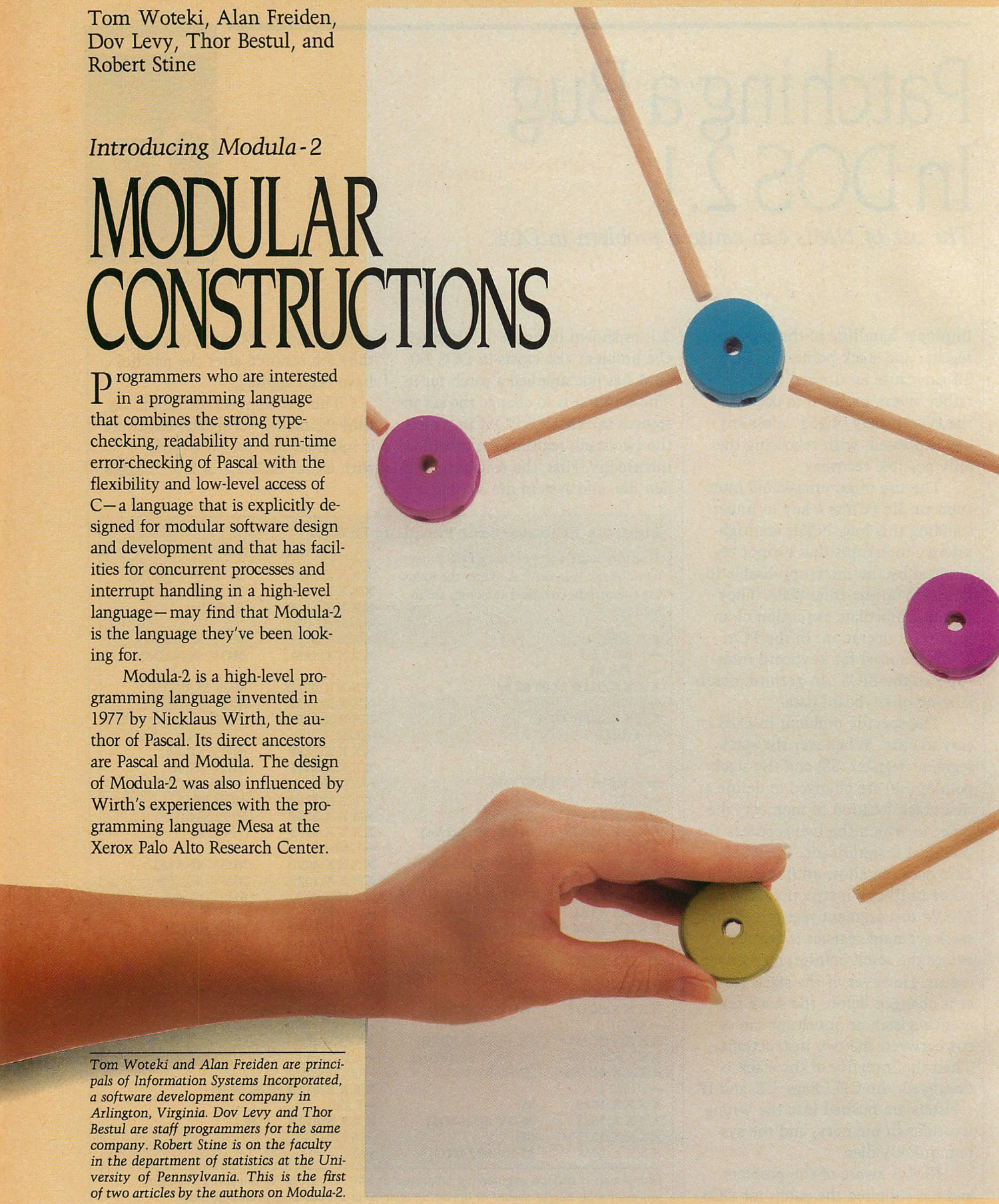
Tom Woteki, Alan Freiden,
Dov Levy, Thor Bestul, and
Robert Stine

Introducing Modula-2

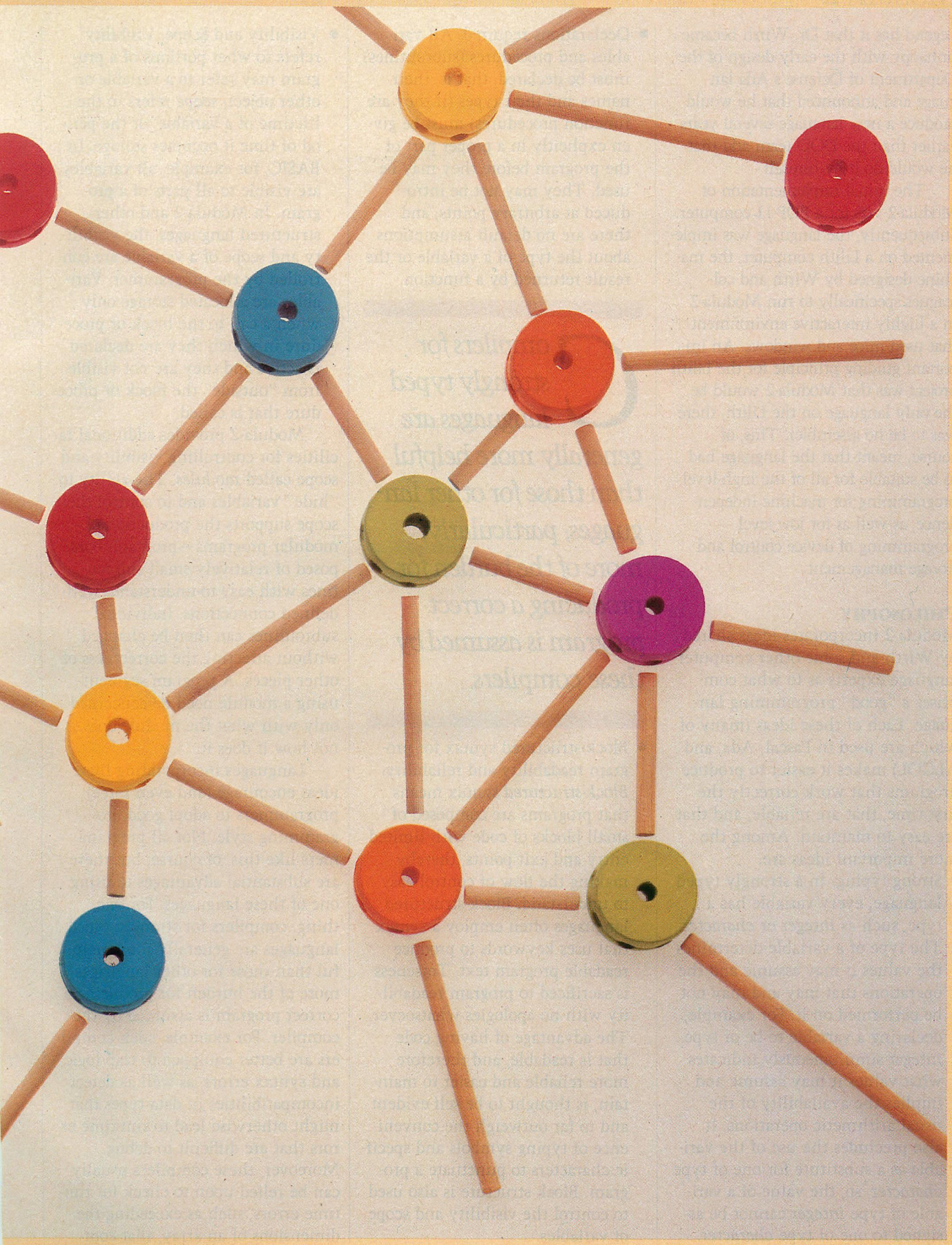
MODULAR CONSTRUCTIONS



Programmers who are interested in a programming language that combines the strong type-checking, readability and run-time error-checking of Pascal with the flexibility and low-level access of C—a language that is explicitly designed for modular software design and development and that has facilities for concurrent processes and interrupt handling in a high-level language—may find that Modula-2 is the language they've been looking for.

Modula-2 is a high-level programming language invented in 1977 by Nicklaus Wirth, the author of Pascal. Its direct ancestors are Pascal and Modula. The design of Modula-2 was also influenced by Wirth's experiences with the programming language Mesa at the Xerox Palo Alto Research Center.

Tom Woteki and Alan Freiden are principals of Information Systems Incorporated, a software development company in Arlington, Virginia. Dov Levy and Thor Bestul are staff programmers for the same company. Robert Stine is on the faculty in the department of statistics at the University of Pennsylvania. This is the first of two articles by the authors on Modula-2.



PHOTOGRAPH • RYUZO

Legend has it that Dr. Wirth became unhappy with the early design of the Department of Defense's Ada language and announced that he would produce a new language several years earlier than the DOD team and that he would do it by himself.

The initial implementation of Modula-2 was for a PDP-11 computer. Subsequently, the language was implemented on a Lilith computer, the machine designed by Wirth and colleagues specifically to run Modula-2 in a highly interactive environment that used mice and windows. An important guiding principle for the Lilith project was that Modula-2 would be the only language on the Lilith; there was to be no assembler. This, of course, meant that the language had to be suitable for all of the high-level programming for machine independence, as well as for low-level programming of device control and storage management.

PHILOSOPHY

Modula-2 incorporates ideas shared by Wirth and some other computer-language experts as to what comprises a "good" programming language. Each of these ideas (many of which are used in Pascal, Ada, and ALGOL) makes it easier to produce programs that work correctly the first time, that are reliable, and that are easy to maintain. Among the more important ideas are:

- Strong typing: In a strongly typed language, every variable has a type, such as *integer* or *character*. The type of a variable determines the values it may assume and the operations that may and may not be performed on it. For example, declaring a variable to be of type *integer* simultaneously indicates what values it may assume and implies the availability of the usual arithmetic operations. It also precludes the use of the variable as a substitute for one of type *character*, so, the value of a variable of type *integer* cannot be assigned to one of type *character*.
- Declarations required: All variables and procedures (subroutines) must be declared; that is, their names and their types (if they are function procedures) must be given explicitly in a proper part of the program before they may be used. They may not be introduced at arbitrary points, and there are no default assumptions about the type of a variable or the result returned by a function.

Compilers for strongly typed languages are generally more helpful than those for other languages; particularly, more of the burden for producing a correct program is assumed by these compilers.

- Block-structured syntax for program readability and reliability: *Block-structured syntax* means that programs are composed of small blocks of code with limited entry and exit points, thereby making the flow of control easy to understand. Block-structured languages often employ a syntax that uses keywords to produce readable program text. Terseness is sacrificed to program readability with no apologies whatsoever. The advantage of having code that is readable, and therefore more reliable and easier to maintain, is thought to be self-evident and to far outweigh the convenience of typing symbols and specific characters to punctuate a program. Block structure is also used to control the visibility and scope of variables.
- Visibility and Scope: *Visibility* refers to what portions of a program may refer to a variable or other object; *scope* refers to the lifetime of a variable, or the period of time it occupies storage. In BASIC, for example, all variables are visible to all parts of a program. In Modula-2 and other structured languages, the visibility and scope of a variable are controlled by the programmer. Variables are allocated storage only when a call to the block or procedure in which they are declared is active and they are not visible from "outside" the block or procedure that is called.

Modula-2 provides additional facilities for controlling visibility and scope called *modules*. The ability to "hide" variables and to control their scope supports the production of modular programs—programs composed of relatively small sub-routines with easy-to-understand, well-defined connections. Individual subroutines can then be changed without affecting the correctness of other pieces. A program segment using a module need be concerned only with what the module does, not how it does it.

Languages incorporating these ideas encourage (and even force) programmers to adopt good programming style. Not all programmers like this, of course, but there are substantial advantages to using one of these languages. For one thing, compilers for strongly typed languages are generally more helpful than those for other languages; more of the burden for producing a correct program is assumed by the compiler. For example, such compilers are better equipped to trap logic and syntax errors, as well as detect incompatibilities in data types that might otherwise lead to run-time errors that are difficult to debug. Moreover, these compilers usually can be relied upon to check for run-time errors, such as exceeding the dimensions of an array, that com-

pilers for other languages do not—and perhaps cannot—trap. The error-checking code may then be turned off for efficiency when the program is fully tested.

There are, however, situations in which a programmer wants to be free of strong typing, to change the type of variable, and to reach down to the machine level. In Modula-2, the programmer can choose to relax the strong typing of the language systematically using constructs that are part of the language, and there are ample facilities to program at the machine level.

Richer than Pascal

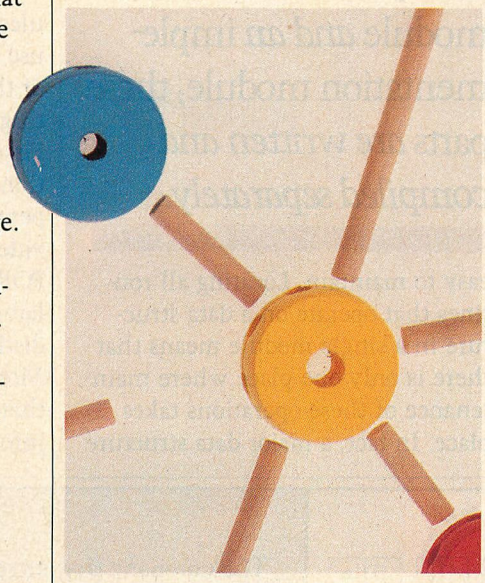
Modula-2 was designed as a general system-programming language. Its features include:

- A rich set of data structuring facilities, richer even than Pascal.
- A complete set of control structures with more systematic syntax than Pascal; every structure that starts with a keyword also ends with one.
- The module concept, which is the feature that most distinguishes Modula-2 from Pascal. The module is Modula-2's foremost tool for controlling visibility and scope, and for hiding information. Modules are also the vehicle for separate compilation, a necessary feature in the design and development of software libraries and large programs.
- Low-level facilities to systematically breach Modula-2's strong data typing and to allow the programmer direct access to the host computer's resources.
- The introduction of coroutines and processes, the keys to multiprogramming and concurrent programming.
- Input/output that is separated from the language and provided instead as library services. In this respect, Modula-2 is similar to C.

A more detailed discussion of these features will help to reveal Modula-2's particular capabilities.

Data Types and Structures

In addition to providing all of the elementary data types and all of the data-structuring facilities found in Pascal, Modula-2 has added several new built-in data types. Thus, we find the CHAR (character), BOOLEAN, INTEGER, REAL, POINTER, and user-defined enumerated types, plus CARDINAL, BITSET, WORD, and ADDRESS



types. CARDINALs are unsigned integers. BITSETs are sets of integers in the range 0 to (*N*-1) where *N* is a machine-dependent constant (on the IBM PC, *N* equals 16). The WORD and ADDRESS types are discussed later in this article.

Data-structuring facilities include RECORDs (with variants), ARRAYs, and SETs. Dimensionless arrays, called *open arrays*, may be declared as parameters to procedures. Open arrays are valuable in developing library routines that operate on variable-length arrays, which cannot be done in Pascal.

Logical and arithmetic operators may be used in declaring numeric constants; in addition, SET constants may be declared.

Systematic Syntax

All the control structures Pascal offers, plus some structures and statements it does not offer, are provided by Modula-2. In addition, the syntax of control structures has been simplified and made more systematic, which makes Modula-2 more readable than Pascal. Highlights of these changes follow.

Repetitive statements. Modula-2 includes the WHILE . . . DO and REPEAT . . . UNTIL statements for repeating sequences of statements. The WHILE . . . DO no longer requires Pascal's BEGIN . . . END block; this illustrates Modula-2's more consistent syntax.

The WHILE and REPEAT statements check for termination of their statement sequences at the beginning and end of the sequence, respectively. Modula-2 introduces the LOOP and EXIT statements for controlling repetitive actions whose termination may occur elsewhere in the sequence. The EXIT statement is used to indicate the termination of a loop. The LOOP statement is especially useful for controlling the devices running concurrently within a main task, for example, controlling a serial communications port asynchronously.

Modula-2 also includes the FOR statement for controlling repetitions by counting. And, unlike Pascal, Modula-2 permits the FOR loop to be executed using increments and decrements other than one.

Conditional Statements. Modula-2 adds an ELSIF branch to Pascal's IF . . . THEN . . . ELSE, as well as an ELSE option for use in CASE statements. Neither of these additions provides any real added capabilities, but they greatly improve program readability.

Control Transfers. In addition to the EXIT statement, Modula-2 provides RETURN and HALT statements. The RETURN statement is used either to specify the value a function returns to its caller or to prematurely exit from a procedure. The HALT statement is used to abort a program. No GOTO statement exists in Modula-2.

ADVANTAGES OF MODULES

Modules are the most important idea distinguishing Modula-2 from Pascal. Conceptually, a module is a collection of related procedures operating on a set of special data types. Every program is itself a module, called a *program module*. Furthermore, most programs are subdivided into several submodules, each one containing a related group of data types, variables, and procedures. Typically, the submodules in a software system comprise a library of software tools available to any program. For this reason we call them *library modules*. Modules are similar to packages in Ada and UNITs in UCSD Pascal.

Modules offer several advantages. First, by using them, a programmer can divide a program into separate packages of routines that operate on only one of a program's major data structures, protecting it from unintended changes. Also, modules help to organize the program in a natural, data-oriented way. The main program becomes an easily-read sequence of calls to the modules' logical services.

Second, modular programs are easy to maintain. Locating all routines that operate on a data structure in a single module means that there is only one place where maintenance of these operations takes place. In fact, a major data structure may be completely replaced with no effect on the main program. This also helps to reduce or eliminate completely the side effects caused by changes to these operations.

A library module consists of two physically distinct parts: a definition module *and an* implementation module; *these parts are written and compiled separately.*

Third, modules may be separately compiled, and then tested, installed in libraries, and used by other modules. Fourth, modules can be used to hide the details of data representations from other modules (see the discussion below).

The concept of software modules is not new to Modula-2, and use of the term usually implies all of the above ideas. What then distinguishes the Modula-2 module? First, Modula-2's separate compilation is quite different from the independent compilation that is provided in most implementations of FORTRAN or C; this is explained later in the discussion of C. Another distinguishing characteristic of Modula-2 is true data abstraction—that is, the ability to hide all the information about a data object

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except its name. A closer look at modules will help clarify this.

A library module consists of two physically distinct parts: a *definition module* and an *implementation module*. These parts are written and compiled separately. The definition module is used to declare the data types, constants, variables, and procedures that are available to a program or other module requiring the module's services. In this sense, the definition part is merely an advertisement of the module's services. No information about how the services are accomplished is provided. For example, only the names of procedures and their formal parameters are declared, not the actual code for the procedures. Even the definitions of data types need not be revealed. The implementation part of a module contains the details of data representation and the code for procedures. This is where the services promised by the definition part are actually provided.

The only compile-time connection between a library module and a program or other module that uses it is with the definition part of the library module. The library module is said to *export* its services to the client module, which, in turn, is said to *import* them. This has several implications: library modules can be designed (their definition parts can be specified) before their implementations are coded. The definition part can be used as input to the design of a program; the implementation of mutually dependent modules can proceed at the same time by different programmers; and the implementation part can be changed at will without affecting the code for any programs using the module, because a client module refers only to the definition.

Listing 1, the definition part of a library module to handle stacks, illustrates these ideas. The module exports the data type Stack and a set of procedures that operate on stacks. The reader should notice that the details of what a stack "really" is—an array, a linked list, etc.—are hidden. Instead, an understanding of stacks is given in terms of what can be done to them.

The procedures Push and Pop illustrate this nicely: apparently a stack is an object onto which integers can be pushed and off of which they can be popped. (It is even possible to generalize the notion of "stacked element" so that the stack-management module is not aware of what data object is being stacked.)

The technique of describing data by what can be done to it is called *data abstraction* or *functional abstraction*. The approach leaves StackHandler's implementation programmer free to use any convenient implementation for stacks and to change that implementation without affecting any program or module that uses the module.

Listing 2 is a program module showing the use of StackHandler to

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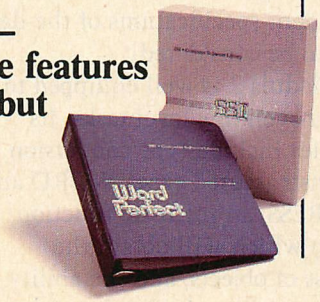

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implement a simple, stack-based adding machine. It imports the type Stack along with some of the routines exported by StackHandler. It also imports some input/output routines from a standard library module called InOut.

The program begins by initializing the stack variable S. It then enters a loop in which integers are repeatedly read and pushed onto the stack until done. Next it enters a WHILE loop, accumulating the sum of elements on the stack. Finally, it writes out the sum.

It should be clear from the example that the only concern for proper program execution is the correct operation of Push and Pop; otherwise it does not matter how stacks are implemented.

LOW-LEVEL FACILITIES

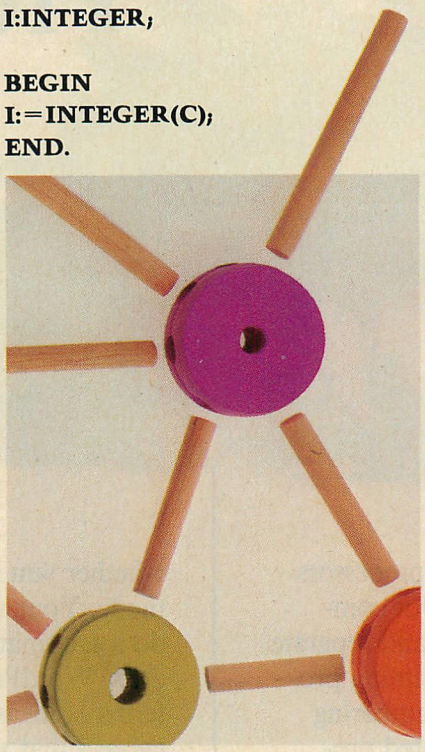
High-level languages, especially strongly typed languages, encourage structured programming. The redundancy introduced by such structure helps minimize mistakes. The rules of a strongly typed language are, however, sometimes too restrictive. For example, storage management can be a problem in a strongly typed language when data of some given structure need to be viewed as having another structure. Or, suppose a programmer wishes to import into a Modula-2 program data produced by another program in a different language. The data are not likely to conform on a byte-for-byte basis to any data structure that exists in Modula-2's high-level data-structuring facilities. Machine-dependent specifications of the data need to be considered.

Modula-2 is well equipped to handle such low-level tasks. Its facilities include type conversion, the unstructured types WORD and ADDRESS, an intrinsic function (ADR) which will obtain the address of objects, and the ability to locate variables absolutely.

Data type conversion is accomplished using type identifiers as functions to convert variables of one type into another. No computation is performed; the compiler merely interprets the underlying bit pattern in a different way. For example, the fragment:

```
VAR
C:CARDINAL;
I:INTEGER;

BEGIN
I:=INTEGER(C);
END.
```



converts the CARDINAL C into a signed integer corresponding to the sequence of bits underlying C. Such conversions are not restricted to simple, unstructured types such as integers; they may be performed on records, arrays, etc. Their proper use is machine-dependent and requires the programmer to be familiar with the internal representations of data on the host computer.

The data types WORD and ADDRESS allow the Modula-2 programmer to deal directly with the computer's memory in units of words. A variable of type WORD occupies one word of storage and is compatible, via type conversion, with variables of any type that also occupy one word. The size of a word is machine-dependent; the IBM PC compilers we examined deal directly with 16-bit words.

The type ADDRESS, which is defined as

```
TYPE
  ADDRESS = POINTER TO
  WORD
```

therefore represents the address of a word in memory. All arithmetic operations and comparisons may be performed on ADDRESSes, and ADDRESSes are assignment-compatible with pointers to any type of data. Thus, pointer arithmetic and storage management programming are possible in Modula-2.

The compatibility of the WORD type with other word-sized types carries through to formal parameters in procedures: if a formal parameter of a procedure is of type WORD, the corresponding actual parameter may be any type that is also word-sized.

Modula-2 provides an intrinsic function—ADR—that returns the address of any object. This gives you the ability to locate a variable at an absolute address in memory. These are convenient features to have for systems programming.

COROUTINES, PROCESSES, AND INTERRUPTS

Modula-2 is designed primarily for implementation on a conventional single-processor computer, but it also offers some basic facilities that support quasi-concurrent processes and true concurrency for programming peripheral devices. The model for quasi-concurrent processing is a computer with only one single-tasking processor that is time-shared among several processes.

On the other hand, the model for true concurrency for peripheral devices is a computer with multiple processors of differing capabilities, with certain parts of some processes being executable only by specific processors. Typical examples of peripherals with special-purpose processors are input/output devices. The model for true concurrency describes the IBM PC very well.

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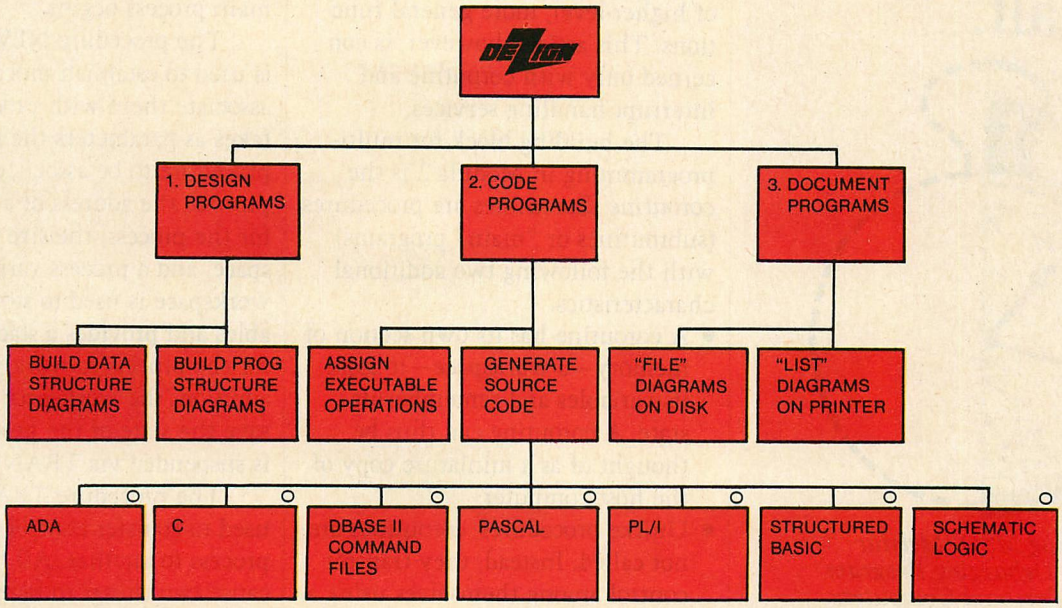

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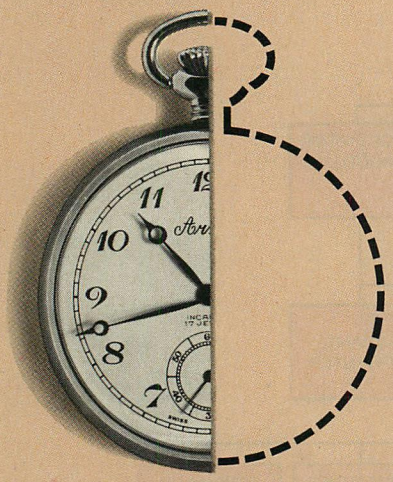

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MODULA-2

Modula-2 offers three groups of overlapping services for both of the programing models just discussed. Two of these groups—coroutines and interrupt-handling—are somewhat machine-dependent and may vary from one implementation to another. The third group—processes and facilities for synchronizing them via semaphores—is made up of higher-level, more general functions. This article, however, is concerned only with coroutine and interrupt handling services.

The building block for multiprogramming in Modula-2 is the *coroutine*. Coroutines are procedures (subroutines or "main" programs) with the following two additional characteristics:

- A coroutine has its own section of memory—a *workspace*—to hold its variables and remember its state. A coroutine can thus be thought of as a miniature copy of the host computer.
- Unlike procedures, coroutines are not called. Instead, they transfer control among themselves using a special TRANSFER procedure. This causes the coroutine to suspend itself, remember its state, and transfer control to the destination coroutine, which resumes execution at whatever point it may have been suspended. In this sense, coroutines are *reentrant*.

The data type PROCESS and the procedures NEWPROCESS and TRANSFER are available to establish and coordinate coroutines. (Unfortunately, there is potential for confusion here. A Modula-2 process is a coroutine.) The procedure NEWPROCESS both binds a procedure to a variable of type PROCESS and allocates its workspace. The procedure TRANSFER is used within a coroutine to transfer control to another coroutine.

The example in listing 3, adapted from one given in Volition Systems' documentation, illustrates the use of processes, or coroutines. Every section of code, such as a procedure, is associated with some process; conversely, every process is associated with some body of code. The "main" program is associated with the main process, which is automatically started at program execution. All additional processes are established and associated with some procedure and started by the main process or by the processes the main process begins.

The procedure NEWPROCESS is used to establish processes and to associate them with procedures. It takes as parameters the name of the procedure to be associated with the process, the address of a workspace for the process, the size of the workspace, and a process variable. The workspace is used to store local variables and provides a stack and heap for the process to work with. In addition, the workspace is used to save the state of the process when it is suspended via TRANSFER.

The procedure TRANSFER is used to transfer control from one process to another. All transfers cause two things to happen: the process transferred from is suspended and its state is saved; the process transferred to is then resumed at its previously suspended point. The first transfer to a process "starts" the process—that is, the procedure associated with the process begins execution at its first statement.

The module SYSTEM provides support for processes and important hardware-level facilities.

The example program works as follows: it first calls NEWPROCESS to establish the process Hi, associating it with the procedure WriteHi and assigning it the workspace HiWrkSpc. (The function procedure TSIZE merely returns the number

of bytes occupied by the workspace. ADR returns the address of the workspace.) The analogous task for the process Ho is then done. Finally, the program transfers control to Hi.

Because this is the first transfer to Hi, the procedure WriteHi executes from its beginning. After writing "Hi," it transfers from Hi to Ho. Ho writes its message, checks to see if it should begin a new line, then transfers back to Hi. Hi now resumes where it left off; that is, it goes to the top of the LOOP statement and starts all over. The display will continue until the computer is rebooted. Control never returns to the main program (process), because there is never a transfer back to Main.

The data type PROCESS and the procedures NEWPROCESS and TRANSFER are imported from the special, implementation-dependent module SYSTEM. This module provides support for processes and important hardware-level facilities (such as WORD, ADR, TSIZE, etc.). Be sure to check what is included in SYSTEM when evaluating a Modula-2 implementation.

Modula-2 can also be used in true concurrent programming of peripheral devices. In order to accomplish this, another procedure—IOTRANSFER—is called to use. IOTRANSFER transfers control between coroutines and attaches a device-handler coroutine to a hardware interrupt vector.

The example program in listing 4, which is built on that in listing 3, illustrates the use of concurrent device programming using processes. This program uses a keyboard-interrupt handler, defined in the program, to terminate the display of the message "HiHo." The keyboard-interrupt handler replaces the PC's ROM BIOS keyboard-service routine for the duration of the program. The example works as follows:

The main process (program) sets a control flag—keybdTerminated. Next it establishes a process—key-

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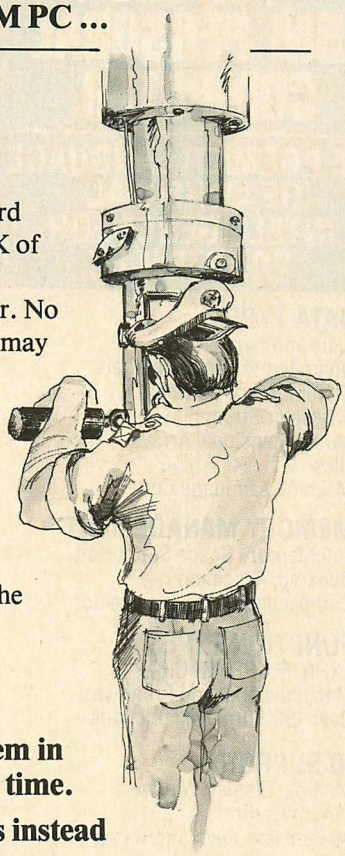

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bd—and associates it with the procedure keybdISR. The program then TRANSFERs control to keybd. The first statement in keybdISR is a call to IOTRANSFER. This procedure will carry out what a normal

Implementations of Modula-2 come equipped with a set of "standard" modules for performing input/output. This is similar to the situation in C.

TRANSFER would plus one other key task: it enables the process keybd to respond to keyboard interrupts by attaching the process to the keyboard-interrupt vector. The next such interrupt, whether generated by hardware or software, will cause keybd to resume at the next statement in keybdISR.

When IOTRANSFER is completed, the main process resumes and sets the procedure WriteHiHo in motion. (WriteHiHo is a simple procedure within the main process.) This procedure will continue to write the message HiHo until HiHoTerminated becomes TRUE.

If a key is pressed at this point, it will cause keybdISR to resume execution with the statement:

```
IF keybdTerminated THEN ...
```

Because keybdTerminated is still FALSE, the program drops through to the next line of keybdISR and begins executing a series of statements that removes the interrupt condition by reading the keyboard port and writing the keyboard-status port. The HiHoTerminated flag is also set to TRUE. All of this code is executed in lieu of the ROM BIOS code. Other than making sure the interrupt condition is removed, this code can be anything the programmer desires.

At this point control returns to the top of the LOOP statement in keybdISR and IOTRANSFER is executed once more. The process keybd is therefore suspended pending a keyboard interrupt, and the process Main, the main program, is resumed. Because it was actually the procedure WriteHiHo that was interrupted, WriteHiHo is resumed; it terminates when HiHoTerminated is checked. Execution continues with the following statement in the main program:

```
WriteString("terminating
  keyboard");
```

The control flag keybdTerminated is set TRUE and a software interrupt is issued through the keyboard-interrupt vector. This causes keybdISR to resume execution with the statement:

```
IF keybdTerminated THEN
  TRANSFER(keybd, Main);
```

Control immediately returns to Main, via the TRANSFER, with keybd no longer attached to the keyboard interrupt. The program resumes and quickly terminates. Upon return to the DOS command line, the standard ROM BIOS keyboard handler is automatically reattached to the keyboard interrupt.

This example was written and tested using the Logitech compiler, although a similar program could have been written using the Volition Systems compiler. Note the use of the procedures INBYTE (to read a byte from an I/O port), OUTBYTE, and SWI (to generate software interrupts), which were imported from the module SYSTEM.

These procedures, and others for generating in-line 8086 code and calling DOS functions, are a valuable part of Logitech's implementation. So is the implementation of IOTRANSFER, which enables the ROM BIOS keyboard-interrupt rou-

tine to be replaced. System-level features like these can distinguish between a so-so implementation of Modula-2 and one that is well suited to systems programming.

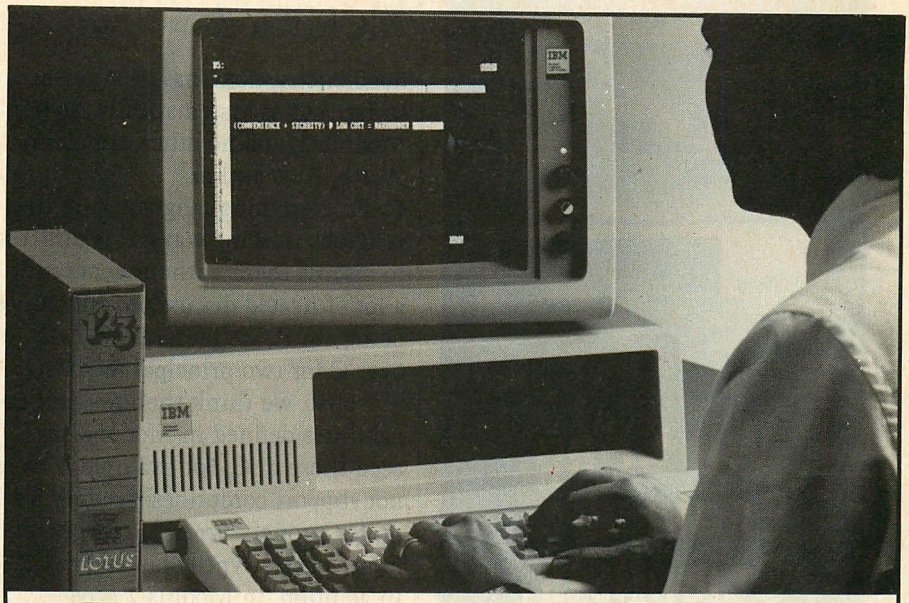
I/O Separate from Language

Many languages (Pascal is a notable example) incorporate input/output statements for reading and writing data sequentially without reference to specific devices or storage media. This approach has advantages. For example, only one form of a PRINT or WRITE statement is needed to handle output of integers, reals, and strings. However, the approach also has disadvantages: I/O varies greatly from one computer model to another, and it is difficult for a single form of I/O, embedded in the language, to take advantage of special features of devices.

Modula-2 circumvents this problem: it provides no intrinsic facilities for input/output. Instead, it offers the low-level facilities described above that allow programmatic access to devices; in addition, the use of modules allows the programmer to build hierarchical I/O systems. In practice, implementations of Modula-2 come equipped with a set of "standard" modules for performing input/output. This is similar to the situation in C.

Modula-2 Versus Other Languages

Pascal. An inadequate description of Modula-2 is that it supplies what is "missing" in Pascal. Wirth's definition of Pascal was not intended to be the language that Modula-2 is, so this statement is misleading. Nevertheless, it sums up the differences between the two for people who have been looking for a language designed in the style of Pascal with the facilities needed for systems programming and modular program development. Although most implementations of Pascal have extensions to correct Pascal's perceived



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deficiencies, none has been pushed so far, and as systematically, as has Modula-2, and no other can claim Wirth as its author.

C. Programming languages are like religions in some ways; it is difficult to discuss them without generating a lot of heated discussion. All things being equal, we prefer Modula-2 over C for two principal reasons.

First, we think the low-level capabilities defined in Modula-2 exceed those of C. For example, C does not support coroutines. Second, we prefer strongly typed languages to more loosely typed ones such as C. In addition, in Modula-2 type-checking can be systematically overridden such that it is explicit from the text of the program what has been done; in C, type conversion (using the cast operator) is inconsistent—sometimes it is required and sometimes it is not. (Compelling programmers to convert types—or anything else, for that matter—is probably what will in the end stop "C-nicks" from becoming "Modulaphiles.") Being able to tell from the program text whether type conversion has been done is invaluable in developing and maintaining software involving many programmers.

As previously noted, the compilers for strongly typed languages assume a greater share of the burden of producing correct programs. This is especially evident when comparing C and Modula-2 in two areas: run-time error-checking and C's independent compilation versus Modula-2's separate compilation. Run-time error-checking was described earlier; here we discuss only the compilation methods.

In C, a program may be broken into several source files, or *compilation units*, that may be independently compiled. By breaking a program into individual compilation units and using "external" variables and "include" files, a programmer can duplicate Modula-2's module concept up to a point. The crucial difference lies in what a C compiler knows about an *external* object (especially functions) as compared to what a Modula-2 compiler knows about an *imported* object. (External objects and imported objects are roughly equivalent.)

A Modula-2 compiler will know everything; a C compiler will know little or nothing. Therefore, a Modula-2 compiler will perform data-type checking across compilation units (separate compilation); whereas, a C compiler will not (independent compilation). Separate compilation can be invaluable in developing and maintaining error-free programs of any size, especially large programs that have more than one programmer. (FORTRAN also has independent, but not separate, compilation.)

Suppose a C function called getthem is defined:

```
getthem(a, b, c, d)
int *a, *b, *c, *d;
/* upon entry a, b, c, d are
   assumed to point to integers
   that are assigned values
   within this function. */
{
*a = 1;
*b = 2;
*c = 3;
*d = 4;
}
```

The job of getthem is simply to assign values to a set of integers. Suppose getthem was used to assign values to four integers and then print the values. Assume getthem is stored in a text file separate from the following program:

```
main()
{
int x, y, z, w;
getthem(x, y, z, w);
printf("%d %d %d %d\n", x, y, z,
   w);
}
```

What happens if a programmer compiles getthem and main independently, links them together, and then runs the resulting program?

Although he intends for the values of w, x, y, z to be assigned by getthem, the actual behavior of the program could be anything from the printing of garbage values, in the best case, to a hard crash of the computer. The reason is that the function getthem expects its arguments to be pointers to integers (and will interpret them as such), but the programmer mistakenly passed the integers themselves in the program. When this happens, the integers are uninitialized. Regarded as pointers, they may, in the worst case, just happen to point into parts of the operating system. The function getthem will then write over the operating system, probably blowing the system in the process.

This kind of error can leave the programmer scratching his head for a long time, wondering what happened, especially if his operating system just goes away without a complaint. In this example, it's not so hard to see what is going on, but in the development of a large program, involving several people and many text files, some rather mysterious errors can crop up.

Aside from programmer carelessness, compilers with only independent compilation support do not check data types across independently compiled text files. If the corresponding routines were written in Modula-2, the error of passing values when pointers are expected would never get past the compiler. This is because compile-time type-checking across separately compiled modules would call immediate attention to the mistake.

The point of this example is that many careless errors are committed (even by the most experienced programmers), and many of these can be avoided automatically by a sufficiently watchful compiler. Modula-2 compilers provide such services. This can be a great aid for efficiently developing large and complex software systems to which many users will have access.

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WHAT TO LOOK FOR IN A MODULA-2 IMPLEMENTATION

Based on the need to produce competitive commercial software, we judge a Modula-2 implementation on five criteria. Wirth's *Programming in Modula-2* (1982) helps define three of the five. He defines the language, describes the low-level facilities (but acknowledges that they will vary from machine to machine) and incidentally mentions some standard library modules.

First, look for full implementation of all the high-level features of Modula-2: data types, control structures, strong typing, and separate compilation. Without these features it's simply not Modula-2.

Second, look for a good implementation of the low-level facilities: ADDRESS, WORD, coroutines, and concurrent device programming. These features are Modula-2's link to the underlying computer. What constitutes a good implementation depends on the compiler. On the IBM PC, for example, it should include two-word ADDRESS types (to deal with the 8088's segment registers) and the ability to attach coroutines to interrupt vectors.

Third, look for native-code compilation. Some compilers produce code for a virtual machine that is emulated at run-time. Although this may have been acceptable, even advantageous, at one time, the current market conditions demand native-code compilation.

Fourth, look at the implementation's relationship to the *de facto* standard operating system. On the PC there would have to be compelling reasons for the compiler not to produce code that is compatible with the PC-DOS environment and its inherent file system.

Lastly, look for implementations of the standard library modules, mentioned by Wirth, that are compatible with the host operating environment. In fact, definition of these modules is in a state of flux. At a minimum, they should include modules to perform interactive, sequential input/output for the keyboard and console display; modules that define sequential files and allow the programmer to connect them to the underlying DOS and to perform input-output with them; a simple module to manage dynamic allocation and deallocation of memory; and a module to synchronize processes via semaphores.

REFERENCES

Weiner, R. and Sincovec, R. *Software Engineering with Modula-2 and Ada*. New York: John Wiley and Sons, 1984.

Wirth, N. "The Personal Computer Lilith." Reprint. Provo, Utah: Modula Research Institute, 1981.

Wirth, N. *Programming in Modula-2*. New York: Springer-Verlag, 1982.

In the first of two articles, the authors have examined Modula-2's distinguishing features and compared it to other popular languages. A second article in the December issue of PC Tech Journal *will compare Modula-2 compilers from Logitech, Inc., Volition Systems, and the Modula Research Institute.*

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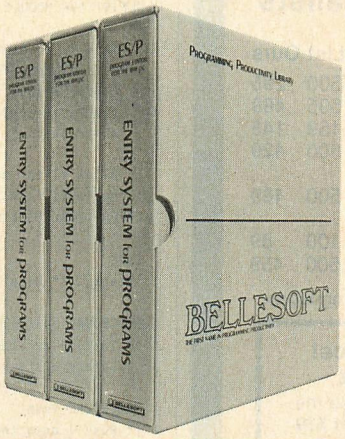

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Listing 1 DEFINITION MODULE Stackhandler

```
DEFINITION MODULE StackHandler;
(*
   This is an example of the definition part
   of a library module.  It illustrates the
   use of opaque or hidden types (the type
   Stack) in conjunction with data
   abstraction.*)

(* Allow client modules to use services
   declared here. *)
EXPORT QUALIFIED Stack, Initialize, Push, Pop, Empty, EmptyStack;

TYPE
 Stack;  (* Hide implementation details. *)

PROCEDURE Initialize(VAR S : Stack);
(* Initialize stack variables. Must be called
   before a stack can be used. *)

PROCEDURE Push(i : INTEGER; VAR S: Stack);
(* Push i onto the stack S. *)

PROCEDURE Pop(VAR S : Stack) : INTEGER;
(* Pop the top element of the stack and return
   it as the result of this function procedure.
   This operation is not defined if the stack
   is empty. *)

PROCEDURE Empty(S : Stack) : BOOLEAN;
(* Return TRUE if and only if S is empty. *)

PROCEDURE EmptyStack(VAR S : Stack);
(* Empty the stack of all items, returning it to its initial state. *)

END StackHandler.
```

Listing 2 MODULE Stack Illustration

```
MODULE StackIllustration;

FROM InOut IMPORT Read, WriteString, WriteLn,
                  ReadInt, WriteInt;
FROM StackHandler IMPORT Stack, Initialize,
                         Push, Pop, Empty;
VAR
 S : Stack;
 i : INTEGER;
 ch : CHAR;
BEGIN
  (* Initialize stack for further work. *)
  Initialize(S);

  (* Collect input data, push onto stack. *)
  REPEAT
    WriteString("Enter: ");
    ReadInt(i);
    WriteLn;
    Push(i, S);
    WriteString("Done?");
    Read(ch);
    WriteLn;
  UNTIL (ch = "Y");

  (* Initialize i then accumulate sum of stack elements. *)
  i := 0;
  WHILE NOT Empty(S) DO
    i := i + Pop(S);
  END;

  (* Write sum in a field 7 digits wide. *)
  WriteString("Sum= ");
  WriteInt(i, 7);
  WriteLn;

END StackIllustration.
```

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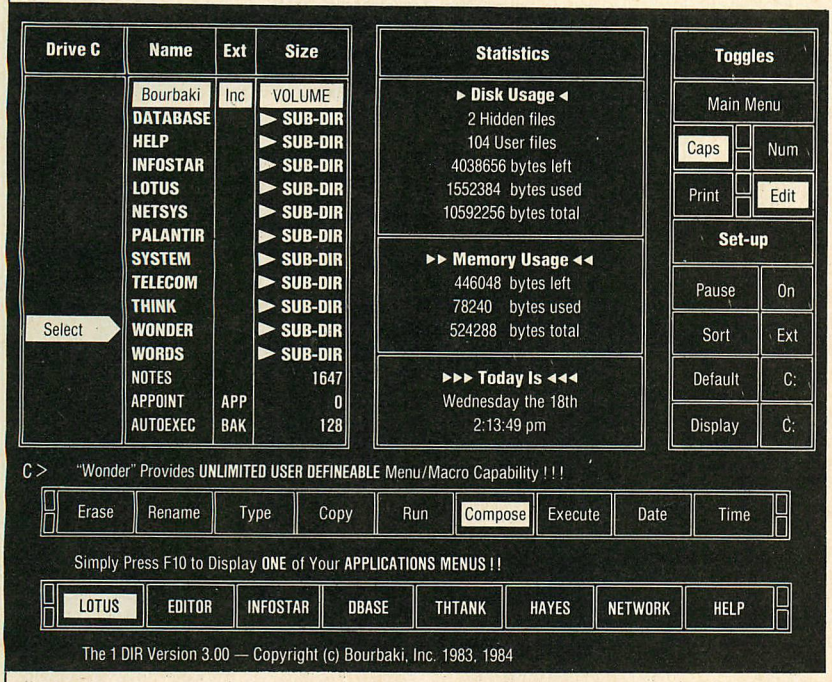

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Listing 3 MODULE HiHo

```
MODULE HiHo;

FROM SYSTEM IMPORT WORD, ADR, TSIZE, PROCESS, NEWPROCESS, TRANSFER;
FROM InOut IMPORT WriteLn, WriteString;


TYPE
    workSpace = ARRAY[0..1023] OF WORD;
VAR Hi, Ho, Main : PROCESS;
    HiWrkSpc, HoWrkSpc : workSpace;

        PROCEDURE WriteHi;
        BEGIN
         LOOP
          WriteString("Hi");
          TRANSFER(Hi, Ho);
         END;
        END WriteHi;

        PROCEDURE WriteHo;
        CONST maxHiHo = 17;
        VAR i : CARDINAL;
        BEGIN
         i := 0;
         LOOP
            WriteString("Ho");
            INC(i);
            IF (i > maxHiHo) THEN
             WriteLn;
             i := 0;
            END;
            TRANSFER(Ho, Hi);
         END;
        END WriteHo;

BEGIN
 NEWPROCESS(WriteHi, ADR(HiWrkSpc), TSIZE(workSpace), Hi);
 NEWPROCESS(WriteHo, ADR(HoWrkSpc), TSIZE(workSpace), Ho);
 TRANSFER(Main, Hi)
END HiHo.
```

Listing 4 MODULE HiHoKey

```
MODULE HiHoKey;

FROM SYSTEM IMPORT WORD, ADR, ADDRESS, TSIZE,
                   PROCESS, NEWPROCESS,
                   TRANSFER, IOTRANSFER,
                   INBYTE, OUTBYTE, SWI;
FROM InOut IMPORT WriteLn, WriteString;

CONST
    keybdInterrupt = 09H;

TYPE
    workSpace = ARRAY[0..1023] OF WORD;

VAR
    Main, keybd : PROCESS;

    keybdWrkSpc : workSpace;

    HiHoTerminated, keybdTerminated : BOOLEAN;

    PROCEDURE WriteHiHo;
    CONST maxHiHo = 17;
    VAR i : CARDINAL;
    BEGIN
     i := 0;
        WHILE NOT HiHoTerminated DO
        WriteString("HiHo");
        INC(i);
        IF (i > maxHiHo) THEN
         WriteLn;
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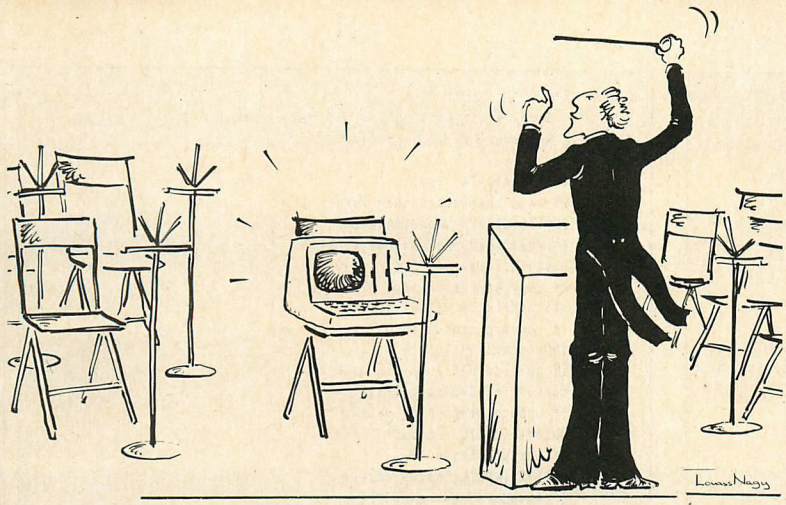

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```
      i := 0;
    END;
  END;
  WriteLn;
  WriteString("HiHo terminated, returning to caller");
  WriteLn;
END WriteHiHo;

PROCEDURE keybdISR;
(* keyboard interrupt service coroutine *)
CONST KBDATA = 060H; (* Keyboard scan code port *)
      KBCTL  = 061H; (* Keyboard control port *)
VAR
  key, status, saveStatus : WORD;
  statusBits : BITSET;
BEGIN

  LOOP

    (* IO-transfer control back to Main making Main
       interruptible. *)
    IOTRANSFER(keybd, Main, keybdInterrupt);

    (*
       When a keyboard interrupt occurs (raised either
       by hardware or software), interrupt Main and
       resume execution here.
     *)
     IF keybdTerminated THEN
        (*
           Check to see if this process has been killed.
           If so do a transfer back to Main, thereby
           detaching this interrupt service routine from
           the keyboard interrupt vector.
        *)
        TRANSFER(keybd, Main);
        END;
```


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```
      (*
        This is the working body of the keyboard
        interrupt service routine.
      *)
      INBYTE(KBDATA, key);
      (* read character, then forget it *)
      INBYTE(KBCTL, saveStatus);
      (* read keyboard control port *)
      status := saveStatus;
      (* copy status of port *)
      statusBits := BITSET(status);
      (* convert status to bit set *)
      INCL(statusBits, 7);
      (* include bit 7 in status bits *)
      status := WORD(statusBits);
      (* update status for output *)
      OUTBYTE(KBCTL, status);
      (* output status *)
      OUTBYTE(KBCTL, saveStatus);
      (* keyboard now reset *)
      HiHoTerminated := TRUE;
      (* terminate HiHo *)

    END;
  END keybdISR;

BEGIN
  WriteString("transferring to keyboard");
  WriteLn;

  (* Set starting condition for keyboard service routine. *)
  keybdTerminated := FALSE;

  (* Create keyboard service process keybd *)
  NEWPROCESS(keybdISR, ADR(keybdWrkSpc), TSIZE(workSpace) DIV 16, keybd);

  (*
     Transfer to keybd. With no interrupts pending we will
     return immediately.
  *)
  TRANSFER(Main, keybd);

  (*
     Start the HiHo's rolling!
  *)
  WriteString("calling HiHo");
  WriteLn;
  HiHoTerminated := FALSE;
  WriteHiHo;
  (*
     WriteHiHo is part of the main process. Assuming it
     gets rolling before any keys are pressed, then it
     is the code that will actually be interrupted. The
     keyboard service routine will set HiHoTerminated to
     TRUE. Control will be then be transferred back to
     the main process so that WriteHiHo will pick up
     where it was interrupted. HiHoTerminated having
     been set to TRUE, WriteHiHo will eventually perform
     a simple subroutine return. Execution will then pick
     up with the next statement:
  *)
  WriteString("terminating keybd");
  WriteLn;
  keybdTerminated := TRUE;
  (*
     Generate a software interrupt from the keyboard. Note
     we have set keybdTerminated TRUE in order to
     kill the keyboard service process.
  *)
  SWI(keybdInterrupt);

  WriteString("That's all folks!");
  WriteLn;
END HiHoKey.
```

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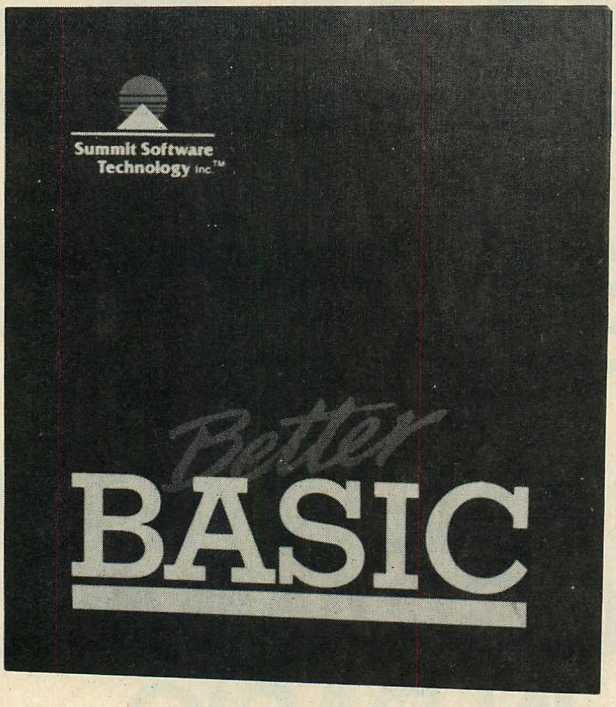

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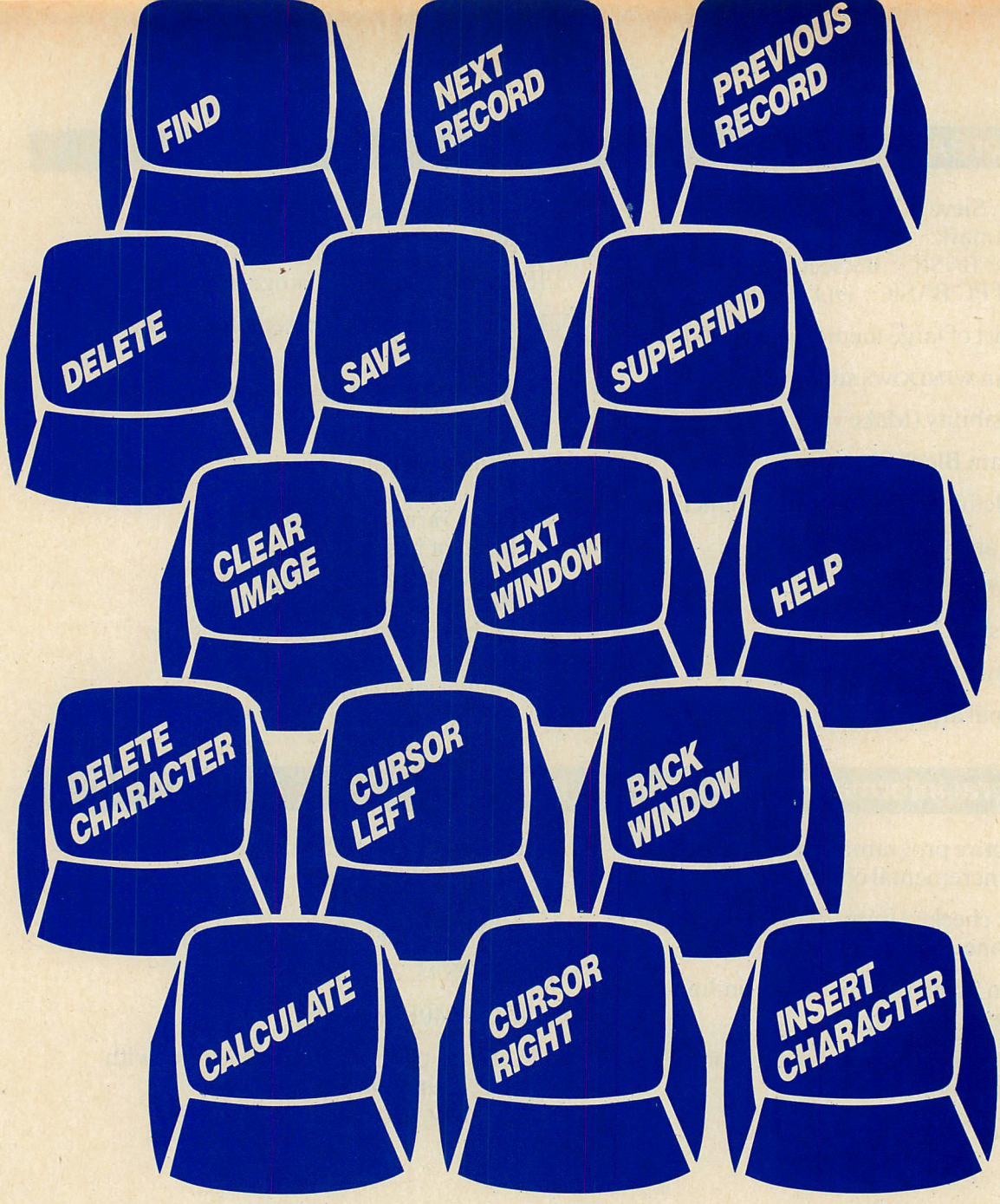

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SHARING FILES

EtherNet and its use of semaphores to prevent users from destroying each other's files

WILLIAM L. COLSHER

Of all the needs that are served by Local Area Network (LAN) systems, perhaps the most misunderstood is file sharing. The real problem with sharing data files among many IBM PCs lies with DOS 2.0. Designed as a single-user operating system, DOS 2.0 provides no facility to arbitrate access to files under its control. In a networking environment, with many users (and many copies of DOS) attempting to read and write information to a single volume, something must be done to prevent them from destroying files.

What follows is a close look at file sharing on one of the major LAN systems available for the IBM PC: EtherNet, as implemented by the 3Com Corporation. After defining the types of shared file access, we'll take a detailed look at the software techniques necessary to use them safely and survey the commercially available packages that take advantage of them.

In the EtherNet system, the basic unit of sharable storage is the *volume*. In many ways, it is convenient to think of a volume as nothing more than an imaginary floppy disk of indeterminate size (anywhere from 64K to 32Mbyte). Each volume has an *owner* (the user who created it) and an *access type*. A volume may also have a password. The 3Com EtherNet system also provides four imaginary disk drives (lettered from the last physical disk drive) in which to place these volumes. The process of associating a volume name with a drive letter is called LINKing.

PRIVATE, PUBLIC, AND SHARED

The access type of the volume determines who can read and write information into it; EtherNet provides three types: *private*, *public*, and *shared*.

Private access is the simplest type. A private volume may be LINKed by one user at a time. That user may be the owner of the volume or, if the volume has a password, any user who knows the password. Once LINKed to a private volume, a user has unlimited read/write capability. Clearly, since only one user may access a private volume at any given time, no special precautions are necessary in this situation.

The next type of access is public. A public volume may be LINKed by any number of users, but they may only READ data or programs. Public volumes may have passwords also. Only the owner of a public volume may write to it, but because many users may be linked to the volume, the owner must take some precautions if he or she intends to write to it.

William Colsher is a support analyst for ComputerLand in Minneapolis. He has degrees from Ohio State University in both computer science and classics.

The final type of access is shared. A shared volume may be read and written to by anyone having the volume's password. Since many users may be linked to a shared volume at any one time, the possibility of causing major damage should be obvious.

A simple example will serve to illustrate the problem. Imagine that we have a database containing the current account balances of all the customers of The First Foundation (a publisher of encyclopedias). Customer Jeff has a current balance of $98.44. Jeff has mailed in a check for the full amount, and a clerk at Workstation-1 begins the process of entering that information. His PC reads Jeff's record, displays the current information, and waits for him to complete the transaction. Meanwhile, another clerk has just taken a new $55.00 order from Jeff. The second clerk, at Workstation-2, begins his transaction. The second PC reads the record, but the record still has a balance of $98.44 because the first clerk hasn't yet finished *his* transaction. You should begin to get the idea by now. At the end of this scenario Jeff's payment will have vanished, since when the second clerk finally finishes his transaction Jeff's balance will be $163.44.

THE SEMAPHORE

The solution to this problem is provided by a concept called the *semaphore*, which is a software traffic light, visible to a suitably written program. When a program encounters a semaphore it does the same things a person would do upon seeing a red light: Wait for it to turn green, turn around and go home, or, ahem, run it.

In most cases, of course, the program, like people, waits for the light to change and proceeds on its way. The consequences of failing to observe the semaphore can be just as disastrous as running a red light.

In the 3Com implementation of EtherNet, semaphore facilities are provided through three functions of software interrupt 60H. The first two functions are, of course, LOCK and UNLOCK. 3Com also provides the very convenient WAIT/LOCK. Like LOCK, WAIT/LOCK will lock a semaphore; but, if the semaphore is already locked, WAIT/LOCK will continuously try the LOCK for a specified period of time.

Before examining methods of implementing the 3Com semaphore service, I would like to reemphasize the point that effective use of semaphores is entirely dependent upon the cooperation of all the programs involved in the file sharing. Every application system *must* define and adhere to a standard set of semaphore names for the files it will manipulate.

The effective use of semaphores is entirely dependent upon the cooperation of every program involved in the file sharing.

Here are some ideas that can be effective in controlling shared files.

- **For All Files.** The first part of the semaphore name should consist of the actual name of the file. Do *not* include the path name or drive letter since those are not necessarily the same for every program, nor for every workstation.
- **For Direct or Random Access Files.** In addition to the file name, it is appropriate to append the *record number* or *physical block numbers* being accessed to the semaphore name. And, since semaphore names can contain wildcard characters (the * and the ?), it is possible to lock ranges of records or blocks using this technique.

The ability to lock a range of records is critical. DOS has an unfortunate habit of reading information from a disk in chunks of 512 bytes. As a result, when an application program reads a single record, it may actually read in several adjacent physical blocks.

The formula to compute the necessary range of physical blocks is simple. First, the block in which the record begins is computed as follows:

```
start block = INT (record
  number / (512 / record
  length))
```

FOR RECORDS GREATER THAN 512 BYTES LONG:

```
end block = start block +
INT (record length / 512
+.5)
```

FOR RECORDS LESS THAN 512 BYTES LONG:

```
IF REMAINDER (record
number / (512 / record
length)) is
  GREATER THAN
  record length
    THEN end block =
    start block
    ELSE end block =
    start block+1
```

Obviously, for files with record length equal to 512 bytes, record number, start block, and end block will all be identical.

To summarize, a useful semaphore might be described syntactically as:

```
filename [.ext] [record
  number] [block number]
```

Keep in mind that all the programs in a system must agree on the structure of the semaphores. Trying to lock an entire file with the filename portion when another program is using filename.ext will fail.

SEMAPHORE SERVICE

As I mentioned above, semaphore service is provided by means of software interrupt 60H. Because some of the popular high level languages available for the IBM PC do not have facilities for invoking such interrupts directly, it is convenient to write the code in Assembly Language. Fortunately, the EtherNet

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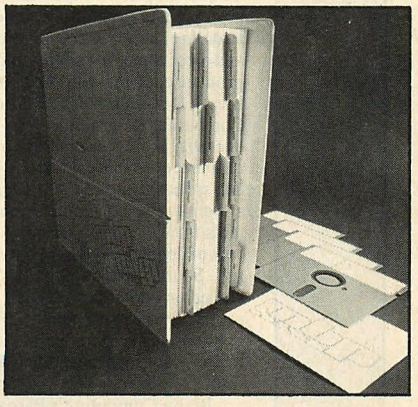

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requirements are clearly defined in the EtherSeries user manual, and the conventions needed to communicate with other languages are well documented in the proper manuals.

Listing 1, ELOCK.ASM, is written in IBM Assembly Language and provides the semaphore service for IBM Compiled BASIC. ELOCK has three entry points: LOCK, UNLOCK, and WAITLOCK, each of which implements the obvious function. These functions are exercised in listings 2 and 3, which are Compiled BASIC programs, called TEST.BAS and COTEST.BAS.

The BASIC program TEST.BAS performs or triggers all the functions and error conditions it is possible to test from a single EtherNet workstation. TEST.BAS begins by attempting to lock a semaphore. The return code from the lock function should be a zero. (A subroutine at line 5000 translates the return codes into sensible messages.) The next section of code unlocks the semaphore just locked and again a completion message is displayed.

The following tests deliberately force various errors to occur. First, an effort is made to lock an invalid semaphore name: in this case, the name is longer than the maximum 31 characters. Next, the program tries to overflow the semaphore list on the server by locking 50 semaphores, then trying to lock a fifty-first. A semaphore can be locked only on an EtherShare volume; this is the next test. The final forced error is an attempt to lock a duplicate semaphore name.

COTEST.BAS must run simultaneously on two workstations to verify that semaphores set from one system can be detected and read correctly by another. In order to function, COTEST.BAS assumes that both workstations have been linked to the same shared volume and that the volume is linked to the same EtherShare drive. (This last is not a requirement but it simplifies the program.) The program *is* quite simple; the first copy to begin execution locks a semaphore called COTESTSEMAPHORE. When the second copy starts up, this condition is detected and that copy begins to perform LOCK operations. Meanwhile the first copy has displayed the message "Press enter to unlock semaphore." When ENTER is pressed, copy one unlocks its semaphore and copy two immediately locks it. The "positions" of the programs are thereby reversed and the process continues.

The fundamentals of semaphore use are clearly illustrated by the two programs just discussed, but the details for a given application can become quite complex. It is important to remember that as far as DOS

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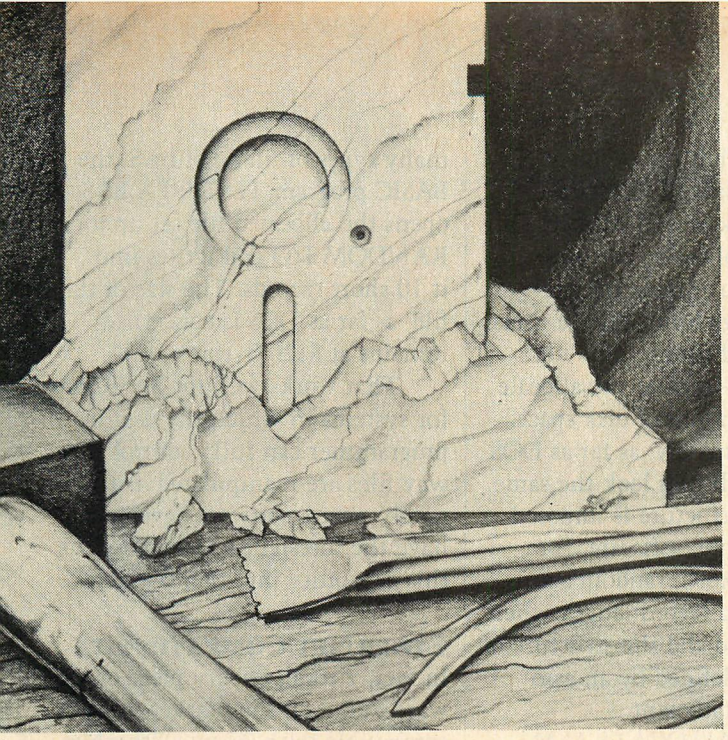

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POLYTRON

is concerned, semaphores have no existence whatsoever. It is entirely the responsibility of the programmer to ensure that no I/O is ever performed to a shared file without checking and locking first the appropriate semaphore.

Semaphores solve significant problems in sharing files. There is one, though, that they do not solve. When DOS opens a file, a copy of the appropriate File Allocation Table (FAT) is also read into RAM. If the file grows or shrinks as the result of some I/O, that change is not reflected in the *volume's* copy of the FAT until the file is closed. With many copies of the FAT for a shared volume in many separate workstations, a great potential for serious damage exists.

Fortunately, the solution is simple—though awkward. All shared files that can change size must be pre-allocated. This will require a great deal of thought on the part of the person who does the pre-allocation, but the problem is not usually a difficult one if the application task is well defined. Of course, the application software must be able to enforce the pre-allocated storage limits on the users.

PC-DOS, of course, does not provide a built-in means to allocate an arbitrary amount of disk space for a file. Fortunately, as far as DOS is concerned, all files look the same. Any internal structure is imposed by the application software. For example, in BASIC, random access files are given a record length when they are opened and the structure of the records is defined by an associated FIELD statement.

Listing 4, ALLOCATE.ASM, shows one way to allocate a predetermined amount of disk space. In this case, 5K is allocated to a file called PREALLOC.DAT. The program first CREATEs the file and then uses the DOS block write function to output 5,120 NULLs. This technique works quite well for many types of files; listing 5, the BASIC program TESTPREA.BAS, opens the allocated file set up for RANDOM I/O and writes into it 10 short records. The size of the file, as far as DOS is concerned, remains at 5120 bytes.

That works well for BASIC and for systems in which the user or programmer can fully control the way files are manipulated. Fortunately, many software developers have the foresight to accommodate this capability into their systems.

ETHERNET COMPATIBILITY

In fact, virtually every piece of software found on the market today is compatible with 3Com's EtherNet system, though few have the ability to safely use shared files. Equally important, most of today's popular packages are licensed for single-user or single CPU use. For example, Lotus 1-2-3 works just fine on the 3Com EtherNet. Dozens of workstations can freely access the pre-

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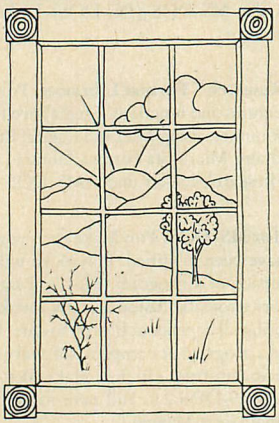

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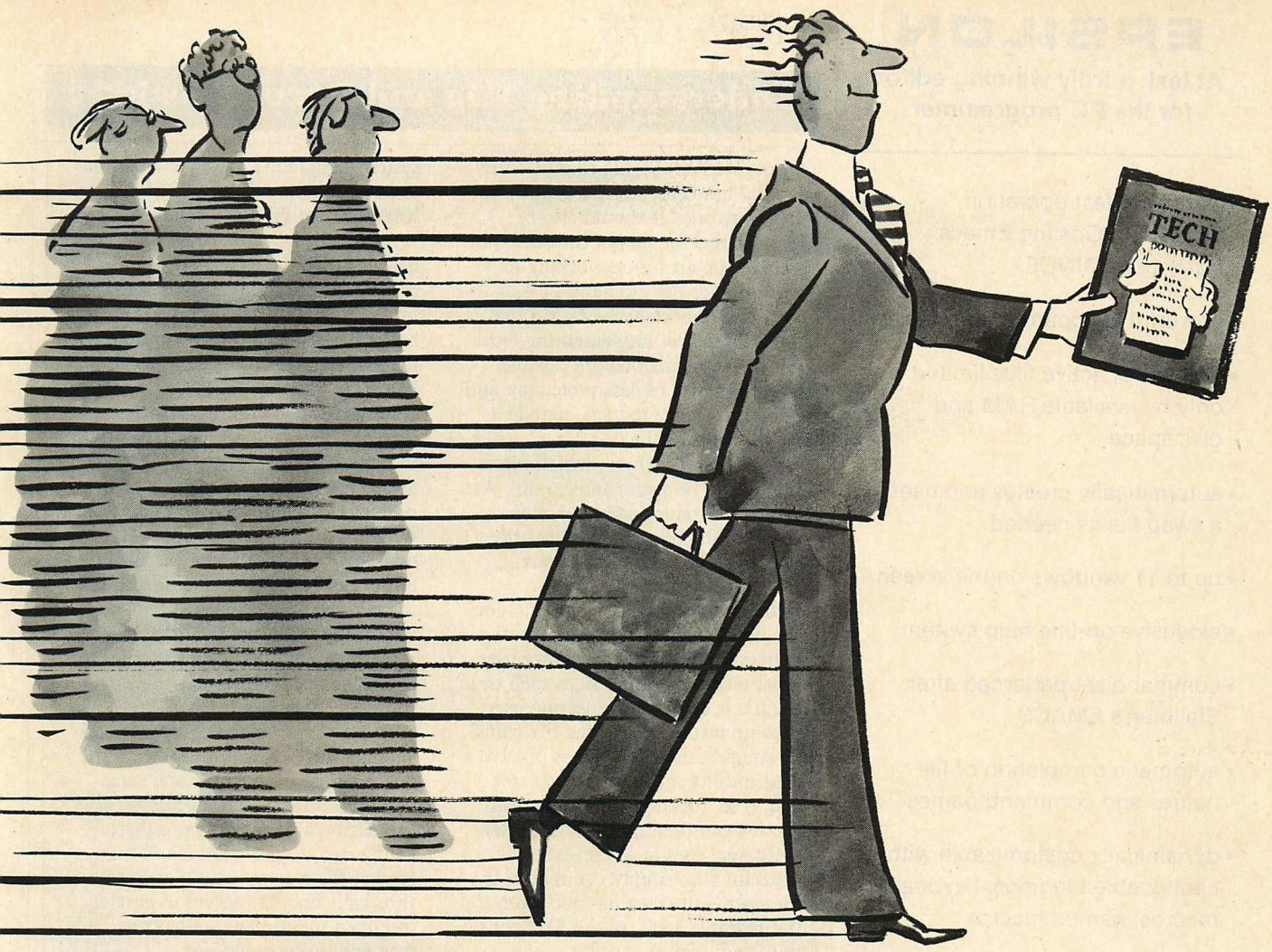

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Understanding File and Record Locking

It goes without saying that *PC Tech Journal* has been positive about local area networks. It should also be obvious that we do not consider the state of the art for networking to be very high at the moment.

One important reason for that is the difficulty of implementing local network systems that are capable of a high level of data protection and integrity. Most products include a facility such as the one Mr. Colsher so well describes here, which forces the user to be aware and careful. At least one product, however, steps ahead of the pack and reduces the attention the user needs to pay.

In the simple file locking systems that most networks include, the user must take *active* steps to protect the data file, and *every* user must take those same steps each time the file is accessed. If just one user slips up just one time, the file could be compromised. The steps involve determining if the file is available and, if so, locking it. The file open process can then proceed. Consider the casual user of a spreadsheet program who simply commands the file open—the user has not taken the required steps, so the file opens but is not locked to other users.

It is certainly possible for programmers to construct programs that obey all the rules. The user then has only to ensure that all programs used on the network are "approved" and will not compromise data integrity. Unfortunately, no standard operating system facility currently exists; each program must be coded to reflect the individual choices of each network system designer. That is, one version of Lotus 1-2-3 for 3Com, one for Xnet, one for PC-Net, etc.

Novell, with its NetWare series, has a slightly better way. Its product is not immune from all problems inherent in network architecture, but it has reduced the contention for files to a *passive* scheme. In the NetWare system, any program can attempt to open any file at the server. There is no need specifically to request a lock. If the file happens to be busy already, the server reports back to the application program, which will usually respond with its own error message about the file either not being available or refusing to open. NetWare is also capable of handling the active case; furthermore, programs can be written for exclusive operation under this environment, if desired.

How is this done? Most network vendors have chosen to intercept the PC-DOS disk access calls and translate them into network accesses, as if the network were just a peculiarly-configured disk. Novell chose to intercept *file system* calls. NetWare thus calls upon its server to provide the *open* function as well as the *read* and *write* functions.

Curiously enough, this design decision has given Novell some flexibility that the other LAN vendors do not have: its software is portable and runs on everybody else's hardware.

Whatever system you may be using, be sure to understand the data protection rules first, then pay them more than lip service.

—*WF*

defined worksheets, change them, and store results in private volumes. Legally, every workstation user must own a copy of Lotus 1-2-3.

The same is true for just about every major package on the market today, including all IBM labeled software. Many of the major software companies are in the process of developing "multiple CPU" licenses for their products. Some of these same companies are also vigorously defending their rights to their software in court. As a result, it is extremely important to get (and follow) sound legal advice before one installs software that is not covered by such an agreement.

Networking is an extremely powerful technology still in its infancy. Nevertheless, the careful user, who is aware of the pitfalls, can derive both immediate and long-term benefits from equipment on the shelves today.

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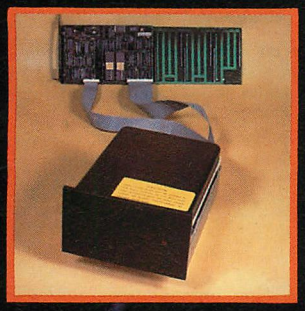

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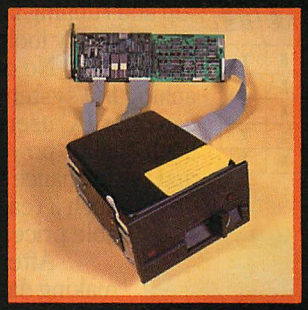

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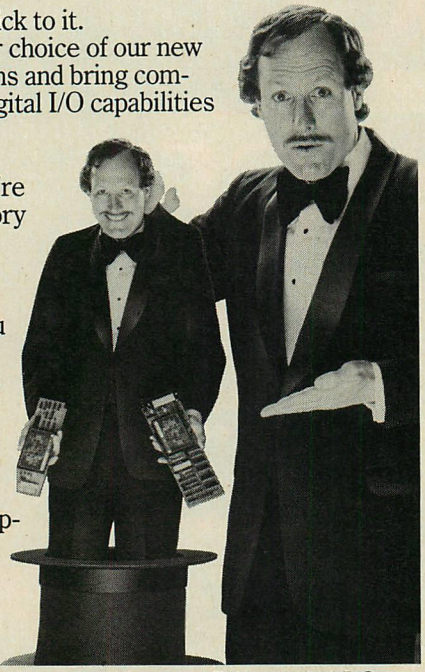

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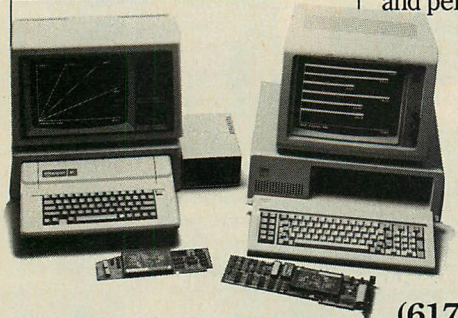

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CIRCLE NO. 144 ON READER SERVICE CARD

Listing 1 ELOCK.ASM

```
;Program Name: ELOCK.ASM
;Author: William L. Colsher
;Date Written: May 19, 1984
;Purpose: This program provides the 3Com/EtherNet semaphore facility
;         to compiled BASIC programs.  Three services are provided:
;         1. Lock/Return - sets a semaphore and returns immediately
;         2. Lock/Wait - sets a semaphore, if unsuccessful, retry
;                        until timeout
;         3. Unlock - unlocks a locked semaphore
;
;Entry Points: LOCK, WAITLOCK, UNLOCK
;
;Calling Parameters: drive_id - integer, specifies EtherShare drive
;                               containing the data in use.  A:=1,
;                               B:=2, etc.
;
;                    sem_name - character string, semaphore name
;                               to be used, must be 31 characters
;                               or less in length and terminated with
;                               a null, i.e.: CHR$(0)
;
;                    time_out - integer, the number of seconds to
;                               wait while re-trying a lock/wait
;
;                    error_cd - integer, error code returned by
;                               EtherShare routine. Actual codes
;                               are listed with functions.
;
;Calling Sequence: CALL LOCK (drive_id,sem_name,error_cd)
;                  CALL WAITLOCK (drive_id,sem_name,time_out,error_cd)
;                  CALL UNLOCK (drive_id,sem_name,error_cd)
;
        ASSUME  CS:ELOCK
ELOCK   SEGMENT 'CODE'
        PUBLIC  LOCK
        PUBLIC  UNLOCK
        PUBLIC  WAITLOCK

LOCK    PROC    FAR

;Entry point LOCK is used to attempt to LOCK a semaphore.
;
;Error codes returned are: 0 - operation successful
;                          1 - semaphor already locked
;                          2 - server not responding
;                          3 - invalid semaphore name
;                          4 - semaphore list full
;                          5 - invalid drive_id
;                          6 - invalid net address
;                          7 - not logged in
;                          8 - write to network failed
;                          9 - semaphore already locked by caller
        PUSH    BP              ;Save BP
        MOV     BP,SP           ;point to param list
        MOV     SI,[BP]+10      ;Get drive_id address
        MOV     AX,[SI]         ;retrieve actual drive number
        MOV     BX,[BP]+8       ;Get pointer to sem_name data
        MOV     BX,2[BX]        ;Skip length and move address into BX

        MOV     AH,12h          ;LOCK function code in AH
        MOV     SI,0            ;Use drive_id instead of net address
        INT     60h             ;do it!

        MOV     SI,[BP]+6       ;get address of error_cd
        MOV     AH,0            ;clear high byte of AX
        MOV     [SI],AX         ;Give caller the return code

        POP     BP
        RET     6

LOCK    ENDP

WAITLOCK PROC   FAR

;Entry point WAITLOCK is used to attempt to lock a semaphore.  If the
;attempt is not successful, the EtherShare routine will retry
;the operation until it is successful or a timeout occurs.
;
;Error codes returned are: 0 - operation successful
```

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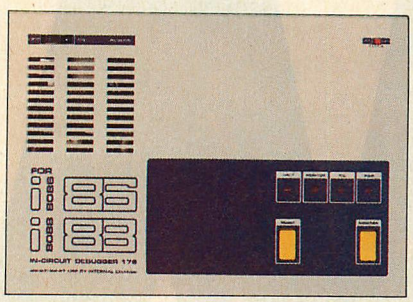

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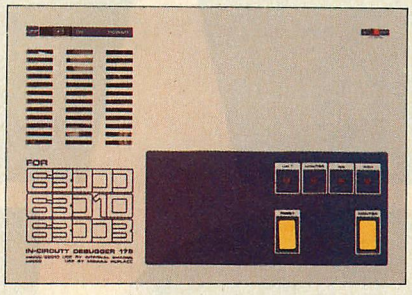
- i8087
- i8088



68000

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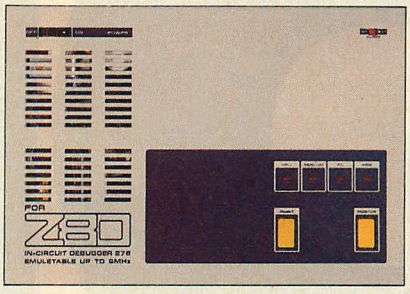
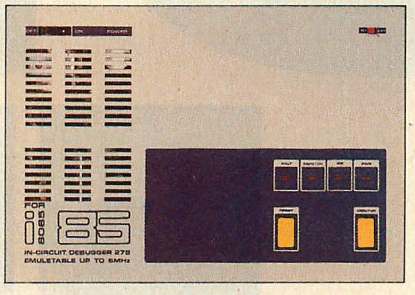


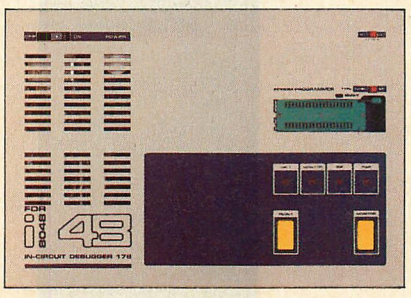
Z80

- Z80
- Z80B
- Z80H



i8085

- i8085A
- i8085A-1
- i8085A-2



i8048

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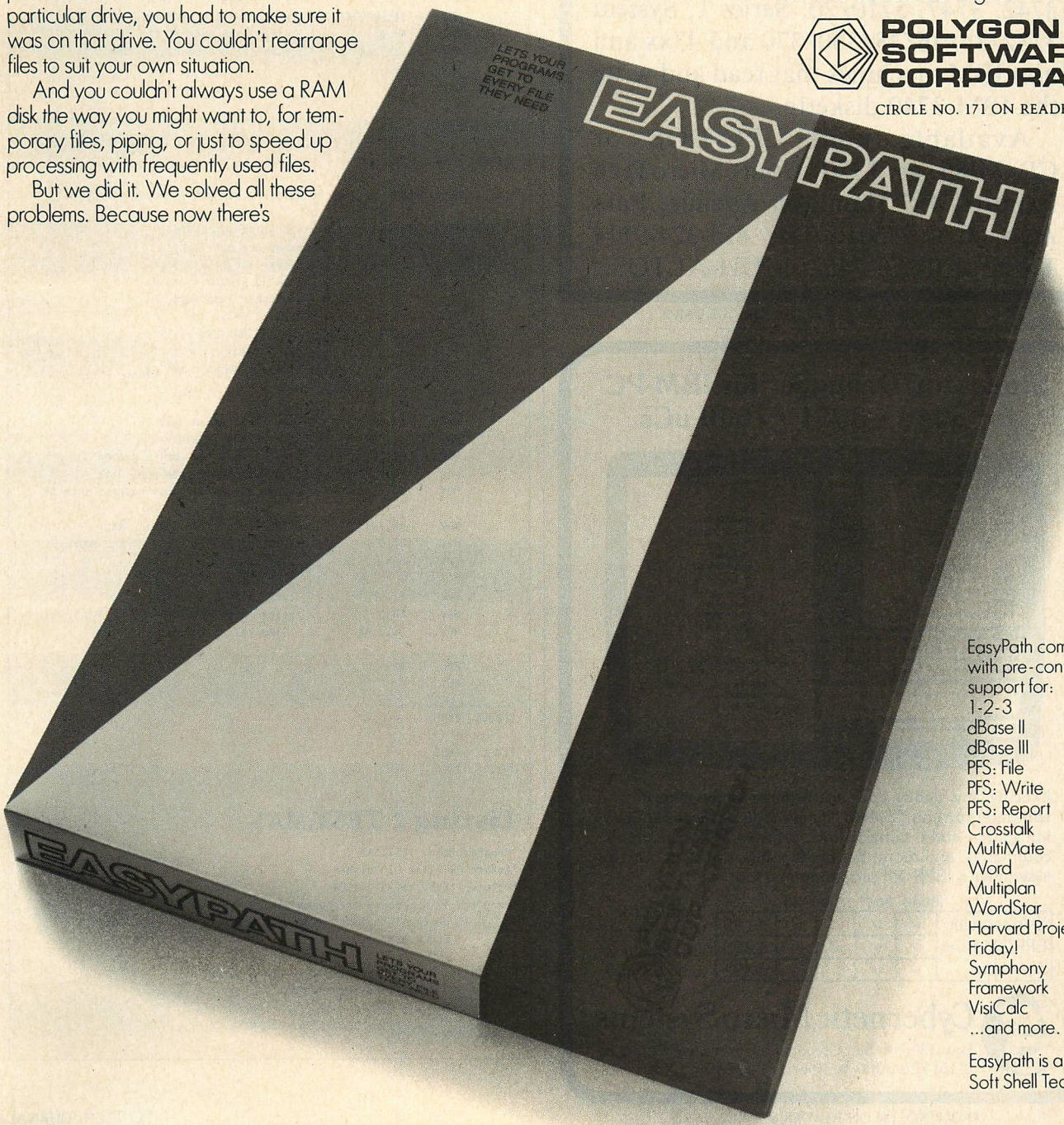

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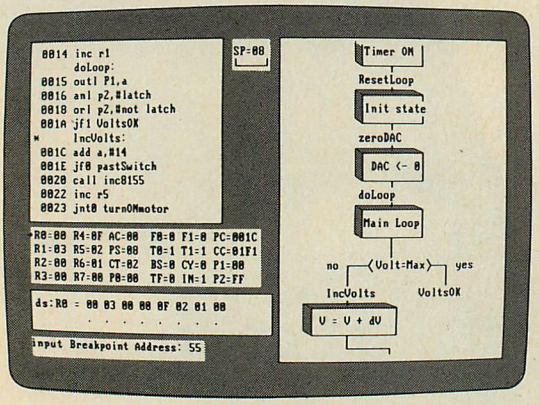

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```
;                       1 - time out
;                       2 - server not responding
;                       3 - invalid semaphore name
;                       4 - semaphore list full
;                       5 - invalid drive_id
;                       6 - invalid net address
;                       7 - not logged in
;                       8 - write to network failed
;                       9 - semaphore already locked by caller

        PUSH    BP              ;save BP
        MOV     BP,SP           ;point to param list
        MOV     SI,[BP]+12      ;Get drive_id address
        MOV     AX,[SI]         ;retrieve actual drive number
        MOV     BX,[BP]+10      ;Get pointer to sem_name data
        MOV     BX,2[BX]        ;Skip length and move address into BX
        MOV     SI,[BP]+8       ;get time_out address
        MOV     DX,[SI]         ;get time_out value

        MOV     AH,11h          ;LOCK/WAIT function code in AH
        MOV     SI,0            ;Use drive_id instead of net address
        INT     60h             ;do it!

        MOV     SI,[BP]+6       ;get address of error_cd
        MOV     AH,0            ;clear high byte of AX
        MOV     [SI],AX         ;Give caller the return code
        POP     BP
        RET     8

WAITLOCK ENDP

UNLOCK  PROC    FAR

;Entry point UNLOCK is used to unlock a currently locked semaphore
;
;Error codes returned are: 0 - operation successful
;                          1 - semaphore not locked
;                          2 - server not responding
;                          3 - invalid semaphore name
;                          4 - semaphore list full
;                          5 - invalid drive_id
;                          6 - invalid net address
;                          7 - not logged in
;                          8 - write to network failed

        PUSH    BP              ;Save BP
        MOV     BP,SP           ;point to param list
        MOV     SI,[BP]+10      ;Get drive_id address
        MOV     AX,[SI]         ;retrieve actual drive number
        MOV     BX,[BP]+8       ;Get pointer to sem_name data
        MOV     BX,2[BX]        ;Skip length and move address into BX

        MOV     AH,13h          ;UNLOCK function code in AH
        MOV     SI,0            ;Use drive_id instead of net address
        INT     60h             ;do it!

        MOV     SI,[BP]+6       ;get address of error_cd
        MOV     AH,0            ;clear high byte of AX
        MOV     [SI],AX         ;Give caller the return code

        POP     BP
        RET     6

UNLOCK  ENDP

ELOCK   ENDS
        END
```

Listing 2 TEST.BAS

```
'Program Name: TEST.BAS
'Author: William L. Colsher
'Date Written: May 21, 1984
'Purpose: This program exercises the 3Com/EtherNet Semaphore
'         protocol implemented in the Assembly language program
'         ELOCK.ASM
'
'Variables: DR% - EtherShare disk drive number
'          SEM$ - Semaphore name
'          RC% - Return code from EtherShare
'          TI% - Time Out value for WAITLOCK
'
```

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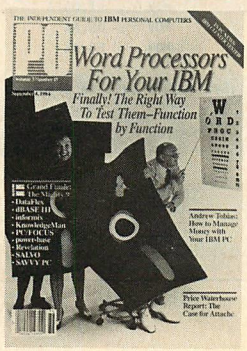

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```
DR%=5

'First Test - Attempt to lock a simple semaphore

SEM$="TESTSEMAPHORE0001"+CHR$(0)
CALL LOCK(DR%,SEM$,RC%)
PRINT "Return code from simple LOCK is: ";RC%
GOSUB 5000

'Second Test - Unlock the Semaphore just locked

CALL UNLOCK(DR%,SEM$,RC%)
PRINT "Return code from UNLOCK is: ";RC%
GOSUB 5000

'Third Test - Try to force some errors.  First standalone error
'            is #3 - Invalid semaphore name.

SEM$="THIS IS AN INVALID SEMAPHORE NAME"+CHR$(0)
CALL LOCK(DR%,SEM$,RC%)
PRINT "Return code from attempted invalid semaphore name is:";RC%
GOSUB 5000

'Fourth Test - Try for a semaphore list full error: #4.  We have to
'             LOCK 51 semaphores to do it.

FOR I=1 TO 50
        SEM$="SEMAPHORE"+STR$(I)+CHR$(0)
        CALL LOCK(DR%,SEM$,RC%)
        NEXT I

SEM$="THE LAST SEMAPHORE"+CHR$(0)
CALL LOCK(DR%,SEM$,RC%)
PRINT "Return code from 51st LOCK is:";RC%
GOSUB 5000

'Clean up the mess

FOR I=1 TO 50
        SEM$="SEMAPHORE"+STR$(I)+CHR$(0)
        CALL UNLOCK(DR%,SEM$,RC%)
        NEXT I

'Fifth Test - Invalid drive ID is return code 5.

SEM$="TEST SEMAPHORE"+CHR$(0)
DR%=1

CALL LOCK(DR%,SEM$,RC%)
PRINT "Return code from LOCK with Drive ID=0 is: ";RC%
GOSUB 5000

'Sixth Test - The last stand alone error is #9, Semaphore
'             Already Locked by this PC.

DR%=5

CALL LOCK(DR%,SEM$,RC%)
CALL LOCK(DR%,SEM$,RC%)
PRINT "Return code from duplicate LOCK is: ";RC%
GOSUB 5000

CALL UNLOCK(DR%,SEM$,RC%)

STOP

5000 'This routine displays error messages
5010 ON RC%+1 GOSUB 5100,5200,5300,5400,5500,5600,5700,5800,5900,6000
5020 RETURN
5100 PRINT"Operation successful":RETURN
5200 PRINT"Semaphore currently locked":RETURN
5300 PRINT"Server not responding":RETURN
5400 PRINT"Invalid semaphore name":RETURN
5500 PRINT"Semaphore list full":RETURN
5600 PRINT"Invalid drive id":RETURN
5700 PRINT"Invalid Ethernet address":RETURN
5800 PRINT"Not logged in":RETURN
5900 PRINT"Write to network failed":RETURN
6000 PRINT"Semaphore already locked by this PC":RETURN

END
```

Listing 3 COTEST.BAS

```
'Program Name: COTEST.BAS
'Author: William L. Colsher
'Date Written: May 21, 1984
'Purpose: This program exercises the 3Com/EtherNet Semaphore
'         protocol implemented in the Assembly language program
'         ELOCK.ASM
'
'Variables: DR% - EtherShare disk drive number
'           SEM$ - Semaphore name
'           RC% - Return code from EtherShare
'

DR%=5
SEM$="COTESTSEMAPHORE"+chr$(0)
Z$=""

WHILE Z$<>"END"
        RC%=1

        WHILE RC%<>0
                PRINT"Attempting to lock semaphore ";SEM$
                CALL LOCK(DR%,SEM$,RC%)
                WEND

        'Now that it's locked, tell the operator to unlock it

        PRINT
        PRINT"Semaphore has been locked, press ENTER to unlock it"
        INPUT Z$
        CALL UNLOCK(DR%,SEM$,RC%)
        PRINT"Semaphore is now unlocked, Press ENTER to attempt to lock
              again"
        INPUT Z$
        WEND

END
```

Listing 4 ALLOCATE.ASM

```
;Program Name: ALLOCATE.ASM
;Author: William L. Colsher
;Date Written: May 19, 1984
;Purpose: This program creates a file and writes 5K nulls to it.

STACK   SEGMENT PARA STACK 'STACK'
        DB      64 DUP('STACK   ')
STACK   ENDS

DATA    SEGMENT PARA PUBLIC 'DATA'

FNAME   DB      'PREALLOC.DAT',0
HANDLE  DW      0
NULLS   DB      256 DUP(0)
EOFMARK DB      1AH
DATA    ENDS

CODE    SEGMENT PARA PUBLIC 'CODE'
ALLOCATE PROC   FAR
        ASSUME  CS:CODE,DS:DATA,SS:STACK,ES:DATA

;Establish DOS return and data addressability

        PUSH    DS
        SUB     AX,AX
        PUSH    AX
        MOV     AX,DATA
        MOV     DS,AX
        MOV     ES,AX

;Set up DOS call to create a new file

        MOV     AH,3CH          ;Create file
        MOV     DX,OFFSET FNAME
        MOV     CX,0            ;Attribute
        INT     21H             ;Do it!

        MOV     HANDLE,AX
```

```
;Now we'll write 5k of nulls to the file

        MOV     CX,20           ;Repeat count

MORE:   PUSH    CX              ;Save it
        MOV     BX,HANDLE       ;File pointer
        MOV     DX,OFFSET NULLS
        MOV     CX,256          ;How namy
        MOV     AH,40H          ;Function 'Write'
        INT     21H

        POP     CX              ;Get back count
        LOOP    MORE

;Now we'll close the file

        MOV     BX,HANDLE
        MOV     AH,3EH
        INT     21H

;And return to DOS

        RET
ALLOCATE ENDP
CODE    ENDS
        END     ALLOCATE
```

Listing 5 TESTPREA.BAS

```
10 'PROGRAM NAME: TESTPREA.BAS
20 'AUTHOR: William L. Colsher
30 'DATE WRITTEN: June 7, 1984
50 'PURPOSE: This program demonstrates the use of a pre-allocated file
60 '         in BASIC.  Notice that after running this program, the
70 '         file PREALLOC.DAT will have the same length as it did to
80 '         begin with.
90 '
100 OPEN "R",#1,"PREALLOC.DAT",20
110 FIELD 1,10 AS A$,10 AS B$
120 FOR I=1 TO 10
130 LSET A$="RECORD"+STR$(I)
140 LSET B$="TEST TEST!"
150 PUT 1,I
160 NEXT I
170 CLOSE
180 END
```


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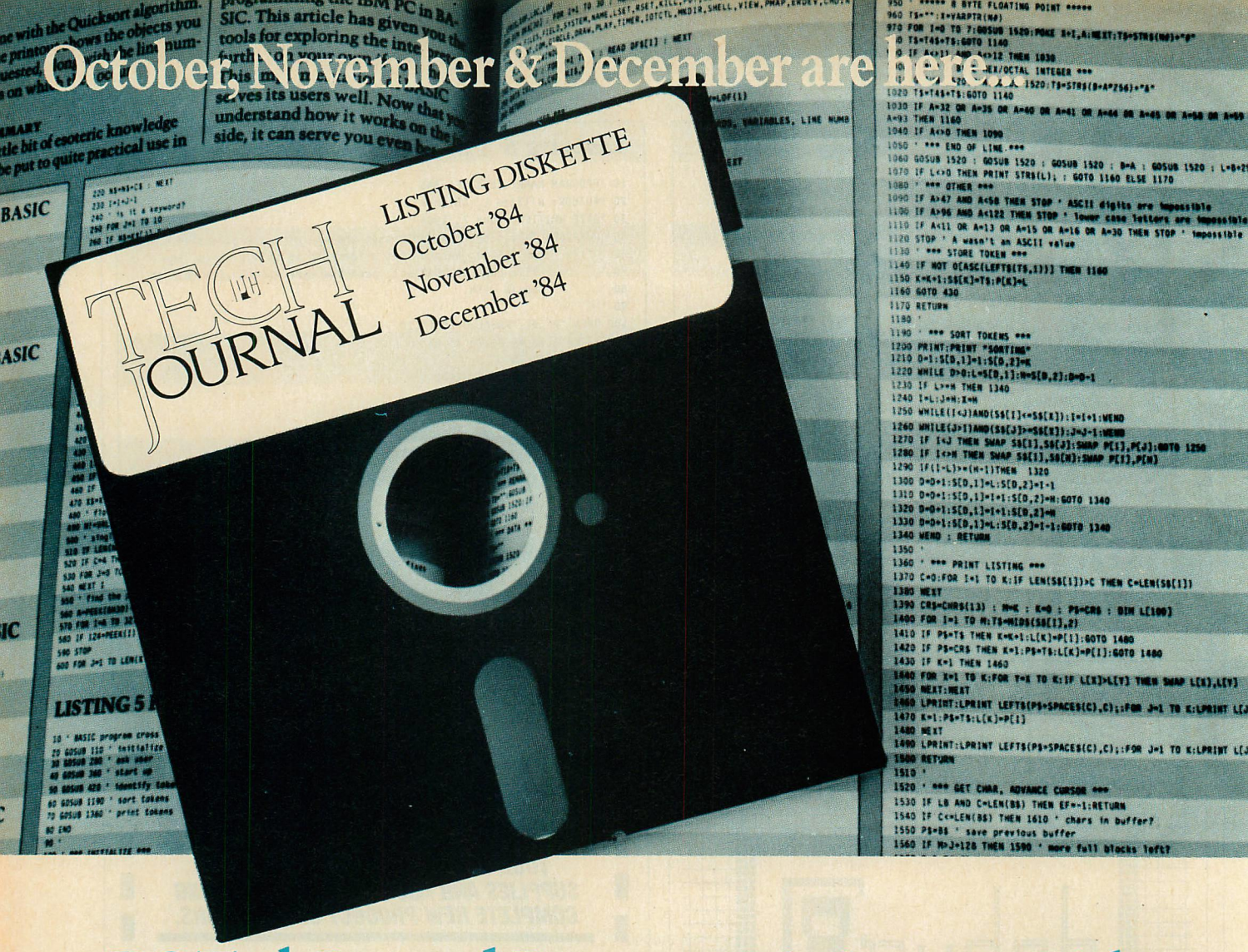

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FIELDS, ITEMS, & SYSTEMS

Details about INFORM may be useful in setting up other data-base management systems.

ELIEZER NADDOR

About 15 years ago, I designed and implemented my first information storage and retrieval system for a small business. Since then the system, called INFORM, has been expanded and generalized. It is composed of numerous programs that chain to one another. INFORM is used in many diverse applications, most of which are related to medical databases.

The package of programs is written in BASIC and has been implemented on several mini- and microcomputers, including the IBM PC. A recent adaptation of INFORM to the PC has been one by Scientific-Atlanta in its System Manager I for the cable television industry.

FROM CHARACTERS TO SUPER-SYSTEMS

The fundamental unit of information in INFORM is the character. The package uses all 256 ASCII characters now available on most computers. Some of the following details may have to be modified for computers that allow access to a different number of characters.

Characters are defined in the following ways:

Alphabetic (52)—the upper-case letters *A* through *Z* (ASCII values 65 through 90) and the lower-case letters *a* through *z* (ASCII values

Eliezer Naddor is a professor of mathematical sciences at The Johns Hopkins University.

97 through 122)

Numeric (10)—the digits 0 to 9 (ASCII values 48 through 57)

Special (33)—the space (ASCII value 32), ASCII values 33 to 47, ASCII values 58 to 64, ASCII values 91 to 96, and ASCII values 123 to 126.

Other (161)—the nonprintable characters (ASCII values 0 through 31 and 127 through 255).

A group of one or more consecutive characters is called a *word*. For example, "1789" is a word of four numeric characters, and "WASHINGTON GEORGE" is a word of 17 characters of which 16 are uppercase alphabetic and one is a special character (space). A database system stores and retrieves words.

Words are placed in *fields*. In INFORM a specific field always has a fixed number of characters, and this number is referred to as the *length* of the field. This length is established when the database is started. If "WASHINGTON GEORGE" is placed in a field, that field's length must be at least 17. If "ADAMS JOHN" is placed in the same field, then INFORM would add spaces to this word so that its length would be identical to the length already established for that particular field.

INFORM recognizes several other characteristics of a field in addition to length, including *head* and *type*. The head of a field is its title or name. For example, the head of the field in which "WASHINGTON GEORGE" and "ADAMS JOHN" are placed might be PRESIDENT, and the head of the field for "1789" might be INAUGURATED.

The type of a field is used by INFORM to check words submitted by the user, to store and retrieve the words, and to display them.

An *item of information* is a collection of related words. Table 1 shows three items from a sample database. Each one of these items has nine fields with the characteristics as shown in table 2.

Table 1: Items in a Sample Database

01	WASHINGTON GEORGE	FED	VA	1732/02/22	1789 57	1799/12/14
02	ADAMS JOHN	FED	MA	1735/10/30	1797 61	1826/07/04
03	JEFFERSON THOMAS	DEM-REP	VA	1743/04/13	1801 57	1826/07/04

Table 2: Items and Fields in a Sample Database

Field No.	Length	Type	Head
1	2	COD	No.
2	17	ALP	President
3	7	D01	Politics
4	2	D02	State
5	10	DAT	Born
6	4	NUM	Inaugurated
7	2	SUB	Age at inauguration
8	10	DAT	Died
9	2	YBD	Age at death

Table 3: Items in an Inverted System

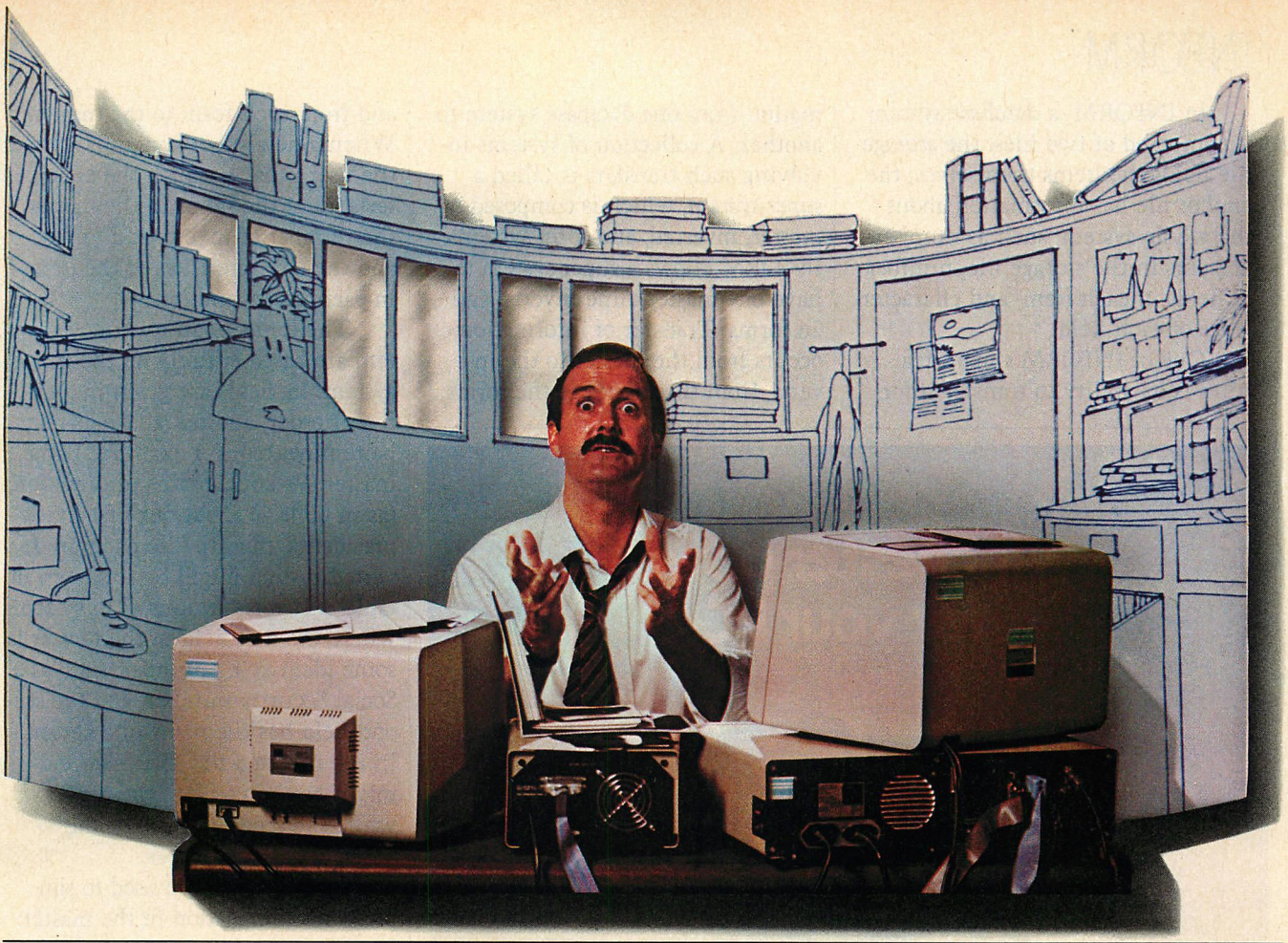
ADAMS JOHN	02	1797
JEFFERSON THOMAS	03	1801
MADISON JAMES	04	1809
MONROE JAMES	05	1817
WASHINGTON GEORGE	01	1789

Table 4: Items and Fields in a Sample Form System

Field No.	Length	Type	Head
1	2	COD	No.
2	17	ALP	President
3	4	D01	Relation
4	15	ALP	Name
5	4	DAT	Born
6	4	DAT	Died
7	45	TEX	Notes

Table 5: Items in a Form System

01	WASHINGTON GEORGE	WIFE	MARTHA CUSTIS	1732 1802 Married 1759
02	ADAMS JOHN	WIFE	ABIGAIL SMITH	1744 1818 Married 1764
02	ADAMS JOHN	DAUG	ABIGAIL ADAMS	1765 1813 M. Col. Smith
02	ADAMS JOHN	SON	JOHN Q. ADAMS	1767 1848 6th President
02	ADAMS JOHN	DAUG	SUSANNA ADAMS	1768 1770
02	ADAMS JOHN	SON	CHARLES ADAMS	1770 1800 Lawyer
02	ADAMS JOHN	SON	THOMAS ADAMS	1772 1832 State Judge
03	JEFFERSON THOMAS	WIFE	MARTHA SKELTON	1748 1782 Married 1772



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In INFORM, a *database system* is composed of two files: the *storage* file holds the items themselves; the *anchor* file has information about the whole system, such as number of items in the storage file, number of fields in each item, and characteristics of each field.

One of INFORM's main features is its ability to transfer information from one database system to another. A collection of systems involving such transfers is called a *super-system*, which is composed of *master*, *inverted*, and *form* systems. INFORM allows a super-system to have one master, nine inverts, and 26 forms. Transfer of information occurs from the master to the inverts, from the master to the forms, and from each form to the master. When a new super-system is started, the user must establish the characteristics of the items in the master, the number of inverts and forms, and the characteristics of the items in each invert and form.

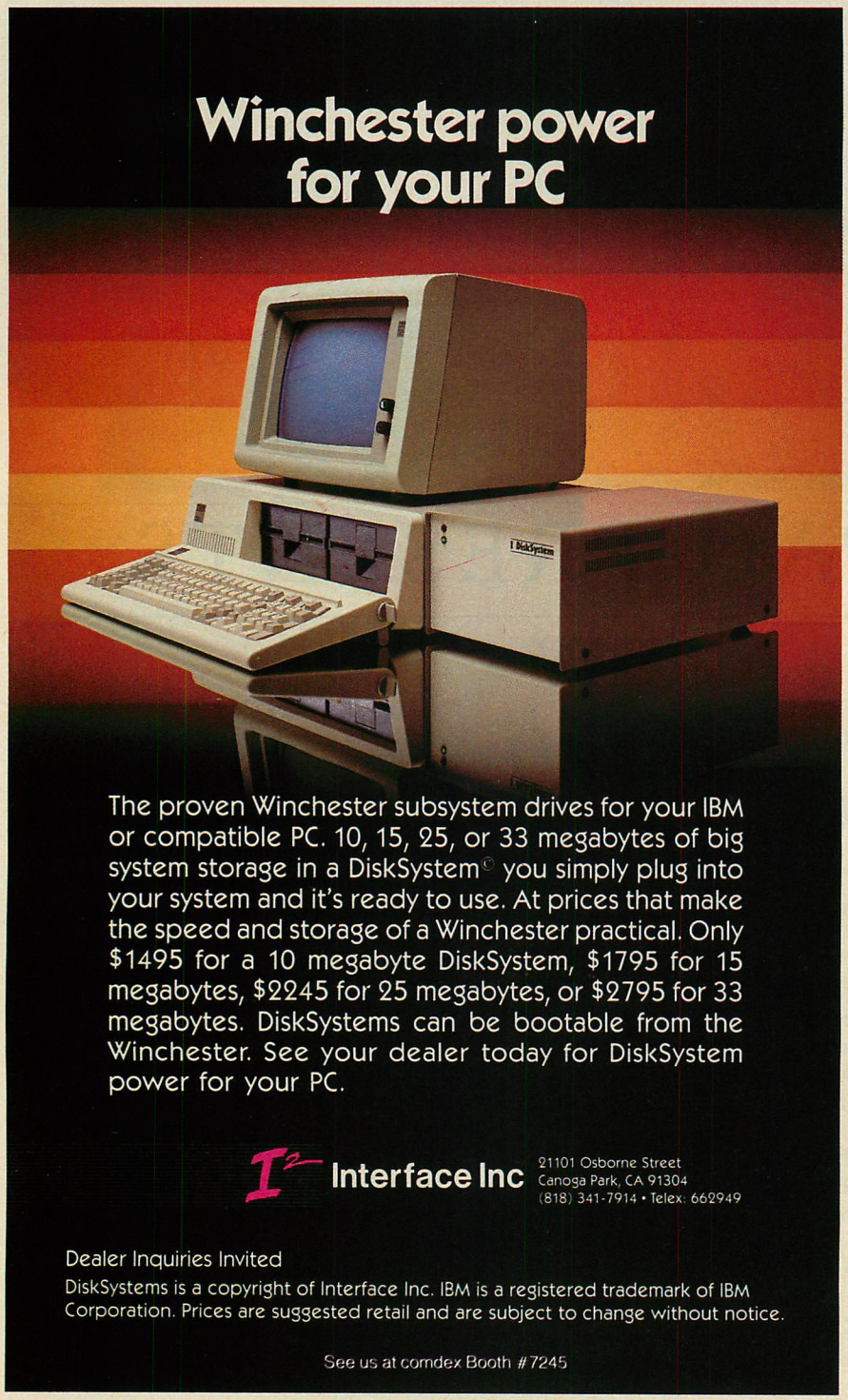
The items in an inverted system are based entirely on the master system. Its fields are given in a different order, and not all fields may be represented. For example, if the master system contains information (as in table 1) about our first five presidents, then the items in an inverted system might be as shown in table 3. Inverts are useful in systems where the first field in the master is some identifying number, such as a Social Security number, and the second field has the name of a person. In the inverted file, the first field might be the name of the person while the second would be the Social Security number.

Form systems are used to supplement information in the master. For example, the master may contain one item for each president, and one of its forms may contain a variable number of items for each president. Table 4 is an example of possible fields in a form on people who are related to presidents. Eight items from this form system are shown in table 5. Note that six of the items in the table pertain to President John Adams.

Other forms in a presidential super-system might include cabinet members, major legislation, and special events. When such forms are used, the master may be extended to include fields for summary information transferred from the forms. For a presidential super-system the master may include a field with the number of the president's relatives and a field with the date of the last listed special event.

Types of Fields in INFORM

When a new system is designed for use with INFORM, each field is assigned a specific type. This type in-



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dicates what characters INFORM should expect when accepting words, how it stores them in the storage file, how it retrieves them, and how it displays them to the user. The main reasons for assigning types to fields are for checking data entries and for conserving space.

Table 6 summarizes 30 common field types used in INFORM. With each type is its three-character head as it is actually used by INFORM. Also included in the table is a brief description of the field and two examples of its possible content. For a complete definition of a field, INFORM needs the field's head, type, length, and a requirement code. Requirement codes will not be discussed in this article.

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STANDARD FIELDS

In fields of length 8, INFORM accepts and displays dates in the form YY/MM/DD, where YY are numbers from 1 to 99, MM from 1 to 12, and DD from 1 to 31. It also accepts and displays the date 00/00/00. Anticipating the next century, INFORM uses a letter to represent one decade, followed by a digit. Thus, A0 to A9 represent the years 2000 to 2009, B0 to B9 represent 2010 to 2019, and so on up to June 4, 2080 (I0/06/04). The total number of days for these dates is 65,536, which equals 256 squared. It is therefore possible to store each date from January 1, 1901, to June 4, 2080, by using only two characters. In fields of length 10 the date format is ZZYY/MM/DD. The YY/MM/DD portion can be stored in two characters and the ZZ portion in one.

Text fields accept any of the 95 printable characters. These characters are stored and retrieved without any modifications.

INFORM considers 40 alphanumeric characters comprised of the 26 upper-case alphabetic characters, the 10 numeric characters, and the four special characters: space ( ), dash (-), comma (,), and period (.). Note that 40 cubed is 64,000. Hence, every three alphanumeric characters can be stored as two ASCII characters.

Code fields contain numbers from 0 to 255. Each of these can be stored as one ASCII character.

Any number of numeric characters, optionally preceded by the minus character, can be contained in a number field. Every two characters of the field (including the minus sign, if any) are converted to a single ASCII character and then stored. In this way a four-digit word is stored as two characters and a seven-digit word as four characters.

Fields containing numbers with decimal points are of the total type. The choice of the word *total* is related to the command TOTAL, which tells INFORM to compute to-

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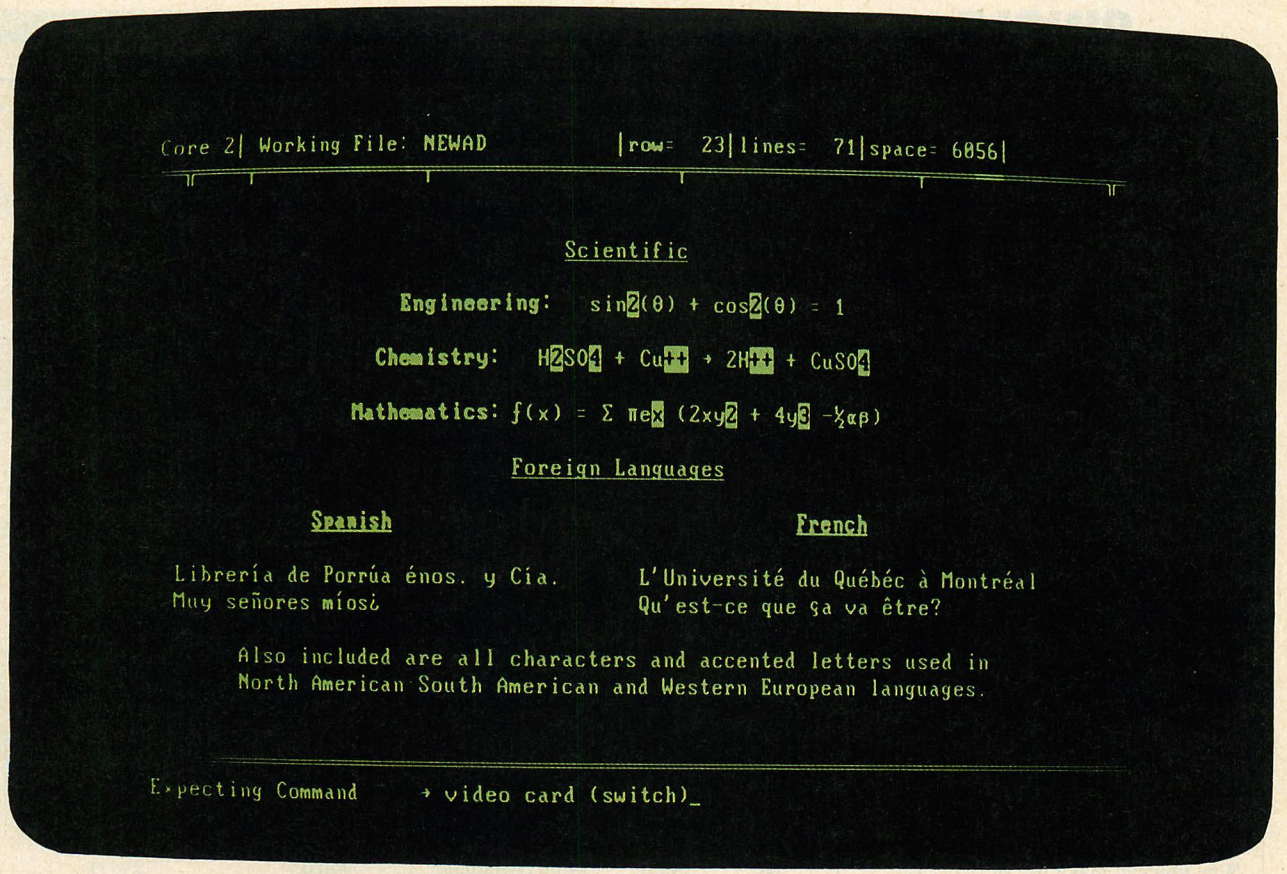

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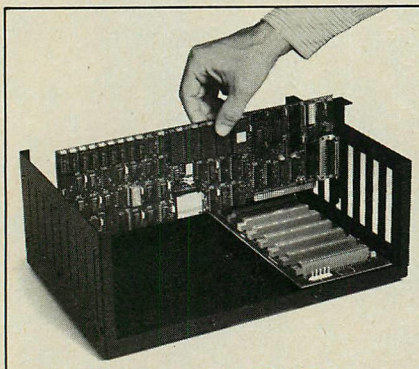

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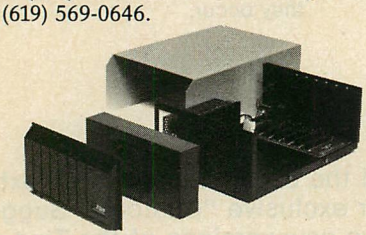

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Table 6: INFORM's Common Field Types

Standard Fields

No.	Type	Description	Example 1	Example 2
1	DAT	Date	83/06/18	1732/02/22
2	TEX	Text (of any form)	(301) 338-7216	$$1,200.###
3	ALP	Alphanumeric	JOHN DOE 3RD	-32,768
4	COD	Code	0	255
5	NUM	Number	0123	12345678
6	TOT	Total	15.99	1234.123
7	HIS	History number	0-2270566	9-1849541
8	MED	Medicaid Number	12-123456-123	30-123456-830
9	SSN	Social Security number	123-12-1234	123-56-8901
10	PHO	Phone	555-1212	301-576-0770

Dictionary Fields

No.	Type	Description	Example 1	Example 2
11	D01	First dictionary	WIFE	SON
12	D02	Second dictionary	FED	DEM-REP
—				
20	D10	Tenth dictionary	MA	VA

Arithmetic Fields

No.	Type	Description	Example 1	Example 2
21	ADD	Addition	156.73	300.00
22	SUB	Subtraction	57	61
23	MUL	Multiplication	125.00	750.75
24	DIV	Division	5.6	3.8
25	MAX	Maximum	102	105
26	MIN	Minimum	12	-8
27	DBD	Days between dates	382	-72
28	MBD	Months beetween dates	37	6
29	YBD	Years between dates	61	90
30	MOx	Multi-operations	120.0	456.78

Table 7: Converting Dates to Integers

Dates From	Dates To	Integers From	Integers To
01/01/01	90/09/17	1	32767
90/09/18	99/12/31	-32768	-29377
A0/01/01	I0/06/04	-29376	-1
00/00/00		0	

tals of all the numbers in the fields whose type is total. Every two numerals in the field are stored in a single character. The decimal point is not stored, of course. INFORM knows where to place the decimal point by inspecting the length of the field. If the length of a field is, say, 7.2, then INFORM accepts and displays numbers in the format ####.##.

History, Medicaid, SSN, and phone fields contain words with the formats #-#######, ##-######-###, ###-##-####, and ###-#### (or ###-###-####), and are stored internally in four, six, five, and four ASCII characters, respectively.

Dictionary Fields

A field whose type is dictionary can contain only specific words that are designated when a new system is started or modified. For example, a field for the name of a state will have a length of 2 and can contain only the words AL, AK, . . . WY. INFORM puts these words in the string " AL AK . . . WY". Because a space precedes each word in the dictionary string, three characters must

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be allocated to each entry. If the Canal Zone (CZ) and the District of Columbia (DC) are appended to the 50 states, then the length of the string containing all the dictionary words is 52 × 3 = 156.

INFORM stores only a single ASCII character for a dictionary word, which points to the location of the word in the dictionary string. For example, assume that the dictionary field of length 8 with the head RELATIVE has the words FATHER, MOTHER, WIFE, HUSBAND, SON, and DAUGHTER. INFORM stores the words in a string of 54 (= 6 × 9) characters. When the user enters the word, say, MOTHER (or even M), INFORM ascertains that this word is the second dictionary word and stores the ASCII character 2 (STX). When retrieving information, that STX character causes INFORM to print the second dictionary word: MOTHER. The use of dictionary words reduces the amount of typing necessary when entering information, decreases errors, greatly reduces the amount of storage, and also cuts the time needed to retrieve information and to prepare reports.

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Arithmetic Fields

The content of an arithmetic field depends on computations involving other fields. In addition to its type, the characteristics of an arithmetic field must include information about these other fields (this is done by using the requirement code). For example, a field type SUB based on fields 6 and 5 will contain the difference between the numbers in fields 6 and 5. Similarly, a field type YBD based on fields 8 and 5 will contain the number of years between the dates in the fields 8 and 5. The computations are done by INFORM whenever data are entered for those other fields. The results are then stored in the appropriate arithmetic fields.

Other Fields

The types of fields listed above are by no means exhaustive. For example, in one of INFORM's packages is a field of the type TIM and the format DDD:HH:MM, where DDD stands for days, HH for hours, and MM for minutes. This type, as well as the types for history, Medicaid, Social Security, and phone numbers, can be generalized and expressed in a single PRINT USING format. For type TIM this format would be ###:##:##.

Methods of Packing and Unpacking

The term *packing* is customarily used to indicate the conversion of a word of a given length to an equivalent word of a shorter length. For

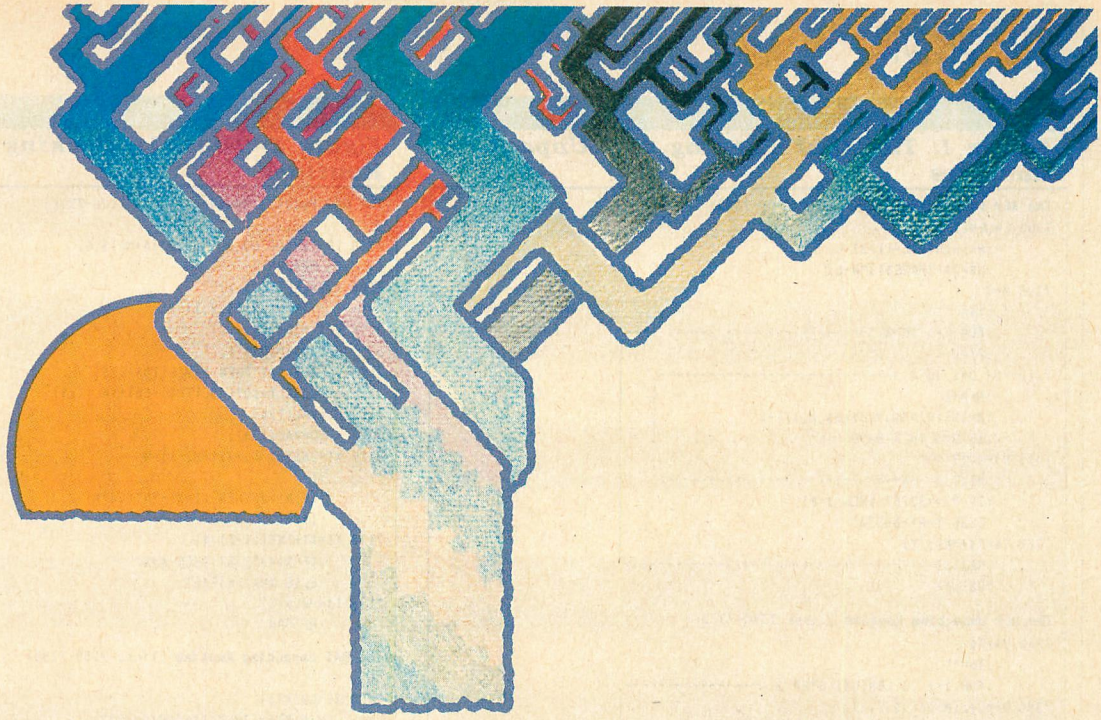

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Figure 1: The DAT Packing and Unpacking Routines

```
The ALP Packing Routine (lines 7300-7320)
7300 L=LEN(T$)
       :N=1+INT((L-1)/3)
       :U$=T$+SPACE$(3*N-L)
7305 M=0
       :T$=""
       :FOR I=1 TO N <-----------------------------.
       :P!=0                                       |
7310 FOR J=1 TO 3 <-----------------------------.  |
       :M=M+1                                    |  |
       :D=INSTR(A0$,MID$(U$,M,1))-1              |  |
       :IF D<0 THEN D=39                         |  |
7315 P!=40*P!+D                                  |  |
       :NEXT J ----------------------------------'  |
       :IF P!<=32767 THEN Y=P!                     |
        ELSE Y=P!-65536!                           |
7320 T$=T$+MKI$(Y)                                 |
       :NEXT I ------------------------------------'
       :RETURN

The ALP Unpacking Routine (lines 7350-7370)
7350 U$=T$
       :T$=""
       :FOR I=1 TO LEN(U$) STEP 2 <----------------.
7355 P!=CVI(MID$(U$,I,2))                          |
       :IF P!<0 THEN P!=P!+65536!                  |
7360 L=INT(P!/1600)                                |
       :P!=P!-1600*L                               |
       :M=INT(P!/40)                               |
       :N=P!-40*M                                  |
7365 T$=T$+MID$(A0$,L+1,1)+MID$(A0$,M+1,1)+MID$(A0$,N+1,1)
7370 NEXT I ----------------------------------------'
       :RETURN
```

Editor's note: Professor Naddor annotates printed copies of his programs with arrows to enhance the readability of their logic. The arrows are self-evident in the listings and should not be entered when the program is typed. These arrows will not be present on the listing diskette available from PC Tech Journal *(see the ad on page 116)*.

Figure 2: The ALP Packing and Unpacking Routines

```
The DAT Packing Routine (lines 7100-7135)

7100 IF T$="00/00/00" THEN T$=MKI$(0)
       :RETURN
7105 T0$=LEFT$(T$,1)
       :T1$=MID$(T$,2,1)
7110 T2$=MID$(T$,4,2)
       :T3$=MID$(T$,7)
7115 IF T0$<"A" THEN Y=VAL(T0$+T1$)
       ELSE Y=10*(ASC(T0$)-55)+VAL(T1$)
7120 M!=VAL(T2$)
       :D=VAL(T3$)
7125 X!=365*(Y-1)+31*(M!-1)+D
       :I=Y
       :IF M!>2 THEN X!=X!-INT(.4*M!+2.3)
       :I=Y+1
7130 X!=X!+INT((I-1)/4)
       :IF X!<=32767 THEN X=X!
       ELSE X=X!-65536!
7135 T$=MKI$(X)
       :RETURN

The DAT Unpacking Routine (lines 7150-7185)

7150 X!=CVI(T$)
       :IF X!=0 THEN T$="00/00/00"
       :RETURN
7155 IF X!<0 THEN X!=65536!+X!
7160 Y=1+INT((X!-.01)/365.25)
7165 K=X!-INT(365.25*(Y-1))
       :L=-1*(Y=4*INT(Y/4))
7170 I=K-(K>(59+L))*(2-L)+91
       :M=INT(I/30.55)-2
7175 D=I-INT(30.55*(M+2))
       :T$=FNN$(Y,2)+"/"+FNN$(M,2)+"/"+FNN$(D,2)
7180 IF Y>=100 THEN T$=CHR$(55+INT(Y/10))+MID$(T$,2)
7185 RETURN
```


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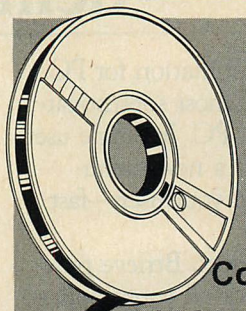

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example, the PC's BASIC functions MKI$, MKS$, and MKD$ do such packing. Any integer between -32,768 and 32,767 is converted by MKI$ to a two-character string. The term *unpacking* is used to indicate an operation that converts a packed word to its original form. For example, the function CVI converts a two-character string to an integer between -32,768 and 32,767.

The coding for packing a date of the form YY/MM/DD is given in lines 7100-7135 of figure 1. (The coding is in Microsoft's BASIC. It can easily be changed to other versions of BASIC. The packing routine is based in part on an algorithm that was available in LEASCO's time-sharing system.) This code assumes that the date is in the string T$ and is a legal date—namely: 01/01/01 to 99/12/31, A0/01/01 to I0/06/04, and 00/00/00.

The scheme in table 7 is used for converting dates to integers. A careful review of the coding should

Figure 3: Testing the DAT Packing and Unpacking Routines

```
--------------------------------------------------------------------------------

06-12-1983 19:13:52                                                        [1]

TYPE,WORD? DAT,83/02/28
           ------------
 83/02/28 to  30009  to 83/02/28
--------------------------------------------------------------------------------

06-12-1983 19:14:18                                                        [2]

TYPE,WORD? DAT,83/02/29
           ------------
 83/02/29 to  30010  to 83/03/01
--------------------------------------------------------------------------------

06-12-1983 19:14:37                                                        [3]

TYPE,WORD? DAT,83/03/01
           ------------
 83/03/01 to  30010  to 83/03/01
--------------------------------------------------------------------------------

06-12-1983 19:14:53                                                        [4]

TYPE,WORD? DAT,84/02/28
           ------------
 84/02/28 to  30374  to 84/02/28
--------------------------------------------------------------------------------

06-12-1983 19:15:15                                                        [5]

TYPE,WORD? DAT,84/02/29
           ------------
 84/02/29 to  30375  to 84/02/29
--------------------------------------------------------------------------------

06-12-1983 19:15:35                                                        [6]

TYPE,WORD? DAT,84/03/01
           ------------
 84/03/01 to  30376  to 84/03/01
--------------------------------------------------------------------------------

06-12-1983 19:15:52                                                        [7]

TYPE,WORD? DAT,90/09/17
           ------------
 90/09/17 to  32767  to 90/09/17
--------------------------------------------------------------------------------

06-12-1983 19:16:14                                                        [8]

TYPE,WORD? DAT,90/09/18
           ------------
 90/09/18 to -32768  to 90/09/18
--------------------------------------------------------------------------------

06-12-1983 19:16:32                                                        [9]

TYPE,WORD? DAT,99/12/31
           ------------
 99/12/31 to -29377  to 99/12/31
--------------------------------------------------------------------------------
```

Figure 4: Testing the DAT and ALP Packing and Unpacking Routines

```
--------------------------------------------------------------------------------

06-12-1983 19:16:50                                                       [10]

TYPE,WORD? DAT,A0/01/01
           ------------
 A0/01/01 to -29376  to A0/01/01
--------------------------------------------------------------------------------

06-12-1983 19:17:08                                                       [11]

TYPE,WORD? DAT,H9/12/31
           ------------
 H9/12/31 to -157  to H9/12/31
--------------------------------------------------------------------------------

06-12-1983 19:17:30                                                       [12]

TYPE,WORD? DAT,I0/01/01
           ------------
 I0/01/01 to -156  to I0/01/01
--------------------------------------------------------------------------------

06-12-1983 19:17:49                                                       [13]

TYPE,WORD? DAT,I0/06/04
           ------------
 I0/06/04 to -1  to I0/06/04
--------------------------------------------------------------------------------

06-12-1983 19:18:03                                                       [14]

TYPE,WORD? DAT,00/00/00
           ------------
 00/00/00 to  0  to 00/00/00
--------------------------------------------------------------------------------

06-12-1983 19:18:15                                                       [15]

TYPE,WORD? ALP,WASHINGTON GEORGE
           --------------------
 WASHINGTON GEORGE to  12  chars to WASHINGTON GEORGE
--------------------------------------------------------------------------------

06-12-1983 19:18:30                                                       [16]

TYPE,WORD? ALP,1789
           --------
 1789 to  4  chars to 1789
--------------------------------------------------------------------------------

06-12-1983 19:18:47                                                       [17]

TYPE,WORD? ALP,83/06/11
           ------------
 83/06/11 to  6  chars to 83.06.11
--------------------------------------------------------------------------------

06-12-1983 19:18:59                                                       [18]

TYPE,WORD? ALP,"COST IS -12,345.67"
           ----------------------
 COST IS -12,345.67 to  12  chars to COST IS -12,345.67
--------------------------------------------------------------------------------
```

show that leap years, for the period between January 1, 1901, to June 4, 2080, are correctly accounted for. The user could test this fact by confirming that 83/02/28 converts to 30,009; 83/03/01 to 30,010; 84/02/28 to 30,374; 84/02/29 to 30,375; and 84/03/01 to 30,376.

The coding for unpacking dates (originally written by David Naddor) is in lines 7150-7185 of figure 1. The function FNN$ in line 7175 ensures that single-digit years, months, and days become two-character strings with a leading 0.

In the ALP type of field, INFORM converts every three alphanumeric characters to a number between 0 and 63,999. The coding for packing is given in lines 7300-7390. (The broken lines showing FOR . . . NEXT loops have been added by a special program that accepts BASIC codes and displays them in the formats given in figures 1 and 2.)

In the coding shown in figure 2, L is the length of the word being packed (T$), N is the number of three-character groups in the word, and U$ is the padded word with 3 * N characters. A0$ contains the 40 alphanumeric characters

In the ALP type of field, INFORM converts every three alphanumeric characters to a number between 0 and 63,999.

"AB . . . Z01 . . . 9 −,." For every three alphanumeric characters, P! is the converted number (0 to 63,999), and Y is the corresponding integer (0 to 32,767 and -32,768 to -1537). The initial word is packed into T$ (line 7320 of figure 2).

The coding for unpacking of packed words is in lines 7350-7370. Note the use of CVI in line 7355.

Figures 3 and 4 illustrate the use of the packing and unpacking routines of figures 1 and 2. Program PUP.BAS (for packing and unpacking) expects the user to enter a TYPE and a WORD. The types shown are DAT and ALP. If DAT is specified, then PUP expects legal dates in the form YY/MM/DD. For ALP it expects words of any length. If a word for ALP contains a comma, PUP requires the word to start and end with quote marks.

Panels [1] to [14] in figures 3 and 4 illustrate the method for packing and unpacking dates. PUP accepts the date T$ (eight characters) and packs it into two characters using the code in lines 7100-7135 of figure 1. Since the ASCII representation of these two characters is not printable, PUP prints the corresponding integer (with CVI). PUP then unpacks the packed date and displays the result.

The use of ALP is shown in panels [15] to [18] of figure 4. The packed word cannot be displayed—PUP gives only the number of characters in the packed word. For example, WASHINGTON GEORGE (a 17-character word) is packed into 12 characters and then unpacked correctly (panel [15]). Panel [17] shows how the packing routine handles nonalphanumeric characters—they are converted to periods.

Other types of fields can be similarly coded and tested. For NUM, TOT, and arithmetic fields, allow for the possibility of negative numbers. In the case of dictionary words that the user enters in abbreviated form, the code must ensure that the abbreviation belongs to a unique word. Appropriate checking and messages must be coded for unacceptable data. For example, the date 83/02/29 is an illegal date (panel [2] in figure 3).

Acknowledgments: The late Michael J. O'Neill contributed to the design and coding of INFORM on a PDP-11/70. Thomas J. Pollard extended the package for use on several medical database systems. David Naddor implemented INFORM on a TRS-80 Model III computer and on an IBM PC.

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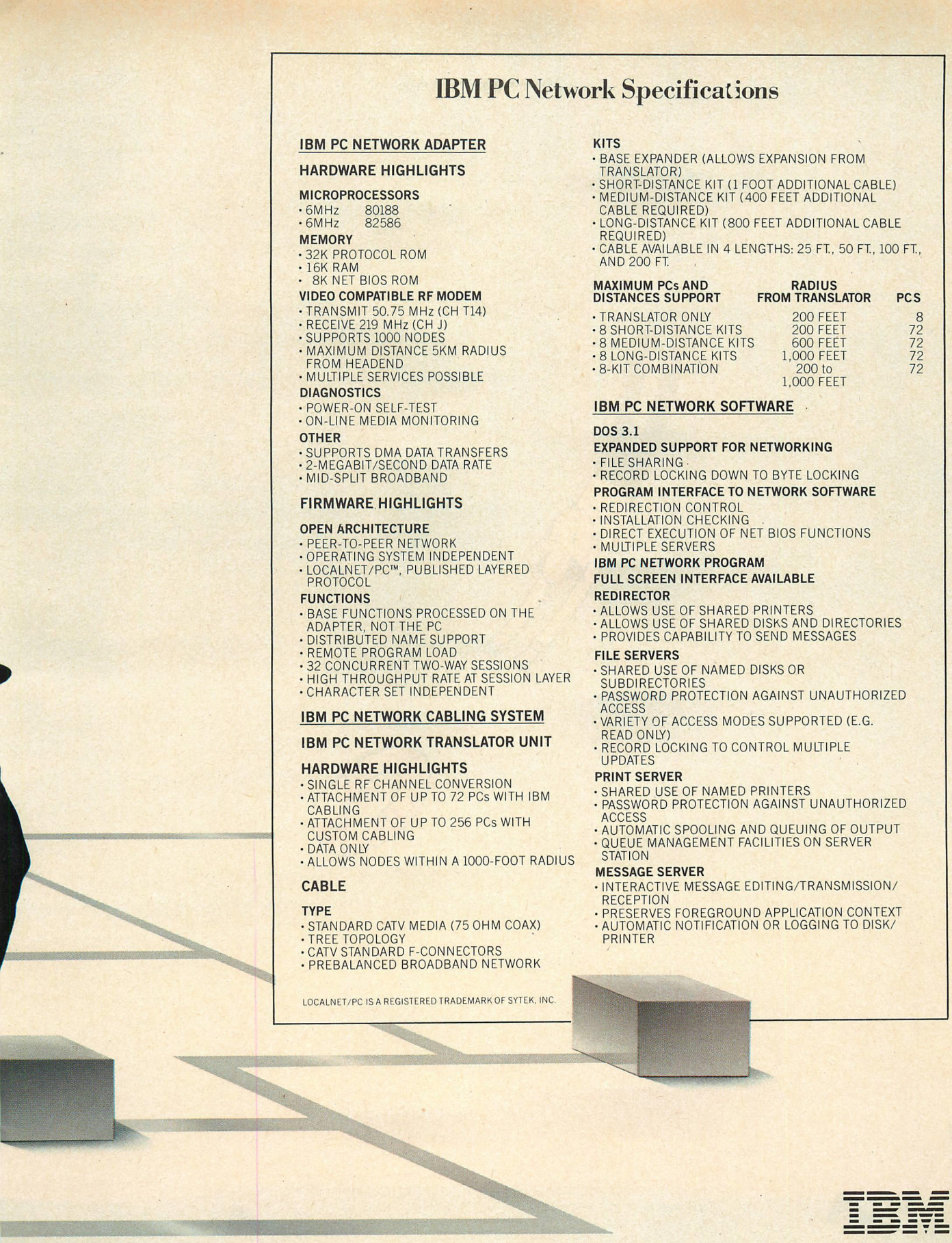

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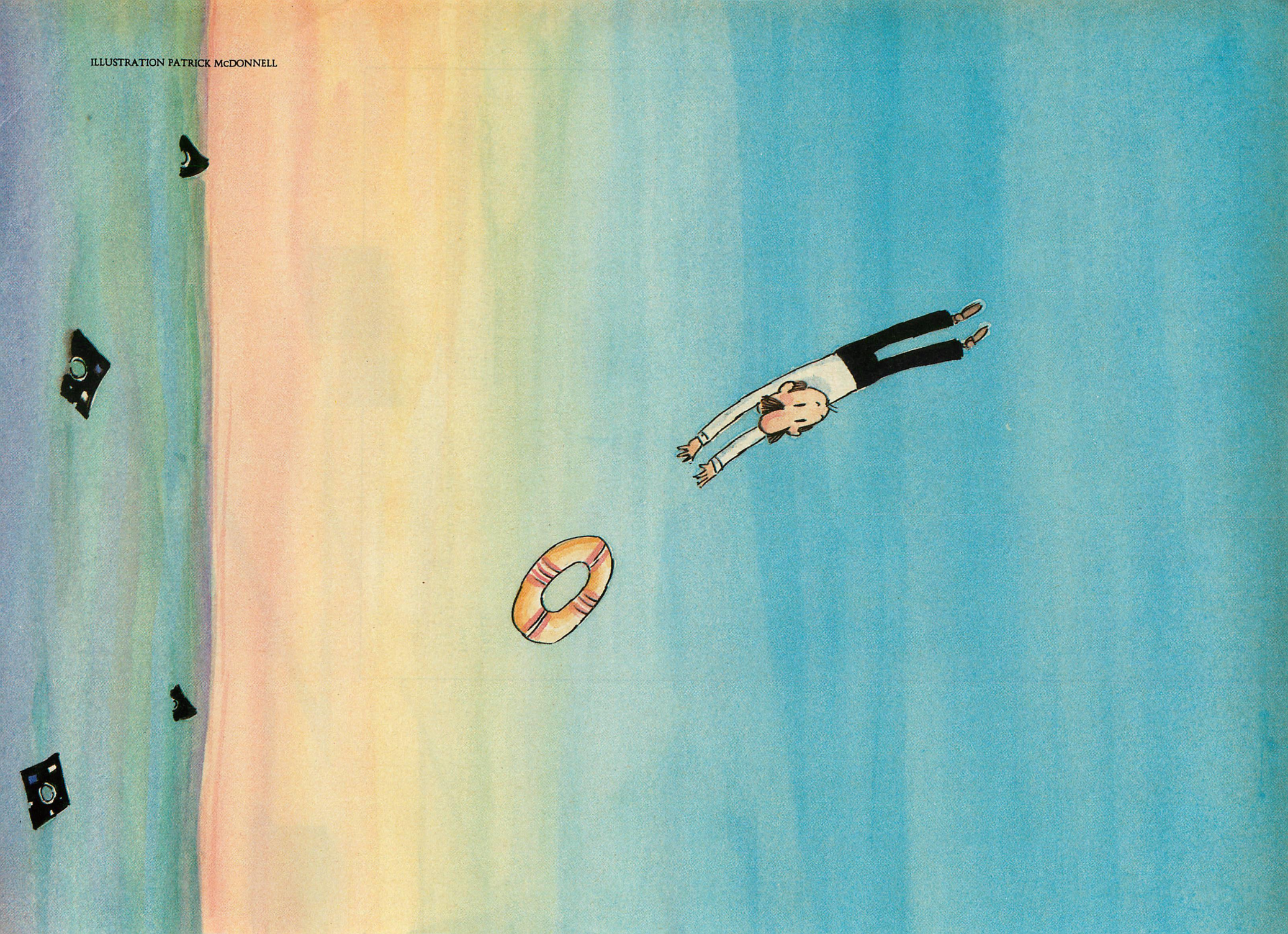


AARGH! I didn't save my program!

Here's a handy utility for recovering BASIC programs

DAN ROLLINS

Every BASIC programmer has probably experienced it at one time or another. You make a critical revision to a BASIC program, but just before you save the new code, the telephone rings, then one thing leads to another, and . . . AARGH! Or you test the program's main-menu option 9—"Exit to DOS"—only to discover afterward that you had not yet saved the program . . . AARGH!

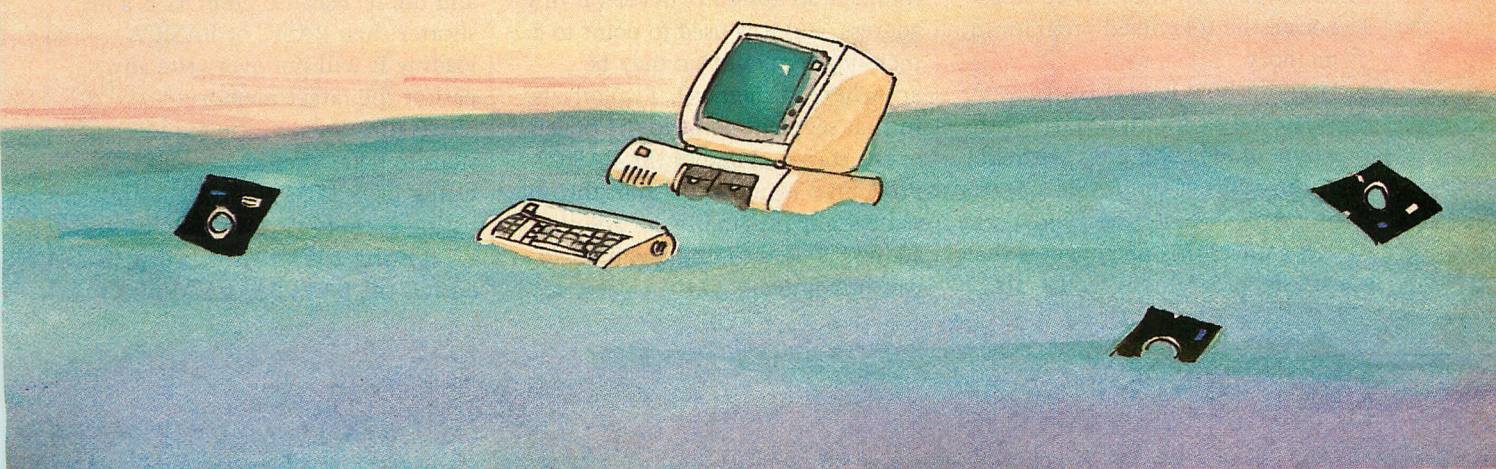
Even the most conscientious programmer can make a minor slip-up now and then. Most of the time, however, bringing the BASIC program back to its revised state after inadvertently executing a SYSTEM command involves making only a couple of changes. However, any duplication of effort is wasted time—lost productivity. And time is money in the programming business.

The "unsaved file" problem has been around as long as BASIC itself. For several years TRS-80 owners have had a simple solution. An option of the BASIC invocation line (BASIC) loads BASIC and attempts to restore any program in memory. IBM PC BASIC is simply a modified version of TRS-80 BASIC; both are products of Microsoft (in fact, parts of IBM PC BASIC are direct translations, in 8088 opcodes, of Z80 machine language). Thus, it seems that what can be done on a TRS-80 should be possible on the IBM PC.

In fact, the solution is quite simple. Consider that after exiting to DOS, the BASIC program text is still in memory. The program is in its "tokenized" state—similar to its format when stored in a disk file. If a method of copying those bytes to a disk file can be devised, then the problem of losing a program is almost licked.

Almost. When a BASIC program is saved, a 1-byte header of FFH is put at the start of the file. This is so that when BASIC loads that file later, it will know that it is not dealing with an ASCII file (which has no special header byte), a "protected

Dan Rollins is a software consultant and freelance writer who lives in Glendale, California.



```
A>DEBUG
-d 0:510 L2
0000:0510 BA 0B      (find the address of the BASIC
                      segment--yours may differ)

-d 0bbA:30 L2        (enter BASIC segment address in
                      reverse order)
0BBA:0030 3B 10      (find the offset of the start of
                      the lost program)

-f 0bba:103a L1 ff   (place a byte of FFH at that offset -1)
-d 0bba:358 L2
0BBA:0358 DB 14      (find the offset of the end of the
                      lost file)

-h 14db 103a         (subtract the start from the end)
2515  04a1           (the second number is the difference:
                      the length)

-rcx
CX 0000
:4a1                 (set CX to the count of bytes to
                      write)

-n %saved.bas        (set up a filename for the saved
                      program)

-w bba:103a          (use BASIC_segment:starting_offset-1
                      as write address)
Writing 4A1 bytes

-q                   (exit DEBUG)

A>BASICA             (execute BASIC)
load"%saved.bas"     (load the saved program)
save"myprog"         (and save it again)
load"myprog"         (now it's okay to edit the program)
```

Figure 1: Sequence for Restoring a BASIC Program

```
Section A

1 '**
2 '** This is the listing before execution.
3 '**
10 X=2 :GOTO 30
20 GOTO 20              '** never executed
30 ON X GOTO 50,60,70   '** only GOTO 60 is executed
40 SYSTEM
50 GOTO 40
60 GOTO 40              '** this GOTO is executed
70 GOTO 40


Section B

1 '**
2 '** This is after restoring with SAVEBAS and
3 '** changing this line
4 '**
10 X=2 :GOTO 55695
20 GOTO 20              '** never executed
30 ON X GOTO 50,25701,70  '** only GOTO 60 is executed
40 SYSTEM
50 GOTO 40
60 GOTO 20295             '** this GOTO is executed
70 GOTO 40
```

Figure 2: Examples of Invalid GOTOs after Using SAVEBAS

file" (which has a header byte of FEH), or a BLOAD-format file (which has a header byte of FDH). There is at least one other difference between the memory image of a BASIC program and its file format; this will be discussed later. For the time being, think of a BASIC program diskette file as a byte of FFH followed by all of the bytes of the tokenized program.

Knowing that the memory image is similar to the disk image, and assuming nothing has happened to overwrite the unsaved program, it is clear that a BASIC program can be retrieved with these three steps:

1. Locate the tokenized program in memory.
2. Find out how long it is.
3. Write a disk file that starts with a byte of FFH and ends with all of the bytes of the BASIC program.

Of course, this presupposes that the BASIC program, as well as its length, can be found and that a method of writing a file is known. The necessary "secret" information is buried in the *Technical Reference* manual. First, find the segment of the lost program by examining the two-byte value at 0000:0510. Then, by using that value as the base segment, find the address of the start of the BASIC program at offset 0030H and the address of the end of the program at offset 0358H (refer to the *Technical Reference* manual, pages 3-22 and 3-23, or page 2-9 in version 2.02).

Thus, a segment pointer is found at an absolute, never-varying address, and it is used to point to a memory segment that may be anywhere in memory. Two offsets in that segment point to the offsets of the start and end of the BASIC program—which are also in the same segment. Finally, an absolute address is used to find a pointer to a pair of pointers.

Knowing the segment and offsets of the start and end of the program, simply subtract the ending offset from the starting offset to determine the length of the program. Then open a file and write a byte of FFH followed by that many bytes. Presto! The lost program has been recovered.

The catch is opening a file and writing to it. It is not possible to run a BASIC program to do this, because doing so would destroy the memory image of the program that needs to be salvaged. To solve this problem, whip out DEBUG (any version) and use it. Because DEBUG is a lot shorter than BASIC or BASICA, loading it will not overwrite any part of the target memory.

Figure 1 shows the sequence of steps to take when using DEBUG. Using DOS 2.0, assemble and link listing 1, then use EXE2BIN utility.

Listing 2 is a BASIC listing that creates the SAVEBAS.COM file

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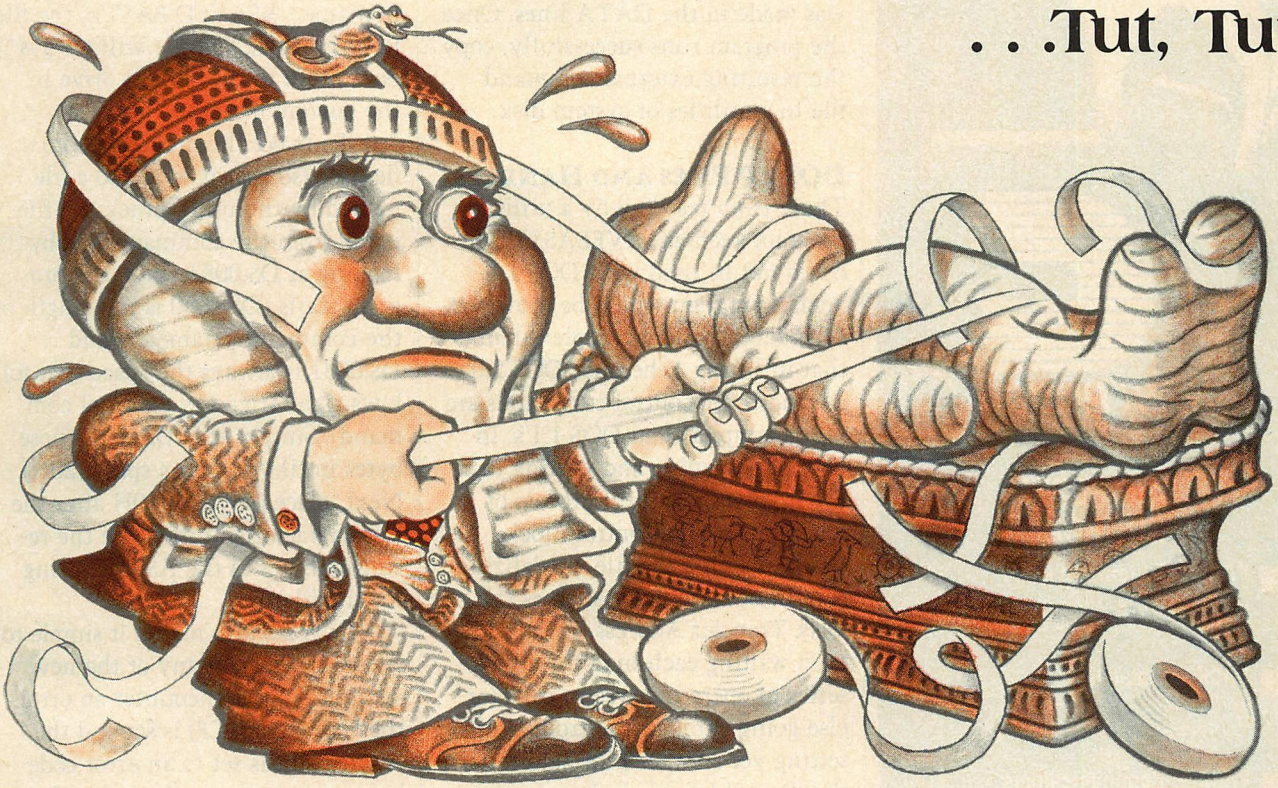

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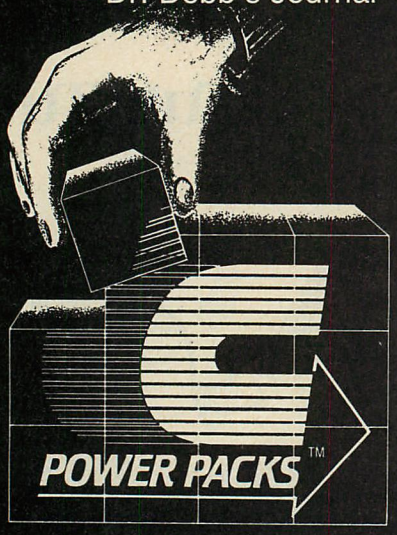

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directly and can be used instead of listing 1. Just enter and RUN the program. The program does a checksum of the data bytes and generates a warning if a typographical error was made in the DATA lines. Once the program runs successfully, copy the resulting external command file to a utilities or system disk.

DOS 2.0 Files and Handles

There is no reason why a utility program such as SAVEBAS.COM could not be used with DOS 1.1. Such a program would be, however, considerably more complex than that in listing 1, because DOS 2.0's advanced file-control commands are much simpler than DOS 1.1's. In DOS 1.1, opening and writing to a file involves a painful process of setting up a File Control Block (FCB), opening the file, initializing certain obscure fields such as the Disk Transfer Address (DTA), and then writing each byte through a series of operating-system calls (or else going through the trouble of setting yet another FCB field to the desired record size).

Listing 1 shows how much simpler this process becomes in DOS 2.0. The program invokes the DOS CREATE_HANDLE service (INT 21H with AH=3CH) to open a "handle" for a file. This is analogous to the BASIC statement

OPEN "%saved.bas" FOR OUTPUT AS #1

where the "#1" is the handle that will be used in later PRINT statements. The main difference between the DOS CREATE_HANDLE service and the BASIC OPEN statement is that the DOS statement indicates what number should be used as a handle, whereas the BASIC statement asks the user to supply that information.

The DOS service requires that DS:DX point to an ASCIIZ string with the path and filespec of the file. That means that somewhere in memory, there must be a string of characters of a valid file name. The last character of that file name must be followed by a byte of 0 (ASCII Zero). And to keep the program as simple as possible, I hard-coded the filename "%SAVED.BAS" as the file to be created. The file will always be written to the default drive in the current directory.

To make the program more flexible (so that it writes to a file named by the user), pluck the filename from the command line by looking at DS:0082 when the program starts (DS:0080 is the length of the command parameters and DS:0081 is always the space that follows right after any external command). Simply scan through those bytes until you find a space (20H). Next, place a byte of 00H after the last character and then use the resulting bytes as the ASCIIZ string for the filespec.

DOS 2.0 also makes it simple to detect an error. If any of the new services should encounter an error, the Carry Flag (CF) is set and the AX register is set to an error code before returning to the caller. For simplicity, this program ignores the cause of the error and just detects the error condition. If any error is encountered (a full disk is the most likely), the program prints an error message and aborts the operation. Disk errors, such as "Disk Not Ready," are handled at a lower level in DOS (that's the *critical error handler*, which prints the "Abort, Retry, Ignore" message).

After it has successfully opened the file, the program then goes through the same "pointer-pointing-to-a-pointer" look-up routine as described for use with DEBUG. Once the start of the BASIC program has been found, the program writes a byte of FFH directly before the first byte. Then it looks up the offset of the end of the BASIC program and subtracts the offset of the first byte (the FFH header byte). This yields the total number of bytes that must be written to the file.

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This value is loaded into the CX register and the DOS WRITE_HANDLE service is invoked (INT 21H with AH=40H). This call also requires that the BX register contain the 16-bit file handle that was sent back from the CREATE_HANDLE call. Notice in the listing that the handle was placed into BX right after the file was opened. No fuss; no need to bother with FCBs, record lengths, and block sizes; no setting of the DTA; no acronyms at all!

If the write operation returns an error, the program passes control to the error-message routine and aborts the operation. After DOS has written the bytes to the file, the CLOSE_HANDLE service is invoked (INT 21H with AH=3EH). Then the program prints a reassuring message and exits to DOS.

There are a couple of other things to note about the program. First, it is set up as a .COM file, meaning that all of its code and data are in the same physical segment and no stack segment is identified (.COM programs automatically use the uppermost 256 bytes in the code segment for the stack). Also, the ORG pseudo-op must be used to set the start of the program to 100H, and the END pseudo-op must specify a label that points to that same 100H offset. One of the advantages of a .COM program is that the user can exit to DOS at any time just by executing an INT 20H—regardless of how much junk has accumulated on the stack.

An extra step is required to create a .COM file from an assembly language listing. After assembling and linking the program (and ignoring the "No Stack segment" warning), process the resulting EXE file with the EXE2BIN utility. In this case, use the command

```
EXE2BIN savebas.exe
  savebas.com
```

SAVEBAS.EXE should then be deleted. Using it further would prove to be disastrous, because it has no valid stack segment.

Another point of interest: When the segment and offsets of the BASIC program are divined through the trail of pointers starting in low memory, some hard-coded addresses, such as [510H], must be accessed. The assembler manual suggests that the user set up a separate "dummy" segment, label these addresses, then access the values via their labels. For "short and dirty" programs such as SAVEBAS.COM, there is no real need to do this. Whenever a hard-coded number is used in an address expression, however, the user must let the assembler know to which segment that number refers.

Any 8088 programming manual will state that the *direct* addressing mode (that is, accessing a nonindexed address) will always default to a reference in the current data segment. What's more, any memory transfer to a 16-bit register should

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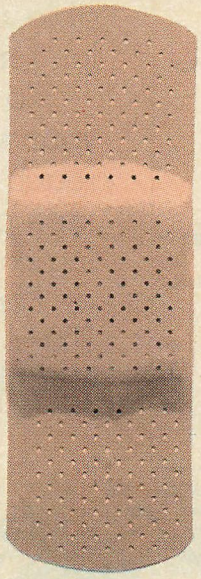

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default to a 16-bit transfer. However, a statement such as

```
mov     ax,[510]
```

is actually faulty in two ways. The assembler is concerned because it cannot associate a segment with the offset and it cannot find a size for the operand (both of which would be provided if the recommended dummy-segment-and-label process had been used). Therefore, the listing will include several statements similar to this:

```
mov     ax,word ptr DS:[510H]
```

Once the assembler is given a segment (DS) and a size (word), it knows not to insert a DS: segment override into the program, and it assembles the statement correctly.

NOTHING'S PERFECT

The fateful day has come. After you spent two hours revising a 1,000-line BASIC program, the devil made you type SYSTEM and press ENTER. Now the A> prompt is winking at you mockingly. Fortunately, you have SAVEBAS.COM handy on your DOS diskette, so you will just type SAVEBAS, gleefully execute BASIC, and load %SAVED.BAS. The program is intact. It should immediately be saved with a new filename and loaded back into memory.

That saving and reloading is an important step. If the SYSTEM statement was encountered on a program line or if you typed it immediately after breaking out of the program, it's likely that the restored program will contain one or more "Undefined-Line" errors. This can be at least partially explained.

The IBM PC version of Microsoft BASIC takes advantage of a sophisticated technique to optimize program-execution speed. It used to be said that programs will run faster if often-called subroutines are placed early in the program. This is no longer true. In older versions of BASIC each GOTO and GOSUB forced BASIC to look through the entire program until it encountered a line that had a matching line number—a time-consuming process for lengthy programs. Later versions of Microsoft BASIC improved upon this by first testing whether the target line were to be found at a lower or higher line number and determining whether to search from the start of the program or from the current line (all searches must go upward in memory because each BASIC line contains only a forward address pointer).

The revolutionary technique that Microsoft utilized in IBM PC BASIC lets it take advantage of two major changes from the original design. First, the target line number (the "10000" part of the statement GOTO 10000) is stored in memory as a two-byte integer, rather than as up to five bytes of ASCII text digits. This removes the necessity of converting the line number to binary each time the GOTO is executed.

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Record lock	Yes	No	No
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16-bit → 8-bit	Yes	Yes	No
MISCELLANEOUS			
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The real revelation, however, came when some anonymous genius said, "Why perform the look-up at all? Why not just store a pointer to the target line?" Unfortunately, this idea would have been difficult to implement. For example, when the BASIC programmer deletes the target line, the program would GOTO whatever moved in to take its place. Each time a new line were inserted into the program, BASIC would need to look through every line and adjust each reference to any line whose physical position had been moved. That method would prove to be unacceptable—delete one character of a remark and have to wait five minutes? No way!

The actual solution is a combination of the old idea and the new idea. That is, before the program is executed, the line number (if any) of each GOTO, GOSUB (as well as each ON var GOTO . . .and ON var GOSUB . . .), RETURN, RESUME, THEN, and ELSE should be stored as a 16-bit binary line number. The first time the statement is executed, that line number will be used in the old look-up procedure. But, as soon as the address of the line is known, the 16-bit line number is replaced by a 16-bit line address pointer. Furthermore, a special token that accompanies each line reference is changed in order to indicate that the line number is in its address-reference format.

Later executions of the statement go faster. The time-consuming search for a GOTO or GOSUB line reference now takes place only once for each program branch.

A problem related to this can occur when the SAVEBAS.COM program is used in a situation in which the SYSTEM command was executed on a program line or from immediate mode after breaking out of a program. Because the break occurred before BASIC was able to restore those line numbers from their address-reference counterparts, the memory image of the program will contain some invalid GOTOs and GOSUBS.

Figure 2 illustrates this problem. Section A shows the program listing before execution. Section B shows it after execution and restoration with SAVEBAS.COM. Notice that the value of the target of each executed GOTO has been changed.

This problem manifests itself only when a program line is edited after the %SAVED.BAS file is read in. That is when BASIC goes through its "reverse look-up" to restore each address reference to a line-number value. Saving and reloading a program before doing any editing will avoid the problem. In any case, it's always a good practice to save and reload the restored program immediately.

SAVEBAS.COM, though short, illustrates several important facets of assembly language programming. More than that, it is a valuable utility. Keep it close at hand when you are working on your programming masterpieces—it will help to protect you from the horrors of: "AARGH! I did it again!"

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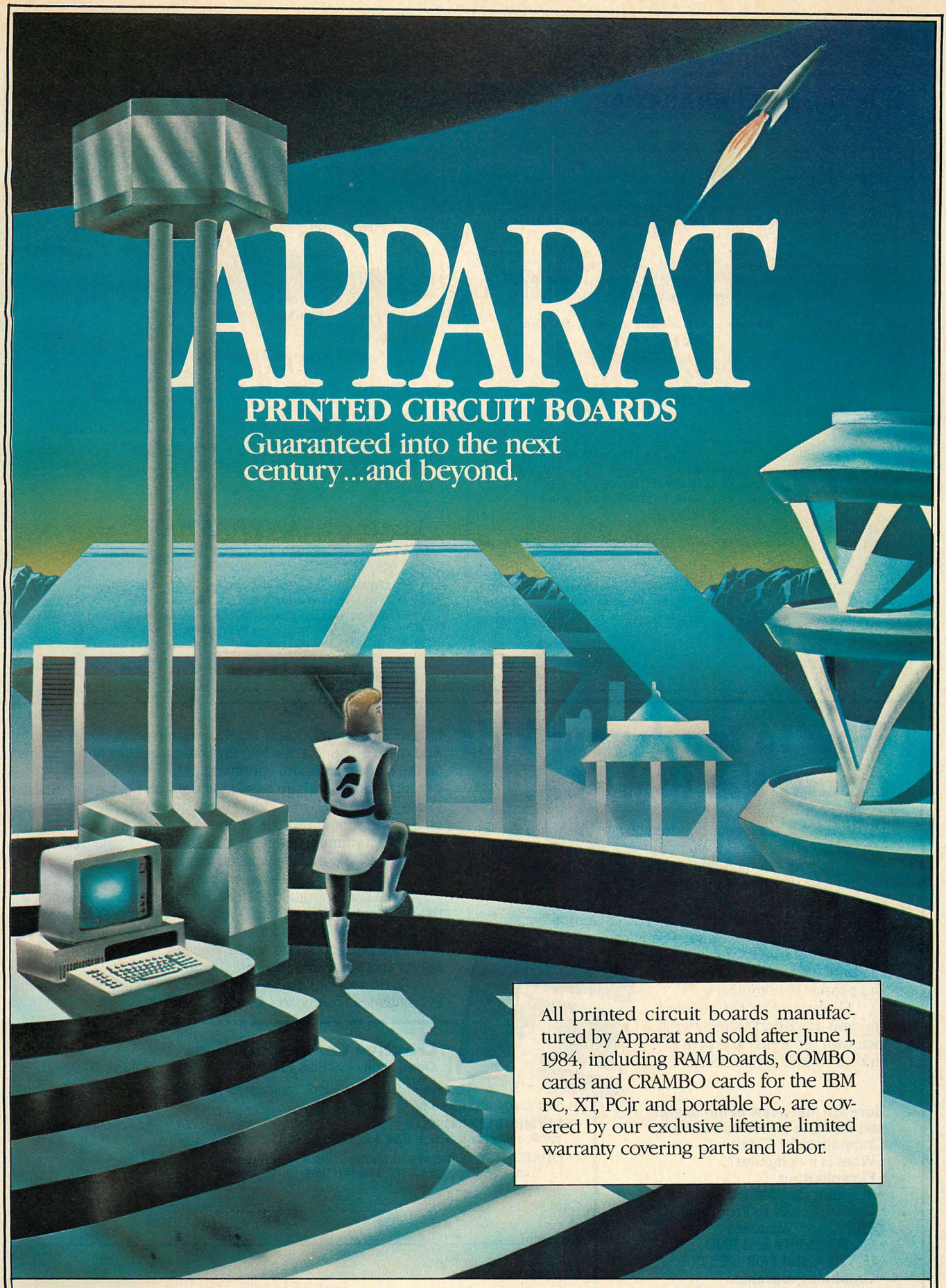

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Listing 1 SAVEBAS.COM

```
;-----------------------------------------------------------------------
;SAVEBAS.COM                by Dan Rollins                01/22/84
;
; This program will create a file from a BASIC program that was "lost"
; through an inadvertent use of the SYSTEM command.  After making that
; mistake, execute this program and the lost program will be saved
; to the default directory as %SAVED.BAS. It should then be saved and
; reloaded before it is edited.
;
; Notes: This program works only for DOS 2.0 or later.
;        It must be executed IMMEDIATELY after exiting from BASIC--
;        before loading or running any program, especially BASIC!
;
;        This is a .COM program, so you must assemble, link, and
;        EXE2BIN
;

com_seg  segment
         assume cs:com_seg,ds:com_seg
         org    100H
begin:
         jmp    code_start
filename db '%SAVED.BAS',0             ;ASCIIZ string of filename
err_msg  db 'File error encountered '
         db 'while writing to %SAVED.BAS ',0DH,0AH,'$'
ok_msg   db 'BASIC program file saved in %SAVED.BAS',0DH,0AH,'$'

code_start:
         mov    dx,offset filename ;point to ASCIIZ string w/ filespec
         mov    cx,0               ;file attribute = read/write
         mov    ah,3cH
         int    21H                ;DOS 2.0 CREATE file-handle service
         jc     file_err           ;exit if error return
         mov    bx,ax              ;save file handle in BX
         mov    ax,0
         mov    ds,ax
         mov    ax,word ptr ds:[510H] ;fetch BASIC segment at 0000:0510
         mov    ds,ax              ;DS => BASIC program segment
         mov    si,word ptr ds:[30H]  ;fetch start of the lost program
         dec    si                 ;point to 1-byte before it and
         mov    byte ptr [si],0FFH ;place the token-file header byte
         mov    cx,word ptr ds:[358H] ;fetch end of the lost program
         sub    cx,si              ;CX = length of the lost program
         mov    dx,si              ;DX is offset of first byte to write
         mov    ah,40H             ;DOS 2.00 WRITE_HANDLE service
         int    21H                ;write CX bytes starting at DS:DX
                                   ; to file handle BX
         jc     file_err           ;exit if error
         mov    ah,3EH
         int    21H                ;close the file handle in BX
         mov    dx,offset ok_msg   ;indicate all OK -
         jmp    short exit

file_err:
         mov    dx,offset err_msg
exit:
         push   cs
         pop    ds                 ;make sure DS:DX points to message
         mov    ah,9
         int    21H                ;write the message at DS:DX
         int    20H                ;exit to DOS
com_seg  ends
         end    begin
```

Listing 2 SAVEBAS.BAS

```
1 '** SAVEBAS          by Dan Rollins          01-23-84
2 '** This program creates a COM program that can be
3 '** used to restore a BASIC program that was lost
4 '** by inadvertently exiting from BASIC via the SYSTEM
5 '** command.  Run this NOW--don't wait until it's too late!
```


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AARGH!

```
6 '** Works with DOS 2.0 only.
7 '**
10 OPEN "savebas.com" AS #1 LEN=1
20 FIELD #1,1 AS A$
30 READ BYTE :IF BYTE <0 THEN 100
40  LSET A$=CHR$(BYTE) :PUT #1
50  CHECKSUM=CHECKSUM+BYTE
60 GOTO 30
100 CLOSE
110 IF CHECKSUM <> 15479 THEN BEEP :PRINT"data line error!" :STOP
120 PRINT "SAVEBAS.COM has been successfully created" :END
997 '**
998 '** data and opcodes of SAVEBAS.COM program
999 '**
1000 DATA &hEB,&h6B,&h90,&h25,&h53,&h41,&h56,&h45,&h44,&h2E
1010 DATA &h42,&h41,&h53,&h00,&h46,&h69,&h6C,&h65,&h20,&h65
1020 DATA &h72,&h72,&h6F,&h72,&h20,&h65,&h6E,&h63,&h6F,&h75
1030 DATA &h6E,&h74,&h65,&h72,&h65,&h64,&h20,&h77,&h68,&h69
1040 DATA &h6C,&h65,&h20,&h77,&h72,&h69,&h74,&h69,&h6E,&h67
1050 DATA &h20,&h74,&h6F,&h20,&h25,&h53,&h41,&h56,&h45,&h44
1060 DATA &h2E,&h42,&h41,&h53,&h20,&h0D,&h0A,&h24,&h42,&h41
1070 DATA &h53,&h49,&h43,&h20,&h70,&h72,&h6F,&h67,&h72,&h61
1080 DATA &h6D,&h20,&h66,&h69,&h6C,&h65,&h20,&h73,&h61,&h76
1090 DATA &h65,&h64,&h20,&h69,&h6E,&h20,&h25,&h53,&h41,&h56
1100 DATA &h45,&h44,&h2E,&h42,&h41,&h53,&h0D,&h0A,&h24,&hBA
1110 DATA &h03,&h01,&hB9,&h00,&h00,&hB4,&h3C,&hCD,&h21,&h72
1120 DATA &h2B,&h8B,&hD8,&hB8,&h00,&h00,&h8E,&hD8,&hA1,&h10
1130 DATA &h05,&h8E,&hD8,&h8B,&h36,&h30,&h00,&h4E,&hC6,&h04
1140 DATA &hFF,&h8B,&h0E,&h58,&h03,&h2B,&hCE,&h8B,&hD6,&hB4
1150 DATA &h40,&hCD,&h21,&h72,&h09,&hB4,&h3E,&hCD,&h21,&hBA
1160 DATA &h44,&h01,&hEB,&h03,&hBA,&h0E,&h01,&h0E,&h1F,&hB4
1170 DATA &h09,&hCD,&h21,&hCD,&h20,-1
```


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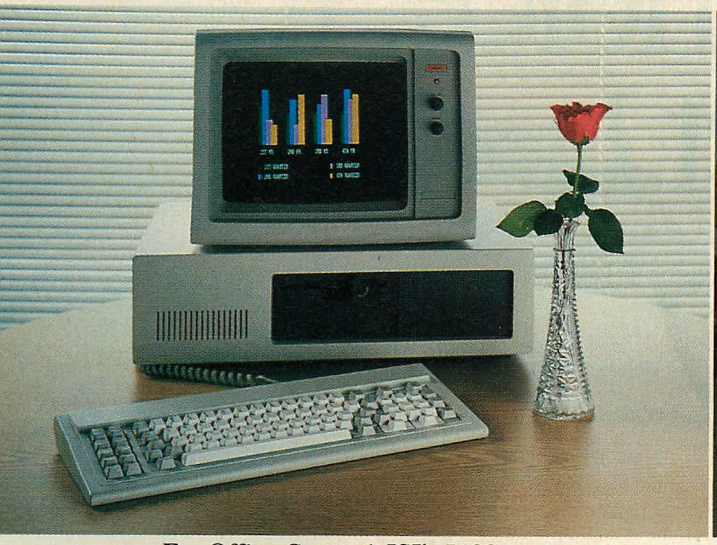
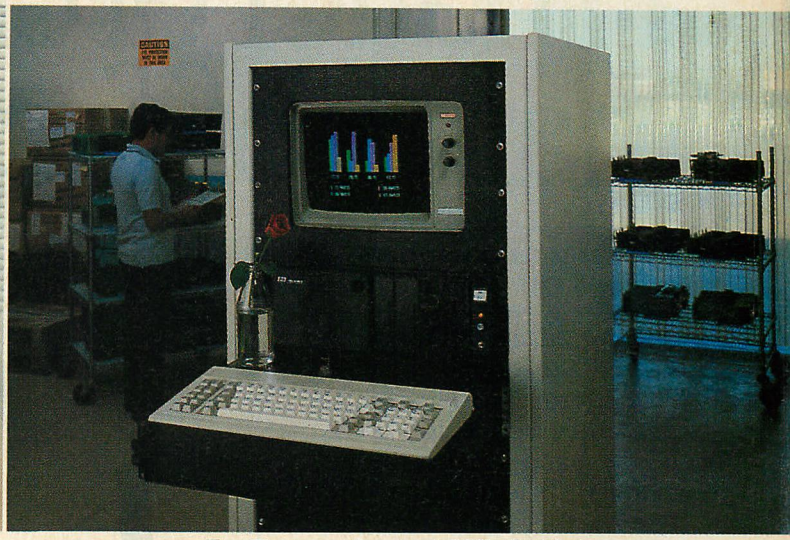


For Office Control: ISI's 5160.



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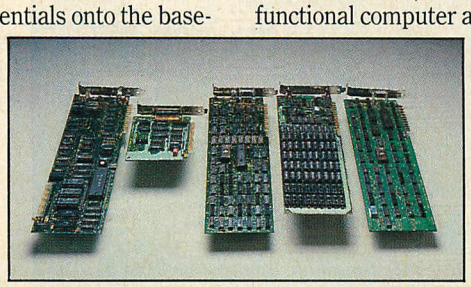

ISI International also offers an expanding array of adapter cards for use with ISI International systems, as well as IBM and other PC-compatible systems.

Factory Control: ISI's 6160.

The ISI 6160 is essentially the same easily expandable processor as the 5160, featuring the same PC and XT-compatibility, but with important additional features that make this the ideal system for factory applications.

For example, it's 19″ rack-mountable RETMA enclosure is ruggedly designed and manufactured, and features fan cooling with positive airflow to eliminate hot spots; changeable filters for extra protection from contamination; and a key-lockable cover for limited access to power and reset switches, as well as to the shock-mounted disk drives.

Both the 5160 and the 6160 offer MS-DOS* and GW-Basic;* in addition, the 6160 factory system offers VRTX†, a multitasking kernel that permits you to run real-time, interrupt-driven control applications.

For operation in a more office-like setting, the 6160 can be dressed up in its own "office" style cabinet, just like the 5160. But underneath, it will still be the most versatile, expandable, functional computer available to run factory control applications.

For more information on either the ISI 5160 office system or the ISI 6160 factory system, call us in the West at (408) 743-4442, in the East at (201) 272-3920, or in the Midwest at (513) 890-6450.

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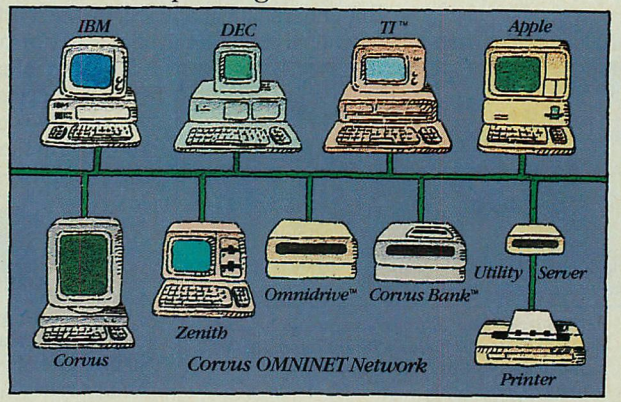

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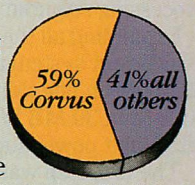

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CIRCLE NO. 221 ON READER SERVICE CARD

SCREENSPEAK

With its main menu screen and its related screen, Smartcom II from Hayes is capable of meeting the needs of most communicators reasonably well.

The ubiquitous Hayes Smartmodem products adorn the shelves and equipment racks of many personal and business computer installations throughout the world. Most communications programs provide access to Hayes 300- and 1200-series modems because of the widespread use of these modems. Even IBM's PC/IX contains built-in configuration files and communications support for these modems.

Hayes Microcomputer Products sells a program called Smartcom II that is designed to work with its own modems. It is available in a stand-alone version and bundled with the Smartmodem 1200B, an internal board-level version of the popular Smartmodem 1200 for the IBM PC, XT, and work-alike computers. Among its major features are the usual communications capabilities associated with "dumb" terminals, plus automatic originating and answering of data calls through a Hayes modem, and a raft of convenience features, such as communications parameters management, batch commands, macro facilities, and both binary and text file transfers between consenting computers. Smartcom II includes a "recall buffer" that is really handy for looking back at material that scrolls off the screen too quickly.

Version 2.0 adds several terminal emulations as well as support for the popular XMODEM file transfer protocol. Smartcom II also provides a simple text preparation editor, control over system configuration parameters, such as display adapter selection, and an optional sorted list of file names from the default disk drive. Smartcom is not copy protected so it may be backed up and installed on a hard disk.

Basic Operations

Smartcom II has a main menu screen, three subordinate work screens (Parameters, Macro Definition, and Configuration), and screens for

Augie Hansen is a programmer for a telecommunications company and a contributing editor to this magazine. This is the fourth in a series about communications products.

AUGIE HANSEN

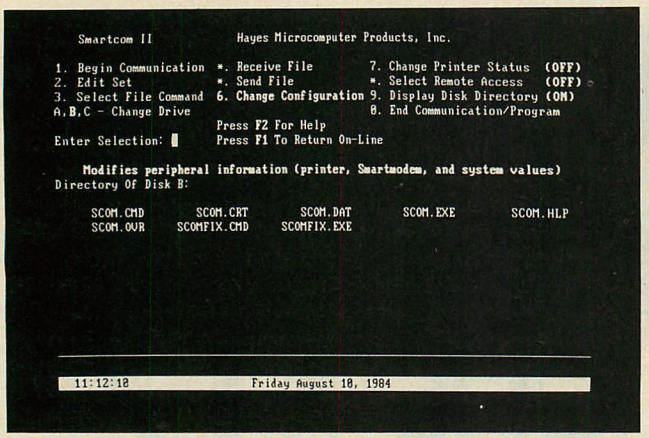

Photo 1: The main SmartCom II menu with the Display Disk Directory option on

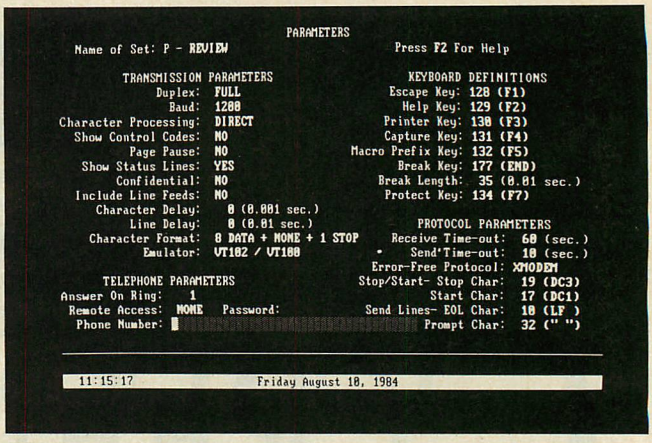

Photo 2: One of the communications sets being edited before use on-line

creating text and displaying on-line information. In addition, help frames are available anywhere Smartcom II requests user input.

Photo 1 shows the main menu. Any item with an asterisk is not available for selection from the current operational mode. Items 7 through 9 (Change Printer Status, Select Remote Access, and Display Disk Directory) may be toggled between ON and OFF conditions. Only selections 1, 2, and 6 (Begin Communications, Edit Set, and Change Configuration) invoke separate work screens. The other selections modify the screen that is being displayed in order to offer additional selections or to gather qualifying data from the user.

Smartcom II permits up to 25 communications sets to be defined and called from the main menu. Photo 2 shows the parameters screen of a communications set. The set name is REVIEW and its ID (the letter one must type to select it) is P. In the photo, entries have been either accepted from the default values or modified using the left

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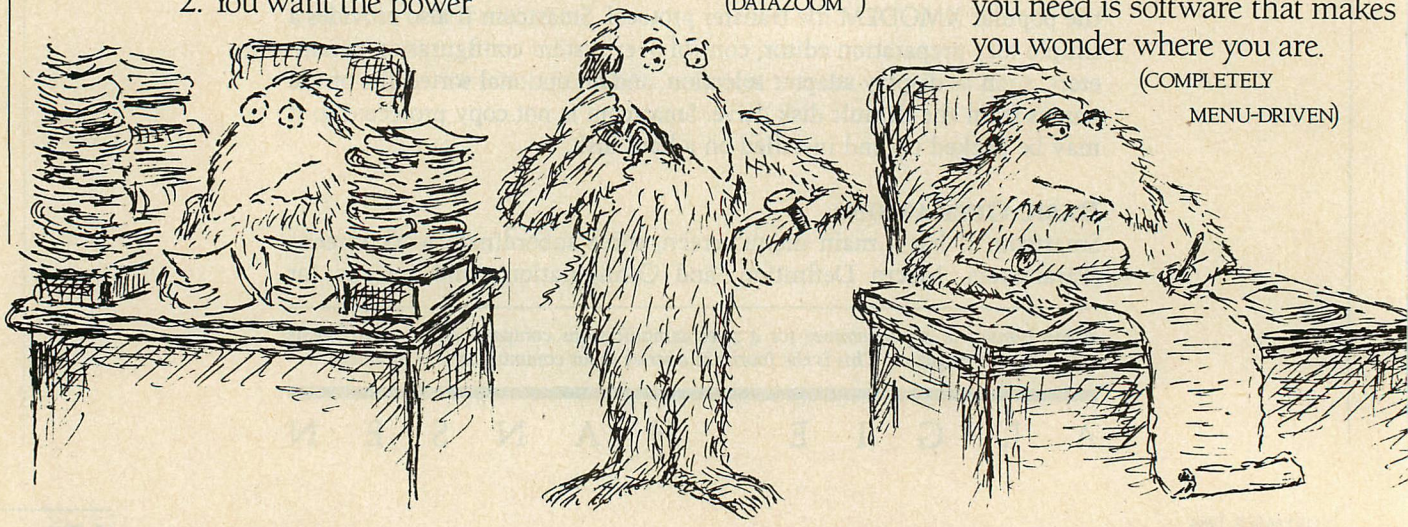

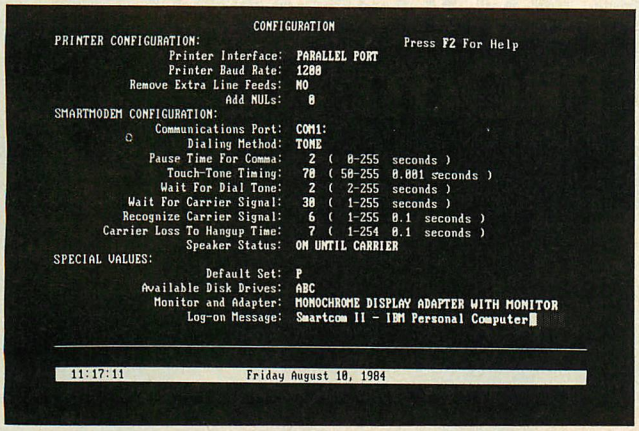

Photo 3: Changing the peripheral default values from the configuration form

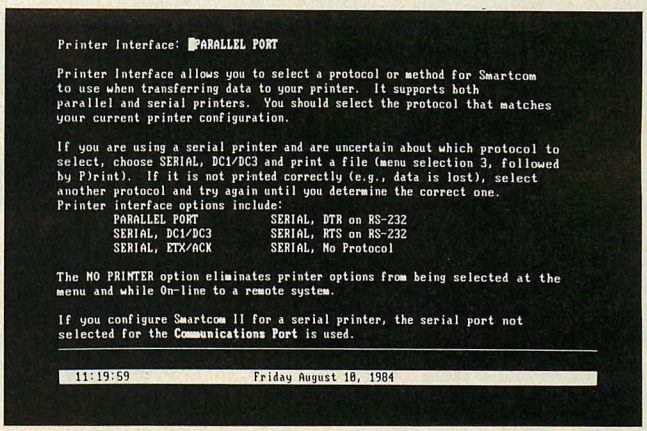

Photo 4: A help frame for the Printer Interface field of the configuration screen

and right arrow keys (previous and next). The up and down arrows and the ENTER key are used to move about in the work screen. The dotted background in the Phone Number field indicates that Smartcom II is waiting for the user to input a number to be dialed. After all entries are finished, the data may be saved to a disk.

Certain printer, modem, and system values are considered to be configuration data, as shown in photo 3. This allows for the selection of ports, transmission rates, dialing method, available disk drives, display adapter and monitor type, and other basic functions and features. Before putting Smartcom II to work for communications purposes, however, the user should do some preliminary set-up in order to identify specific installed peripherals. For example, the program must be told what type of printer, if any, is available. The IBM parallel printer is used as a default, but several types of serial printers may be selected. Only one printer may be designated for use by Smartcom II.

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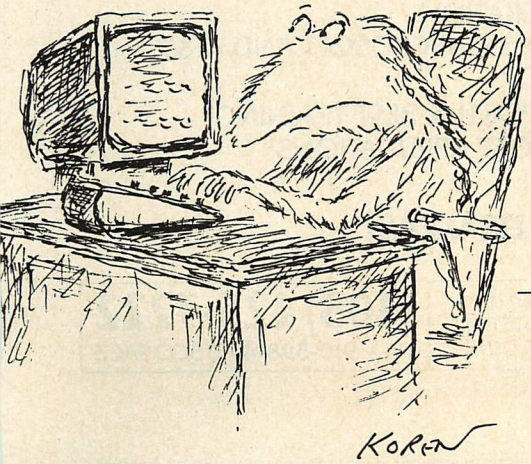

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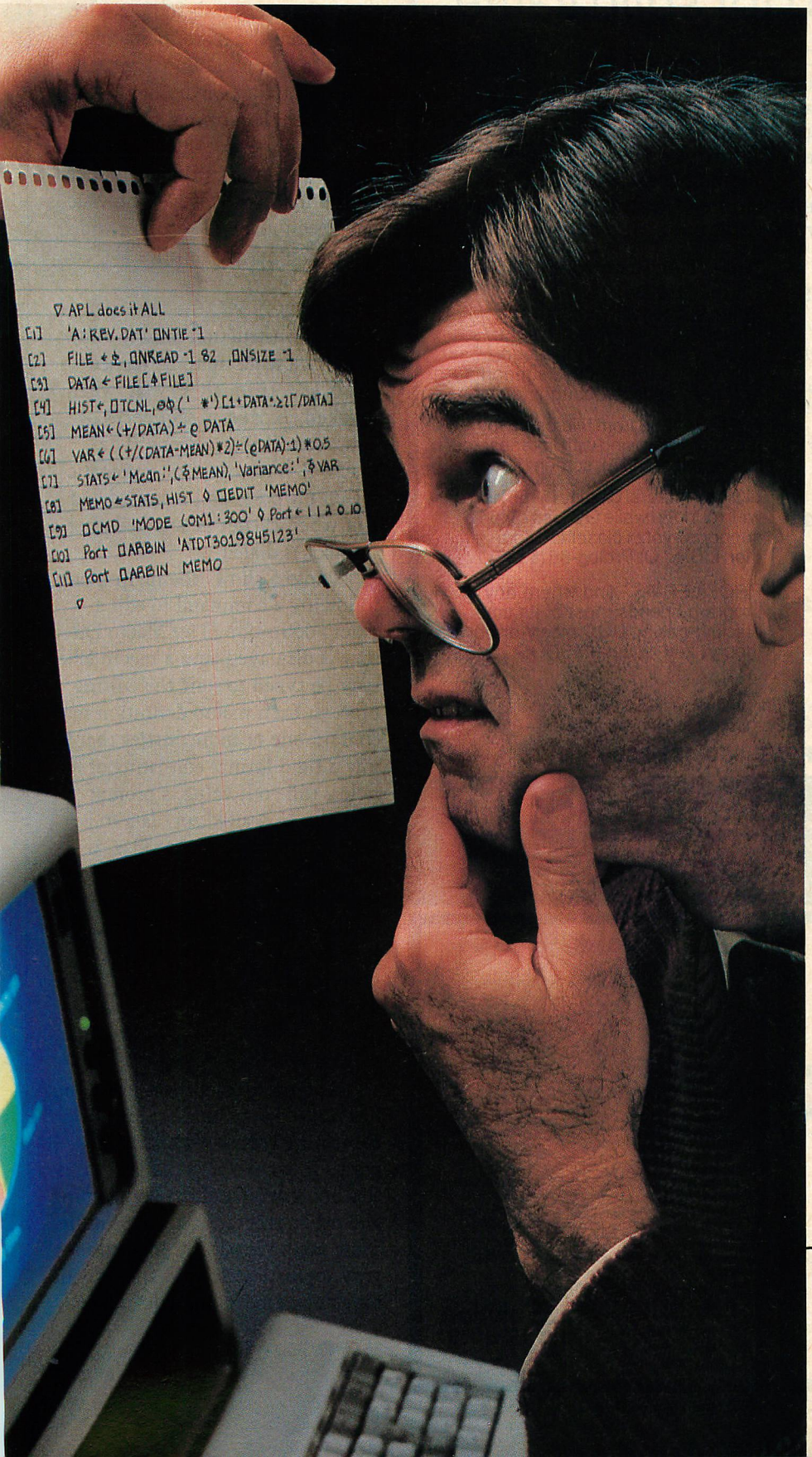

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SMARTCOM II

The user may request help on any field of this work screen, or any other screen, by typing F2. Photo 4 shows the help frame for the Printer Interface field.

After the initial set-up work is done, the user needs to type selection 1 from the main menu and respond to a few additional requests for information. Smartcom II emulates a simple terminal for the most part, as do most of the other general purpose communications programs on the market. However, provisions have been made to permit a wide range of other capabilities.

MACROS

A macro instruction facility allows a user to create up to 25 named entities (A through Y) that, when invoked, expand to sequences of Smartcom II instructions. The macro Z is reserved for automatic log-on purposes and is loaded and run when carrier is detected after a number is dialed.

Photo 5 shows the main menu following a command to edit a macro definition. The Macro Directory is displayed, and a macro label may be typed to start the editing process. Each macro definition may contain one or more entries that follow a rigid format consisting of four fields: time-out value, a prompt string to be waited for, data to be sent, and carriage return flag. In photo 6, the automatic logon sequence for the selected communications set is being edited. A protection option allows users to keep sensitive data from being viewed. Once protected, the data may be used, but they cannot be viewed or edited.

The macro facility is useful but has limited application. Several competing communications programs provide command languages that include branching and looping and other programming capabilities; these facilities permit preparation of very sophisticated scripts for a wide range of purposes including com-

pletely unattended operation. Unattended operation of Smartcom II makes sense only when the program is in the remote-access mode described later in this review.

File Transfer

Smartcom II offers four file transfer methods—two for text files only, and two for binary and text files with limited ability for error detection and correction.

Files that contain only text characters and a standard set of formatting control characters (line feed, carriage return, etc.) may be sent between computers using either the "send lines" or "stop/start" methods. The prompt, start, and stop characters have default values of carriage return, XON, and XOFF respectively. Each may be changed to mutually agreed upon values on the configuration screen.

Special protocols are supported to assist those who seek more error-free transfers of text and binary data. The Hayes Verification protocol and the XMODEM protocol may be selected from the "Send File" and "Receive File" options of the main menu. Both have limitations, but offer a higher degree of reliability than the standard text protocols; each is capable of transferring binary files such as DOS command files.

The Hayes Verification and XMODEM protocols are very similar, differing primarily in the size of data blocks (512 vs. 128 bytes) and number of retries (7 vs. 10) of block transmissions. The Hayes protocol is used to transfer files between Hayes-equipped systems; it can also be used with Mycroft Labs' M.I.T.E. program. XMODEM is the choice for communications with systems running PC-TALK and Crosstalk XVI, among others.

Data Capture

Smartcom II lets users capture data to a printer, to a disk file, and to memory. A main menu selection toggles the printer on and off as needed and a four-kilobyte buffer offers some protection against data loss caused by host systems that do not use flow control techniques, such as XOFF/XON.

The function key <F4> is used to start disk data capture. Subsequent pressing of the <F4> key alternately suspends and restarts data capture. All data are recorded in a disk file named TEMP, which is recreated at the beginning of each data capture session. Pressing the ESC key stops disk data capture and allows the user to rename the file to something more descriptive.

Special protocols are supported to assist those who seek more error-free transfers of text and binary data.

Smartcom II uses a display buffer that can store up to 40 pages of text if sufficient memory is installed. The buffer always contains the latest data from the active session, and it may be viewed at any time with the aid of buffer-recall keys (Home, PgUp, PgDn, up and down arrows, End, and ScrollLock). This is one of the best features Smartcom II offers, and it is especially helpful when text scrolls off the top of the screen faster than it can be read. With many programs, the data would simply vanish. This program makes it possible to scroll back and forth through the "lost" data simply and quickly.

Terminal Emulation

The factory setting for terminal emulation is TTY, which understands the basic control codes for bell, backspace, carriage return, horizontal tab, line feed, null, and delete. Such a terminal is adequate for many simple communications tasks that require no more than sending and receiving ASCII characters. The TTY setting is used for contacting

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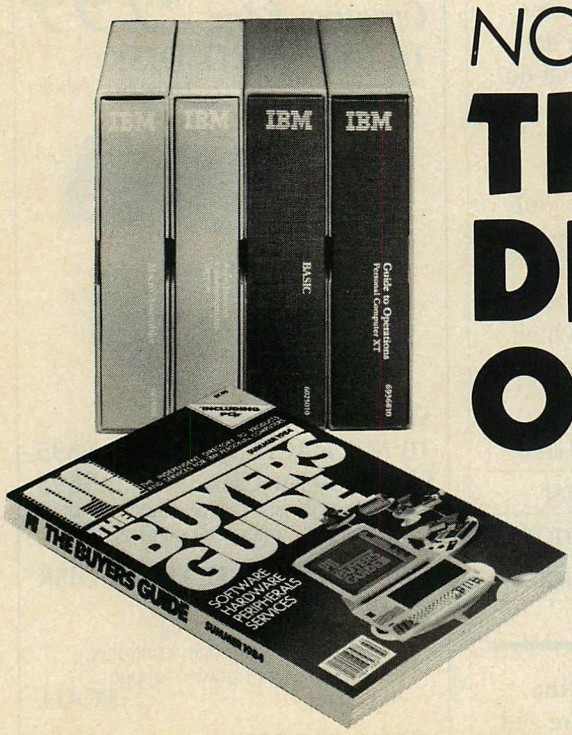

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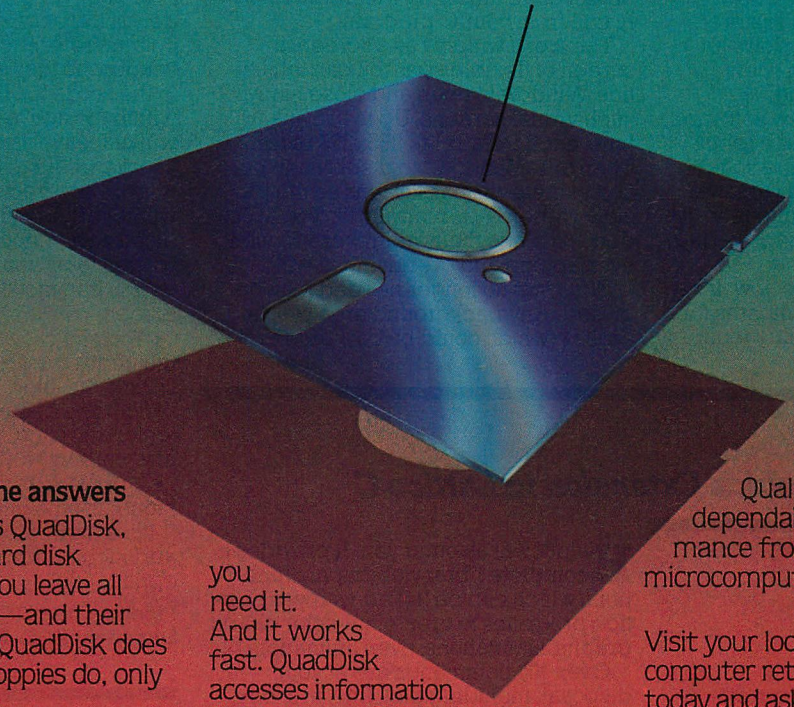

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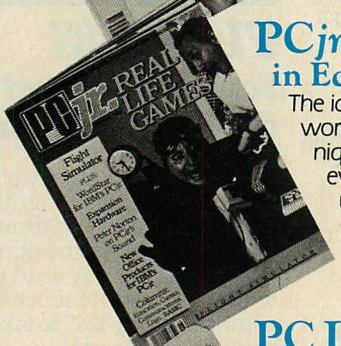

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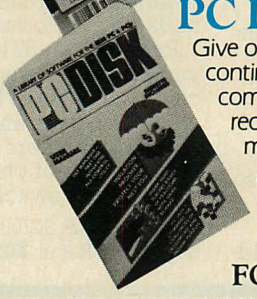

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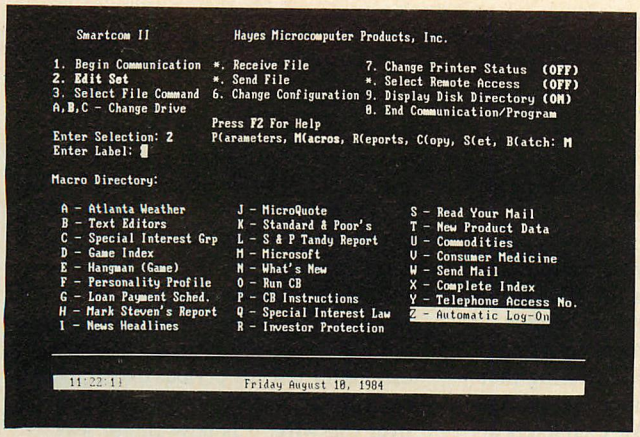

Photo 5: Preparing to edit macro commands under the Edit Set option for set Z

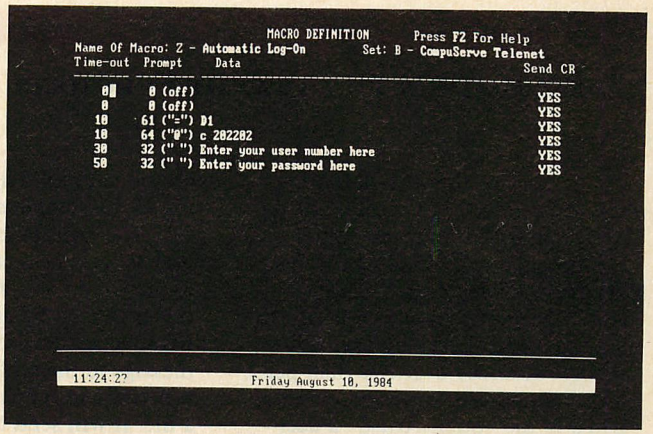

Photo 6: Editing an automatic log-on sequence macro for CompuServe via Telenet

information services, bulletin boards, and general purpose networks. However, if the user needs to run full-screen visual editors, spreadsheets, and other programs that interact intimately with the screen, Smartcom II offers two terminal emulators that may help.

A TeleVideo terminal subset that includes the basic TTY functions plus a clear screen command and cursor positioning is provided, but for no apparent reason. The functions that are available more closely fit the description of a Lear Siegler ADM3a terminal. Granted, programs can be written that require no more than this subset to do useful work, but every existing application I tried to use with the emulation needed many more of the TeleVideo functions to work correctly. This emulation compares poorly to those provided by Crosstalk XVI and The Impersonator (see "High-tech Mimicry," Augie Hansen, *PC Tech Journal*, September 1984, p. 46).

The emulation of Digital Equipment Corporation's VT100/102/52 series of terminals is considerably better than the TeleVideo subset. With Smartcom II set up as a VT100, I was able to run all available screen-oriented programs on an IBM PC running Venix/86 and on a VAX 11/780 running Berkeley UNIX (BSD 4.2). The VT100-series emulation is not as complete as those provided by PC/InterComm or SmarTerm 100, but it is on a par with the Crosstalk XVI emulation of this popular terminal family. When the VT100/102 emulation is active, the numeric key pad keys,

The program never caused my system to lock up—even when I deliberately forced it into difficult situations, such as trying to write a file to a full disk.

some of the function keys, and several other special keys are redefined. The user must press the ScrollLock key to cause the redefined keys to revert to their standard definitions. The backspace key sends a BREAK signal in the VT100/102 mode, which for poor typists means extra keystrokes and retyping command lines. There is no set-up screen, so some settings, like margin bell, can not be altered, and there is no support for the reverse video screen.

A VT52 emulation may be selected either from the parameter screen or from the VT100/102 emulation by issuing the escape sequence for "Enter VT52 mode." This mode worked well with all the full-screen programs tested. When the graphics mode is entered, the symbols produced in the VT52 mode are identical to those of the VT100/102 mode. The graphics symbols are nearly those specified in the VT100 manual except for a few that differ as follows. Because of firmware limitations, the letters *b* through *e*, *h*, and *i* all display blanks instead of special symbols. Letters *o* through *s* all display the same horizontal scan line instead of horizontal scan lines at decreasing heights above the base line of the character cell. A vertical bar should display a not equals sign, but this is not available in the extended IBM character set, so a # is displayed instead. The behavior of Smartcom II in the graphics mode is typical of other VT100-series emulators that support the graphics capabilities.

REMOTE ACCESS

Smartcom II can be placed in an unattended mode of operation so that it can await incoming data calls and transfer files with another PC running Hayes software. The permissible exchange is quite restrictive and seemingly complex. As described in the manual, systems that are not Hayes-equipped cannot participate in such communications. The computers involved in a remote access call may be running different operating systems, as long as the com-

THE XMODEM FILE TRANSFER PROTOCOL

In a few years, the XMODEM file transfer protocol has become the de-facto standard of microcomputer communications. Ward Christensen created it to give users running CP/M operating systems a means to send text and binary files with reasonable accuracy over less than perfect dial-up lines. It was wisely donated to the "public trust," a decision that benefits all those who want to exchange information between computers, and one that ensured its widespread acceptance.

At first, XMODEM was popular primarily among hackers and bulletin board users, but its support in the business community has been growing steadily as the protocol is added to many of the major business-oriented communications packages.

Meaningful communications can take place between two people if they have at least one language in common with each other. In amateur radio communications, a global example, the common medium of exchange is the English language, the only spoken language that nearly every radio operator knows as a first or alternate language. XMODEM has acquired a similar degree of universality: it is used as a primary or backup file transfer protocol by most major communications programs, it is available on the majority of bulletin board systems, and it has even been pressed into service on a large number of minicomputer and mainframe operating systems. In addition, XMODEM is virtually free—it costs only a little extra time in coding and adds a relatively small amount of code to the final program.

XMODEM DESCRIPTION

An XMODEM protocol file transfer between two computers is diagrammed in figure 1. The vertical lines show relative time proceeding down the page. Various "messages" are depicted as arrows pointing in the direction of the receiver of the message. For this discussion it is assumed that the computer represented on the left of the figure is sending a file to the computer on the right.

The transfer is initiated by the user telling the receiving computer to prepare to receive a file. The receiver gets set up and then sends a negative acknowledgment (NAK) message to the sender indicating that it is ready to synchronize and receive a file. It will send NAK characters at 10-second intervals until the sender starts sending the file or until nine NAKs have been sent, indicating that the sender is not responding.

Assuming that the sender synchronizes, the first block is transmitted. A block, depicted in figure 2, consists of a start of header (SOH) character, a block number (sequential up to 254) expressed as an ASCII character followed by the character equivalent of the one's complement of the block number, then 128 bytes of data, padded if necessary to fill the block, and a CHECKSUM value derived from the transmitted data.

The CHECKSUM is calculated by adding the ASCII values of the characters in the 128 byte block, then ANDing the result with 255. If the receiver calculates the same CHECKSUM value for the received data, an acknowledgment (ACK) is returned to the sender indicating success. Failure is indicated by a NAK, which would result in a retransmission of the block until it is received correctly or until nine retries have been made. When the sender has no more data, it transmits an end of tape (EDT) character and awaits an ACK that terminates the transfer.

TESTING THE LIMITS

XMODEM is not without limitations. In fact, it has three major ones that could lead to its demise within the next two or three years as more sophisticated file transfer protocols gain acceptance.

The first limitation is *accuracy*. Although many who use XMODEM believe it provides error-free file transfers, it does not. Its original design uses a simple CHECKSUM method of error detection, which does a good job of fereting out single-bit errors, but it fails to detect some multiple-bit errors in transmitted data. Especially at high transmission rates, noise and other perturbations of the communications path can easily last for periods exceeding the time it takes for one bit to cross over the wire. It is possible for several bits to be altered in a way that produces identical CHECKSUMS on the transmitting and receiving ends of the path, which implies that the 128 bytes of data in the block are good when, in fact, they have been corrupted. The estimated accuracy for XMODEM of 99.5 percent or so is an improvement over the 95 percent attainable with simple parity techniques, but it pales in comparison to the performance of cyclical redundancy check (CRC) methods that are virtually 100 percent accurate. The proprietary protocols of Smartcom II, Crosstalk XVI, and similar communications programs use CRC error detection for improved accuracy over what XMODEM offers.

A second limitation of the original XMODEM in MS-DOS applications is *compatibility*. Due to its CP/M legacy, XMODEM produces a received file that may differ in size from that of the transmitted file in an MS-DOS (or PC-DOS) environment. CP/M files are always a multiple of the default sector size, 128 bytes, without regard to their actual content. Under MS-DOS, the size of files is reported accurately to the byte for .COM files because this is the only way for the operating system to know how large the file is. Text files are marked by an end-of-file (EOF) character (Ctrl-Z).

Some programs that process text files depend exclusively on the presence of the EOF and report file size only to the nearest multiple of 512 bytes, the size of a standard DOS sector. When transferred by XMODEM, some types of files tend to grow because extra EOF characters are used to pad the last received block to a

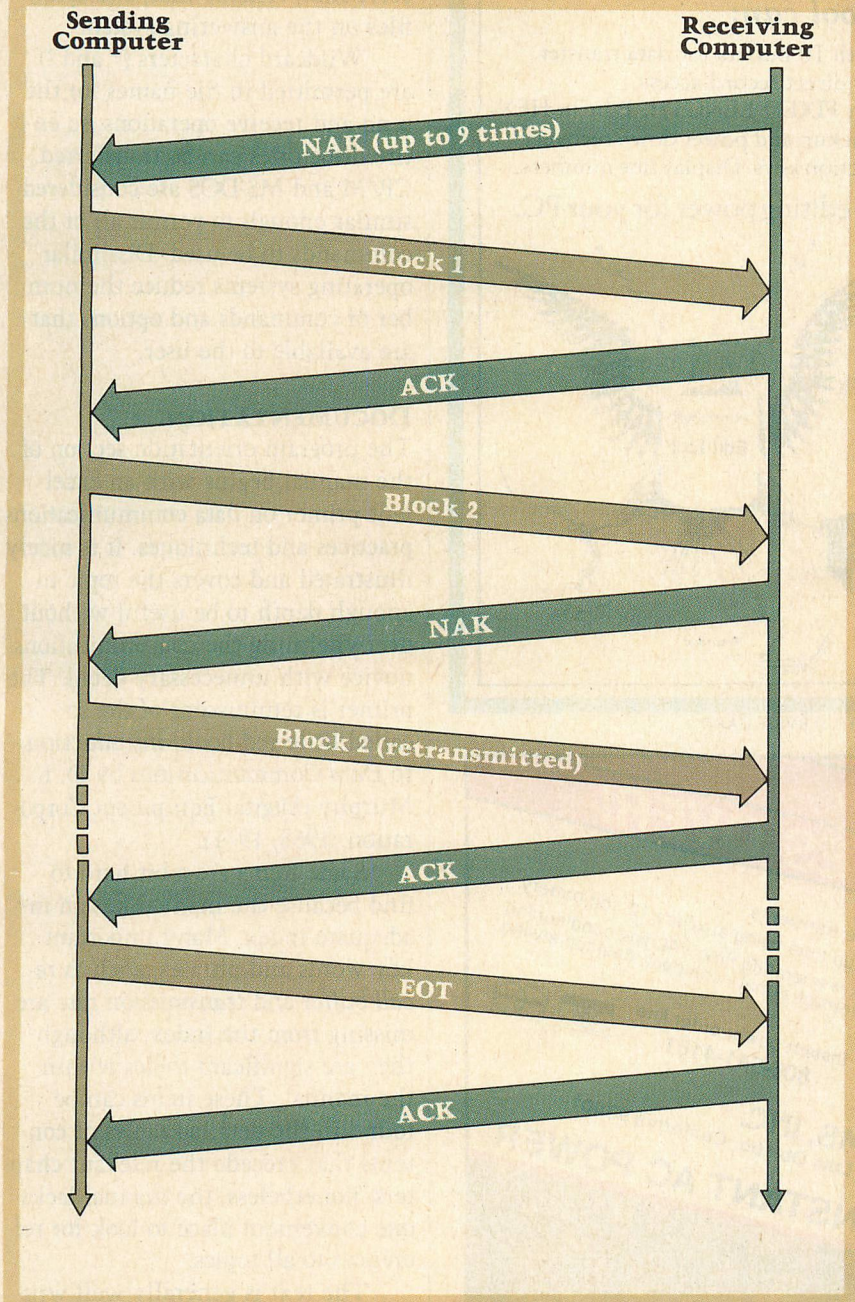

Figure 1: XMODEM Protocol File Transfer Diagram

SOH	#	$\overline{\#}$	128 bytes of data	CHECKSUM

Figure 2: XMODEM Block Description

full 128 bytes. This poses no serious problem in the case of text files, but binary files may have an incorrect size reported and stored in the disk directory, a potential problem for programs that depend on accurate file-size information and a potential waste of valuable disk space.

XMODEM's *lack of multiple file transfers* is the third major shortcoming. XMODEM permits only one-file-at-a-time transfers so the user must either attend the session to enter all file information manually or prepare a detailed automatic script to handle the session, if such a capability is available. A more general approach used by some communications programs allows the user to specify a list of files to transfer rather than just one, and permits the use of DOS wildcard characters (* and ?) in the formation of filenames (for example, b:*.c to transfer all of the C language source files in the current directory on drive B:).

Twists and Turns

Several modified forms of XMODEM are available that attempt to patch improved performance features into the original design with varying degrees of compatibility. The best of the modified versions behave exactly as the original unless special options are invoked to alter the operation of the protocol. Among the modifications are the use of CRC as an alternative to CHECKSUM error detection, and accurate file-size recording for received files.

XMODEM is no longer alone in the public domain of file transfer methods. Kermit has arrived and is destined to have a major impact on the micro-to-mainframe and micro-to-micro communications scene because it addresses the issues ignored by XMODEM and offers many powerful new features. Stay tuned. —*AH*

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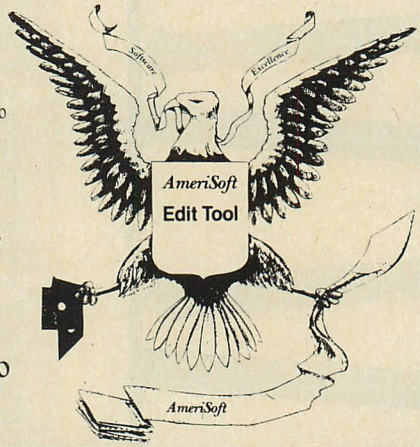

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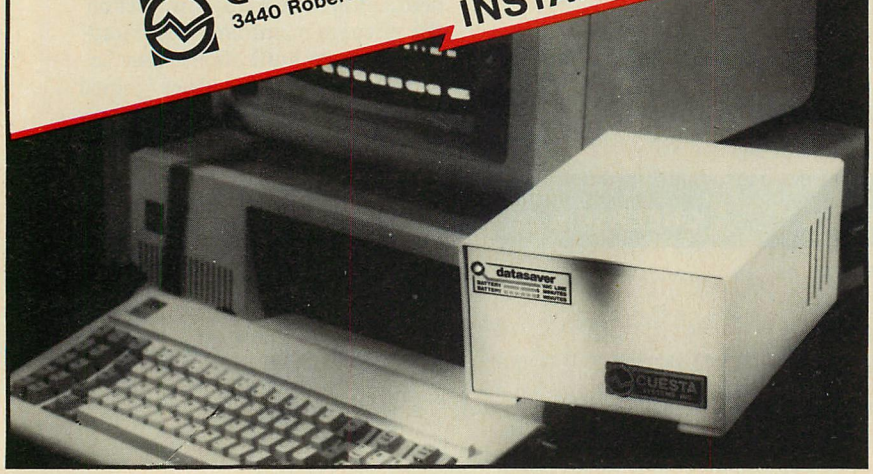

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munications software is Smartcom II. Remote-access operation permits the caller to change drive selection, display disk directories, send and receive files, rename files, and erase files on the answering system.

Wildcard characters (* and ?) are permitted in file names for the send and receive operations, so entire directories can be transferred. CP/M and MS-DOS are considered similar enough to permit all of the commands to be used. Dissimilar operating systems reduce the number of commands and options that are available to the user.

DOCUMENTATION

The program orientation section of the manual begins with an excellent primer on data communications practices and techniques. It is nicely illustrated and covers the topic in enough depth to be useful without overwhelming the communications novice with unnecessary detail. The primer is reminiscent of the so-called little red book, *Introduction to Data Communications* by D. E. Murphy (Digital Equipment Corporation, 1968, 1971).

Some items are a bit hard to find because the manual has an inadequate index. Many important key words and phrases, such as *recall buffer* and *transmission rate* are missing from the index, although they are significant topics within the manual. These items can be found in the detailed tables of contents that precede the relevant chapters; nonetheless, the manual lacks one convenient place to look for references to all topics.

The text is generally well written and the quality of the production is high. Some items, however, are referred to inconsistently. For example, in some parts of the manual, Ward Christensen's claim to fame is spelled XMODEM, and in other parts, X-MODEM. Although such inconsistencies shouldn't make the program unusable, they could be troublesome to novice users.

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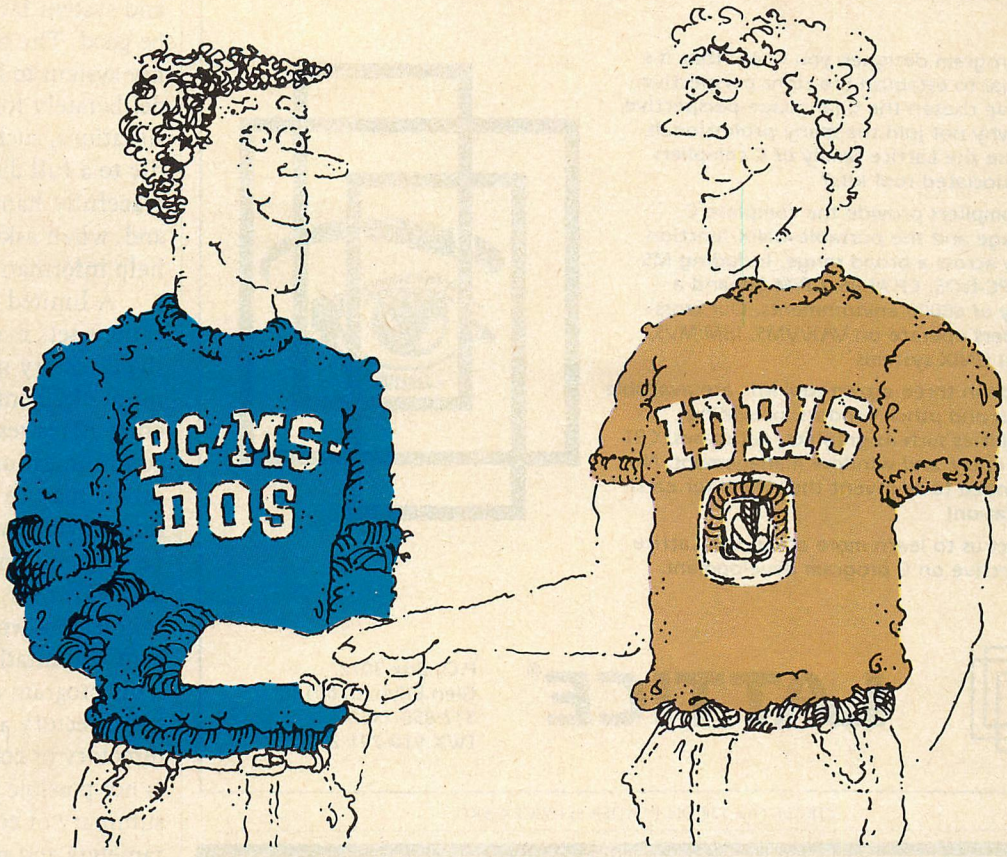

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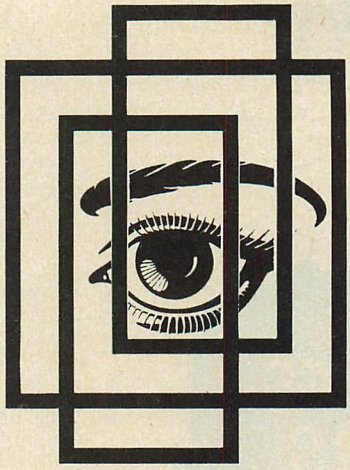

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LASTING IMPRESSIONS

The error-handling of user input and system I/O functions appears to be good. The program never caused my system to lock up, even when I deliberately forced it into difficult situations, such as trying to write a file to a full disk. Smartcom II gracefully handles nonsense input and, when asked, displays useful help information.

A limited number of communications sets may be defined because the directory may contain a maximum of 25 entries. A twenty-sixth entry (Z) is reserved for a standard communications set upon which others may be based. Some of the sets provided with the program can be deleted to make room for new sets. However, some computer communicators would find the Smartcom II limitation too confining. This program does not have a dialing directory as such, but rather a directory of communications sets. It is not possible to view a capsule summary of communications parameters and phone numbers—a design characteristic shared by Crosstalk XVI (see "Crosstalking," Augie Hansen, *PC Tech Journal*, July 1984, p. 90). However, the number of command files available to Crosstalk XVI is limited only by the number of available disk directory entries, and the command files provide considerably more flexibility in setting up and customizing communications with a remote system than do the communications sets of Smartcom II.

Experienced users quickly tire of menu systems that don't permit shortcuts. This program could provide a few more shortcuts than it does, but it is less cumbersome to use than some of its competitors.

Smartcom II provides neither a way to execute PC-DOS commands from within the program nor a way to leave the program without terminating the call. Either capability would achieve the desired result of permitting general access to the

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computer while communications are in progress, although the former method is preferable. The display buffer and the buffer recall commands are nicely done. This is a welcome operating convenience and one that other programs could use.

The text preparation editor is another story. It allows for text entry and editing of whatever can be held in memory. If the input exceeds available buffer space, part of it is written to disk. Any text that has been written out cannot be edited by the Smartcom II editor. It is necessary to leave the program and use some other editor in order to make changes to the text.

RECOMMENDATIONS

Smartcom II is part of the 1200B internal modem package. It is a good program that will serve the needs of most communicators reasonably well. For those who already have a modem or who prefer an external modem, shop around for a communications program. There are several that are better and excel in certain areas of communications. Articles published in *PC Tech Journal* in the last several months give some pointers to consider before buying a communications program.

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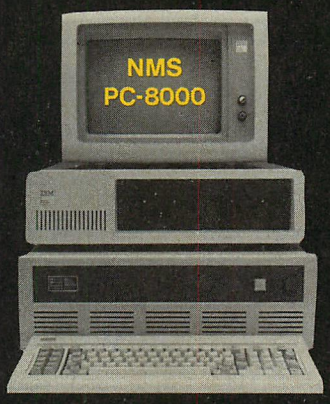

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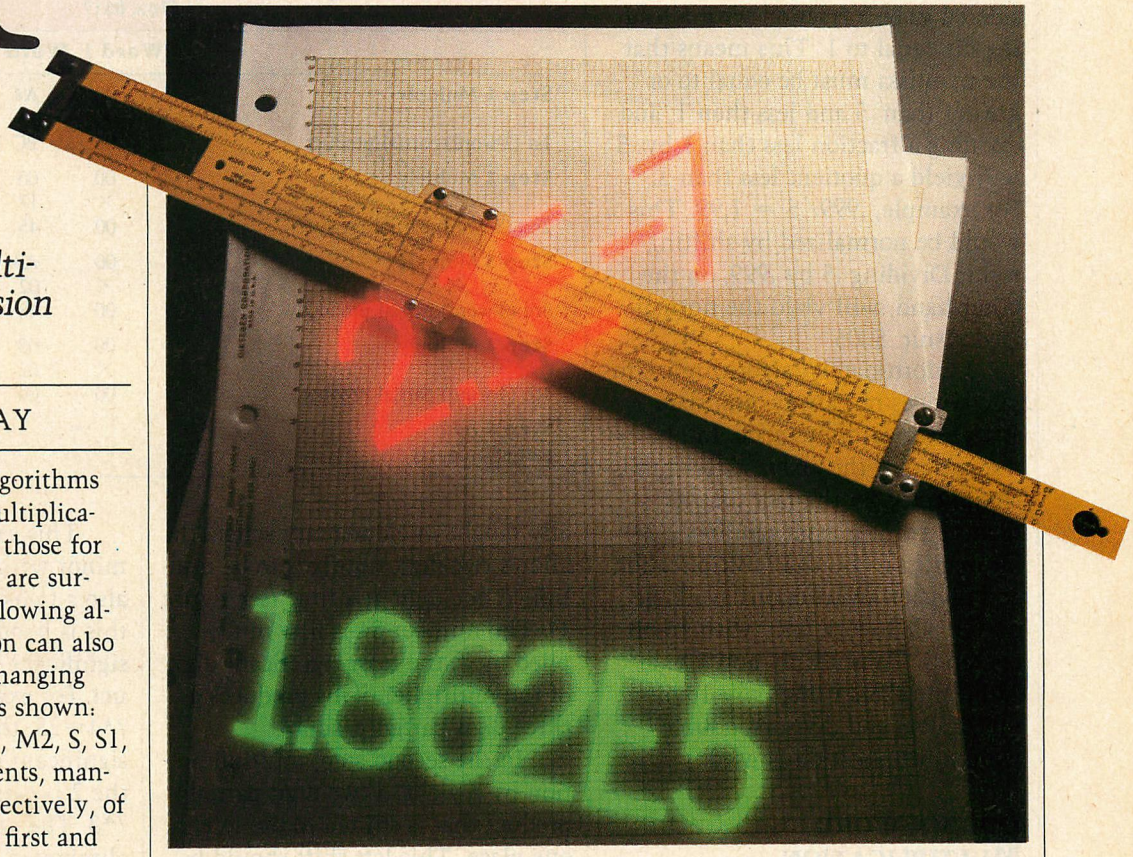

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Floating-point multiplication and division on the IBM PC

ROBERT GRAY

Assembly language algorithms for floating-point multiplication and division, unlike those for addition and subtraction, are surprisingly simple. The following algorithm for multiplication can also be used for division by changing only steps 4 through 6, as shown:

1. Let E, E1, E2, M, M1, M2, S, S1, and S2 be the exponents, mantissas, and signs, respectively, of the result and of the first and second operands
2. Restore leading 1s in M1, M2
3. E2=E2−128 (subtract bias from E2)
4. E=E1+E2 (set product exponent to E1+E2+bias)
5. M=M1 * M2
6. IF M <.5 THEN shift M left 1:E=E−1 (normalize)

For division, use the following instead of steps 4, 5, and 6 above:

4. E=E1−E2 (set result exponent to E1−E2+bias)
5. M=M1/M2
6. IF M > 1 THEN shift M right 1:E=E+1 (normalize)

7. IF S1=S2 THEN S = positive ELSE S = negative
8. Round
9. Set RESULT to E, S, M
10. EXIT.

This algorithm is relatively simple, partly because the binary points do not need to be aligned, and normalization is less complicated for multiplication and division than it is for addition and subtrac-

Robert Gray is an assistant professor of information systems at Virginia Commonwealth University; he teaches courses in advanced programming techniques.

tion. For multiplication, the exponents are added and the mantissas are multiplied. The multiplication of two 24-bit numbers yields a product containing 47 or 48 bits, so normalization requires no more than a single shift to the left. The lower 24 bits are dropped after rounding.

For division, the divisor's exponent is subtracted and the mantissas are divided. The quotient will be at least one-half, but less than 2, and normalization accordingly consists of, at the most, one shift to the right. In order to understand this, recall that, according to the format used on the IBM PC, the mantissa of a floating-point number is considered to be a fraction with a leading bit equal to 1. This means that the mantissa must be equal to or greater than .5 and less than 1, and dividing a fraction less than 1 by .5 will yield a quotient less than 2. For example, .999/.5 = 1.99. This would be normalized by shifting right. Dividing .5 by .999, on the other hand, will yield the normalized result .5005.

Unfortunately, algorithmic simplicity does not always translate straightforwardly to code. Implementation of the above algorithm is complicated by the fact that its floating-point format requires a 24-bit mantissa, and the multiplication and division instructions available on the 8088 work only with 16-bit operands. To multiply and divide 24-bit numbers using only 16-bit multipliers and divisors, double-word multiplication is used.

DOUBLE-WORD MULTIPLICATION

Double-word multiplication poses no great difficulty, because the technique is already familiar to most people, although in a different context. Consider the following:

```
  34
×27
```

The algorithm for solving this kind of multiplication problem is generally taught in elementary school. It allows two-digit numbers to be multiplied one digit at a time (see figure 1). The number 34 is first multiplied by 7, the least significant digit of the multiplier. This produces a three-digit partial product.

In the second step, multiplication by 2 yields a two-digit partial product that is shifted to the left one place. This left shift should be understood. The second partial product is not really being shifted at all; rather, the multiplier, which is actually 20 (20+7=27), was effectively shifted to the right one place. The true product, then, is 680, a three-digit number.

In the third step, the partial products are added in order to yield the final product: 918.

Figure 1: Multiplication of two-digit numbers

34 × 27				
Step 1 Multiply	34 * 7	=	238	first partial product
Step 2 Multiply	34 * 2	=	68	second partial product
Step 3 Add partial products		=	918	final product

Figure 2: Multiplication of two-digit numbers one digit at a time

34 × 27				
Step 1 Multiply	4 * 7	=	28	first partial product
Step 2 Multiply	3 * 7	=	21	second partial product
Step 3 Multiply	4 * 2	=	8	third partial product
Step 4 Multiply	3 * 2	=	6	fourth partial product
Step 5 Add partial products		=	918	final product

Figure 3: Double-word multiplication one word at a time

Hex 03A4 × Hex 0217	Word 1	Word 2		
Step 1 Multiply	00	A4		
	×	17		
1st (2-word) partial product	0E	BC	=	0E BC
Step 2 Multiply	00	03		
	×	17		
2nd (3-word) partial product	00	45	=	00 45 00
Step 3 Multiply	00	A4		
	×	02		
3rd (3-word) partial product	00	48	=	01 48 00
Step 4 Multiply	00	03		
	×	02		
4th (4-word) partial product	00	06	=	00 06 00 00
Step 5 Add partial products			=	00 07 9B BC

This explanation overlooks a minor wrinkle. The multiplicand is also a two-digit number. Ordinarily, this is handled by carrying the most significant digit of the partial product. For example, in the calculation, 7*4=28, the 8 becomes the least significant digit of the product and the 2 is carried into the product of 7*3. The use of carries could be eliminated altogether by simply writing each partial product with the appropriate number of left shifts (see figure 2).

If a word is regarded as a single digit, precisely the same technique may be used to multiply double-word integers on the 8088 (see figure 3). Because it involves only marginally more effort than multiplying 24-bit numbers, the assembly

Figure 4: Multiple-precision division. Remainders are successively divided for extra accuracy.

	Decimal	Hexadecimal	
	$6\overline{)27}$ =	$6\overline{)1B}$	
	Word 1	**Word 2**	
Step 1 Divide			
Dividend=27	0001	1011	
Divisor=6		0110	
Remainder=3	0011		Quotient=4 0100
Step 2 Shift remainder left	0011	0000	
Step 3 Divide			
Dividend=48	0011	0000	
Divisor=6		0110	
Remainder	0000		Quotient= 8 1000
Step 4 Add partial quotients			= Binary 0100.1000
			= Hex 4.8
			= Decimal 4.5

Figure 5: Decimal division. The divisor is continually shifted to the right and divided into those digits of the dividend or remainder above and to the left.

	$23\overline{)5879}$	
Step 1		
Align. Divisor is aligned under leftmost two digits.	5879 23	
Divide. Divisor is divided into digits above and to the left.	58 23	Quotient=2
Subtract.	5879	
2 × 23	= 46	
Remainder	= 1279	
Step 2		
Align. Divisor is shifted right one place.	1279 23	
Divide. Divisor is divided into digits above and to the left.	127 23	Quotient= 5
Subtract.	1279	
5 × 23	= 115	
Remainder	= 0129	
Step 3		
Align. Divisor is shifted right one place.	0129 23	
Divide. Divisor is divided into digits above and to the left.	129 23	Quotient= 5
Subtract.		
5 × 23	129	
Remainder	= 115	
	= 014	Quotient=255

language routine in listing 1 will multiply two 32-bit operands to produce a 63- to 64-bit, or four-word, product. Only the lower 48 bits will be used by the floating-point multiplication routine.

The routine in listing 1 is called by the floating-point multiplication routine in listing 2. Note that the floating-point multiplication and division routines given here exit to common rounding and error

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routines included in the procedure FLOAT_A (see "Significant Figures, I," October 1984, page 54).

DOUBLE-WORD DIVISION

Floating-point division presents two problems. First, although the 8088 allows a double-word dividend, the quotient's length is governed by the length of the divisor, which cannot exceed 16 bits. The floating-point format discussed earlier, however, requires that 24 bits of accuracy be maintained. The 8088 performs an integer division, giving an integer quotient and an integer remainder. It would be best to carry out the division to convert the remainder to a fraction, much as is done in ordinary decimal division when the division is carried out to additional places. The entire result can then be expressed as a 24-bit integer mantissa. For example,

$27/6 = 4\ R\ 3 = 4.5 = .45E+1$

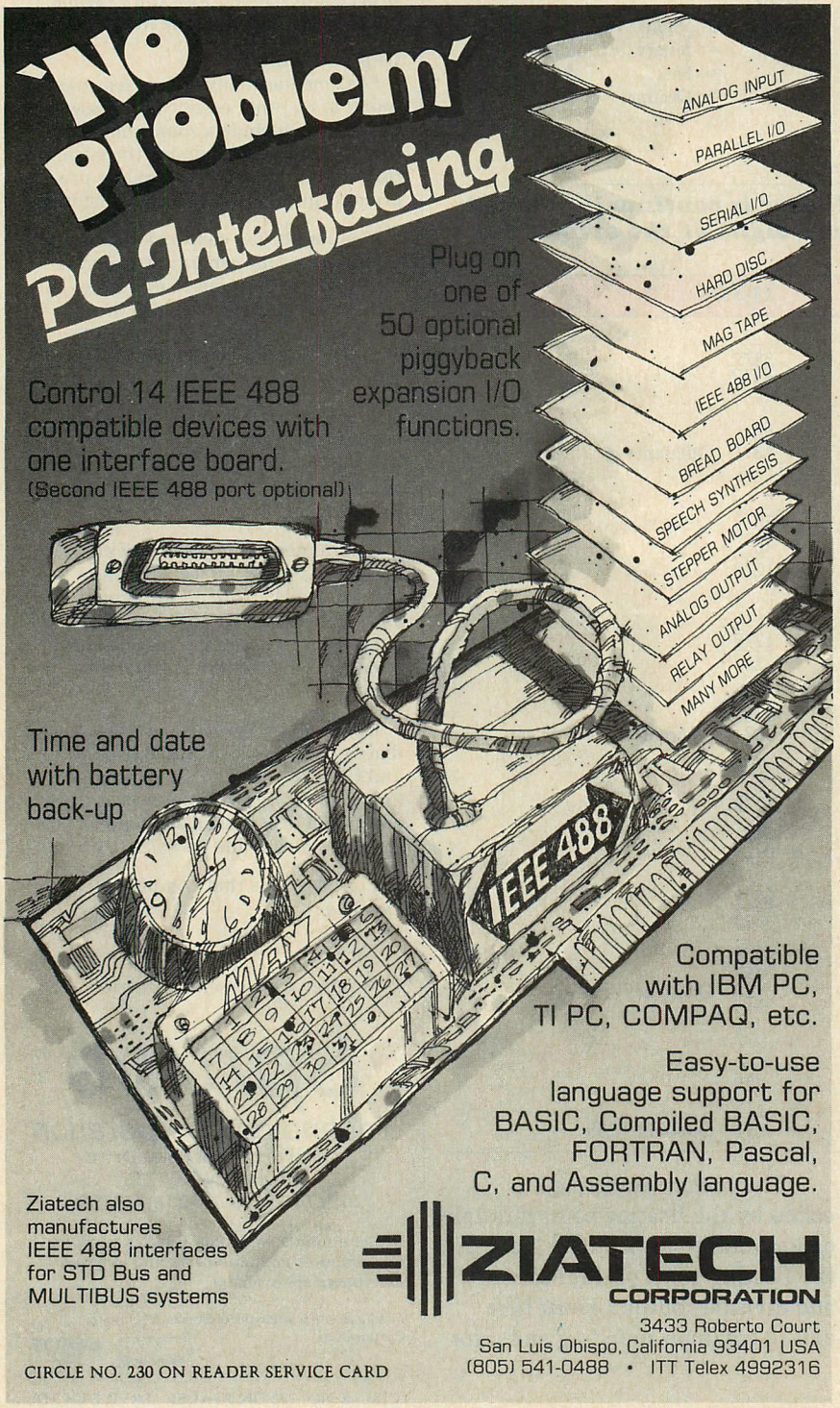
To do this on the 8088 microprocessor, use the same algorithm that is ordinarily used in long division. Assuming that the divisor is a 4-bit number, a technique like that illustrated in figure 4 can be employed. The first step is to divide and obtain a remainder. The remainder is then shifted to the left and divided to yield the next word of the quotient. The remainder from this division is again divided in order to form the third word of the quotient. This process is repeated until the desired number of digits of accuracy is reached.

No simple algorithm exists for dividing by only one digit at a time; the algorithm that is ordinarily used is a matter of guessing.

Constructing an algorithm for this is fairly simple:

1. Q=0; COUNT = the number of words of accuracy desired
2. Repeat the following steps (2.1 through 2.3) COUNT times:
   - 2.1 QT,R = A/B
     (Divide dividend *A* by divisor *B* to yield quotient *QT* and remainder *R*)
   - 2.2 $Q=Q*2^{16}+QT$
     (Shift quotient left one word and add in partial quotient *QT*)
   - 2.3 $A=R*2^{16}$
     (Shift remainder left one word for next division).

This algorithm will allow the 8088's division instruction to be used in order to obtain a quotient of more than 16 bits. Unfortunately, this algorithm does not address the other problem posed by double-



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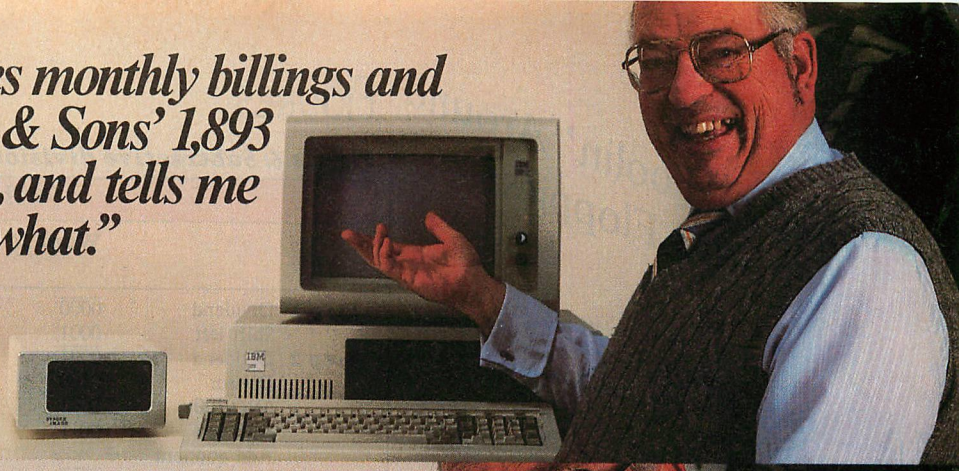

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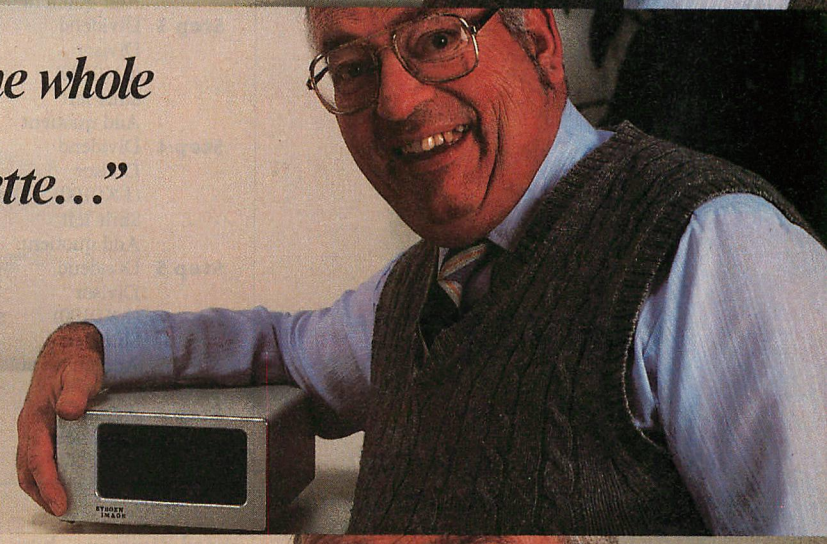

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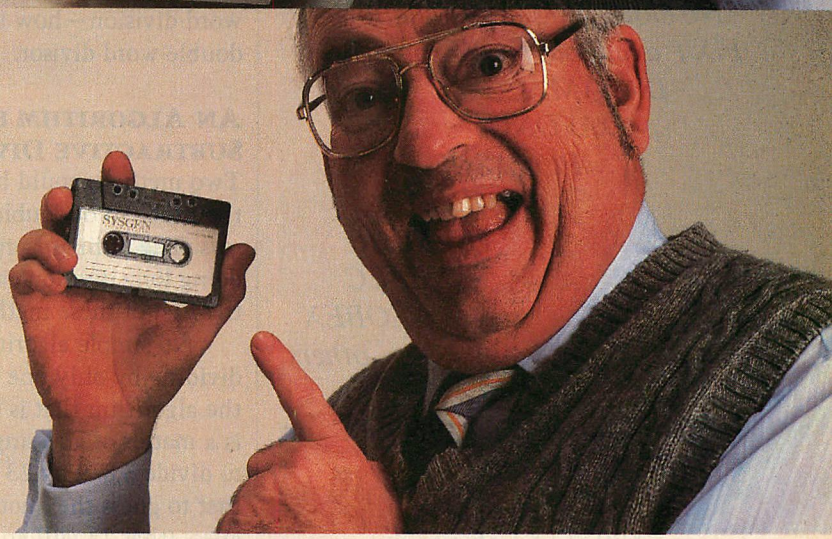

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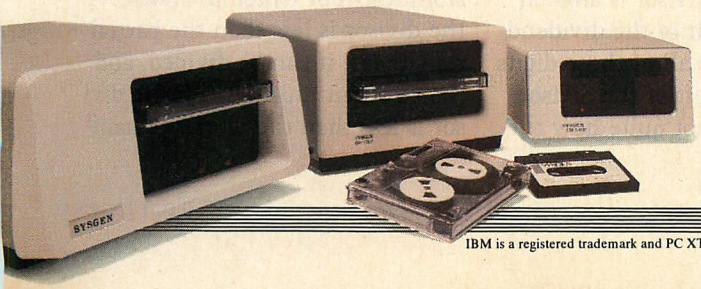

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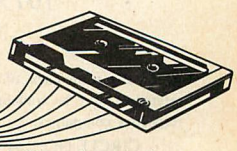

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Figure 6: Subtractive division

4)13 = 0100)1101

			Word 1		Word 2	
Step 1	Dividend		0000		1101	
	Shift left		0001		1010	
Step 2	Dividend		0001		1010	
	Divisor		0100		> 0001 101	so quotient = 0
	(0×0100)	=	0001		1010	
	Shift left		0011		0100	
	Add quotient	+			0	
Step 3	Dividend		0011		0100	
	Divisor		0100		> 0011 01	so quotient = 0
	(0×0100)	=	0011		0100	
	Shift left		0110		1000	
	Add quotient	+			0	
Step 4	Dividend		0110		1000	
	Divisor		0100		< 0110 1	so quotient = 1
	(1×0100)	=	0010		1000	
	Shift left		0101		0000	
	Add quotient	+			1	
Step 5	Dividend		0101		0001	
	Divisor		0100		< 0101	so quotient = 1
	(1×0100)	=	0001		0000	
	Shift left		0010		0010	
	Add quotient	+			1	
			0010		0011	
Step 6	Adjust remainder		0001		0011	
			Remainder		Quotient	

word division—how to divide by a double-word divisor.

AN ALGORITHM FOR SUBTRACTIVE DIVISION

Two methods could be used to solve the problem of double-word divisors. The ordinary procedure for doing long division can help clarify the first of these methods.

No simple algorithm exists for dividing by only one digit at a time; the algorithm that is ordinarily used is a matter of guessing. For example, to divide 5,879 by 23 it is necessary first to guess the quotient. That guess (that 23 will go into 58 three times, for example) is tested by calculating the actual quotient (which, for this example, would show the guess to be incorrect, because 3*23>58), and the estimate is lowered (or raised) accordingly. The process is illustrated in figure 5.

Initially, the divisor is aligned under the first digit of the dividend, and we divide into all of those digits above and to the left of the divisor. Of course, this is not quite how the process is explained in school, but the effect is the same. The correct quotient is determined by guesswork. In figure 5, it is 2. The divisor is then multiplied by this quotient and subtracted from the dividend to form a partial remainder.

The divisor is then shifted right and divided into the partial remainder. When the quotient is 0 (that is, when the divisor is larger than the partial remainder), multiplying the quotient times the divisor yields 0. In this case, no subtraction is performed, but the divisor is still shifted to the right.

None of the individual components of this long-division algorithm involves division. Quotients are guessed. Remainders are found by multiplication and subtraction. In binary, this method is even simpler. In the first place, the guesswork is eliminated. There are only two possibilities from which to choose. If the divisor is less than the partial remainder, it can be divided, and the quotient must be 1. If the divisor is less than the partial remain-

der, the quotient is 0. Furthermore, since the only possible quotients are 1 and 0, the multiplication is unnecessary. The product must be equal to 0 or to the divisor. The algorithm is therefore reduced to one of successive subtraction.

This is the technique typically used on microprocessors that lack a division instruction. The algorithm, which is shown below, is not difficult. It is, in fact, simply a variant of the algorithm that is ordinarily used to divide decimal numbers.

1. Let A=dividend: B=divisor: Q=0
2. A=A*2 (Shift dividend left one)
3. Repeat steps 4 and 5 *N* times (*N* is the number of bits that are in the divisor)

Because the only operations that affect both words are subtraction and shifting, it is a fairly simple matter to adapt the subtractive algorithm for use with double-word operands.

4. IF A ≥ B THEN
   A=A−B
   (Subtract quotient bit times the divisor to form a new partial remainder)
   Q=Q*2+1
   (Because *A* can be divided by *B*, this bit is a 1)
   ELSE
   Q=Q*2+0
   (*A* cannot be divided by *B*, so this bit is 0)
5. A=A*2
   (Shift the dividend/partial remainder left)
6. R=A/2
   (Shift remainder to the right one space to adjust)

This algorithm leaves the quotient in Q and the remainder in *A*. Because *A* is shifted to the left *N*+1 times, *A* must contain space for 2*N* bits (the carry flag is able to hold the shifted bit on the first shift). Another 2*N* bits are required to store the divisor and the quotient. The algorithm can be refined slightly to save at least the space that is required for the quotient.

The dividend is shifted to the left once on each iteration. After the last iteration, the upper *N* bits of the original dividend contain the remainder, and the lower *N* bits are empty. By modifying steps 4 and 5 of the algorithm described above, those otherwise unoccupied bits can be used to store the quotient. Change steps 4 and 5 as follows:

4. IF A ≥ B THEN
   A=A−B:Z=1
   ELSE Z=0

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5. A=A*2
   A=A+Z (place new quotient bit in bit just vacated)

At the end, the low-order *N* bits of the original dividend will contain the quotient, and the high-order bits will contain the remainder. This is precisely how the divide instruction works on the Intel 8088 microprocessor. The technique for this subtractive division is illustrated for a 4-bit divisor in figure 6.

Because the only operations that affect both words are subtraction and shifting ($A=A*2$ is equivalent to a shift to the left), adapting this algorithm for use with double-word operands is a fairly simple matter. The user should just remember to subtract the borrow, if any, from the upper word and to rotate the carries when shifting.

A Nonsubtractive Algorithm

D. E. Knuth, in *The Art of Computer Programming*, vol. 2 (Reading, MA: Addison-Wesley, 1973), provides an alternative approach to the problem of dividing by a double-word divisor. The following convention may be used for writing the double-word operand *M*:

M=MHI+eMLO

where *e* is $1/2^{16}$. This is just another way of indicating that MHI is 2^{16} times greater than MLO, or that it occupies the high word. Then, according to Knuth, the double-word division M1/M2 is *approximately* equivalent to

```
(M1HI+eM1LO)/
  (M2HI+eMELO) =
((M1HI+eM1LO)/
  M2HI)*(1-(M2LO/M2HI) )
```

With some thought and much head-scratching, the following four-step algorithm can be derived:

1. B=(M2LO/M2HI)/2^{16}
   (Divide divisor low word by divisor high word; that is, compute proportion of divisor that is a result of low word)
2. B=1-B
   (Subtract it from 1)
3. A=M1/M2HI
   (Divide dividend by high word of divisor)
4. M=A*B
   (Subtract that part of the quotient that results from the missing part of the divisor)

The division by 2^{16} is not really necessary. The effect can be obtained by shifting the operands. In this case it simply means, for example, that *B* is subtracted from the word following the 1.

The subtractive algorithm has the advantage of being conceptually simple and easily implemented. It does not, however, take advantage of the 8088's divide instruction and

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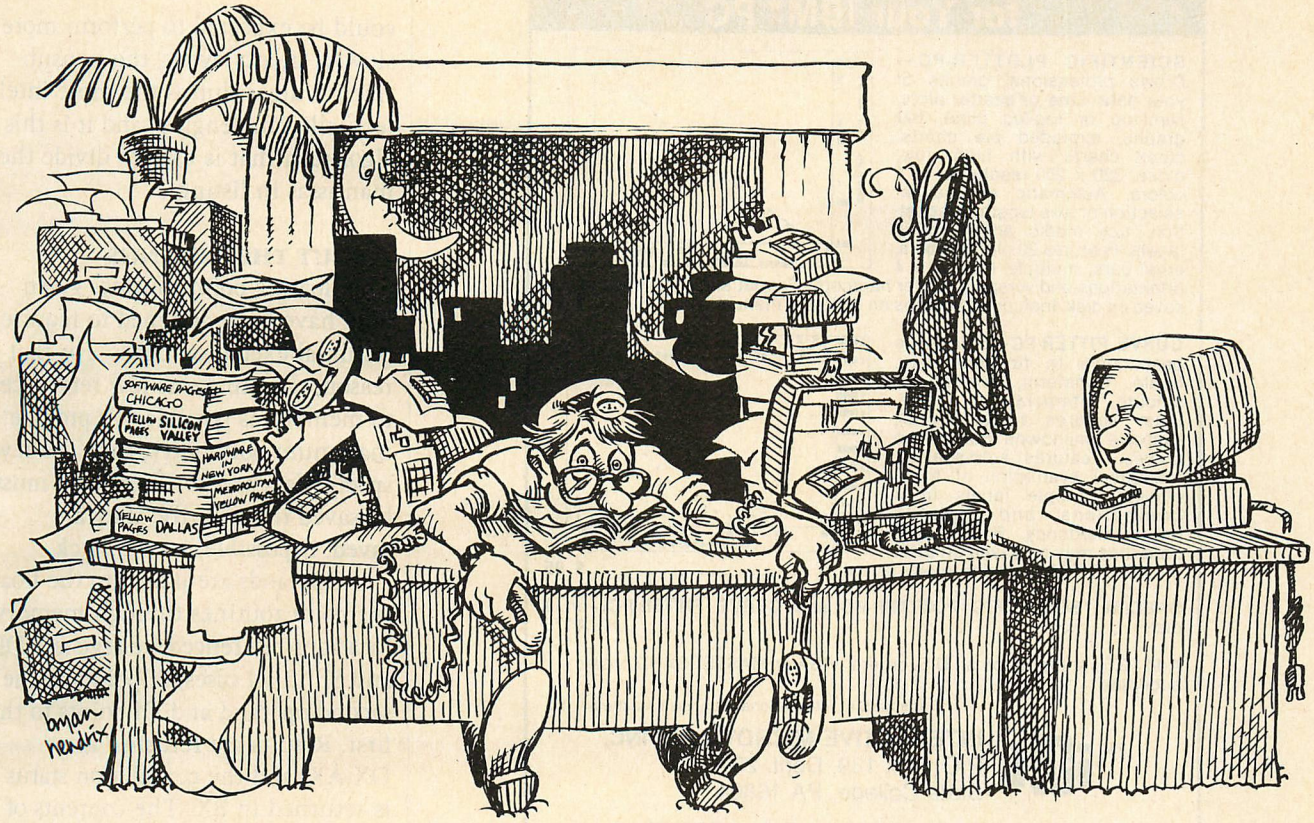

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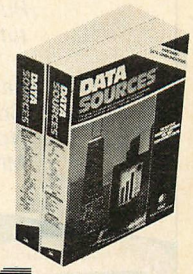

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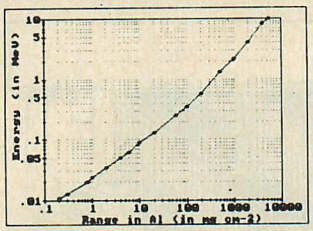

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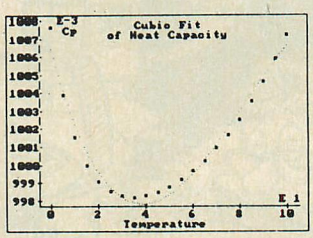

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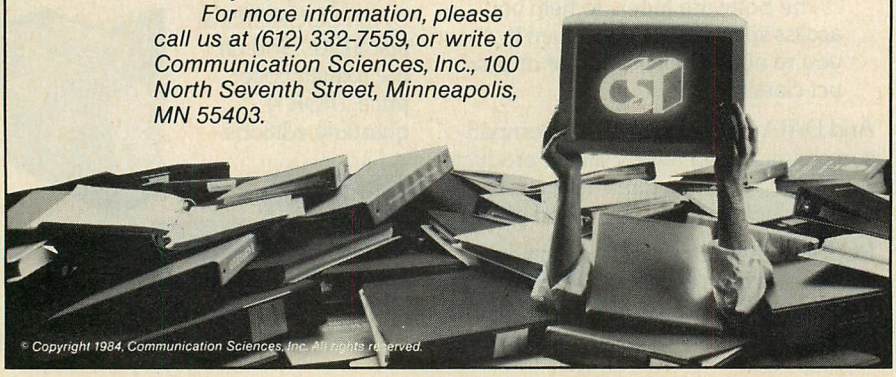

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could be expected to perform more slowly. In any event, the nonsubtractive algorithm is the more intellectually challenging, and it is this algorithm that is used to divide the mantissas in listing 3.

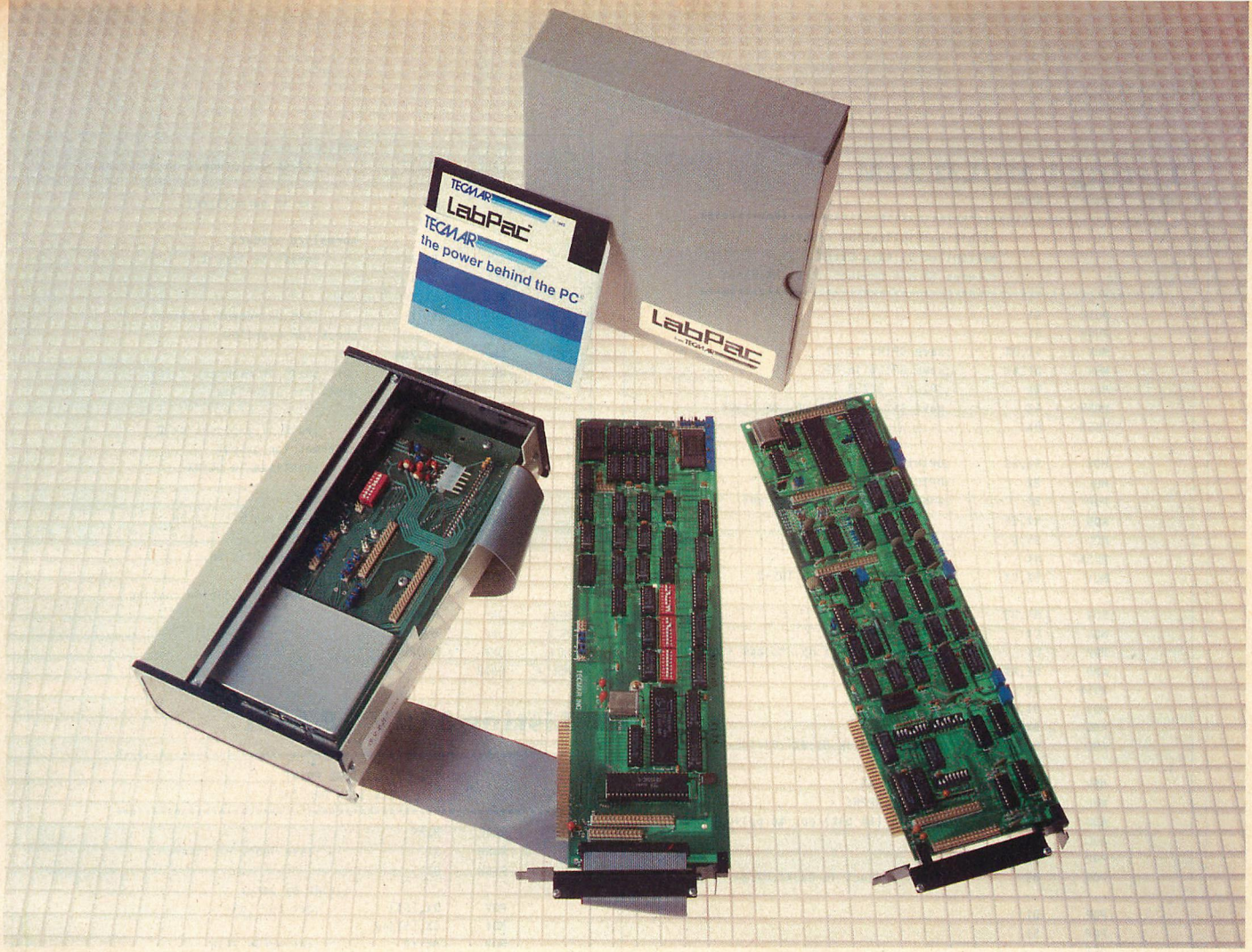
ABOUT THE LISTINGS

The floating-point routines given here have been designed to require minimal execution times. For that reason, they make as few references to memory as possible. To provide maximum portability, they use few special data areas. Where data must be saved temporarily, they are saved, if possible, on the stack.

Operands are passed to the floating-point routines through memory locations referenced by registers DI and SI. In all cases, SI points to the second operand and DI points to the first. Results are returned in DX:AX, and the completion status is returned in BX. The contents of CX are destroyed. SI and DI are preserved. All routines use common exit and error routines contained in the addition routine published in my article in the October issue.

When floating-point numbers are stored, the routines require that the low word be stored first. This may seem backwards, but it actually takes advantage of what is otherwise a confusing aspect of the 8088. A register with contents 1 2 would appear in memory as 2 1. A double-word operand with contents 1 2 3 4 would be stored as 2 1 4 3. This is not very clear. Storing the low word first, however, gives 4 3 2 1. Debugging with eight-digit hexadecimal numbers is frustrating enough without rearranging their parts.

Programmers should find these simple algorithms helpful when they are working with floating-point multiplication and division.



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Listing 1 MUL32.ASM

```
MUL32   PROC    NEAR
;***************************************************************
;                   32 bit multiplication routine
;                   multiplies DX:AX x CX:BX
;                   returns 64 bit product in DX:AX:CX:BX
;***************************************************************
        PUSH    SI
        PUSH    DI
        MOV     SI,DX       ;save OP1HI in SI
        MOV     DI,AX       ;save OP1LO in DI
        MUL     BX          ;OP1LO x OP2LO
        PUSH    AX          ;save 1st (32 bit) pp. on stack
        PUSH    DX
;
        MOV     AX,SI       ;OP1HI in AX
        MUL     BX          ;OP1HI x OP2LO
        POP     BX          ;add 2nd (48 bit) pp. to pp1
        ADD     AX,BX
        ADC     DX,0
        PUSH    AX
        MOV     BX,DX       ;pp1 + pp2 in BX:TOS:TOS+2
;
        MOV     AX,DI       ;OP1LO in AX
        MUL     CX          ;OP1LO x OP2HI
        POP     DI          ;add 3rd (48 bit) pp. to pp1 + pp2
        ADD     DI,AX
        PUSH    DI
        MOV     DI,0
        ADC     BX,DX
        ADC     DI,0        ;pp1+pp2+pp3 in DI:BX:TOS:TOS+2
;
        MOV     AX,SI       ;OP1HI in AX
        MUL     CX          ;OP1HI x OP2HI
        ADD     AX,BX       ;add 4th (64 bit) pp. to pp1+pp2+pp3
        ADC     DX,DI
        POP     CX
        POP     BX          ;final product in DX:AX:CX:BX
;
        POP     DI
        POP     SI
        RET
MUL32   ENDP
```

Listing 2 MUL_F.ASM

```
MUL_F   PROC    NEAR
;***************************************************************
;                   floating point
;                 multiplication routine
;***************************************************************
        PUSH    SI              ;save index registers
        PUSH    DI
        SUB     DX,DX           ;clear work registers
        MOV     AX,DX
        MOV     BX,DX
        MOV     CX,DX
;                           check for zero operand
        OR      DX,[DI]+2       ;OP1 high word in DX
        JZ      MF2             ;zero only if operand is 0
        OR      CX,[SI]+2       ;OP2 high word in CX
        JZ      MF2
;                           compute exponent
        MOV     AL,DH           ;E1 in AX
        MOV     BL,CH           ;E2 in BX
        SUB     BX,128          ;subtract bias
        ADD     AX,BX           ;E=E1+E2+bias
;
        MOV     BX,[SI]         ;get OP2 low word in BX
        MOV     SI,AX           ;save exponent in SI
        MOV     AX,[DI]         ;get OP1 low word in AX
        SUB     DH,DH           ;clear high bytes
        MOV     CH,DH           ;M1 is DL:AX; M2 is CL:BX
;                           compute result sign
        MOV     DI,DX
        XOR     DI,CX
        AND     DI,10000000B    ;isolate sign bit in DI
;                           restore leading ones
        OR      DL,10000000B
        OR      CL,10000000B
;                           multiply mantissas
        CALL    MUL32           ;47-48 bit product in AX:CX:BX
;
        OR      AX,AX           ;is it normalized?
        JS      MF1
;                           normalize product
        SHL     BX,1            ;shift it left 1
        RCL     CX,1
        RCL     AX,1
        SUB     SI,1            ;and decrement exponent
;                           check for overflow
MF1:    CMP     SI,255
        JG      MF3             ;exit if exponent > 255
;                           check for underflow
        CMP     SI,0
        JLE     MF4             ;exit if exponent <= 0
;                           reformat for output
        MOV     DL,AH           ;mantissa in DL:AX
        MOV     AH,AL
        MOV     AL,CH
        MOV     DH,CL           ;trailing bits in DH
        MOV     CX,BX           ;and CX
        MOV     BX,SI           ;exponent in BH
        MOV     BH,BL
        JMP     RO              ;ROUND in addition routine
MF2:    JMP     FINISH
MF3:    JMP     OVER_F
MF4:    JMP     UNDER_F
MUL_F   ENDP
```

Listing 3 DIV__F.ASM

```
;***************************************************************
;                       FLOATING POINT
;                     DIVISION ROUTINE
;***************************************************************
DIV_F   PROC    NEAR
        PUSH    SI              ;save index registers
        PUSH    DI
;                           divide by zero?
        MOV     DX,[SI]         ;get op2 (divisor) in CX:DX
        MOV     CX,[SI]+2
        MOV     BX,10           ;set error flag
        MOV     AX,DX           ;is op2 zero?
        OR      AX,CX
        JNZ     D1              ;if zero, quit with BX=10
        JMP     EXIT
;                           compute result sign
D1:     MOV     AL,CL           ;OP1 high byte in AL
        XOR     AL,[DI]+2       ;XOR with OP2 high byte
        AND     AX,0080H        ;isolate sign bit
        PUSH    AX              ;save it
;                           compute exponent
        SUB     AX,AX
        MOV     BX,AX
        MOV     AL,CH           ;E2 in AX
        MOV     BL,[DI]+3       ;E1 in BX
        SUB     AX,128          ;remove bias
        SUB     BX,AX           ;E1-E2
        INC     BX              ;add 1 since shift right later
;
        CMP     BX,255          ;overflow if
        JLE     D3              ;E>255
        JMP     D13
;
D3:     CMP     BX,0            ;underflow if
        JGE     D5              ;E<0
        JMP     D14
;                           compute 1-(OP2LO/OP2HI)/2^16
D5:     PUSH    BX              ;save E in BL
        SUB     AX,AX
        MOV     BH,CL           ;OP2HI in BX
        MOV     BL,DH
        OR      BH,10000000B    ;restore leading 1
        MOV     DH,DL           ;OP2LO in DX
        MOV     DL,AL
        OR      DX,DX           ;if OP2LO is zero
        JNZ     D6
        XCHG    BX,AX           ;put OP2HI in AX
        MOV     SI,BX           ;set result in BX:SI to zero
        JMP SHORT D8            ;and skip this step
```

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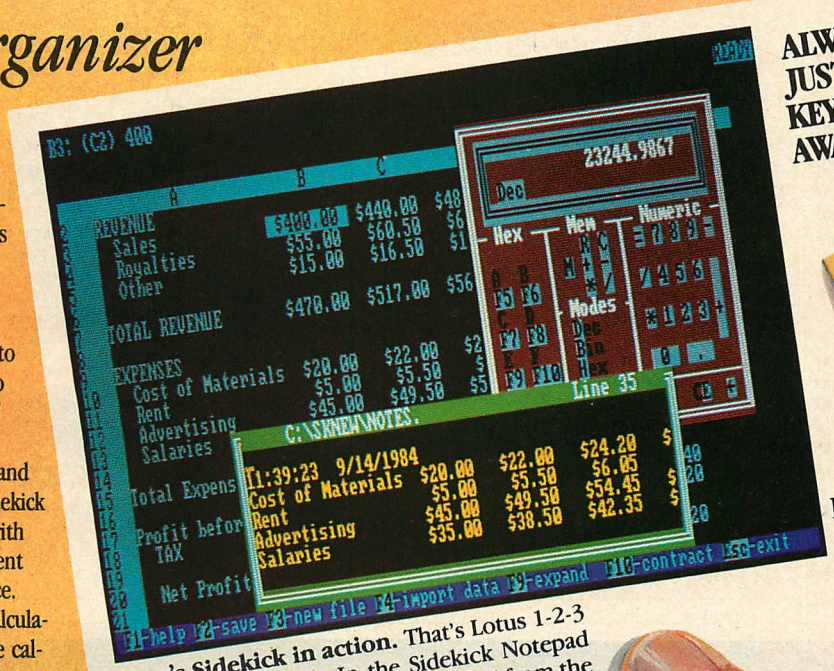

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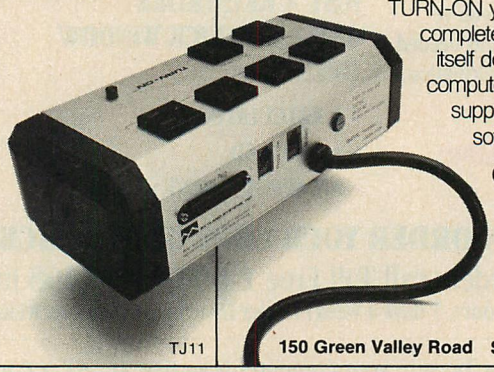
```
;                                   compute OP2LO/OP2HI first
D6:     SUB     CX,CX
        CMP     DX,BX           ;if OP2LO>=OP2HI, quotient>=1
        JB      D7
        SUB     DX,BX           ;subtract OP2HI to prevent overflow
        MOV     CX,1            ;save quotient 1 or 0 in CX
;
D7:     DIV     BX              ;OP2LO/OP2HI now in CX:AX
;
        PUSH    CX              ;save OP2LO/OP2HI
        PUSH    AX
        SUB     AX,AX           ;divide remainder in DX:AX
        DIV     BX
        POP     DX
        POP     CX              ;OP2LO/OP2HI in CX:DX:AX
;                               subtract it from 1
        PUSH    DI              ;save DI & OP2HI
        PUSH    BX
        SUB     DI,DI           ;clear registers
        MOV     SI,DI
        MOV     BX,DI
        SUB     DI,AX
        SBB     SI,DX
        SBB     BX,CX
        POP     AX              ;retrieve OP2HI & DI
        POP     DI
;                               compute OP1/OP2HI
D8:     PUSH    BX              ;save 1-OP1LO/OP2HI
        PUSH    SI
        MOV     BX,AX           ;OP2HI in BX
        SUB     AX,AX           ;clear AX & SI
        MOV     SI,AX
        MOV     DX,[DI]+1       ;OP1 in DX:AX
        OR      DH,10000000B    ;restore leading 1
        MOV     AH,[DI]
;
        CMP     DX,BX           ;if OP1>=OP2HI
        JB      D9
        SUB     DX,BX           ;subtract OP2HI to prevent overflow
        INC     SI              ;and save quotient of one in SI
```

```
;
D9:     DIV     BX              ;divide OP1/OP2HI
        MOV     CX,AX           ;save quotient in CX
        SUB     AX,AX
        DIV     BX              ;divide remainder in DX
        MOV     DX,CX           ;OP1/OP2HI now in SI:DX:AX
        SHR     SI,1            ;shift it right
        RCR     DX,1
        RCR     AX,1            ;now in DX:AX
;                               compute (OP1/OP2HI)*(OP2LO/OP2HI)/2^16
        POP     BX              ;1-OP2LO/OP2H9)/2^16 in CX:BX
        POP     CX
        MOV     SI,BX           ;if OP2LP/OP2HI was zero
        OR      SI,CX           ;product is OP1/OP2HI
        JZ      D10             ;so no need to multiply
        CALL    MUL32           ;do the multiplication
;                               normalize
D10:    POP     BX              ;get exponent in BX
D11:    OR      DX,DX
        JS      D12             ;if sign bit off
        SHL     CX,1            ;shift it left
        RCL     AX,1
        RCL     DX,1
        DEC     BX              ;decrement exponent
        JMP     D11             ;see if normalized
;                               reformat for output
D12:    MOV     BH,BL           ;exponent in BH
        XCHG    AH,AL           ;move trailing bits up to DH
        XCHG    DL,AH           ;4 byte mantissa in DL:AX:DH
        XCHG    DH,DL
        SUB     CX,CX
        POP     DI              ;result sign in DI
        JMP     RO              ;ROUND in addition routine
;
D13:    POP     DI              ;get sign in DI
        JMP     OVER_F
D14:    POP     AX              ;remove sign from stack
        JMP     UNDER_F
DIV_F   ENDP
```


how to be two places at once



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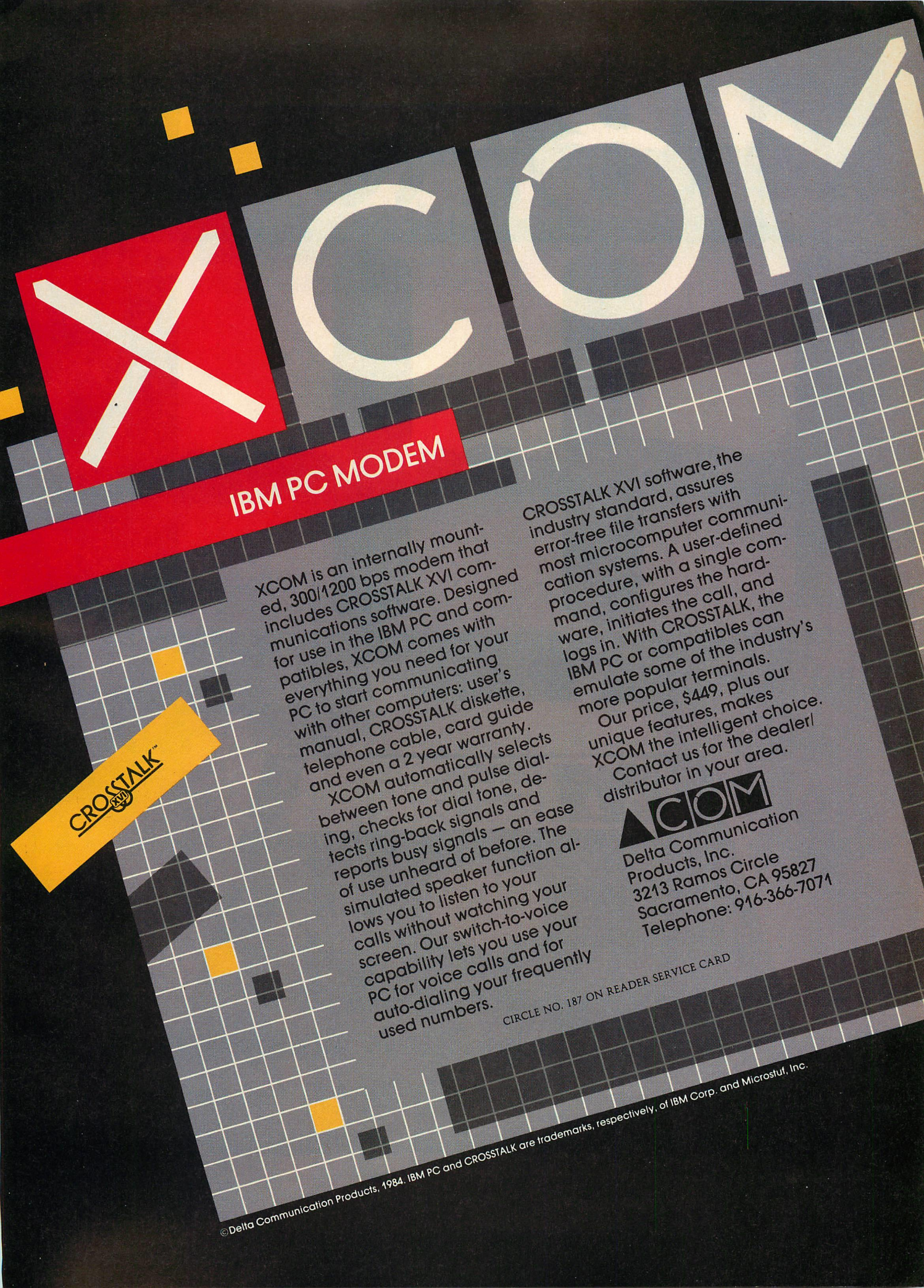
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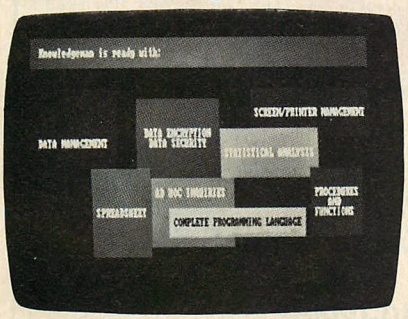

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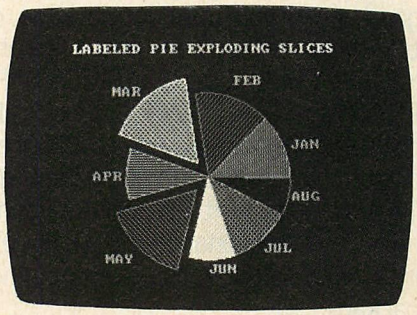

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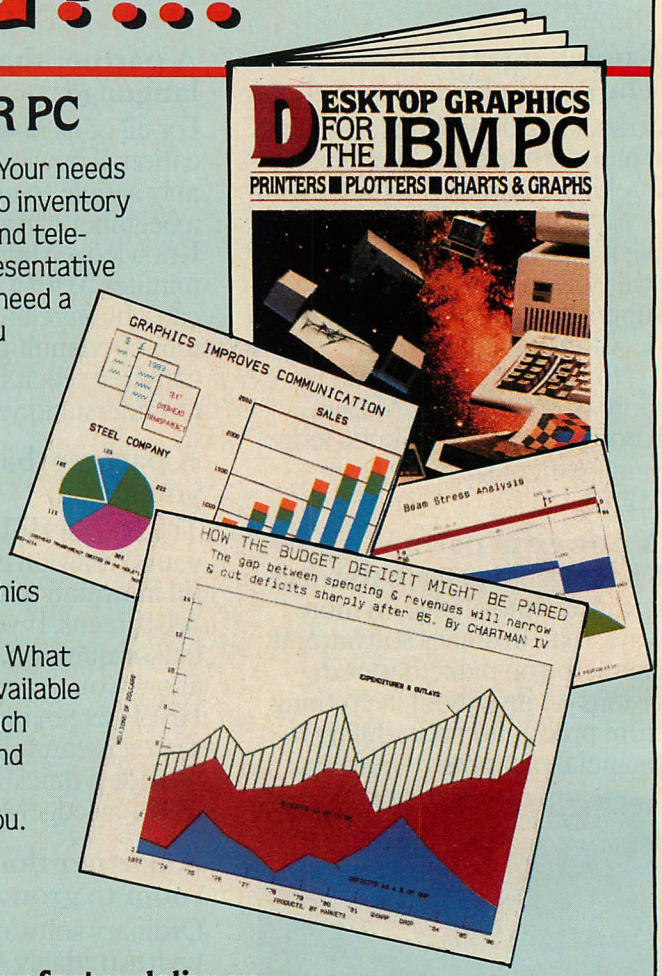

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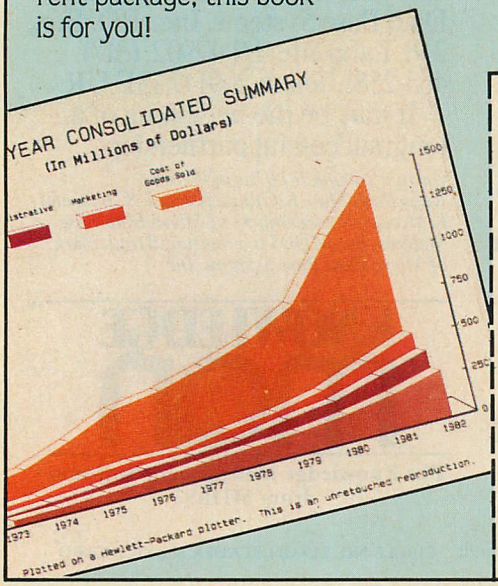

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A DIGITAL-INPUT PORT

Adapting the serial communications port in the IBM PC to generate an external interrupt and accept four-bit input

RAYMOND DEMERS

The serial communications port in the IBM PC permits the simplest of circuitry to be used to generate an external interrupt and to accept a four-bit input from switch or relay contact closures. The programmer can generate an interrupt alone; an interrupt along with the ability to accept four-bit digital input as a combination of the four bits; or an interrupt along with the ability to accept data one bit at a time.

These functions can be controlled with BASIC, using the statement ON COM(n), which sets up a line number to which the program branches when there is information coming into the communications buffer (see listing 1). This buffer indicates that it is receiving information when the voltage on pin 4 (Request to Send) is momentarily bridged to pin 3 (Received Data), assuming the RS-232-C port is configured as Data Terminal Equipment (DTE). If a programmer wants an external contact closure to make something happen in his program, he should wire the contacts to pins 3 and 4 (see figure 1). (Table 4 shows bit and pin names and values.)

Raymond DeMers is district sales manager for Ramtek, a manufacturer of sophisticated color graphics systems in Pittsford, NY.

Figure 1: Circuit to Generate an Interrupt Alone

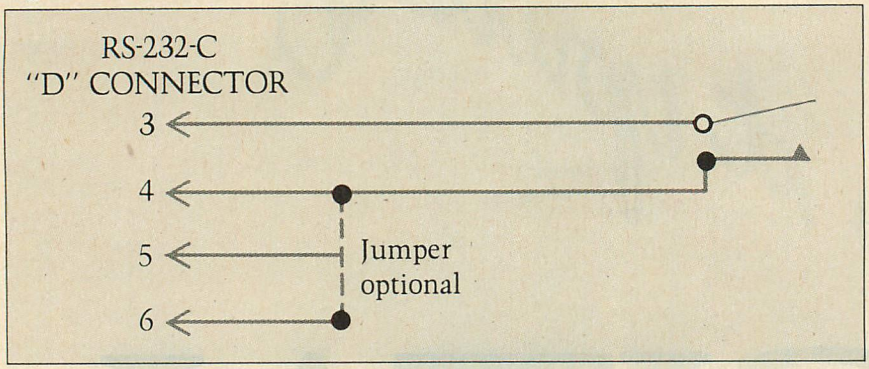


Figure 2: Circuit to Generate an Interrupt along with the Ability to Read Digital Input as a Combination of the Four Bits

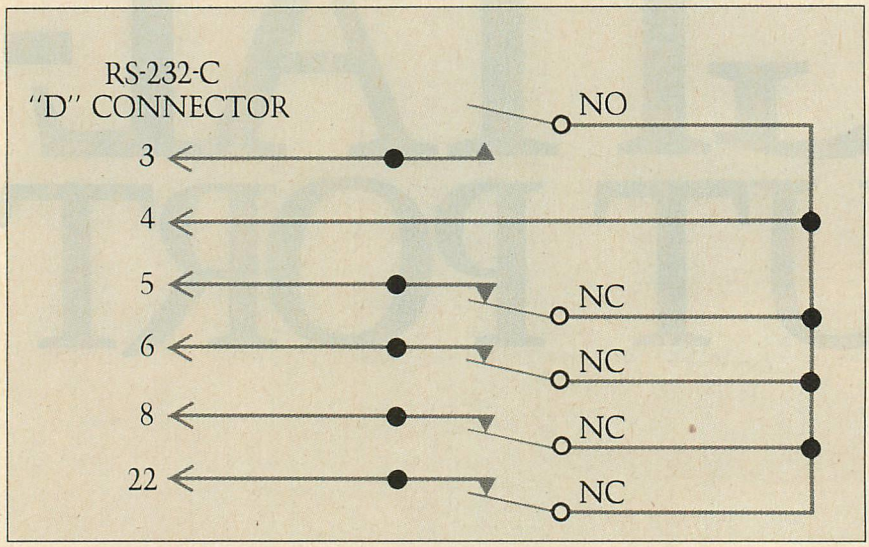
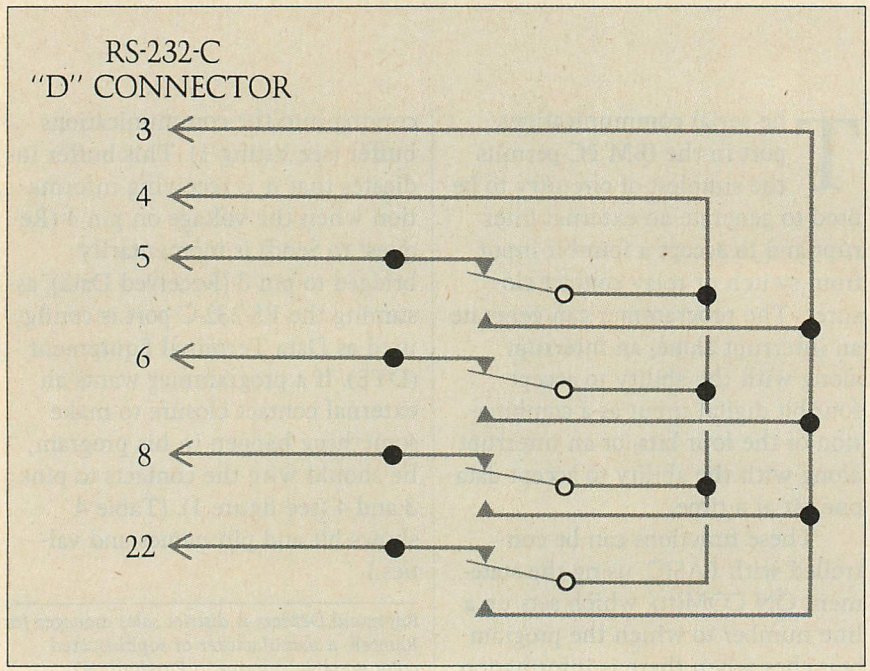


Figure 3: Circuit to Generate an Interrupt along with the Ability to Read Digital Input One Bit at a Time



To generate an interrupt only, use the statement

OPEN "COMn: , , , , CS,DS" AS 1

to direct the system to ignore the Clear-to-Send (CTS) and Data-Set-Ready (DSR) inputs. Another option is to use the default statement; *this* may be used only if pin 4 (RTS), pin 5 (CTS), and pin 6 (DSR) are jumpered on the plug. Failure to use one of these options will produce a communications error.

If a programmer wants to read digital input after the interrupt occurs, he should wire the contacts to pins 6 (DSR), 8 (RLSD), and 22 (RI). The default statement OPEN "COM . . ." is used, and the necessary input voltages are provided by the normally closed switches, one for each of the four input lines. Figure 2 shows the configuration that permits data to be read as a combination of the four bits.

The switches in this figure permit a value from 0 to 15 to be input. After the desired combination of data switches is opened, the normally open switch is closed to cause an interrupt and permit the subroutine to read the value and do something with it. The data switches must be reclosed before the next OPEN "COM statement.

The circuit in figure 2 allows digital input to be read from one bit at a time. The digital value and the interrupt are generated by the same switch, a momentary-contact type.

With COM (1) ON, BASIC looks for an input in the communications port as every statement is executed; when input is detected, the program branches to the indicated subroutine. The first statement in the subroutine provides debouncing by shutting off the interrupt capability so that erroneous inputs caused by contact bounced will be prevented. The interrupt is turned back on before the program leaves the subroutine.

If the circuits were set up to generate an interrupt only, nothing

Table 1: Bit and Pin Names and Values

Bit in Use	Value	Pin #	Abbr.	Input Name
4	16	5	CTS	Clear/-to/-Send
5	32	6	DSR	Data/-Set/-Ready
6	64	22	RI	Ring Indicator
7	128	8	RLSD	Received Line Signal Detector

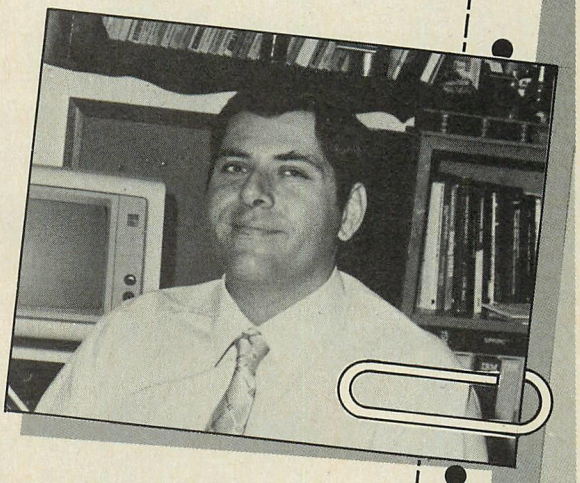
more need be done. If a digital value is also being input, the value needs to be read; it can be found by looking at the Modem Status Register at address hex 3FE or decimal 1022. For the switches in figure 2, the value will be between 0 and 240, in steps of 16, in proportion to the switches set. For figure 3, the value will be 112, 176, 208, or 224.

The techniques described above will give programmers another digital input port at virtually no cost. Two possible uses for this capability are the attachment of "foreign" devices to the PC and the use of a modem connected to this digital-input port; imaginative programmers will undoubtedly discover many other possibilities.

Listing 1 TEST.BAS

```
1000 '      **********  TEST FOR INTERRUPT INPUT  **********
1010 '
1020 OPEN "COM1:" AS 1            ' OPEN WITH DEFAULT SETTINGS
1030 COM (1) ON                   ' ENABLE INTERRUPT
1040 ON COM (1) GOSUB 2000        ' WHERE TO GO WHEN INT. RECEIVED
1050 CLS
1060 LOCATE 25,30                 ' FIND DISPLAY AREA
1070 PRINT "INPUT VALUE ="        ' PRINT CONSTANT
1080 COUNT=COUNT+1                ' COUNTER
1090 PRINT "THIS IS LINE";COUNT   ' BUSY WORK FOR SCREEN
1100 GOTO 1080                    ' GO BACK
1110 '
1120 '      **********  END OF MAIN PROGRAM  **********
1130 '
1140 '
1150 '      **********  INTERRUPT SERVICE SUBROUTINE  **********
1160 '
2000 COM (1) OFF                  ' DEBOUNCE BY TURNING OFF INT.
2010 LOCATE 25,43                 ' FIND DISPLAY AREA
2020 PRINT INP(1022);" "          ' DISPLAY TOTAL OF DIGITAL INPUT
2030 FOR K=1 TO 500:NEXT          ' DECODE AND USE INPUT HERE
2040 COM (1) ON                   ' TURN INTERRUPT BACK ON
2050 RETURN                       ' RETURN TO MAIN PROGRAM
2060 '
2070 '      **********  END OF SUBROUTINE  **********
```


Hello, I'm Bill Salkin . . .



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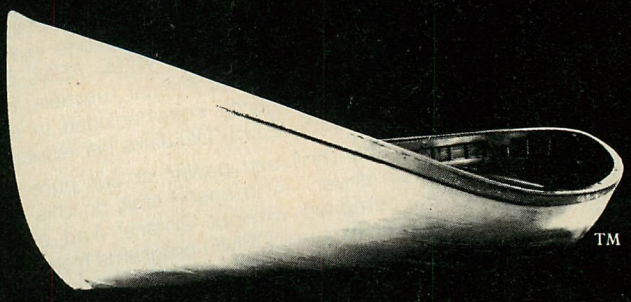

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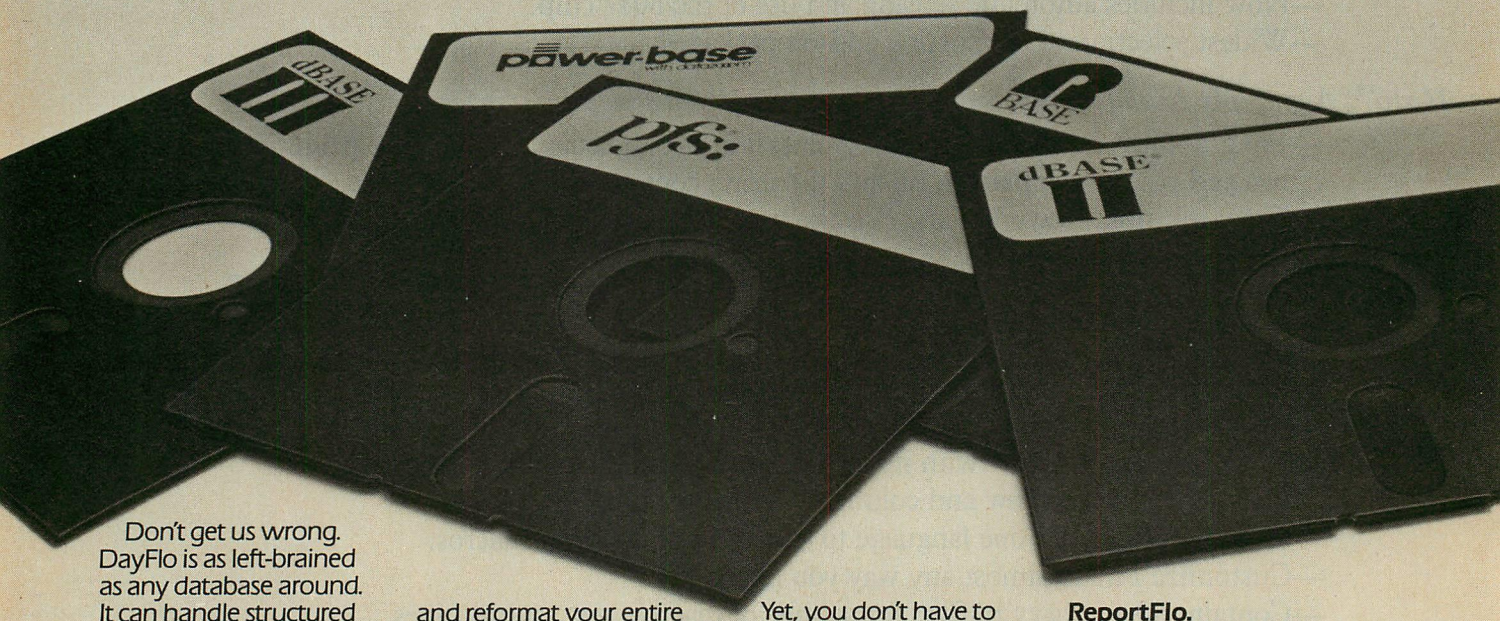
Traditionally, databases have been left-brained.



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• Fixed field length.	• Variable field length. No counting character spaces.
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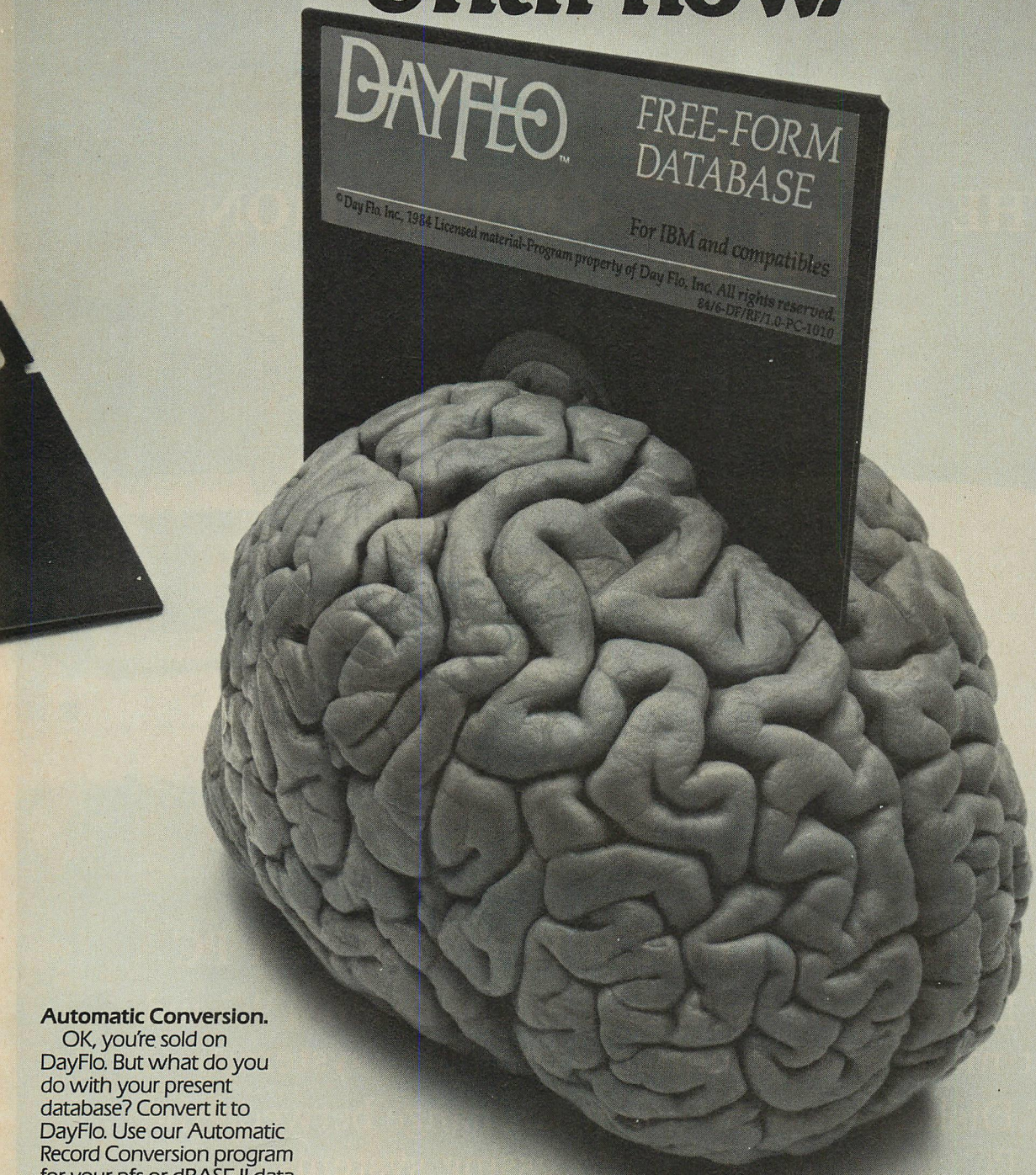

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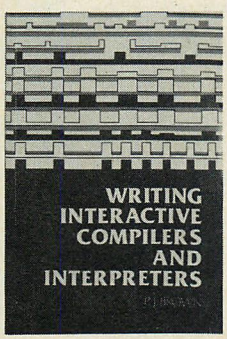

Writing Interactive Compilers and Interpreters
P. J. Brown
(John Wiley & Sons Ltd., New York, 1981)
265 pages; paper, $15.95

The State of Maryland recently instituted a law requiring automobiles to be inspected annually for emissions control. To this end, it thoughtfully set up eight stations to service the entire state. A sweltering day in July therefore found me sitting amidst a sea of noxiously idling cars (many of which were releasing clouds of black smoke and had as much chance of passing the test as growing diamonds in their distributor caps) reading a book on compiler design. The fact that I managed to read every one of the 265 pages will give the reader some idea of my attitude toward the Maryland Department of Motor Vehicles. P. J. Brown's *Writing Interactive Compilers and Interpreters* is so well written however, I almost managed to forget that I was slowly roasting in a carbon monoxide sauna bath.

Wittily written and well-organized, the book is a philosophical discussion of compiler design and provides an excellent overview of the problems inherent in designing this type of software. The reader will not be ready to dash off an interactive Pascal interpreter after having read this book, but it does form an excellent base for progressing to more advanced and detailed texts. The consistent emphasis on designing stable, bug-free, and well-documented software is punctuated with pithy and sensible expedients.

The first section deals with planning, documentation, resources (such as programming languages), and the importance of a good user interface. The reader is introduced to the 13 deadly sins of compiler design, all of which are generally applicable to any software project.

Chapter two is an overview of the modules required in interactive compilers. It covers terminology, the source and internal languages, the editor, error checking, dictionaries and tables, storage management, break-ins, and I/O.

While the first two chapters are easy reading, the third chapter, which discusses the design of an internal language and the encoding of source statements, can be a bit sticky. The author warns that packing information into bits is a dirty business, but promises to warn the squeamish when to avert their eyes.

Each of the book's next three chapters is devoted to one or more of the compiler modules described in chapter two. Chapter four examines the translator module functions, such as lexical analysis and parsing by recursive descent and operator precedence. Included here is a short, but excellent discussion of grammars and their use in parsing.

The following chapter deals with the functions of the run-time unit. The detection and handling of errors, including exception handling, is stressed. Subsequent segments discuss execution of Reverse Polish and statements, variable allocation and reference, and several approaches to the infamous string "garbage collection" problem.

Three additional support modules are described in chapter six. One is the pre-run module, responsible for locating context-dependent syntax errors and infilling context-dependent information required by the run-time system. The recreator module translates code from the internal storage format back to the source language. In this segment, an algorithm for regenerating source code from Reverse Polish is provided and used to illustrate several examples. Lastly, the command module is covered; this section of a compiler initializes the system, cleans up at the end of the session, and provides a stable environment for graceful error recovery.

Chapter seven is devoted to testing, debugging, and "issuing"—the British term for handing it out to users. Strong emphasis is placed on locating and fixing bugs; One suggestion is to offer users a free beer for finding and reporting a bug. Theoretically, the programmer will be anxious to generate an error-free program so the money can be used instead to purchase beer for the compiler writer. The thirteenth deadly sin—leaving the user to find the compiler's errors—is one that could be used profitably as graffiti in several software houses of my acquaintance.

The last chapter covers a few more advanced and esoteric topics, such as interpreted and cross compilers, microprogramming and the interesting concept of throw-away compiling.

One of the most enjoyable aspects of this book is the absence of dogmatic declarations. Often, several alternative methods are presented. The reader thus gains considerable insight into the design decisions (or the lack thereof) that produced the compilers with which he or she may be familiar.

Each section ends with a summary and suggestions for further reading. The bibliography is fairly extensive, but suffers from being slightly dated (reprinted in 1981). Contemporary compiler classics like Aho and Ullman's *Principles of Compiler Design* are missing.

For those who are interested in learning about compiler writing, but who have always been depressed by confronting the strange Greek characters found in the normal compiler design text, this book will provide an informative and amusing introduction. Be forewarned however: it is not a straight how-to book. There are no listings and the few program bits are written in BASIC or pseudo-code. This makes for easy reading, but may disappoint those looking for a more rigorous discussion.

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The Case of the Missing Programmer

Software buyers without access to source code can be left stranded when programmers disappear.

The recent shakeout in the microcomputer industry has prompted sophisticated software buyers to worry about the potential effect of the disappearance of a programmer. Programmers can disappear in several ways: they can switch employers, be acquired, go bankrupt, or graduate from high school and go off to college in a far-off city. By *programmer*, I mean the person responsible for the development of the software that the buyer plans to use—the person who, if a problem develops, can find and fix it in a reasonable amount of time and at a reasonable cost.

Typically, a contract for the preparation of custom software or the purchase of an expensive business program will include some form of progress reporting (in the case of a development contract), acceptance testing, and a warranty that the program will do something (exactly what is often a point of prolonged negotiation) for a certain period of time (again, a matter of negotiation). The contract may also provide for maintenance—the programmer's agreement that, for a periodic fee, he will help the buyer and advise him. Thus, contractually, the buyer has protected himself against the risk that bugs that escaped his acceptance testing will bring his system to a halt.

It would be naive to assume that this contractual provision is complete protection—we are dealing with people, not deodorants. If a programmer changes employers or if his company is acquired, the new employer is likely to ask for a noncompetition agreement in the employment contract, seeking to prohibit the programmer from doing business with anyone except his new employer's customers. If a programmer's software house goes bankrupt, the creditors will be looking for every possible way to recover their money. If a programmer is taking final exams, it may be difficult to get his attention.

In short, software buyers have reason to worry about having access to source code in the event that customer support does not.

The first solution that comes to mind is to ask for a copy of the source code—both a hard copy and a machine-readable copy, and perhaps a copy of the development notes so that the logic of the program can be more easily followed. This request is also a good way to measure the programmer's sense of trust. On occasion, the programmer will agree, but he will (or should) ask that the buyer agree to treat the source code as confidential, to use it for limited purposes only (such as only if the programmer is unavailable or fails to solve a software-related problem), and to indemnify the programmer against any loss that may result from the disclosure of the code.

As is often the case with the first solution that comes to mind, this one presents potential problems. A buyer should give some careful thought to whether he really wants physical possession of the source code under those conditions. Does he have the means to protect it from disclosure? Does he want that responsibility? Even though, surprisingly, some programmers may agree to part with the source code, the buyer may not want it, preferring the risk that the program may malfunction to the risk that the source code will escape while it is in his possession.

A middle ground that has been used is *source code escrow*. To alleviate the programmer's fear that the buyer will use the source code to do his own maintenance, the source code is given to a third party (called the *escrow agent*). To alleviate the buyer's fear that the programmer will disappear, the agent is instructed to terminate the escrow by delivering the source code either to the buyer or to the programmer under certain conditions.

Ideally, the escrow would be terminated only if the holder of the source code received instructions from both the buyer and the programmer, but the real world is seldom so simple. Other conditions that justify terminating the escrow must be drafted. This can be a complicated process, because these termination conditions must protect against either party terminating the

Max Stul Oppenheimer is a partner in the law firm of Venable, Baetjer, and Howard, located in Baltimore.

escrow without the other party's knowledge, they must give each party the ability to contest the other party's attempt to terminate the escrow, and they must protect against the possibility that one party may be unavailable or may refuse to respond. In addition, such agreements must function swiftly.

Finally, the programmer's concern that the source code does not escape must be addressed—it is now the escrow agent rather than the buyer who has possession and who therefore will be asked to agree to maintain confidentiality and back up that agreement with a promise to pay the price if he fails.

Finding an escrow agent willing to accept these responsibilities may not be easy. Normal escrow agents (banks, trust companies, brokers, etc.) are not yet used to dealing with source code escrows. The buyer may find one so naive that it does not fully understand the risk involved and will not be concerned about the confidentiality agreement; the programmer probably would not be happy with such an escrow agent. A trusted mutual friend or customer might serve in the role. If the trust were strong enough, the programmer might be willing to forgo any indemnity. However, if a genuine, fully-at-risk escrow agent is required, the buyer should expect to be charged an escrow fee large enough to cover the costs of protecting the source code, refereeing minor disputes, and obtaining an insurance premium adequate to the risk involved.

Use of the source-code escrow can reduce a buyer's risk that the programmer will voluntarily abandon the ongoing maintenance of the program. There is, however, a remaining area of risk if the software house becomes bankrupt. When a company chooses or is forced into bankruptcy, any interest that it has in any property may be placed in the hands of a trustee. Among the trustee's powers is to reject "execu-

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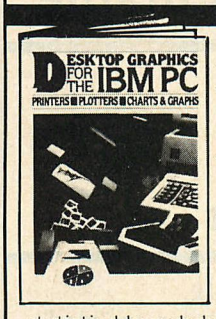

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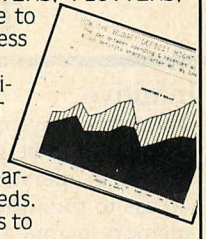

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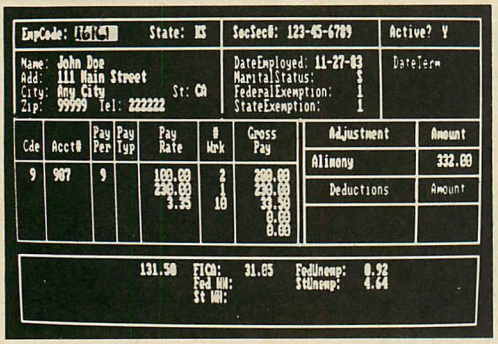

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tory" contracts—those that have not yet been substantially performed. Thus, the bankruptcy court could conceivably have jurisdiction over the escrowed code and could sell it to the highest bidder (possibly a competitor of the buyer) rather than allow the escrow agent to deliver it to the buyer.

Although this would not preclude the buyer from using his version of the program, it would deny the buyer's access to the code and could place the program (along with whatever of the buyer's trade secrets might be deduced from the code) in a competitor's hands. The theoretical solutions to the problem are easy to state: structure the transaction in such a way that either the escrowed code is no longer the "property" of the programmer or the contract is not "executory." Under ordinary circumstances, the programmer will not want to agree to either of these solutions, so the difficulty arises in attempting to negotiate a practical implementation.

The best solution to the problem of obtaining and maintaining a functioning program is to use the utmost care in selecting a programmer or software house that is competent, reliable, and financially sound. Second-best solutions include structuring a payment schedule that does not run too far ahead of the progress on the development and installation of the program, developing an acceptance test that will be passed only if there is a high probability that the software performs as required, agreeing to a reasonable warranty and maintenance program, and making some provision for access to source code when it is the only economical way to keep the buyer's business in business.

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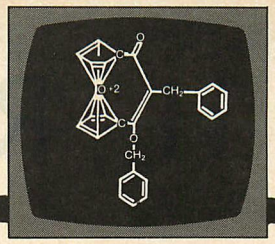

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TECH RELEASES

Hardware, software, and other developments for the PC

AT Keyboard

THE AT ARRIVES

A fifth sibling has joined the IBM PC family, and this one is the most sophisticated of the bunch. The **PC/AT** (for advanced technology) is being extolled for running two to three times faster and delivering almost five times the user memory and more than twice the information storage capacity previously available on PCs. The PC and PC/XT cannot be upgraded to match AT capabilities.

The performance increase of the AT is due in large part to the Intel 80286 microprocessor and system planar board architecture. The PC/AT, which is available in both a **Base** and an **Enhanced** model, is equipped with a 1.2-Mbyte diskette drive and includes a new version of BASIC and a clock/calendar with battery back-up. The Base model offers 256K for standard memory, and the Enhanced version offers 512K. In addition to these features, the Enhanced model has a 20-Mbyte fixed-disk drive and a serial/parallel adapter.

Both models may be expanded further through customer-installed options, including additional memory increments of 128K, 256K, and 512K and additional drives—a 20-Mbyte fixed-disk drive, a 1.2-Mbyte diskette drive, and a double-sided (320/360K) diskette drive. The maximum allowable secondary storage is 41.2 megabytes.

The AT's new, high-capacity diskettes use 96 tracks-per-inch media. The diskettes used on lower-end members of the PC family, at 48 tpi, can be read on the AT. However, once the AT writes on them, they may be read only by the AT. The 320/360K diskette drive enables the same disks to be run on all PCs.

Three new operating system releases support the AT: PC-DOS 3.0, PC/IX 1.1, and Microsoft Xenix. Xenix, which will run only on the Enhanced AT, is required for multi-user operation and for the AT to address its full three megabytes of memory.

The system unit of the AT contains eight option slots to support additional devices, features, or memory. Six of the slots support either 8- or 16-bit cards, and two support only 8-bit cards. One of the 16-bit slots is used for the combination fixed-disk and diskette drive adapter; the Enhanced model uses another 8-bit slot for the serial/parallel adapter.

IBM has given the AT a new 84-key keyboard that is not interchangeable with other PCs. Changes from the 83-key unit used on the PC and XT include the addition of a Sys key, lights to indicate when the NumLock, ScrollLock, and CapsLock keys are in use, and new locations for some of the special function keys—most notably, the Esc and PrtSc keys. The keyboard is attached to the system unit via a 10-foot coiled cable, and it has an adjustable typing angle.

Among the AT's other features are a power-supply switch that can select the appropriate voltage range for a particular country; a temperature-controlled cooling fan; a security lock on the system unit cover; and a decorative rear panel.

Currently available IBM products that are supported on the AT are the Color Printer, Graphics Printer, printer cable, printer stand, Monochrome Display, Color Display. SDLC communications adapter, Binary synchronous communications adapter, Cluster Network adapter, monochrome display and printer adapter, color/graphics monitor adapter, communications cable, and game adapter.

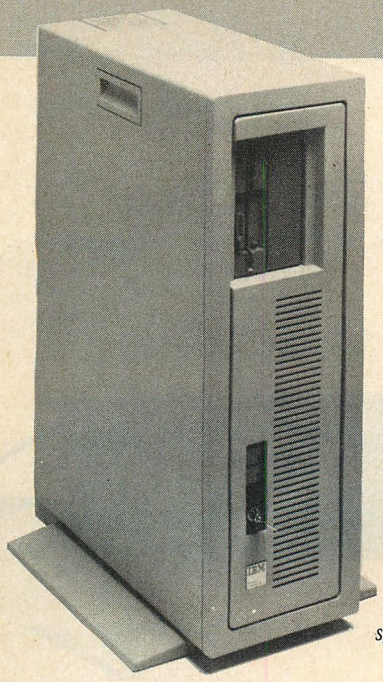
Among the most attention-getting features of the AT has been the relatively low price. The Base model is listed at $3,995 and the Enhanced version is $5,795. A fully loaded AT with three megabytes of main memory, 41.2 megabytes of disk storage, keyboard, display, and operating system would cost close to $14,000.

Prices for disk storage and memory expansion options are as follows: 20-Mbyte fixed disk, $1,595; 1.2-Mbyte diskette, $650; 360K diskette, $425; 128K memory upgrade, $350; 256K, $495; and 512K, $1,125.

NEW DOS VERSIONS

The latest IBM operating system, **DOS 3.0,** retains all of the functions of DOS 2.1 and adds support for the AT hardware. It is compatible with all IBM personal computers, but IBM stresses that 3.0 does not replace 2.1. In fact, 3.0 occupies more memory (36K as opposed to 24K for 2.1), leaving less room for user applications.

Besides support for the AT hardware, DOS 3.0 does provide some enhancements over 2.1. These include: a full range of file-sharing abilities; ability to restrict access to all or part of a file when



System Unit

PC/AT

in the shared mode; a modified version of 2.1 Print to support path specifications and an internal programming interface; additional function calls for enhanced file management; additional facilities for error-reporting; an enhanced version of BASIC; support for additional display interfaces and printers, such as the IBM Color Printer; a VDISK, which allows use of part of the memory for a virtual disk and supports the extended memory of the AT; and the ability for DOS to adapt itself for six international versions of the keyboard configuration.

IBM also announced that it will release **DOS 3.1** early next year. This newer version will include support of IBM PC Network hardware and software.

Both DOS 3.0 and 3.1 will sell for $65 each, while a trade-up from 3.0 to 3.1 will cost $30.

UNIX FOR THE AT

Microsoft's **Xenix,** based on AT&T's UNIX System III and including many of the Berkeley enhancements, will provide the AT with its most powerful capabilities. Xenix, which will run only on the Enhanced version of the AT, allows the computer to address its full three megabytes of memory (DOS does not). Only on Xenix will the AT support multi-user operation. It also allows a user to run several programs at the same time, and it supports co-residence with DOS on fixed disk. Files from DOS 2.0 and 3.0 can be transferred to Xenix. The system's other features included file sharing protection and access control, three program editors (vi, ed, and sed), two command interfaces (the Bourne and Visual shells), and a hierarchical file system. Xenix is priced at $395.

In addition to Xenix, IBM has prepared two supporting programs; they are the **Xenix Software Development System** and the **Xenix Text Formatting System**. The Software Development System contains a set of applications software development tools, including language translators, a C compiler, an 80286 assembler, interactive debugging, and source code management tools (make and SCCS). The Text Formatting System is designed to simplify the production of technical reports, formal papers, and documentation by formatting the articles to required specifications. Prices: Software Development System, $455; Text Formatting System, $145.

IBM's other UNIX derivative, PC/IX, which was introduced last year for the PC and XT, will also run on the AT. PC/IX is a single-user system selling for $900.

WINDOWS FOR PCs

A major addition to IBM's line of software, announced at the introduction of the AT, is **TopView**, a windowing and multitasking program. TopView will be available in the first quarter of 1985 for not only the AT, but also the PC, XT, and Portable PC. The program's facilities feature pop-up menus accessible through the keyboard or a customer-installed mouse. These menus can be used with the program's cut-and-paste capabilities with which data are transferred from one application to another—for example, from a spreadsheet to a report.

The windowing facility displays multiple windows on the screen at one time and can be updated even when the particular application is executing in the background. A user can size, move, and scroll windows as desired, unless the window is for use with an application that writes directly to the video buffer. TopView supports graphics applications, but they cannot be windowed.

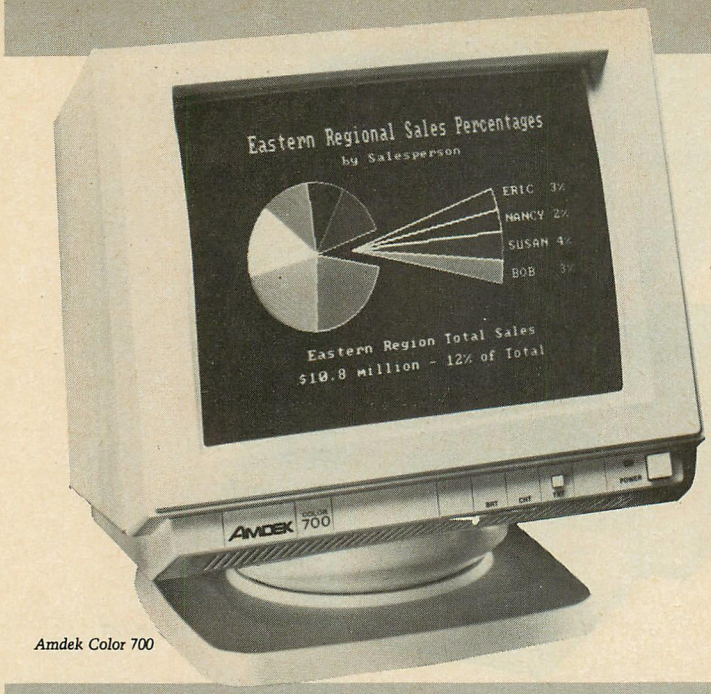
TopView is compatible with many existing IBM programs, including MultiPlan, DisplayWrite 1 and 2, VisiCalc, Personal Editor, and, in addition, several programming languages.

A related program will be released with TopView to assist programmers in designing applications programs that use TopView's facilities. The **TopView Programmer's Toolkit** contains a window design aid, program information files, filter tables used to provide copy, cut, and paste capabilities, language interfaces to access TopView facilities from applications programs, and guidelines for writing device drivers for pointing devices other than those already compatible with TopView.

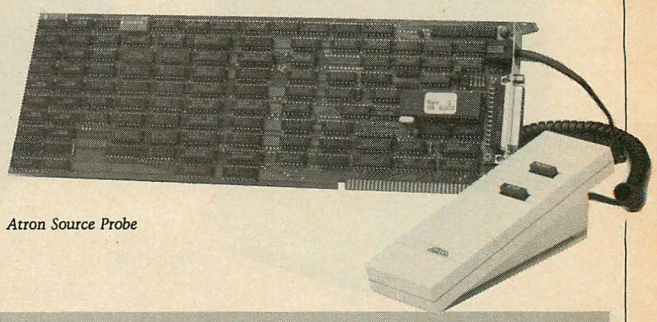
TopView is priced at $149, and the TopView Programmer's Toolkit is $395.

NETWORK ANNOUNCEMENTS

In conjunction with its announcements about the AT and new software, IBM introduced several products as part of its PC Network. With these products, as many as 72



Amdek Color 700



Atron Source Probe

Personal Computers can be linked in a local area network. The **IBM PC Network** is a two-megabit Carrier Sense Multiple Access/Collision Detect Broadband network using 75-ohm CATV coaxial cable.

The **IBM PC Network Adapter** is the feature card that contains the Network BIOS and enables that computer to communicate and share information with all others on the network. It comes with a nine-foot cable and contains an 80188 microprocesor, 82586 LAN controller, one single-frequency RF modem, two VLSI gate arrays, 40K ROM, and 16K RAM.

The IBM PC Network also contains a **Translator Unit** to provide the necessary broadband frequency translation. It directly connects up to eight PCs. One translator unit is required for each network. With IBM's preassembled **Network Cable Kits**, up to 72 nodes can be attached within a 1,000-foot radius of the Translator Unit. The cabling components include a base expander, short-, medium-, and long-distance kits, and cable in 25-, 50-, 100-, and 200-foot lengths.

Greater capability—up to 1,000 PCs connected within a five-kilometer radius—is possible by connecting to an OEM broadband network.

Software to support the operation of the PC, AT, XT, and Portable PC on the network will be available in the first quarter of 1985, along with the new version of DOS (3.1) that will include network support. The **IBM PC Network Program** provides services to share data and devices among applications in network machines and to send messages among the network machines.

Prices: IBM PC Network Adapter, $695; IBM PC Network Translator Unit, $595. Prices for cabling components are $29 to $99, according to length and function.

IBM also announced the IBM PC Network **SNA 3270 Emulation Program**, which can be installed on PCs in the network to give them communications access to a large IBM host computer system via the Systems Network Architecture communications protocol. The emulation program is scheduled to be released in the first half of 1985 and will cost $375.

HARDWARE

Two new, high-resolution video monitors have been announced by the **Amdek Corporation** for use with the IBM PC. The **Amdek Color 700** and **710** combine .31mm dot pitch black matrix picture tubes with ultra-high resolution—720 horizontal by 240 vertical (480 vertical for the 710). A built-in, switchable color matrix allows the monitors to display 16 colors. Text can be displayed in up to 96 columns by 25 lines, and can be switched from white to green. The Color 710 also has an etched glass CRT to reduce glare and a long-persistence phosphor to provide the greater vertical resolution. Prices: Color 700, $749; Color 710, $799.

Amdek Corporation
2201 Lively Blvd.
Elk Grove Village, IL 60007
312-595-6890

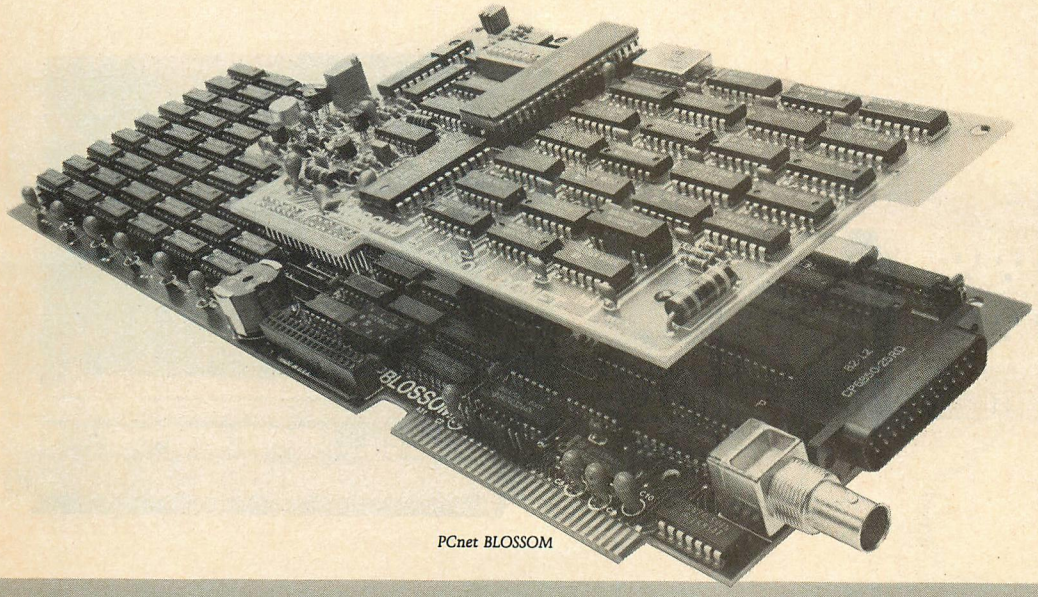
CIRCLE 461 ON READER SERVICE CARD

Source Probe, a software development tool combining in-circuit emulation with real-time, source-level debugging, has been announced by **Atron Corporation**. Source Probe plugs into the PC and has a cable that plugs into the 8088 CPU socket. The user can single-step a program to be debugged at the source code level and display symbolically defined data structures in windows on the screen. While single-stepping, the programmer can scroll forward or backward. $3,190.

Atron Corporation
20665 Fourth Street
Saratoga, CA 95070
408-741-5900

CIRCLE 455 ON READER SERVICE CARD

Real-time, in-circuit **emulators** that support Intel's 8086, 8088, 80186, and 80188 microprocessors are available from **Microcosm, Inc.** The company plans to support other manufacturers' processors in the future. Each Microcosm emulator consists of an Emulation Base connected to the host computer through a standard RS-232C interface. The Emulation Base is connected to the Probe Module, which, in turn, connects to the target processor socket. By plugging directly in-circuit, the emulator provides active control of the target system. A human interface combines



PCnet BLOSSOM

menus, a debug command language, and special purpose utilities. $7,000 for 8086 and 8088 support; $8,500 for 80186 and 80188 support.

Microcosm Inc.
14355 SW Allen
Beaverton, OR 97005
503-626-6100

CIRCLE 453 ON READER SERVICE CARD

Access Technologies, Inc. has developed cartridge components and program development support for the PC*jr*. To aid *jr* software developers, Access is offering a socketed **cartridge board** for EPROMs and a cartridge software **development manual**. Production quantities of cartridge components also are available, including plastic cases, PC boards, capacitor sets, and foam supports. Access also offers cartridge duplication, assembly, testing, labeling, and packaging services. Prices very according to the amount ordered.

Access Technologies, Inc.
7730 Roswell Road
Suite 208
Atlanta, GA 30338
404-394-0119

CIRCLE 450 ON READER SERVICE CARD

An interface board that emulates the functions of the IBM 3270 is being offered for PCs and compatibles by **CXI**. The **3270 PC Connection** can be used to alternate between mainframe host and PC applications, transfer data to and from the host, and interact with five host applications concurrently using windows. It also has windows for two notepads and a DOS session. The 3270 PC Connection is available both as a coaxial connection for attachment to IBM 3274 cluster controllers and as a modem connection for remote attachment emulating 3274. The product includes the necessary software. Price: $1,595.

CXI
3606 W. Bayshore Road
Palo Alto, CA 94303-4229
415-424-0700

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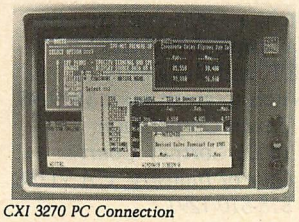


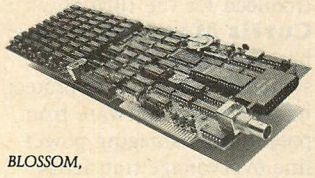
CXI 3270 PC Connection

The **IDM System-PC** (for Intelligent Database Machine), is a new tool offered by **Britton Lee** for corporate information centers and systems houses. Used in conjunction with an IBM PC, the IDM allows up to 64 directly connected PCs in a star network to access databases that before were available only through the central computer. The IDM is a special-purpose computer with a multiprocessor that runs a special operating system designed for efficient database access. In the IDM System-PC, database-intensive activities are handled by the IDM, and user-intensive activities are handled by the PC. It uses one of two query languages—Intelligent Database Language or SQL. Three IDM models are available: 500/0 supports 2.5 gigabytes of storage and 24 PCs; 500/1 is 25-percent faster than the 500/0 and supports 10 gigabytes and 64 PCs; 500/2 has twice the performance of the 500/1 with the same storage capacity and 64 PCs. Prices: 500/0, $45,000; 500/1, $69,500; 500/2, $99,500.

Britton Lee
14600 Winchester Blvd.
Los Gatos, CA 95030
408-378-7000

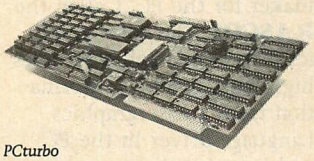
CIRCLE 459 ON READER SERVICE CARD

Orchid Technology has developed three add-on productivity boards to enhance IBM PC performance. The first is **BLOSSOM**, a multi-



BLOSSOM,

function board with 64K RAM and up to 384K of memory. **PCnetBLOSSOM** provides expanded memory and I/O, allowing multifunction and networking capabilities to be combined within one card slot. **PCturbo** allows the com-

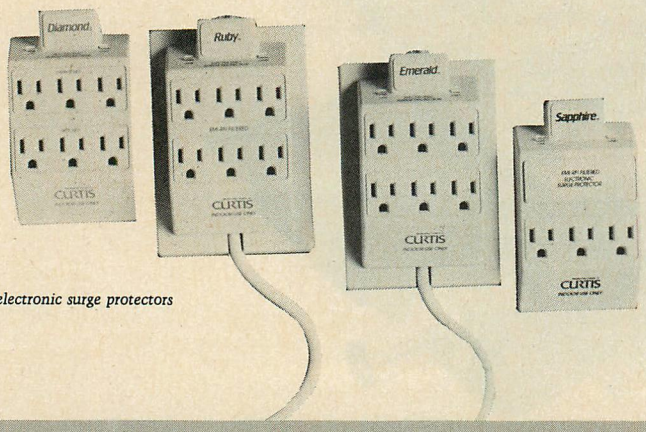


PCturbo

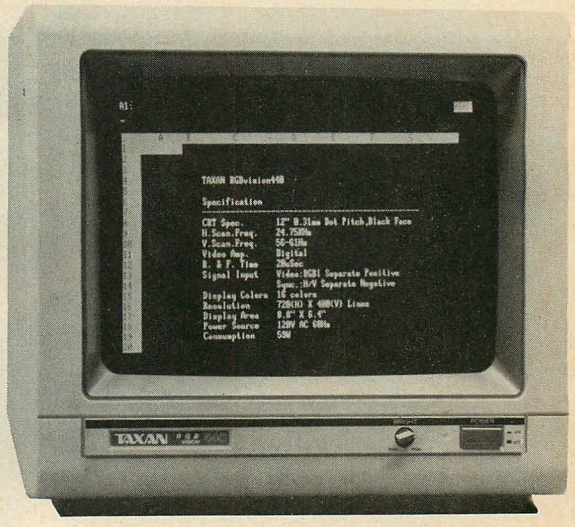
puter to execute programs at high speed. It is available with either the Intel 8086 or 80186 microprocessor. Prices: BLOSSOM, $395; PCnetBLOSSOM, $795; and PCturbo, $1,095.

Orchid Technology
47790 Westinghouse Drive
Fremont, CA 94539
415-490-8586

CIRCLE 454 ON READER SERVICE CARD



Curtis electronic surge protectors



A new line of electronic surge protectors, dubbed the **Diamond**, **Ruby**, **Emerald**, and **Sapphire** by the manufacturer, has been introduced for the IBM PC. **Curtis Manufacturing** has developed the four switched protectors to protect hardware and software from potentially damaging power-line overvoltage transients. From $49.95 to $89.95.

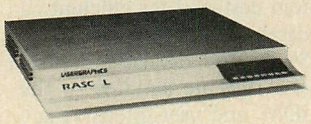
Curtis Manufacturing Inc.
305 Union Street
Peterborough, NH 03458
603-924-7803

CIRCLE 452 ON READER SERVICE CARD

Lasergraphics has introduced a raster color image maker for the PC. Called the **RASCOL**, the color graphics printer controller receives high-level graphics information from a Lasergraphics Language driver in the PC and rasterizes it into color dots to drive the accompanying printer at full resolution and speed. RASCOL takes over the computer-intensive job of rasterization so that the PC is able to perform other functions while the print is being made. When not being used to generate images, RASCOL operates as a 200,000-character print buffer. It is compatible with the Diablo Systems C-150 and Xerox 1770 color ink jet printers. $1,995.

Lasergraphics, Inc.
17671 Cowan Avenue
Irvine, CA 92714
714-660-9497

CIRCLE 460 ON READER SERVICE CARD



Lasergraphics' RASCOL

A two-megabyte memory expansion and multifunction board is now available from **Tall Tree Systems** for the PC, PC/XT, and compatibles. Up to eight of these **JRAM-2** boards can be used in a single system. JRAM-2 provides users with up to 704K, plus a RAM disk—called JETDRIVE—of up to 16 megabytes. The RAM disk is said to run programs, such as WordStar and dBASE II and III, from 50- to 100-percent faster than a fixed disk and 5,000-percent faster than a floppy disk. The JRAM-2 board comes with a print spooler called JSPOOL, which allows a spooler buffer of up to 16 megabytes to be placed beyond DOS memory. Several modules are available for the board, including various combinations of a clock/calendar and serial and parallel ports. JRAM-2 is $219, including JETDRIVE and JSPOOL; $399 with clock/calendar and serial and parallel ports installed. Additional RAM is $50 per 64K bank and $400 per 256K bank.

Tall Tree Systems
1032 Elwell Court
Suite 124
Palo Alto, CA 94303
415-964-1980

CIRCLE 451 ON READER SERVICE CARD

Taxan Corporation has recently introduced a new color monitor. Called the **RGBvision 440**, the monitor is to be used with the Persyst BoB Board. It features 720-by-500 resolution, .31-dot pitch, a 4,000-character display capability, black-face CRT, and the ability to switch to green text. $899.95.

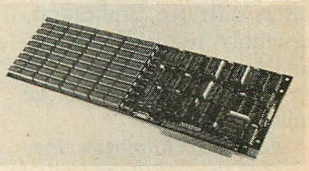
Taxan Corporation
18005 Cortney Court
City of Industry, CA 91748
818-810-1291

CIRCLE 456 ON READER SERVICE CARD

A memory expansion board, called the **2megaboard**, has been developed by **Datatron** for the IBM PC and compatibles. Using either 64K or 256K RAM chips, the product lets the user expand to two megabytes on a single expansion board. The company claims that speed improvements of 40 to 250 percent have been shown with BASICA, SuperCalc3, WordStar, and Lotus 1-2-3. 2megaboard comes with MegaCache software, which creates a "memory window" to store the most recently used data, and MegaSpool printer spooling software. Price (with 64K) is $395.

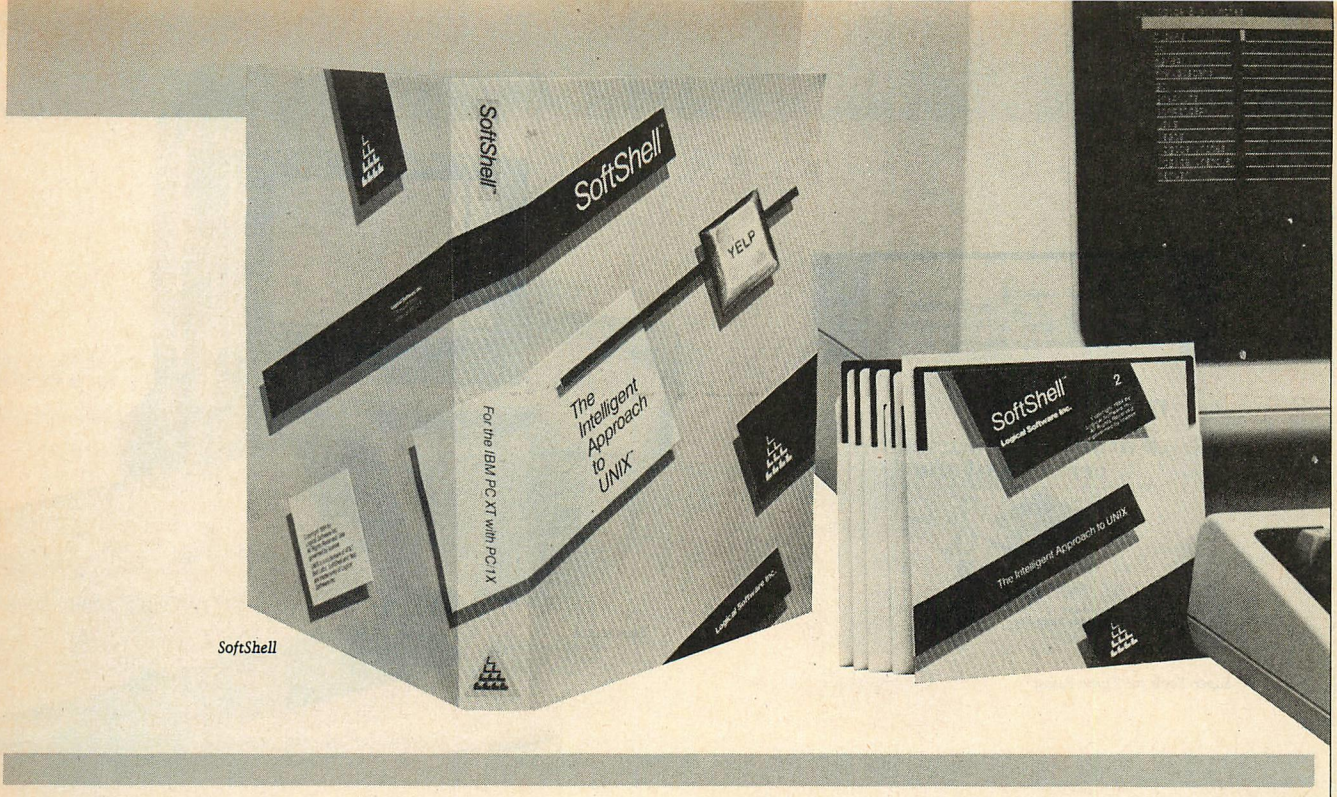
Datatron, Inc.
2942 Dow Avenue
Tustin, CA 92680
714-544-9970

CIRCLE 463 ON READER SERVICE CARD



Datatron's 2megaboard

Modula-2 users have a new product to use from the **Modula Corporation**: the **accelerator card**. When used in conjunction



SoftShell

with a slightly modified interpreter, the accelerator card increases execution speed to that of compiled code. Prices: interpreter, $40; accelerator card, $245.

Modula Corporation
950 N. University Avenue
Provo, UT 84604
801-375-7400 or
800-LILITH2

CIRCLE 458 ON READER SERVICE CARD

Nestar Systems, Inc. has introduced the **IBM SNA Gateway** as an addition to its PLAN series of personal computer networking systems. The IBM SNA Gateway 1.0 allows a dedicated IBM PC on the network to emulate a remote IBM 3274 supporting up to 16 user stations for each gateway. User stations are PCs that are running DOS 2.0 or 2.1 and emulating IBM 3278s and 3279s (base color mode). The gateway station interfaces with IBM mainframes that support the 3270 SNA protocols, at the same time allowing other IBM PCs to function as the interactive workstations. Hardware requirements for the gateway station include an IBM PC (256K), an IBM SDLC card, a Nestar PLAN Network Interface Card, and an appropriate modem connected to a communications line or host that is locally attached via a modem eliminator. The user stations require an IBM PC (196K) and a Nestar PLAN Network Interface Card. Prices: IBM SNA Gateway $3,000; each workstation, $200.

Nestar Systems, Inc.
2585 East Bayshore Road
Palo Alto, CA 94303
415-493-2223

CIRCLE 467 ON READER SERVICE CARD

SOFTWARE

The **Sim-8049 Simulator/debugger** by **Cybernetic Micro Systems** for the IBM PC will execute machine code and dynamically display the source code, register values, flags, I/O pins, and program branches in windows. It supports the Timer/counter and External Interrupts and even the use of 8155 external RAM. The Sim-8049 provides 50 commands consisting of single alphabet keys or control characters; the commands provide register value declaration, trap specification, single step, auto-step, and others. Several of the commands allow immediate control of external pins. In addition, the user has access to all of the 8048 memory; selected data are displayed and can be altered easily. The Sim-8049 displays both the source (symbolic) names and the numeric values. Prices: Sim-8049 Simulator/debugger, $395; evaluation disk and manual, $39.50.

Cybernetic Micro Systems
P.O. Box 3000
San Gregorio, CA 94074
415-726-3000

CIRCLE 465 ON READER SERVICE CARD

SoftShell is a new, full-screen interface that provides users with direct access to even the most complex programs and packages available with the UNIX operating system. Developed by **Logical Software**, SoftShell greatly simplifies the use of UNIX's distinctive hierarchical file and command structure, yet retains the full power of the system's unique capabilities. In addition to providing templates to facilitate choosing options for major commands, SoftShell offers a structured "walk" to traverse the many layers of the UNIX file system, and context information to orient users at all times within the UNIX system. SoftShell runs on many varieties of UNIX and is terminal-independent. License fees for binary copies of SoftShell range from $295 (for the IBM PC/XT) to $995 per copy, depending on CPU.

Logical Software
17 Mount Auburn Street
Cambridge, MA 02138
617-864-0137

CIRCLE 469 ON READER SERVICE CARD

Choice!, a new product by **Wild Hare Computer Systems, Inc.**, is a COBOL interpreter that allows user programs written in Data General's Interactive COBOL to run directly on the IBM PC. All programs and data files stay Data General-compatible and are easily uploaded and downloaded as desired. There is no source code modification, no data file restructuring, no program recompilation, and no time wasted on conversions. The price starts at $499.95.

Wild Hare Computer Systems, Inc.
P.O. Box 3581
Boulder, CO 80307
303-442-0324

CIRCLE 476 ON READER SERVICE CARD

Super Tools for Turbo Pascal

Excelator

Super Tools for Turbo Pascal, by **Paragon Courseware**, is a new programming tool kit for improving the performance of Turbo Pascal on IBM PCs and compatibles. The tool kit contains a Window Package, a Function Evaluating Package, a System Information Package, and a Graphics Package. $29.95.

Paragon Courseware
4954 Sun Valley Road
Del Mar, CA 92014
619-481-1477

CIRCLE 472 ON READER SERVICE CARD

Oracle Corporation has announced the release of **ORACLE** for the PC/XT and PC/AT operating under PC-DOS. ORACLE is the relational database management system compatible with the IBM SQL/DS and DB2; when running on the PC, it is identical to the ORACLE that runs on mainframes and minicomputers. Programs written for SQL/DS or DB2 will run unmodified on any version of ORACLE, including the PC version. Oracle Corporation also announced networking software that allows PC ORACLE to communicate with the IBM mainframe and DEC VAX minicomputer versions of ORACLE. The new facility, called **ORACLE Link**, allows PC users to access and update data stored in the shared database on the mainframe or minicomputer, or to copy that data into the database on their PCs and operate independently. PC ORACLE includes the ORACLE relational DBMS, Application Generator, Report Writer, Integrated Data Dictionary and ORACLE Link. $1,000 (with a minimum order of $6,000).

Oracle Corporation
2710 Sand Hill Road
Menlo Park, CA 94025
415-854-7350

CIRCLE 468 ON READER SERVICE CARD

A new mouse-driven, free-form painting program, the **PC PAINTBRUSH**, has been announced by **IMSI**. Touted as a MacPaint look-alike for IBM PCs and compatibles and PC*jr*, PC PAINTBRUSH runs on seven color cards, one with 720-by-704 resolution for 4-color or 640-by-400 for 16-color. If the display is on a monochrome monitor, each of the 30 backgrounds is automatically transformed into a unique black and white texture. In addition to painting with a variety of colors and patterns, many text fonts are available. PC PAINTBRUSH interfaces with all IBM-compatible joysticks. $139.

IMSI
633 Fifth Avenue
San Rafael, CA 94901
415-454-7101

CIRCLE 471 ON READER SERVICE CARD

Oxford Software Corporation has announced the new release of **pcMAINFRAME**, 1.2.0, featuring extended 3278/9 terminal emulator and protocol support, the flexibility to access any database or multiple files, and an ability to upload and update KSDS files. pcMAINFRAME is a data transfer system that allows PC users to download and upload generalized files in a real-time environment between personal computers and the central host IBM mainframe computer. Prices: $9,000 for DOS, includes 8 PCs; $12,000 for OS, includes 8 PCs. $300 for each additional PC for DOS or OS.

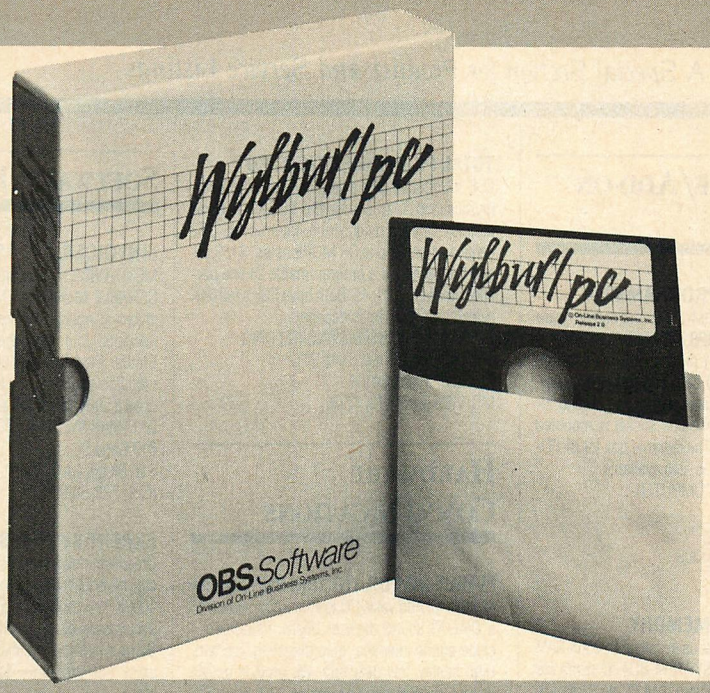
Oxford Software Corp.
174 Boulevard
Hasbrouck Heights, NJ 07604
201-288-1515

CIRCLE 474 ON READER SERVICE CARD

A powerful new product that automates most of the time-consuming manual tasks of software systems analysts has been introduced by **Index Technology Corporation** (InTech). The **Excelerator** is a fully integrated, menu-driven software environment developed to assist the professional systems analyst in all phases of systems analysis, design, organization, and documentation. InTech has initially configured Excelerator for the IBM PC/XT, and supplies, with the software, additional plug-in circuit boards to increase the microcomputer's memory and enhance its graphics capabilities. Excelerator also employs a Microsoft Mouse for rapid screen design and menu selections. The package includes the software, full documentation, keyboard template, the Microsoft Mouse and WORD packages, 128K memory expansion board, graphics board, and a screwdriver. $9,500.

Index Technology Corp.
5 Cambridge Center
Cambridge, MA 02142
617-491-7380

CIRCLE 466 ON READER SERVICE CARD



Wylbur/pc

OBS Software announced the release of a new product, **WYLBUR/pc**, a program development system for personal computers. The WYLBUR/pc does for microcomputers what the firm's earlier product, WYLBUR, has done for mainframes. The WYLBUR/pc package provides a database development environment that includes an EXEC programming language, PC-to-mainframe communications, a full screen editor, screen panel formatting, file handling capabilities, and a RUN command to invoke other programs. Prices: WYLBUR/pc, $550; trial diskette with manual, $50; or with user notes, $10.

OBS Software
555 Sansome Street
San Francisco, CA 94104
415-391-9555

CIRCLE 470 ON READER SERVICE CARD

VS FORTRAN Release 4 is the latest release of **IBM**'s VS FORTRAN licensed program. Release 4 implements the AUTODBL option, compiler-generated reentrant object code, a runtime load capability for certain library routines, support for VSAM key-sequenced data sets, new and improved compile-time options, and significant performance and usability enhancements in both the compiler and library. Charges for the compiler and library together are $699 for the initial basic license, $524 for DSLO, and $233 for the monthly basic license, $174 for DSLO. Charges for the library only are $207 for the initial basic license, $155 for DSLO, and $69 for the monthly basic license, $51 for DSLO.

IBM
To locate your nearest authorized dealer or product center, call 800-447-4700.

CIRCLE 473 ON READER SERVICE CARD

Gateway Microsystems Incorporated has released two new communications products for the IBM PC, PC/XT, and compatibles. **MicroGate/WS** provides interactive and batch micro/mainframe communications in a single software/hardware product. **MicroGate/FT** is a software product that permits ASCII and binary files to be exchanged between PCs with a minimum of effort and expense. Prices: MicroGate/WS, $995.00, including one Gateway SCC printed circuit board, a user's guide, and a modem cable; MicroGate/FT, $179.95, including two complete sets of software and documentation—one for each side of the file transfer link. Additional single unit MicroGate/FT kits are priced at $99.95; optional six-foot modem cables are available for $35.00 each.

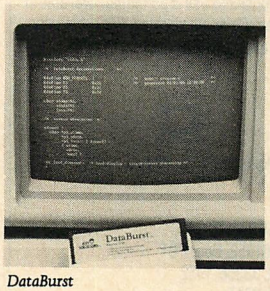
Gateway Microsystems
9501 Capital of Texas Highway North
Suite 105
Austin, Texas 78759
512-345-7791

CIRCLE 475 ON READER SERVICE CARD

The **DataBurst Language Support Package** (LSP) from **Key Solutions** provides an interface for C application developers on the IBM PC. The LSP generates C source programs that use the DataBurst runtime screen processor to manage all screen and keyboard operations during program execution. The DataBurst development system is an integrated package comprising a screen format editor, format compiler, source program generators, and a runtime screen processor. As an extension of DOS, the runtime screen processor provides a mainframe-like data entry facility with full screen I/O by managing external screen formats. Prices: DataBurst development system, $225.; Language Support, $40.

Key Solutions, Inc.
P.O. Box 2297
Santa Clara, CA 95055
408-554-6125

CIRCLE 477 ON READER SERVICE CARD



DataBurst

Mouse Systems Corporation has announced that IBM's new Color Paint program for the enhanced PC*jr* supports Mouse Systems' **PC Mouse**. The PC Mouse package includes a three-button optical mouse with Designer Pop-up Menu software for running many of the most popular business applications programs. $195.

Mouse Systems Corp.
2336 H Walsh Avenue
Santa Clara, CA 95051
408-988-0211

CIRCLE 483 ON READER SERVICE CARD

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TECH BOOK

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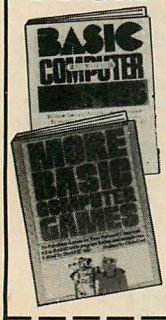

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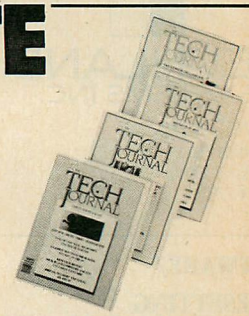

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Contact: Miroslaw Malek, University of Texas at Austin, Computer Science Department, Austin, TX 78712, 512-471-5704

December 12-14
International Computer Symposium (ICS 84)
Taipei, Taiwan, Republic of China
Sponsor: IEEE
Contact: Shi-Kuo Chang, Department of Electrical and Computer Engineering, Illinois Institute of Technology, IIT Center, Chicago, IL 60616.

December 13-16
Fourth Annual Southeast Computer Show & Software Exposition
Atlanta, GA
Sponsor: CompuShows
Contact: CompuShows, P.O. Box 3315, Annapolis, MD 21403, 800-368-2066

December 17-19
IEEE First International Conference on Office Automation
New Orleans, LA
Sponsor: IEEE
Contact: Robert W. Taylor, Program Chairman, IEEE ICOA 84, IBM San Jose Research Lab, K52-282, 5600 Cottle Road, San Jose, CA 95193, 408-256-7268

JANUARY

January 13-16
12th Annual ACM SIGACT-SIGPLAN Symposium on Principles of Programming Languages
New Orleans, LA
Sponsor: ACM
Contact: Brian K. Reid, Computer Systems Laboratory, ERL 444, Department of Electrical Engineering, Stanford University, Stanford, CA 94305

January 22-25
UniForum
Dallas, TX
Sponsor: /usr/group
Contact: Richard Lewis, 800-323-5155

January 28-30
Office Automation Conference
Tucson, AR
Sponsor: IEEE
Contact: AFIPS, 1899 Preston White Drive, Reston, VA 22091, 703-620-8900

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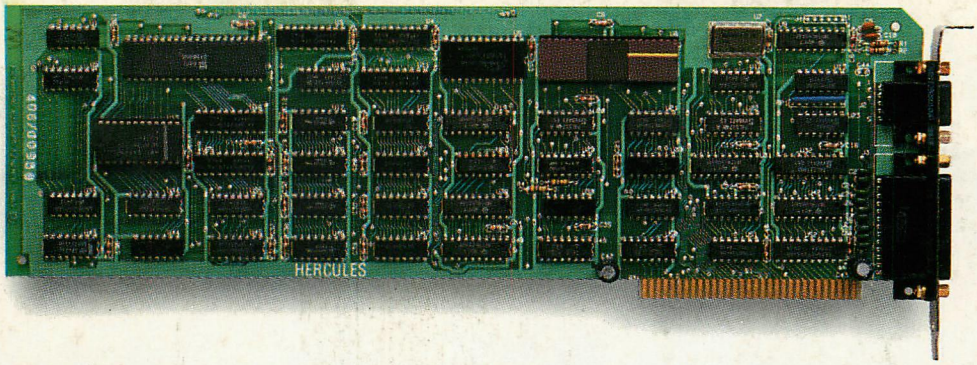

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