BYTE

THE SMALL SYSTEMS JOURNAL®

MARCH 1988 VOL.13, NO.3

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PRODUCT FOCUS

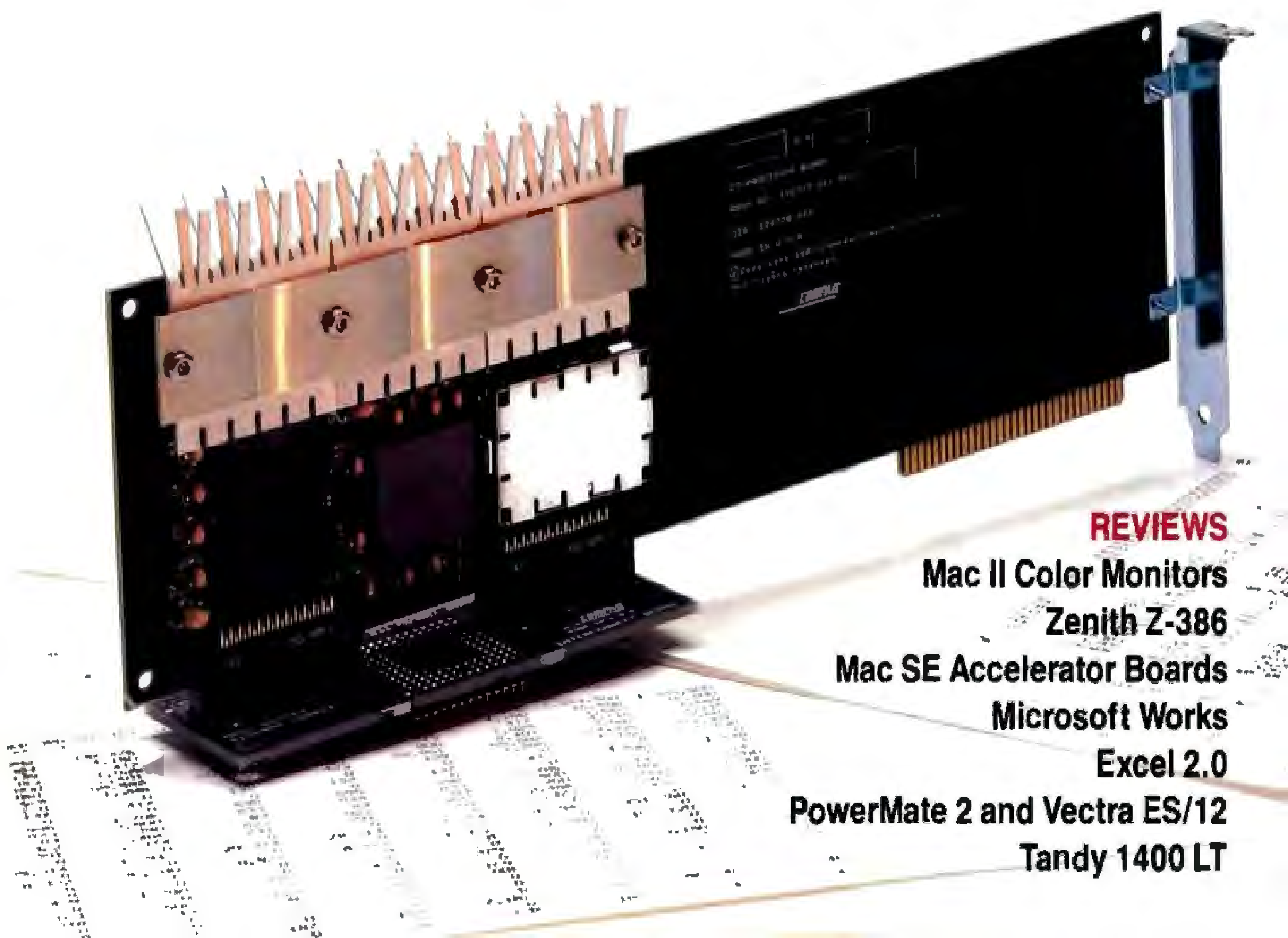
Enhanced EGA/VGA Boards

IN DEPTH

The New Coprocessors

The fastest-ever PC number crunching

Compaq's Weitek
Math Coprocessor System



REVIEWS

Mac II Color Monitors

Zenith Z-386

Mac SE Accelerator Boards

Microsoft Works

Excel 2.0

PowerMate 2 and Vectra ES/12

Tandy 1400 LT

Why Parad

"Paradox* is once again the top-rated program, with the latest version scoring even higher than last year's top score." (Software Digest's July 1987 Ratings Report—an independent comparative ratings report for selecting IBM PC Business software).

All tests for the Ratings Report were done by the prestigious National Software Testing Laboratory, Philadelphia, PA, and the message is crystal clear: there is no better relational database manager than Paradox.

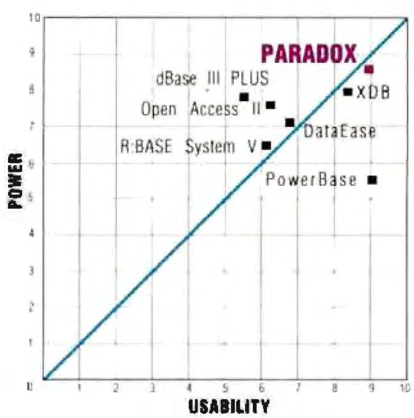
NSTL tested 12 different programs and amongst other results, discovered that Paradox is 3 times faster than dBASE; 6 times faster than R:BASE on a two-file join with subtotals test†.

Paradox does the impossible: combines ease-of-use with power and sophistication

Even if you're a beginner, Paradox is the only relational database manager that you can take out of the box and begin using right away.

Because Paradox employs state-of-the-art artificial intelligence technology, it does almost everything for you—except take itself out of the box.

If you've ever used 1-2-3* or dBASE* you already know how to use Paradox. It has Lotus-like menus, and Paradox documentation includes "A Quick Guide to Paradox for Lotus users," and "A Quick Guide to Paradox for dBASE users."



Source: Software Digest

Ideal programs have high levels of both power and usability. Programs plotted in the upper righthand portion of the diagram above come closest to achieving that ideal.

> "Paradox still offers superior import/export facilities using Lotus 1-2-3, dBASE, ASCII and other file types. It transfers between formats with stunning speed"
>
> *Rusel DeMaria, PC Week*

Paradox responds instantly to "Query-by-Example"

The method you use to ask questions is called Query-by-Example. Instead of spending time figuring out *how* to do the query, you simply give Paradox an example of the results you're looking for. Paradox picks up the example and automatically seeks the fastest way of getting the answer. Paradox, unlike other databases, makes it just as easy to query multiple tables simultaneously as it is to query one.

Source: Software Digest

Software Digest Rating	Overall Evaluation	Program Name	Version Tested	Ease of Learning	Ease of Use	Error Handling	Performance	Versatility	Memory Requirement	Price
☆☆☆☆	8.7	Paradox	1.1	🟦	🟦	🟦	🟦	🟦	512K	$495
☆☆☆☆	8.2	XDB	1.10	🟦	🟦	🟦	🟦	🟦	320K	$750
☆☆☆	7.6	PowerBase	2.3	🟦	🟦	🟦	🟨	🟪	384K	$349
☆☆☆	7.0	Open Access II	2.0	🟨	🟨	🟦	🟦	🟦	256K	$395
☆☆☆	7.0	DataEase	2.5/2	🟦	🟦	🟪	🟦	🟦	384K	$600
☆☆	6.6	dBASE III PLUS	1.1	🟨	🟨	🟦	🟦	🟨	384K	$695
☆☆	6.4	R:BASE System V	1.1	🟨	🟨	🟦	🟪	🟦	512K	$700

RATINGS KEY
(On a scale of 0 to 10)

Overall Evaluation
- ☆☆☆☆☆ 9.0 or higher
- ☆☆☆☆ 8.0 - 8.9
- ☆☆☆ 7.0 - 7.9
- ☆☆ 6.0 - 6.9
- ☆ 5.0 - 5.9

All Other Ratings
- 🟦 7.0 - 9.9
- 🟨 5.0 - 6.9
- 🟪 UNDER 5.0

ox is the best

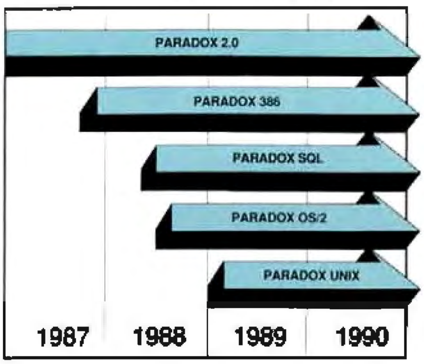
There's no power like Paradox Power

PROGRAM	Overall Power	Overall Performance	Overall Versatility	Single-Record Search (sec.)	Indexed Group Record Search (sec.)	Search without an Index (sec.)	Subtotal 100 Groups (sec.)	Subtotal on Two-File Join (sec.)	Three-File Join (sec.)	Subtotal on Three-File Join (sec.)	Four-File Join (sec.)	Many-to-Many Join (sec.)
Paradox	8.4	9.2	7.5	1.0	6	100	221	325	459	364	322	18
dBASE III PLUS	7.9	8.9	6.9	0.5	17	93	525	1013	646	449	445	39

*Source: Software Digest**

Paradox saves you from future shock

Trends for the future with Paradox



Paradox 386 allows users to take advantage of 16 Megabytes of Memory on a 386 machine. This allows Paradox users to work with databases that could in the past only be handled by minicomputers and mainframes.

Your investment today in Paradox applications is protected as new hardware and operating systems are used in your company. Paradox 2.0 applications will run unchanged on Paradox 386, Paradox OS/2, Paradox Unix and Paradox SQL! All versions of Paradox will be completely application and menu compatible. Paradox SQL will allow access to remote databases via SQL. Users will just type in a query as they normally would, and Paradox will translate that Query to SQL.

" Paradox 2.0 will do for the LAN what the spreadsheet did for the PC

David Schulman,
Bendix Aerospace "

Paradox makes your network run like clockwork

Paradox is just as valuable to multi and network users as it is to single users. It runs smoothly, intelligently and so transparently that multiusers can access the same data at the same time—without either being aware of each other or getting in each other's way. It works exactly the same way whether you're flying solo or as part of the crew.

" Anyone who hasn't seen the network version of Paradox should take a look. Ansa has dramatically advanced the state of the art in multiuser network databases

Phil Lemmons,
BYTE

Paradox was a delight to use, both as a standalone product and from a local area network server.

Don Crabb,
InfoWorld "

How to make your network network

To run Paradox 2.0 or the Paradox Network Pack on a network you need

- Novell with Novell Advanced Netware version 2.0A or higher
- 3Com 3Plus with 3Com 3+ operating system version 1.0, 1.1 or higher
- IBM Token Ring or PC Network with IBM PC Local Area Network Program version 1.12 or higher
- Torus Tapestry version 1.4 or higher
- AT&T Starlan Network with AT&T PC 6300 Network Program version
- Other network configurations that are 100% compatible with DOS 3.1 and one of the listed networks

System Requirements for Single User:
- DOS 2.0 or higher
- IBM® PS/2 and PC, Compaq® PC families and other 100% compatibles
- 512K RAM
- Two disk drives, 3½-inch and 5¼-inch supported
- Compatible monochrome, color, or EGA monitor with adapter

System Requirements for the Network Workstation:
- DOS 3.1 or higher
- 640K RAM
- Any combination of hard, floppy, or no disk drives
- Compatible monochrome, color, or EGA monitor with adapter

Optional Equipment:
- EMS and EEMS Boards, AST RAMpage Board,™ Intel Above Board® or other expanded memory adapters
- Printers: Compatible dot matrix, letter quality, or laser printer

**Reprinted with permission by Software Digest from its July 1987 report covering 12 relational database programs*

†Test was designed and executed by NSTL. A 1,000-record and a 10,000-record file were joined. A short text field from the 1,000-record file and a numeric field from the 10,000-record file were selected (using the 1,000-record file indexes). The short text field was grouped and sorted in ascending order, the numeric field was subtotaled for each group, and the results output to a null printer. Test times from the last keystroke on the command sequence until return of program control were recorded and averaged.


Paradox:
the top-rated
relational
database
manager
in the world...
PARADOX
Introduction
2.0
RELEASE
Ansa

Paradox: the new corporate standard

Paradox automatically updates your data and lets you control access to information

In "Co-Edit" mode, changes made by anyone are automatically updated to everyone. You can pre-set a "Screen-Refresh" interval to occur anywhere from 1-second to 1-hour intervals. (If you don't make a pre-set choice, Paradox automatically updates every 3 seconds so that your screen always shows you updated data).

While Paradox 2.0 lets everyone share and update information simultaneously, you can configure it to keep secrets secret.

You can restrict others' rights in a variety of ways with safeguards protecting confidential files and/or giving someone "Read Only" rights which is to allow "View," but prevent "Change." The Paradox technique—automatic file and record locking—ensures data accuracy and integrity in any multiuser environment.

For a brochure or the dealer nearest you call (800) 543-7543

> "With Version 2.0, Paradox becomes a sophisticated multiuser product that boasts an impressive selection of data-protection features and password-security levels
>
> *Rusel DeMaria, PC Week*"

Get serious support for serious Paradox application programming

When you subscribe to the Paradox Developer's Resource Program (PDRP), you get all the resources and support you need for sophisticated Paradox application development: unlimited access to our toll-free PAL programmers support line; the Paradox Developer's Toolkit; a subscription to *Turbo Technix*, Borland's bi-monthly technical magazine; and a 20% discount on the Paradox User's Journal published by the Cobb Group.

Call our Customer Service Department at (408) 438-8400 for your free PDRP information kit with all the details.

PARADOX

by Ansa

A Borland Company

PARADOX

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Circle 284 on Reader Service Card →

EDITORIAL

Not Just for the MacFaithful

"Gridlock surrounds S.F. computer show" screamed the headline in the *San Francisco Chronicle*. "More than 20,000 people turned up for the first day of the three-day computer show, compared with 30,000 for all three days of the show last year. Hundreds...were unable to get into a packed keynote address.... There was almost complete gridlock from Market to Howard streets...and traffic backed up onto the Bay Bridge.... Some drivers complained that it took a half hour to go one block."

I'm writing this on the flight back from this winter's MacWorld Expo and can attest that it's all true—and perhaps even a little understated. It was a *great* show, in some ways reminiscent of the early days of microcomputing, with an electric atmosphere, a spirit of innovation and excitement, and a profusion of new hardware and software.

It may be remembered as the show of the expandable Macintosh—a show when there finally were enough innovative products for the full Macintosh line (not just for the Mac II) to satisfy all but the most fanatical criticisms about limited RAM, small and monochromatic screens, inadequate expansion, and unfulfilled visual potential.

My briefcase barely fits under the seat in front of me: It's crammed full of literature and sample software for everything from accelerators and expansion products for the Plus and SE; to 68030-based accelerators, professional-quality animation, and digitized video products for the Mac II; and back to software that lets you accurately and flexibly drive color printers from monochrome Macs. The list goes on and on.

It was a great show. And not just for the MacFaithful.

Cross-Pollination

It's axiomatic that many of the concepts and technologies that had their first widespread commercial appearance on the Mac already have influenced and improved the IBM world. But, until recently, little has gone the other way. It's left the Mac world essentially isolated from the mainstream—a fertile but foreign land to the overwhelming majority of microcomputer users.

Some Mac users like it that way. They regard the "purity" of the Mac as an almost religious issue. At several of the show's panel discussions, members of the audience actually castigated some manufacturers for "selling out" because they adapted Mac products for PCs, or vice versa.

Some PC users like it that way, too. These are the folks who made up their minds about Apple's "little beige toaster" when it first appeared and don't realize that the current crop of Macs and third-party hardware and software embody the most desirable traits of the IBM side (e.g., expandability and adaptability).

It's silly—dangerous, even—to put on blinders and track only one class of machine, or worse, only one brand of machine: Good ideas know no boundaries, except artificial ones, such as closed minds and closed architectures.

And that's why BYTE (which is sometimes incorrectly perceived as an MS-DOS publication) attends Mac shows. Because no matter whether you're a Mac user or a PC user, you need to know what's going on in the other camp: Sooner or later, you must deal with and choose among the best ideas that emerge there.

This cross-pollinization benefits every computer user, and it's a fact of life of microcomputing today: The best features of hardware and software—wherever they originate—*will* eventually show up everywhere. Keeping you informed of these developments, keeping your options open—that's what BYTE is all about.

Some Specifics

At MacWorld, we covered all the best product and technology news virtually live for the Microbytes Daily area of BIX. We then produced a Show Report (see below) immediately after the show closed. I've already mentioned some of the most interesting products—many of which we'll soon be reviewing.

But if you've missed our earlier coverage of MacWorld, here's a sampling of some of the show's other interesting items. As you read them, you'll see many examples of cross-pollinization.

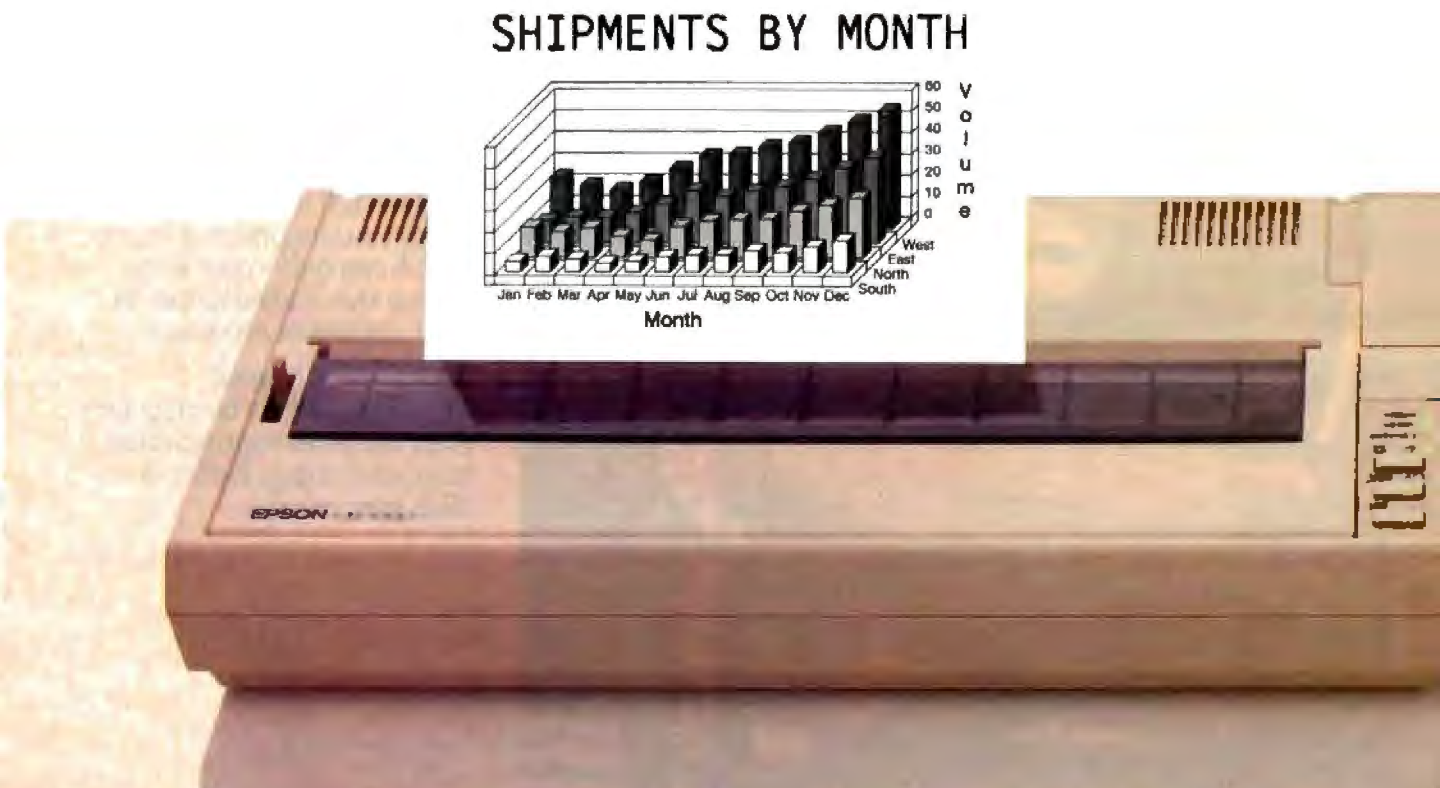
- Apple rolls out three new laser printers: from a $6599 model on the high end to a $2799 PostScriptless model on the low end, with a $4599 PostScripted model in the middle.
- Sculley talks of twenty-first century "knowledge navigator."
- Mainstay announces "Agenda-like" program for Mac.
- New Apple product lets MS-DOS PCs be AppleTalk nodes.
- Apple and DEC share technology.
- Activision program lets HyperCard users generate reports.
- WINGZ "integrated spreadsheet" puts graphs, text on one page.
- Truevision, maker of the Targa and Vista graphics cards for the IBM PC, announced a similar card for the Mac II.
- SuperMac's 24-bit color card for the Mac II.
- MacNeal-Schwendler introduces engineering software for Macs.
- Lotus introduces Modern Jazz.
- Mac CAD package has modular design.
- Kodak's first Mac projection pad.
- Program lets you map "information."
- Summagraphics announces digitizer for the Mac.
- Deutsch Research introduces a simulation program for analog and digital circuits.
- SuperMac/Levco brought out programming environments for its TransLink accelerator card.
- Apple Programmers Group offers new versions of MPW Pascal and MPW C.
- Digital film recorder does slides from Mac graphics.
- Two faxes for the Mac.
- Apple resists display PostScript.
- Cricket presents "Cricket Presents."
- Cricket shows beta paint program.
- Radius accelerator runs at 25 MHz.
- WordPerfect for the Mac: The "look and feel" of the Mac with all the keyboard functions of the IBM version.

And much more.

We'll also be producing a Show Report after this month's West Coast Computer Faire. We'll be glad to send you a copy for just the price of the paper, printing, and postage. Just drop us a note (send it to WCCF Show Report, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458); please enclose a check or money order for $3 and be sure to include your name and mailing address.

—Fred Langa
Editor In Chief
(BIX name: flanga)

OTHERS PALE B



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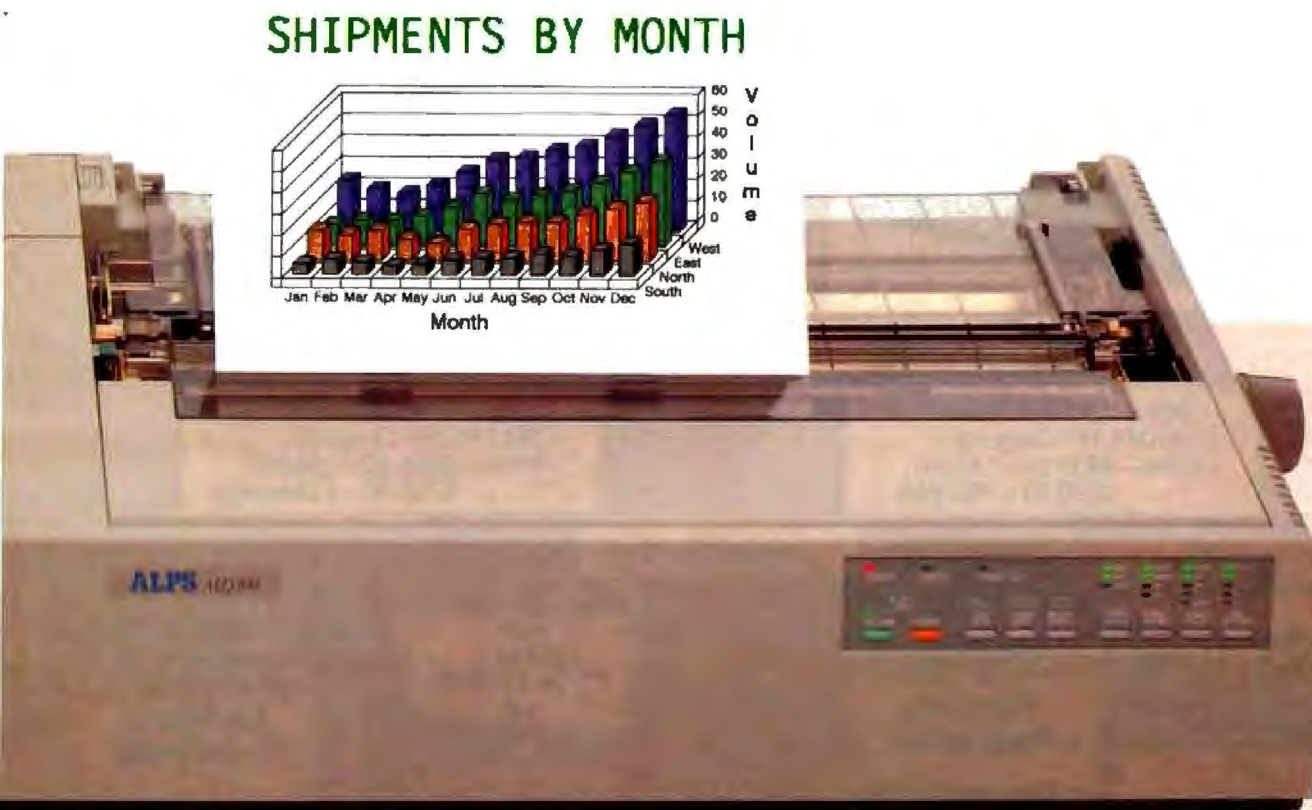

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From: John
Re: Monitor Analysis

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MICROBYTES

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

SQL Promises Portability, but It's Not Easy Becoming a Standard

Incompatible database formats have long been a problem for computer users. It's not uncommon to find several different database programs being used within a single organization, all generating incompatible data. If we're to believe industry watchers and prognosticators, however, this problem will be solved by making Structured Query Language (SQL) the standard.

Although SQL is just a language for querying and communicating with databases, it requires a standard SQL "engine," or data format, to be used effectively. "The real promise of SQL is the portability of files and indexes," pioneering computer designer George Morrow told Microbytes. "If you follow the rules of SQL, everyone can use the data." The problem, however, is that very little data is currently in SQL format. "Unfortunately," said Ansa Software's cofounder Rob Shostak, "most of the world's data resides in flat files accessed by COBOL programs."

SQL may indeed be the next standard. But how long will this standardization take? And how will it affect database developers? With Oracle's recent announcement of an SQL add-in program for Lotus 1-2-3, SQL products for the PC are becoming a reality. Microrim also has announced SQL support, but the new version of R:base implements only some SQL commands and has no provisions for transferring files between R:base and SQL. According to Morrow, R:base users "will be greatly disappointed" when they discover that their files are still incompatible.

Shostak told Microbytes that Ansa is working on a version of Paradox that will accept data from SQL databases by providing a "seamless" translation of Paradox queries into SQL. "What users really want to do is access SQL data with commands they already know," Shostak said. But do MIS managers want microcomputer users to be able to modify or update mainframe databases? In a survey of Fortune 500 companies, "many executives said they don't want micro users to be able to update the mainframe," said Shostak. Ansa is debating whether to provide a mechanism for exporting data from Paradox back into SQL databases.

Another problem is performance. According to Morrow, the main bottleneck in current PC database products is I/O. "SQL will be even slower, because the bottleneck is the CPU. SQL is highly interpretive. SQL gives you a nice language, but the price you pay is that it's CPU-bound," said Morrow. Morrow's company, Intelligent Access, has been developing SQL interfaces that are built into the hardware of disk controllers.

Of course, Ashton-Tate is also working on SQL products and has hired several experts in the field. Industry speculation has A-T acquiring a company with SQL expertise. But according to Oracle's marketing director, Gene Shklar, the first player to drop out of the SQL game will be A-T. "They simply don't have the technology to compete with us," he claimed. Shklar said that products like dBASE III, R:base, and Paradox are not based on the SQL model and therefore can offer only partial support of SQL.

In any case, no standardization takes place overnight. In the meantime, we'll have to thrash away at incompatible data files and put up with converting to ASCII format.

New Approach Will Make Scanners Smaller

Scanners will begin to change over the next 2 years as manufacturers adopt alternative technologies. The approach that looks to be the scanner technology of the future is called "contact image sensor." It should enable manufacturers to design scanners that are much more compact, much less expensive, and have much less image falloff than anything on the market today. One thing that makes today's charge-coupled device

continued

Nanobytes

We'll resist unfair comparisons to *glasnost*, but **IBM** opened its doors a bit following published reports regarding PS/2 Model 50s showing up DOA. The company invited writers from several computer publications to its offices in White Plains, NY, to correct what it says are "misstatements" in the press. One person was quoted in a prominent news weekly as saying that 40 percent of the Model 50s he had ordered arrived defective; but IBM officials said that the quoted person never ordered even one Model 50. We've heard about some minor problems with the machines but have yet to find the rumored graveyard. . . . **Speech Systems** Inc. (Tarzana, CA) is investigating the use of a phonetics-based speech-recognition system to help improve the language abilities of people with hearing disabilities. The study is funded by the U.S. Department of Education. SSI's Phonetic Engine **converts speech to phonetic codes**; the approach is based on phonemes (basic elements of speech) rather than on whole words. . . . **Quintus Computer Systems** (Mountain View, CA) is testing a version of its Prolog compiler for 80386-based computers. **Quintus Prolog** adheres to Edinburgh syntax and provides a complete split-screen development environment with full-screen editor, incremental compiler, debugger, on-line help, and interfaces to C, FORTRAN, and Pascal. The split screen puts source code in the upper window, while Prolog executes in the lower window. . . . **Teknowledge** (Palo Alto, CA) is bringing its **Copernicus** expert-system environment to the MS-DOS world. The "knowledge engineering tool" runs under Microsoft Windows on 286- or 386-based computers and uses a

continued

DOS extender to allow execution in protected mode. A company official told us that this version is aimed at programmers who want to do the development work on an IBM PC and port it to a mainframe or use the micro as an "intelligent terminal." . . . The new **24-bit Mac II display card** from **Jasmine Technologies** (San Francisco, CA) uses "extensions" to the Mac QuickDraw routines to make it possible for existing programs to be compatible with the device. The software for the Rembrandt II and III cards employs the PICT2 format used by QuickDraw, enabling you to paste an image to the Clipboard and then copy it into any application. The card is designed around custom gate arrays but makes use of the Texas Instruments 34010 graphics processor. . . . Having shipped its Pegasys I CAD program for the Macintosh, **IGC Technology** (Walnut Creek, CA) plans two **more Mac CAD packages**. Pegasys Expert, slated for this quarter, will add "true 3-D, macros, more menus," and more, said an IGC official. Pegasys II will run on the Mac II in full color and take advantage of that box's 68881 numeric coprocessor. . . . **Hewlett-Packard** (Palo Alto, CA) plans to release its workstations based on Motorola's **68030** in mid-1988. The new members of the HP 9000 Series 300 line will be object-code-compatible with HP-UX. An 030 upgrade board will be available for the older, 68020-based models 330 and 350, HP said. . . . This WORM does not crawl. **Micro Design** (Winter Park, FL) said it has speeded up its LaserBank 800 WORM drive by replacing its 8-bit host adapter with a 16-bit device. Claimed DOS throughput is now 90K bytes per second. The $9995 unit can hold 800 megabytes of data. . . . Now there are mondo characters. **Worthington Data Solutions** (Santa Cruz, CA) has released a package that lets an HP LaserJet Plus–compatible printer print characters 2 inches tall, or what type-shop types would call 153 points. License cost for BIGfont is $159. . . . Researchers at the **California Institute of Technol-**

continued

(CCD) based scanners so bulky and expensive is the reduction optical system that requires an optical path—that is, the distance between the scanned document and the CCD sensing array—of nearly 400 millimeters. Most scanners aren't that thick because a series of mirrors and lenses is used to reduce the optics. Adding to the bulk and cost is a reflection source, usually a fluorescent lamp.

Contact image sensors, however, have a maximum optical path of not more than 50 mm and replace a bulky lamp with a strip LED array. In a typical contact image scanner, the paper original travels beneath two sets of LED arrays positioned roughly at 45-degree angles above the paper. The light that shines down on the paper is reflected up at 90 degrees through a rod lens array before reaching the photosensor array.

Contact image technology is generally viable right now, but scanner makers say it currently costs about 3 times more than the more commonly used CCD approach. Contact image has its limitations as well. The dynamic range, for instance, is restricted to 6 bits (64 levels) of gray, while it's possible to push CCD to 8 bits, and even to 10 bits in some cases.

How long before contact image sensor technology makes its presence felt? A representative of one scanner company predicted that within 12 months, contact image sensors will be just as cost-effective as CCD, and within 18 to 24 months, it will be more cost-effective. Most major scanner manufacturers, including Datacopy and Dest, admit that they are tracking the technology and say they will have contact image–based products, perhaps in the form of 8½-inch hand-held page scanners, ready when the market wants them.

You, Too, Can Build a VGA Board

Want to enter the fast-growing graphics-board business? Two companies want to help you by offering a "manufacturer's kit" that they say will provide everything you need to build a VGA-compatible graphics board for the IBM PC.

Award Software (Los Gatos, CA) is supplying the BIOS and the design for the card, while Cirrus Logic (Milpitas, CA) brings the VGA-compatible chips. Cirrus, which provides VGA chips to companies such as Video Seven, claims that its two-part chip set is the only VGA-compatible set currently available.

Like many announced VGA cards, the Award/Cirrus board design features VGA, EGA, CGA, and Hercules compatibility, plus support for both the new analog monitors and the older digital TTL monitors. The board also features autoswitching between the graphics modes. Other enhancements include an 800- by 600-pixel by 16-color mode, support for a mouse in hardware, and performance that Cirrus claims is 4 times that of the IBM EGA.

According to Award, people who purchase the $5000 manufacturer's kit will be able to begin selling the board in 30 days. The kit includes an evaluation board, schematics, film for making the boards, manufacturing instructions, the text for an owner's manual, and two color photographs for marketing literature. According to Award, even FCC certification has been taken care of; the board design has passed the certification requirements, and getting a new version of it certified is a mere "paper formality," the firm said.

Award and Cirrus said that several manufacturers, including some monitor makers, should have versions of the board ready to ship by now for retail prices of $400 to $500. One manufacturer is even toying with the idea of bundling the board with a new desktop-publishing package; the board would provide high-resolution text.

Air Force Takes Tip from PC Industry

In a radical departure, Air Force planners have decided to base the next generation of USAF fighters and bombers around open-architecture hardware, an approach that they admit has proven successful in the personal computer industry. According to Lt. General Bill Thurman, commander of the Air Force's Aeronautical Systems Division (Wright-Patterson Air Force Base, OH), future aircraft will incorporate interchangeable printed circuit cards, like those in an IBM PC, instead of dedicated "black boxes" that have been used for the past few decades.

"Instead of contracting for a company to build an entire specialized radar set," Thurman said, "we'll contract for common cards." The approach, which the Air Force refers to as "modular avionics," is not new, although the

continued

ogy (Pasadena, CA) used a Macintosh II to control an experiment that measured chemical reaction times occurring in femtoseconds. (Light travels from here to the moon in about one second; in a femtosecond, light wouldn't even make it across the width of a human hair.) The Mac manipulated a data-acquisition system and a laser actuator controller, under a program written in LightSpeed C by research fellow Mark Rosker.... **Hecht-Nielsen Neurocomputer Corp.** (San Diego, CA) has developed software for helping a neural network system learn patterns. AR/NET, in conjunction with the company's Anza add-in board for the IBM PC and compatibles, uses a massively parallel structure to recognize a learned pattern immediately. "Regardless of the number of patterns the network has learned, it can respond to any pattern it has learned," said company president Robert Hecht-Nielsen. The software can be set to signal the user when it encounters a pattern it doesn't understand.... Mac users can **share PostScript fonts** residing on a network with a printing utility from **Olduvai** (South Miami, FL). "The display fonts are the only ones that need to be present on the user's machine. The utility can find and download the PostScript font to the PostScript printer," said Olduvai president Juan Chotsourian. FontShare costs $295 per network and is compatible with networks such as TOPS, AppleShare, MacServe, and HyperNet.... It's a Compaq 286 controlling the four **robot-controlled cameras** NBC now aims at **Tom Brokaw** on the Nightly News.... And now it's time for Digital Exercise! **International Component Manufacturing** gets our Who'd-a-Thought-It? award this month for its Exer-flex "exercise putty." The silicone-based putty "strengthens fingers and reduces operator fatigue among computer users," the company says. It can even improve your digital dexterity and reduce tension, ICM claims. Now we're awaiting little spandex leotards for our fingers to wear while exercising.

Air Force's decision to support the concept is.

"We want to develop architectures that will integrate avionics to cut weight and costs," Thurman explained. "By using highly specialized cards that have very high speed integrated circuits, which are just starting to become available, we will reduce a 50-pound aircraft data processor to a 3-pound computer on a card."

Among the planes that will incorporate open architectures are the Advanced Tactical Fighters, which are the follow-ons to the current generation F-15S and F-16S, and the Advanced Technology Bomber (the "Stealth" bomber). Thurman, who is often referred to as "the architect of the Air Force of the twenty-first century," told Microbytes Daily that some current planes, including possibly the F-16, will be retrofitted with modular avionic systems "wherever appropriate," adding that "we just won't rip out the avionics of an F-16 for the sake of doing it." He sees modular avionics as a great opportunity for all card manufacturers.

Valdocs Lives, New Owner Says

Veteran microcomputer users may recall TPM, the Valdocs text management and operating system that runs on the old Z80-based Epson QX-10 and QX-16. Rising Star Industries, the developer of Valdocs, went bankrupt about 2 years ago, leaving Valdocs at version 3 Plus. However, a small company called Interface Solutions (Yuba City, CA) has acquired the assets of Rising Star and plans to eventually release new products based on Valdocs.

Don Soegaard, president of Interface Solutions, told Microbytes Daily that the company's first project is porting Valdocs 3 Plus to a single-board Z280 computer, which will plug into the QX-10 or QX-16. The Z280 is a 16-bit version of the 8-bit Z80 and has performance characteristics comparable to an 80286, according to Soegaard. The Z280 board will have up to 3 megabytes of on-board RAM, a SCSI port, serial and parallel ports, and an internal bus to allow additional card-to-card interfaces for a floating-point processor or more RAM. The Z280 version of Valdocs will initially be very similar to version 3 Plus, but it will support electronic mail in the background, using the Epson's on-board Z80 for that purpose.

The next step will be to rewrite Valdocs in C and port it to MS-DOS and OS/2, said Soegaard. Valdocs is written in Z80 assembly language and in Forth. Soegaard said the rewritten version will include a relational database, an expanded indexing system, and a new editor, which will be "a stand-alone desktop-publishing system."

Soegaard emphasized that Valdocs will be a starting point for a greatly expanded software system. "Unfortunately, the concept of Valdocs was totally lost, because it was too slow on the Z80 and was released with a lot of bugs." Soegaard said he believes that there is still a place for the Valdocs interface, and he estimates that there are some 50,000 QX-10 users. Interface Solutions welcomes inquiries from OEMs and software developers.

Ethernet Inventor Speculates on Future LANscape

By the year 2000, the local-area network (LAN) scene will consist of four standards, Ethernet inventor Bob Metcalfe told an audience recently. Metcalfe, who is a vice president at 3Com, said the surviving quartet will consist of AppleTalk, IBM's Token Ring, Ethernet, and FDDI (Fiber Data Distributed Interconnects).

"You might have believed that I would say that Ethernet should be the only LAN, and I admit that that argument does have a certain charm," he said, "but that won't be the case." Metcalfe predicted that Ethernet will remain the predominant LAN standard, since 500,000 Ethernet connections are currently in use today, and, he said, 3Com is shipping about 30,000 connections per month.

AppleTalk's advantages, said Metcalfe, are that it is the easiest LAN to install and it is built into the Macintosh. Its biggest drawback, he added, is its slow speed, especially when the LAN consists of more than four Macs; nevertheless, it will be around for the next 12 years.

Metcalfe characterized Token Ring technology as old (about 5 years behind Ethernet, he said) and slow (with data-transfer specifications of 4 megabits per second, as compared to Ethernet's 10 megabits per second). IBM has been hurt by the comparison, Metcalfe said,

continued

as evidenced by "the great lengths which IBM has tried to prove that 4 is greater than 10." He alluded to IBM published documents stating that Ethernet operates at only 20 percent of specification, which comes to about 2 megabits per second. "It is convenient that 4 is bigger than 2," he said while denying the IBM claims. In reality, Ethernet operates at more than 90 percent of specification, or more than 9 megabits per second, he said.

At more than $10,000 per workstation, fiber-based FDDI networks currently are cost-prohibitive for most systems, Metcalfe said. But by the year 2000, lower costs, improved technology, and greater user needs will make FDDI much more common. One reason FDDI will become attractive is that the average LAN in the year 2000 will be carrying at least 10 megabits per second, as compared to today's average of about 1 megabit per second. "Ten-megabit Ethernet is empty today but will fill up by 2000," Metcalfe said. "By that time, FDDI will be there."

Among the LANs that should not be in the repertoire, Metcalfe said, are AT&T's StarLAN and the proposed IEEE 16-megabit-per-second Token Ring standard, both for reasons relating to lack of performance. StarLAN, which currently operates at 1 megabit per second, "will not be a major player," while the IEEE's 16-megabit-per-second proposal "does not offer a big enough [performance] advantage," Metcalfe said.

Metcalfe obviously has his preferences about which LANs should be around at the turn of the century, but he is realistic enough to know that there will be more than just four LAN environments. "The risk is that there will be too many members of the repertoire by 2000," he said, "not that there won't be enough."

Transputer Board Boosts Sun to 640 MIPS

A new Transputer-based board from Topologix (Denver, CO) converts Sun workstations to parallel processing supercomputers. The Topology 1000 board features four 32-bit INMOS T800 Transputers, each with its own memory array, which gives each board a peak performance of 80 reduced-instruction-set computer (RISC) MIPS (million instructions per second).

A maximum of 64 megabytes of high-speed dynamic RAM can be used per board. You can connect up to eight boards to a standard Sun workstation (via a simple wiring harness), yielding a peak performance of 640 RISC MIPS, the equivalent processing power of 40 or 50 68020s, Topologix claims.

"The Topology 1000 is basically an accelerator board for the Sun," Topologix president Jack Harper told Microbytes Daily. "But it gives you a lot more horsepower than an average accelerator board." To illustrate the board's capabilities, Topologix ran the standard programming problem that determines the most efficient (in terms of time and money) travel plans for a sales rep visiting 12 cities. According to Harper, a standard Sun-3 takes 15 hours to solve the problem, while the same workstation with one Topology board takes 20

continued

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minutes. When the workstation has four Topology boards, the problem is solved in 5 minutes, he said.

The system has parallel Common LISP software (which supports parallel processing applications) and an extended C compiler (for parallel numeric applications). It also provides a Unix interface that permits Lisp and C access to Unix system calls.

A non-bus-oriented architecture, in which all elements are linked, permits construction of computer networks of arbitrary size and topology. The resulting flexibility is one of the board's strong points. On one hand, Harper said, you can overlay a grid onto an image, making each Transputer responsible for processing in individual grid areas. However, he said, the system can also be turned into a tree machine for other applications.

Topologix will be targeting the Topology 1000 at "general-purpose" markets—simulation, image processing, and so on, Harper said. The board is available for "about $500 per MIP."

Some Mac Developers Not Following Rules, Apple Says

Software developers who take shortcuts when writing programs for the Macintosh may be getting by with it for the time being, but those shortcuts are short-sighted, Apple software engineers told Microbytes Daily.

"If a programmer has adhered to *Inside Macintosh* rules," one Apple spokesperson said, "the software can very easily be ported to run under future versions of the Mac operating system." Apple has said to developers "that if they follow the rules of *Inside Mac*, they won't have any problems, and we mean it," he said. "But not all of them have listened to us, and they are going to have to recode in the future."

How serious is the problem? According to another engineer, only about 15 percent of all Mac programs tested followed the *Inside Mac* rules. With about 50 percent of the programs, only slight edits and recompiles will be required to operate properly in the future. The remaining 35 percent will need significant work, however.

The Apple engineer pointed to Microsoft's Excel as an example of one program that hasn't adhered to the Mac rules. "The version of Excel you buy today won't run under the Mac operating system 2 years from now," he claimed.

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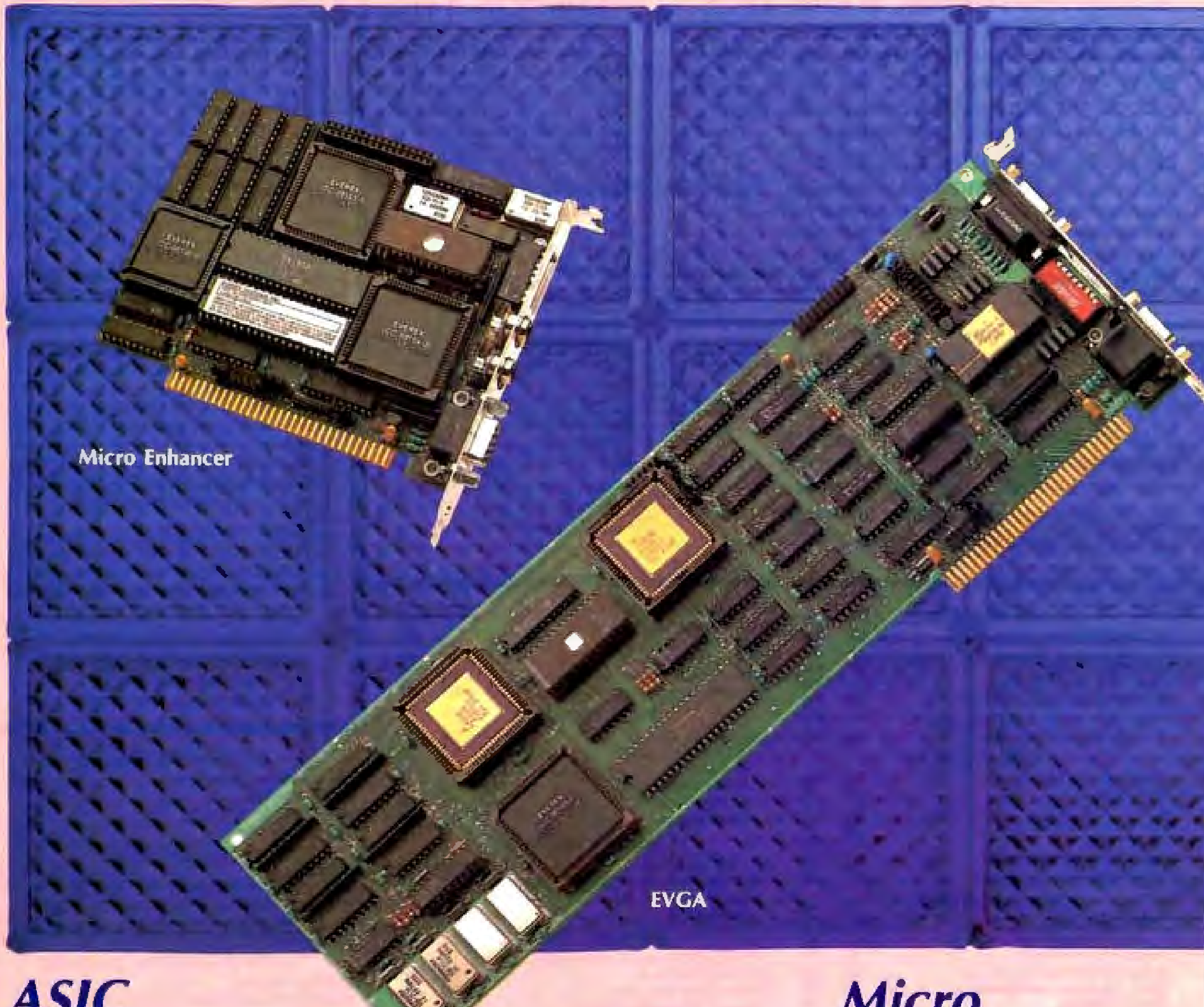

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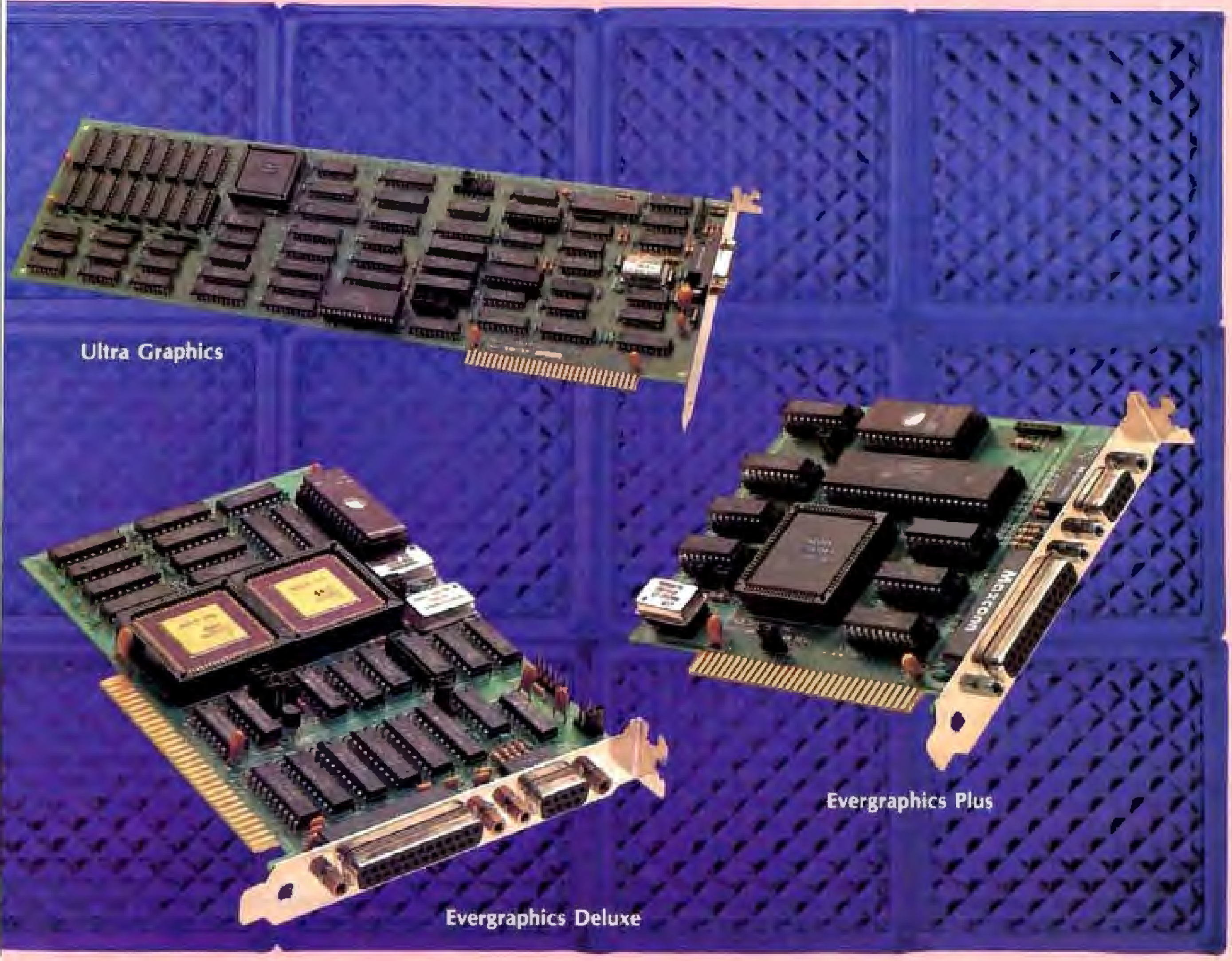

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LETTERS

FEA Concerns

Nicholas M. Baran's article, "ANSYS-PC/Linear and MSC/pal 2" (November 1987), failed to focus appropriately on the critical issues in the evaluation of a professional-level IBM PC finite-element analysis (FEA) system. The report was highly subjective and unjustifiably biased toward MSC/pal 2.

Let me begin by stating that I am not without my own biases. I work for a mechanical engineering consulting firm that provides training and technical support to users of the ANSYS program. Although Mr. Baran did note several of MSC/pal 2's deficiencies—limited problem size capacity, lack of an adequate element library, and so on—he tended to dismiss these critical factors as unimportant. On the other hand, he took every opportunity to minimize ANSYS-PC/Linear's superior features (e.g., interactive modeling capability, advanced analysis options, and upward compatibility with the mainframe version).

Mr. Baran stated that ANSYS-PC/Linear is a more expensive program than MSC/pal 2. This is true. However, in PC FEA, you do indeed get what you pay for. The degree of sophistication and complexity of professional-level FEA code is at least an order of magnitude above common PC-based applications. The absence of an element as basic as a three-dimensional solid in MSC/pal 2 is a serious liability. We live in a world composed of three-dimensional solid objects; to model them effectively often requires a continuum element of this type.

Mr. Baran claimed that time-to-solution on similar analysis problems was equivalent for both programs. He did not elaborate on the type of problem he solved; he stated only that the model contained 2000 degrees of freedom. ANSYS-PC/Linear uses a wave-front solution method, influenced by element rather than node order. If you don't know the value of the maximum wave front in the model, the number of degrees of freedom is largely irrelevant. Numerous benchmark studies have shown that ANSYS-PC/Linear has the fastest time-to-solution of any MS-DOS finite-element program.

Mr. Baran raised the issue of ease of use and learning. It seems he based his entire evaluation upon the single user's manual in his possession. Each ANSYS-PC/Linear lease or purchase includes training credits for an introductory seminar on using the program. Apparently Mr. Baran did not avail himself of this opportunity. He stated that ANSYS-PC/Linear is difficult to learn. I have to ask, relative to what—a spreadsheet? a word processor? We are talking about learning to effectively use a powerful engineering analysis tool; to use it properly requires an investment in time and effort.

One of the most serious deficiencies in Mr. Baran's review is his dismissal of ANSYS-PC/Linear's interactive model-generation capability (which MSC/pal 2 lacks). He states, "The interactive mode is most suitable for issuing a few on-line commands to obtain a plot or a small listing. For creating a moderate-size model, I found it much easier to prepare the input file using a text editor and then to run PREP7 in batch mode using my input file." To prefer working in batch mode when an excellent interactive capability exists (with on-line help, immediate plotting, and error correction) is insane. I wonder if Mr. Baran prefers shaving in the dark—that's what it feels like to create an FEA model in batch mode.

Now that I've gotten all that off my chest, let me say that Mr. Baran's criticism regarding difficulty in obtaining a hard copy in ANSYS-PC/Linear was entirely valid. However, Version 4.3 of ANSYS-PC/Linear is now available, and its new vector display mode option completely corrects this problem.

Victor R. Urbach
Westbury, NY

I stated in the article that ANSYS-PC/Linear is the more capable and flexible product. On the other hand, I think it's a bit presumptuous to claim that the "degree of sophistication and complexity of a professional-level FEA code is at least an order of magnitude above common PC-based applications." It all depends on what you plan to do with the program. And though we do live in a three-dimensional world, a great many problems can be solved in two dimensions with beam or plate elements.

In the years I worked as an engineer performing stress analyses of mechanical and structural components, I would say 80 percent of the problems involved beam and plate elements rather than solid elements. Many of these types of problems can be solved accurately using MSC/pal 2 as well as ANSYS-PC/Linear.

Since MSC/pal 2 does not use a wave-front equation solver, the value of the maximum wave front does not help us compare performance. I intentionally avoided attempting a formal benchmark because of the different solution methods. My own experience in running identical problems on both programs was that their performance is roughly equivalent. And let's face it, whether it takes 40 minutes on one or 48 minutes on the other, both programs are pretty slow on an IBM PC.

Let's not confuse a program's ease of use with the process of learning and applying the concepts of finite-element analysis. While a great deal of training and education are involved in applying FEA competently, there is no reason why the user interface of a program like ANSYS-PC/Linear should be so complex. There is no reason that a beginning user should have to spend hours leafing through the manual trying to figure out how to generate a mesh pattern.

I'm sorry, but all the finite-element programs I've seen, including MSC/pal 2, could benefit from improved user interfaces. There is no reason why engineers should have to continue to put up with terse command languages and forbidding documentation.

Finally, I stand by my evaluation of ANSYS-PC/Linear's interactive modeler. No, I don't like shaving in the dark, but I also don't like shaving with a dull blade. I still maintain that the interactive modeler is extremely difficult to use. Perhaps with a training course, my attitude would change, but I was evaluating the program

continued

from the point of view of users who might be trying to learn the program on their own. —Nicholas M. Baran

Sign Language vs. Finger Talk

Ohio State University's program, SpeechSign (Microbytes, December 1987, page 14), does not "help teach sign language." It teaches the manual alphabet, commonly known as "finger talk."

Finger talk is excruciatingly slow. Sign language positions the whole body, in the context of the surrounding environment, in symbols that transmit information.

Fluent signers routinely transmit information at 100 times aural speed.

There are three widely used sign languages. The oldest is American Indian Sign (AIS), used by the Boy Scouts. Next came American Sign Language (ASL), used by the hearing-impaired and for cross-cultural communications. Last came Gorilla Sign Language (GSL), ASL restructured for the Great Apes.

True sign language uses syntax and grammar radically different from aural language. NATO and the UN unofficially recognize ASL as a universal language. The Boy Scouts use AIS to conduct business and personal conversations during International Jamborees. GSL is the only language routinely used for two-way transmission of sophisticated abstract concepts between animals and humans.

None of this is possible with language-bound finger talk. To reach the Dick-and-Jane kindergarten level of sign, the hardware would have to have at least 500 megabytes of RAM, with a clock speed of at least 50 megacycles and a graphics screen the size of a barn door. Then comes the program, which will, while under development, spin off sign language translators centuries beyond what we have today.

Eugene Austin
Tilden, NB

"Information," Please

I congratulate BYTE for printing "Information Theory" by Ramachandran Bharath (December 1987). An open discussion in the computer field about defining the term "information" is long overdue, and maybe this article will lead the way. For too long, the term has been picked up and used without regard to its precise meaning.

Mr. Bharath provided us with a comprehensive introduction to information theory, and he made the technical nature of the theory crystal clear. The reader could easily see that the theory is based on mathematical proofs and, as such, could not be used to deal with the issues relating to the value of the contents of the

continued

messages being measured. Perhaps Mr. Bharath's warning and clarification of this fact at the end of the article was not strong enough. I would like to reinforce the warning.

Information can be explained simply as data that is prepared into a form that makes it easier for someone else to use. Information theory provides us with mathematical tools to evaluate the reliability of information, not with a methodology to evaluate its relative value.

We tend to be too technical in our collective quest for systems solutions. We would be better off clarifying what information is and how it is processed, in the broadest sense of the word, so that we can provide more reliable, more effective, more acceptable systems solutions.

Information is a dynamic and personal, yet powerful, thing. It changes everything with which it comes into contact. That is part of the nature of information. Information scientists and librarians have obviously given attention to this topic, as have economists, political scientists, and behavioral scientists. Now is a great time to learn from these discussions. We need more dialogue to discover just what information is.

Kevin Stumpf
The Infotorium
Kitchener, Ontario, Canada

Karmarkar Kudos

Ever since I saw "Karmarkar's Algorithm" by Andrew M. Rockett and John C. Stevenson (September 1987), I have found more and more reasons to thank you for including material at this level of mathematics.

The article is proving to be a most useful adjunct to lecture material in a course on linear programming that I am taking—even the errors in the BASIC listing made me think things through.

Since I have found the spreadsheet a good self-instructional tool, I have constructed a Lotus 1-2-3 worksheet that steps through the iterations of the example given. This worksheet provides a useful look at what is actually happening at each stage.

I would be glad to provide BYTE readers with a listing of the formulas and a description. If readers would send along a disk, I would copy the worksheet onto it and mail it back to them.

H. J. Hunter
P.O. Box 13398
Kanata, Ontario, Canada K2K 1X5

Semantic Accuracy

In "Modeling the Brain" (December 1987), Matthew Zeidenberg asserts that the system makes "accurate role assignments" in such sentences as "The man hit the boy with the mallet." It's best not to say "accurate" in setting a default semantic value for an ambiguous sentence without context validation. The article deals with semantics at sentence level only, so matters of context are not considered. Given that approach, ambiguous sentences are best left with semantics not fully resolved. The pleasure many people derive out of ambiguous sentences, similar to that of enjoying optical illusions, argues that an isolated sentence does have a flip-flop semantic value.

For a system to analyze syntactic ambiguity, other input should be considered before making a semantic decision. Each relevant piece of data adds weight to an interpretation, and some particular (even externally set) weight of certainty sets the meaning, at least until contradictory information is received. Since ambiguity can be resolved before or after its occurrence, the system needs to look back as well as forward. Consider "The 4-year-old was showing his buddies his new mallet when a car veered around the corner. They ran for safety, but the man hit the boy with the mallet." Or "The man hit the boy with the mallet, then the red-headed kid, but missed the baby, before he regained control of his car and rounded the corner." Not to mention "The man hit the boy with the mallet with his car."

The fact that people do not stop at the end of each sentence for an interminable period of interpretation makes clear that once we think we know what we're talking about, we suspend analysis (right or wrong). A computational model should likewise go to the heights and depths, at need only.

Cathy Miller
Salt Lake City, UT

A Vote for Tweaking

With regard to Fred Langa's December 1987 editorial on benchmarks, it was a shame that benchmark optimization (referred to as "tweaking") came off so badly. On the contrary, I assert that unless each benchmark is optimized, the results will have little meaning in the IBM PC marketplace.

When compilers are benchmarked without "tweaking," we are verifying their ability to handle a particular source code. Source code compatibility is essential in an environment that requires the continued use of many different machines and compilers. In the big-business management information-systems environment, programs can be distributed as source code, or perhaps a publisher will produce different versions of a program for the various target machines. In any case, source code compatibility is an ab-

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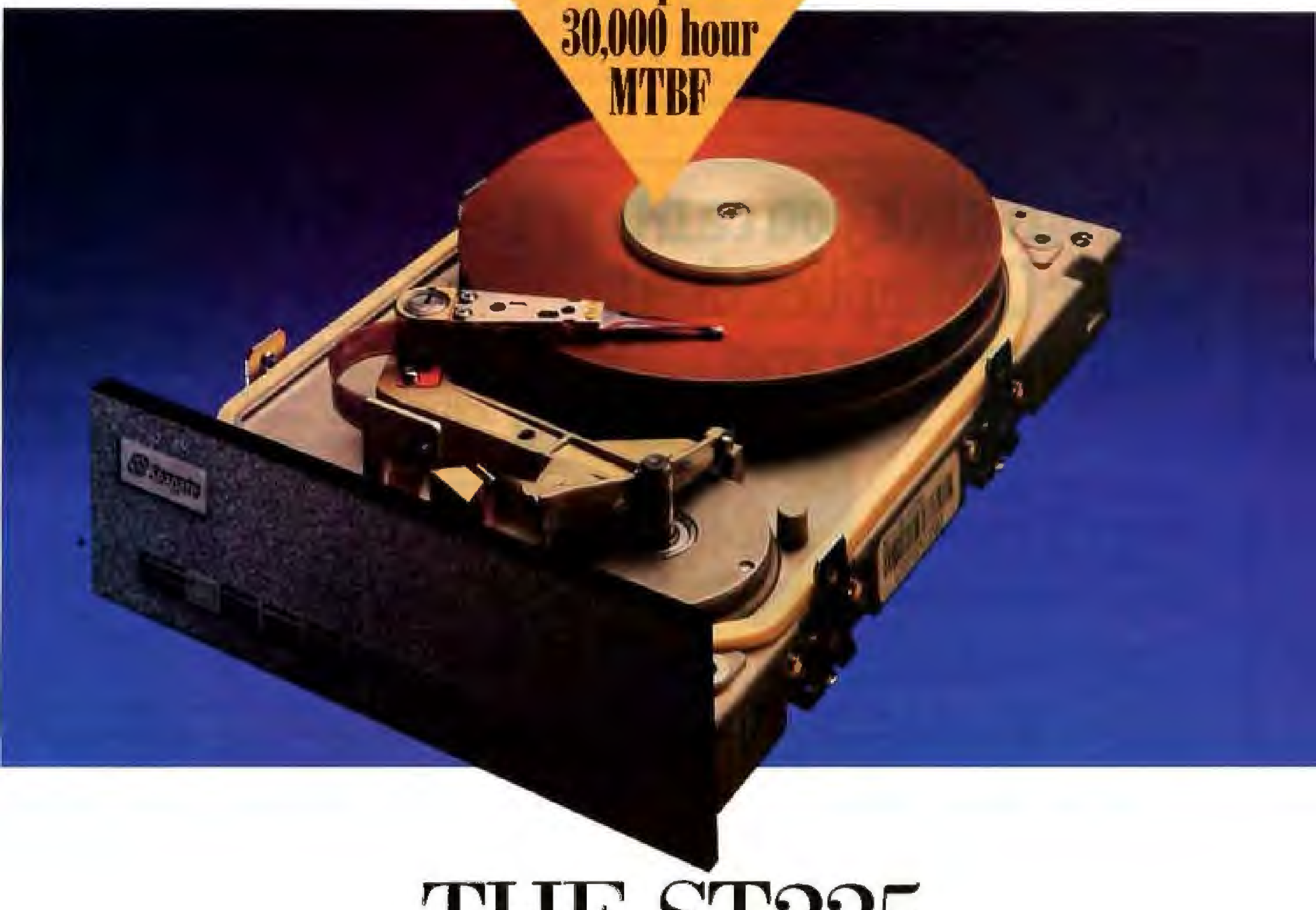

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solute requirement in a big-computer environment.

The basis for the IBM PC software markets is not source code but compatibility at the machine level. PC programs are distributed as object code, and only object code compatibility is required. Users do not care whether the program source code is "compatible" with some standard, but they do care whether the object code program is compatible with their hardware and how fast it runs. If "incompatible" source code features would improve performance (and produce the same results), this is a topic of real interest to programmers serving the PC marketplace. Performance optimizations for particular languages and compilers are useful news.

The thing that is constant about a PC marketplace is a "standard interface" between hardware and software; that interface is where applications object code meets the operating system, BIOS, or other hardware interface code. When rating new hardware or software, the only thing that matters is performance while using the standard interface. Applications can be rated directly. Compilers can be rated as applications that produce applications, and by the performance of the resulting applications. Hardware can be rated by the performance of known applications that use the standard interface.

Of course, "performance" is always relative to something; it is useful to investigate software performance on some "standard hardware." Perhaps the standard hardware in the 8086 environment would be both a classical IBM PC and a PC AT; in this way, programs that take advantage of the 286 could be identified. Different but similar hardware standards would apply to the various 68000 environments. To investigate hardware improvements, there would be a suite of "standard software," and the comparative performance (between the "standard hardware" and the "improved" version) would indicate the effectiveness of the new hardware.

In summary, the failure to "tweak" a benchmark for a particular compiler emphasizes source code compatibility over object code performance, an emphasis that is misplaced in the PC marketplace. Optimizing each benchmark for each compiler (to produce the fastest and tightest code to perform the desired function) should be a normal course of business—unless, of course, you're addressing a big-computer environment.

Terry Ritter
Austin, TX

Fantastic

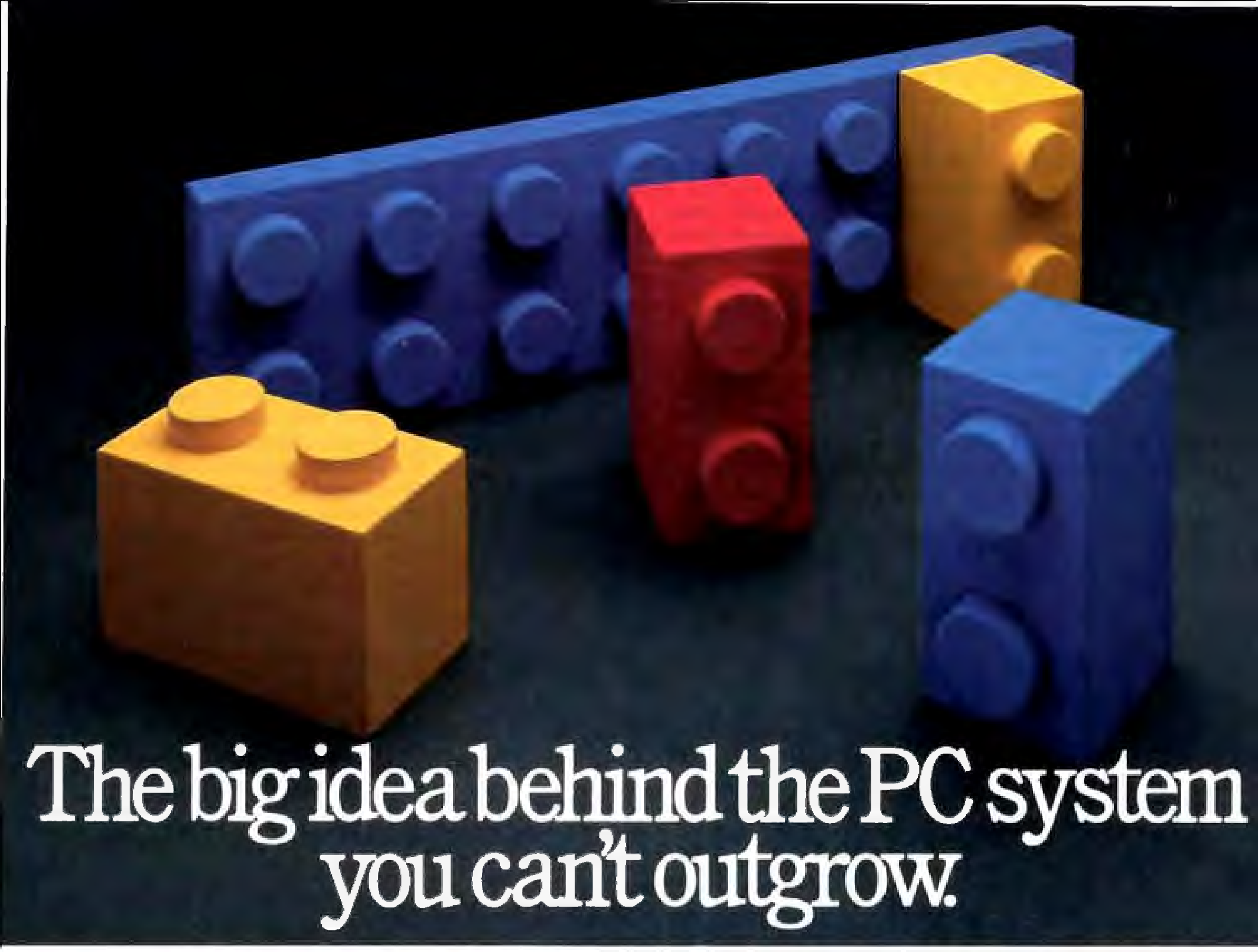
I have one basic comment regarding the planned revision of your benchmark programs (December 1987 editorial): Fantastic! There is a definite need for the revision, as the erratic results obtained by the current benchmarks demonstrate.

I have a few thoughts regarding the revisions:

• Retain the Sieve, Sort, Savage, Whetstone, and Dhrystone tests for historical reasons, if no other; they're not all bad. The Float test should be discarded, since it doesn't represent any real-world processing and is susceptible to being reduced to the trivial by better compilers. The Fibonacci test should be discarded for lack of interest; the algorithm used in the current form is terrible, and the Sieve and Sort tests do a better job of testing integer operations.

• Provide for both higher-level and assembly language forms of the tests. In the higher-level language form, the programs test how well compilers make use of processors' features, and they can serve to compare a compiler's quality for a particular processor. In the assembly language form, a better comparison of processors'

continued



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effects on performance can be made, since the variation introduced by compilers is eliminated, thus allowing more meaningful comparisons across processor families.

• Verify that the benchmarks' algorithms have been correctly transformed. The Savage program is relatively easy to verify, since the result should be very close to the number of times the loop is executed. The number of primes found is a reasonable verification of the Sieve program. A visual inspection of the Sort program's results could suffice, but I would prefer something more automated, perhaps sorting randomly rearranged successive integers and then testing for successive integers. The Whetstone program produces some intermediate numerical results that can be verified.

• Extend the Sieve and Sort tests such that 32-bit arithmetic and more than 65K-byte data referencing are required. In the case of the Sort test, make the record size greater than 64 bytes so as to make the test more realistic, and remove opportunities for playing silly games with the 68000 family of processors.

• Devise one or more benchmark programs to test character string manipulations. A large percentage of most computers' time is spent processing textual information, yet there is no well-known benchmark for this type of processing. Devising such a test will be difficult due to such things as character string representation and limits, providing standard text to process, higher-level languages' treatment of (or lack of) character string data types, and so on. Possibly, the character can be combined with some sort of file-accessing benchmark. In any event, there should be more than 65K bytes or characters to process.

• When publishing the benchmark results, the length of time to generate the program, the amount of code generated (both with and without run-time library code), and the size of the translators (compiler, assembler, and linker) are useful data. This data, of course, applies only to the tools needed to produce the executable benchmark programs, but the numbers are of some value in their own right and are sometimes helpful in interpreting the benchmark results.

Everett M. Greene
Ridgecrest, CA

FIXES

Photo Swap

Snow Software informed us of a photo error in the What's New section of the January issue. The photo that appears on page 94 is the Snow Report Writer Screen, rather than Silverado, as it is labeled. The Silverado screen appears on page 96.

Copy Protection and Drawbase

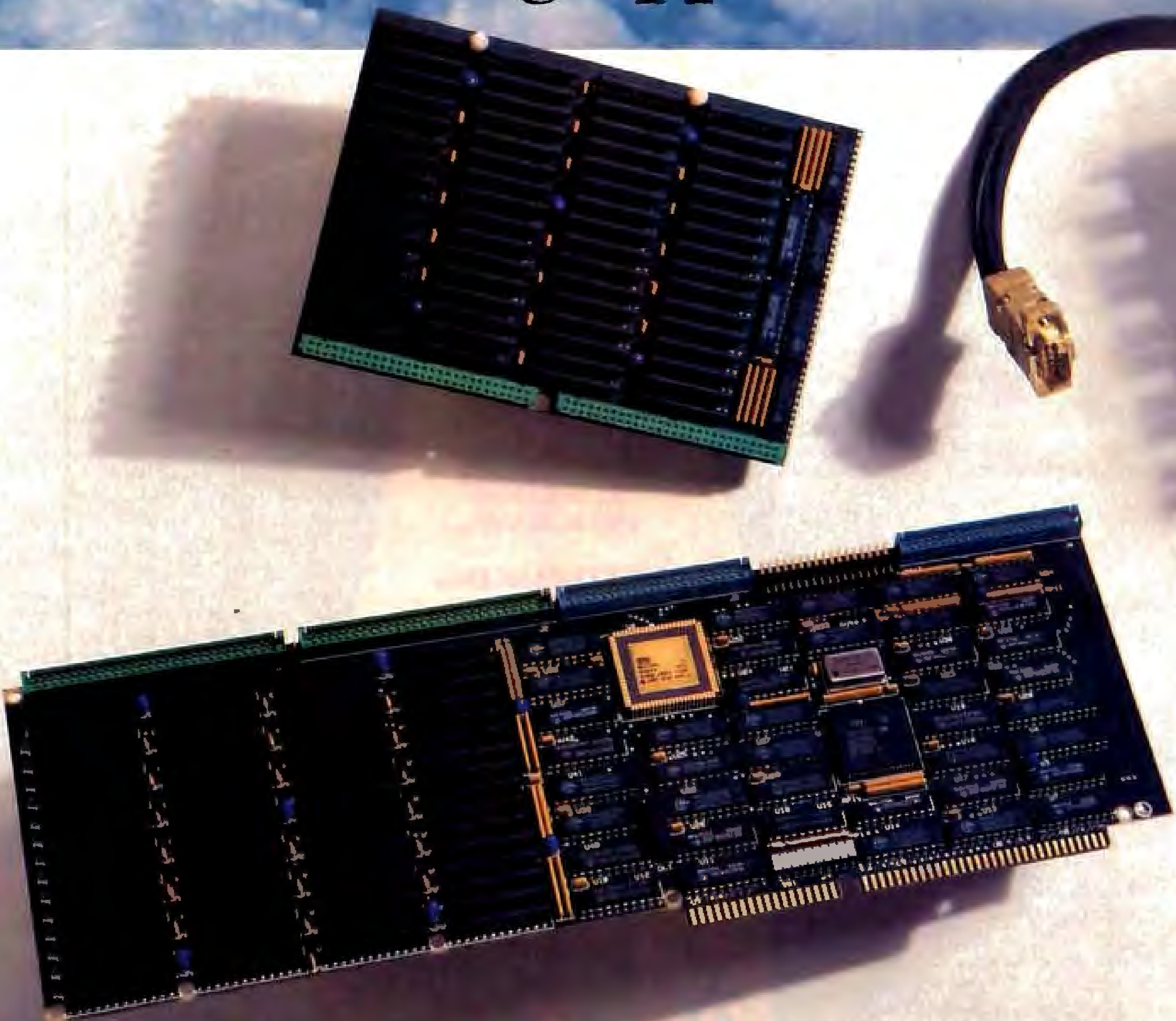
In the What's New section of the January issue, on page 78, some new programs from Skok Systems Inc. are described as not copy-protected.

Drawbase HLR is *not* copy-protected. However, Drawbase 2000, Drawbase 3000, and Drawbase 4000 *are* copy-protected.

Data-Acquisition System Not Micro Channel–Compatible

In the What's New section of the January issue, on page 86, we incorrectly stated that The Automation Group's MDL-16 data-acquisition system is a Micro Channel–compatible product. It is not. The MDL-16 is a stand-alone RS-232C and RS-244 data-acquisition board. It operates as an independent serial peripheral and does not require any slot space in your computer. ■

Now Taking Applications.



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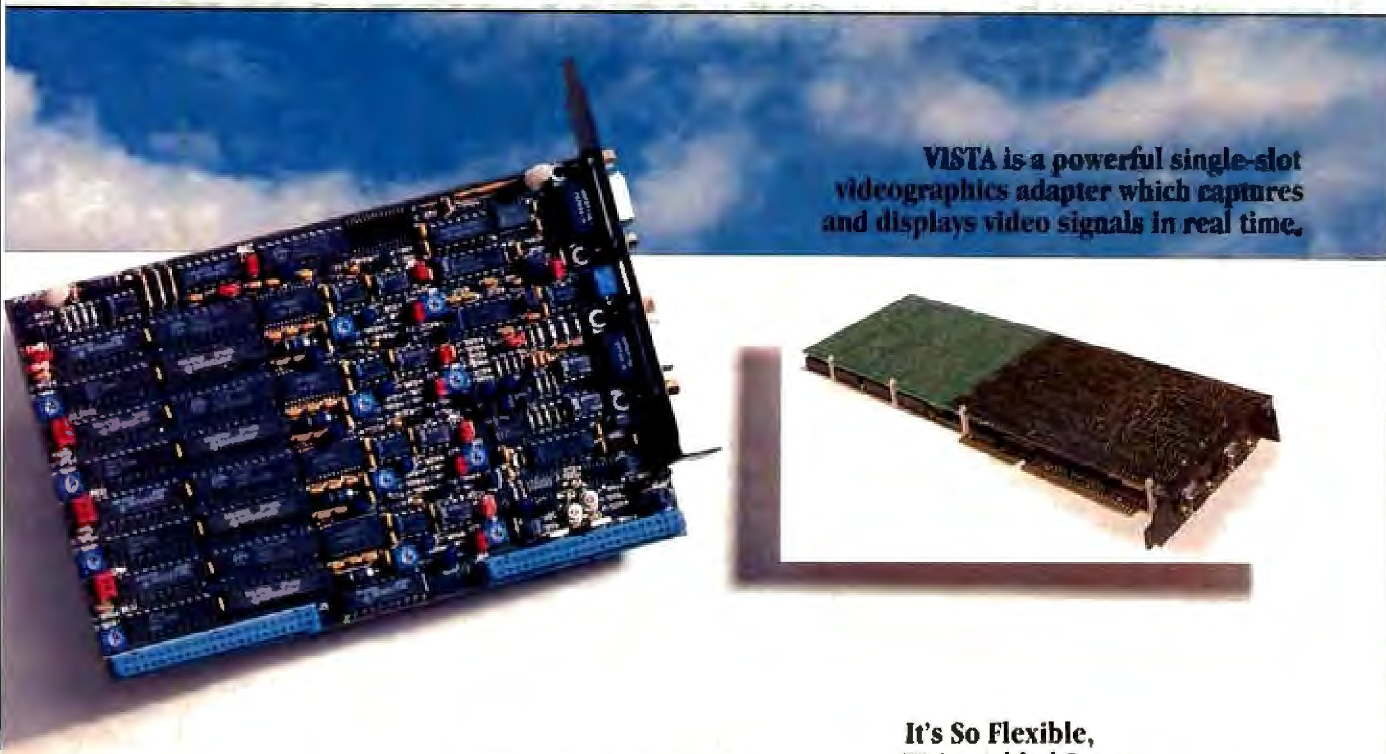

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- Display can be color-mapped, RGB, or a versatile combination of both
- Interlaced and non-interlaced display
- Binary and fractional programmable zoom capability, creates horizontal and vertical magnify or minify
- Smooth horizontal and vertical programmable panning, includes wrap-around and split screen
- Suggested Retail Price: $5995.

ADDRESSABLE RESOLUTIONS:

32 bits/pixel	16 bits/pixel	8 bits/pixel
1024x1024	2048x1024	4096x1024
512x2048	1024x2048	2048x2048
256x4096	512x4096	1024x4096

CAPTURE RESOLUTIONS:*

NTSC	PAL
(RS-170A)	(CCIR-624)
756x486	738x576
604x486	590x576
504x486	492x576
432x486	422x576

Resolutions are programmable; these are nominal ones for interlaced NTSC and PAL compatible.

DISPLAY RESOLUTIONS:*

NTSC	PAL	Interlaced	Non-Interlaced
(RS-170A)	(CCIR-624)		
1512x486	1476x576	1024x768	768x576
1008x486	984x576	(60 Hz)	(50 Hz)
756x486	738x576		
604x486	590x576	768x768	756x486
504x486	492x576	(60 Hz)	(60 Hz)

Resolutions are programmable; these are nominal ones.

COMPUTER REQUIREMENTS:

Host Type:	IBM PC AT and 100% Compatibles. Compaq 386. Apollo DN 3000-single-slot board
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CHAOS MANOR MAIL

Jerry Pournelle answers questions about his column and related computer topics.

More on SpeedStor

Dear Jerry,

I'm totally baffled as to why anyone would use SpeedStor to split a 42-megabyte hard disk into two 21-megabyte partitions, making the big disk look like two small disks. If you're going to do that, why not just have two 21-megabyte hard disks to start with? Storage Dimensions' advertising would seem to imply that the raison d'être of SpeedStor is to bypass the asinine 32-megabyte disk volume limitation of MS-DOS. When I finally get around to buying a 130-megabyte drive, I'll want to have it set up as one 130-megabyte volume, not four 32-megabyte partitions that look to MS-DOS like four separate physical drives.

SpeedStor gives you a choice of three kinds of partitions: bootable, DOS-compatible, and DOS-extended. The first two are bound by the 32-megabyte limitation; the third is not. That means if you set up the entire drive as an extended DOS partition, you have to boot off another drive, probably a floppy disk drive. There is, however, a better way. Partition the disk into a 1-megabyte bootable partition (C:) and the remainder as a DOS-extended partition with 1K-byte sectors and 2K-byte clusters (D:). Put your boot-up files in the first partition, and make the last line of the `AUTOEXEC.BAT` read `D:`. The system should boot up exactly as before, except that you'll wind up with a `D:>` prompt instead of `C:>`, and the volume size (if the drive is like mine) will be around 41.5 megabytes.

When you choose the sector and cluster size, SpeedStor will warn you that `CHKDSK.COM` will not operate. That's true, but when you got Golden Bow's Vopt, you also got `CHKDSK.EXE` (on the distribution disk), which works just fine on the bigger volume and nonstandard cluster, as does Vopt itself.

Incidentally, what do you think of the new enhanced keyboard? I love it—with one exception. Having two Control and Alt keys is great—if only IBM (and, of course, everyone else) hadn't put the Control keys directly below the Shift keys. Because of that, I'm continually pressing the wrong one while typing. The solution would be simple: Reduce the keys to standard size and put them alongside each other next to the space bar, getting them out from under Shift. Do you agree? If so, you probably have the clout to suggest that to someone (say, Key Tronic) with some chance of getting it implemented.

Ron J. Goodman
Warrensville, OH

Well, I could say I like having two logical disk drives, but in fact I was just too lazy to figure out the proper installation the first time, and after that it was a bit late with stuff stored on both disks. I expect I'd have done it differently another time.

DataDesk keyboards come with a switch and replacement key caps; you can put the Control key to the left of the A key, where it belongs, and relegate the CapsLock down to below the Shift. I love DataDesk keyboards. I'm typing this on one.—Jerry

Mouseless Microsoft Word

Dear Jerry,

Regarding the `Delete Word` command in Microsoft Word (Computing at Chaos Manor, October 1987): You can create a macro to delete a single word in Word, using SuperKey. Try this:

```
<LFT><F8><Del>
```

(using SuperKey terminology). The left arrow command is to account for the case when the cursor is on the last character of a word that is followed by a punctuation mark, when pressing F8 would send the cursor to the punctuation mark.

I wonder if PC-Write would get rave reviews if users had to pay the same for it as they pay for the "big" programs ($450 list, $229 street price). I've tried PC-Write, and I find its interminable dot commands and myriad special keystrokes for every little function illogical and confusing. Give me Microsoft Word's pop-up mnemonic menus (automated by a few SuperKey macros) any time.

Robert Hawkins
Greenville, MS

continued

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. He can be reached c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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Yeah, I know you can do almost anything with macros in Microsoft Word 4.0. WordStar 4.0 is pretty good, too. I understand they're adding macros to Word Perfect as well. Every time one of the editing programs improves, the others do. Makes for an embarrassment of riches, but I'd rather have that problem than not enough choices. —Jerry

Floatable Computer?

Dear Jerry,

I have a problem. I am lusting for a computer, and I live on a boat. Living on a boat means that I have only 12-volt electricity, very little space, no proper lighting, and so on.

I would like to get an MS-DOS computer. It must run on 12 V DC, be very sturdy, and not drain too much electricity, and I must be able to buy (rather than transfer) software for it.

You have written several times about the Zenith Z-181, but the problems you mention with regard to null modem cables and so forth seem too great for me. I have the boat in the Caribbean now, and I have enough problems getting things like lightbulbs.

Could you please comment on the Toshiba T1100 Plus and the NEC MultiSpeed in relation to the Zenith Z-181? Can you think of any other portables that might be in this class?

Bren Jacobson
Northville, NY

I may have made the difficulties of transferring software to the Z-181 sound greater than they were; anyway, given Traveling Software's wonderful Laplink (which comes with cables), that's all history.

I am told that Zenith makes a 12-V power adapter. I find my Z-183 (which has a hard disk drive) nearly perfect except for its weight. Whether it will stand up to a corrosive salt water atmosphere is another story.

The Toshiba and NEC portables are also very nice. I prefer the Zenith, largely on the basis of the keyboard and backlit screen. Again, I'd be awfully concerned about corrosion.

I used to have the smallest legal midget ocean racer (a 20-foot Weber-designed sloop) on the Pacific coast. That was before computers. I miss her. —Jerry

In Defense of DP Departments

Dear Jerry,

You've come down rather critically regarding data processing departments having much control over the purchase/setup/use of personal computers. My experience in relatively small corporations having from 10 to 30 or so PCs at any one time leads me to the following conclusions:

Early in 1988 there are still many, many more totally new and completely naive PC users than there are even very moderately experienced users. Of every 10 users I've dealt with, only 2 had learned after 6 months how to use a utility program like PC Tools other than by rote while referring to written notes. For them, if it isn't on a menu, it isn't possible to do without help. Only 1 in 10 had moved on their own to a level of competence more than minimally acceptable within the one or two applications (word processing or Lotus 1-2-3) necessary to do their jobs. Fully 8 of every 10, if asked to do something that required learning a significant new area of an application that they had worked with for some time, demanded training and hand-holding before they would even begin to approach the problem.

For the large majority of users, there is no willingness to take a manual home or

continued on page 269

ASK BYTE

Steve Ciarcia answers your questions on microcomputing.

dBASE Deletions

Dear Steve,

At the office, I work on an IBM PC using various software packages, including dBASE II Plus. I discovered that, while using one database and executing an APPEND from another database, all the characters like the Hebrew letter "Mēm" (on a Hebrew keyboard) are totally deleted. This ruins the whole display of the data that I've just added to the database with APPEND. (Every occurrence of the letter Mēm is deleted, and the rest of the letters are carried back one space for each deletion.)

The IBM guide (*IBM Personal Computer—National Supplement—Israel*) regards the Mēm character as decimal 13 (hexadecimal 0D). SideKick regards the character as decimal 141 (hexadecimal 8D).

I am not a professional programmer; I'm working as a secretary while studying for my second degree in education, and most of my knowledge is self-learned. Therefore, I don't have the tools to solve this problem on my own. What could be the reason for the malfunction of dBASE that I described above, and what can I do to correct it and avoid the problem in the future?

Dalia Hasson
Haifa, Israel

I never cease to be amazed at the awful consequences of even simple changes to programs. In your case, dBASE is eating the disappearing Mēm in the mistaken belief that it's a carriage return instead of a printable character.

In the ASCII character set, a carriage return is represented by a decimal 13 (hexadecimal 0D), and that's what most programs expect to see. Some programs ignore the high-order bit when looking for control codes, so both hexadecimal 0D and 8D are often treated as carriage returns because they differ only in that bit position.

You can write a small dBASE program to see what ASCII code dBASE uses for Mēm:

```
CLEAR
SET TALK OFF
STORE 0 TO keyval
DO WHILE keyval = 0
 @ 5,5 SAY "Press a key to display
  the ASCII value"
  keyval = InKey()
ENDDO
?
? "The ASCII value is"
? keyval
```

If Mēm turns out to be 0D, then there's no simple fix. What you'll need to do is write programs that convert Mēm into some other (unused) character before storing it in the database, then convert it back before displaying it. This is barely acceptable if you're using programs to control all the database operations, but it's unworkable if you're doing it by hand.

Perhaps a variant of that idea might be useful. You could write a program to scan a database file and replace all occurrences of Mēm with another character. You could write another program to convert them back after you've done the APPEND. *This might work, but the scanning that the program will have to do might fail if dBASE filters out the hexadecimal 0D and 8D characters. You'll have to try it to see.*

I'd also expect that you'd have problems with Hebrew characters that map to other ASCII control codes, such as hexadecimal 0A (linefeed), 0C (formfeed), and 07 (bell). I wish I had a clean solution for you, but I suspect that there just isn't one. It's a shame that dBASE isn't more international, but it's also a shame that there isn't a solid standard that would allow programmers to handle multiple character sets. —Steve

A 360K-byte Apple Drive

Dear Steve,

I have an Apple II Plus, and I was wondering why I couldn't rewire the disk drive card so that it could control a 360K-byte floppy disk drive (say, a Remex 480—cost around $35). If I could patch the card to do this, I could write software to control the drive appropriately. I know the Apple disk drive was done this way when Apple converted from DOS 3.2 to DOS 3.3.

Leo Kratz
Fairgrove, MI

With the current availability of industry-standard disk drives at bargain prices, many Apple computer owners would like to make a switch. Actually doing so, however, is a major problem. When Apple introduced it 10 years ago, the Apple disk drive was an elegantly engineered solution to the need for a minimum-hardware disk system for Apple's entry into the rapidly growing personal computer market.

The Apple disk system uses a group coding (GCR) data format that uses software to perform tasks that are commonly done in hardware with industry-standard systems. The Apple disk drive/controller hardware remained essentially unchanged in the transition from DOS 3.2 to 3.3; a coding change in the PROMs enabled the system to discriminate two consecutive zero bits when reading the disk. This permitted an increase from 13 to 16 data sectors per track because of greater data density permitted by the larger number of usable code groups. DOS 3.3 thus uses a single-sided, 35-track, 16-sector GCR format. The only change required for the transition from 3.2 to 3.3 was a new disk controller PROM and the new master disk software; the drive itself was unchanged.

When IBM established the de facto industry standard as a double-sided, double-density 40-track 360K-byte disk drive, modified frequency modulation (MFM) encoding, using an NEC µPD765 series controller chip, Apple's elegant solution became something of a millstone. Because of control signal and other differences, the Apple drives can-

continued

IN ASK BYTE, Steve Ciarcia, a computer consultant and electronics engineer, answers questions on any area of microcomputing. The most representative questions will be answered and published. Send your inquiry to

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The Ask BYTE staff includes manager Harv Weiner and researchers Eric Albert, Tom Cantrell, Bill Curlew, Ken Davidson, Jeannette Dojan, Jon Elson, Frank Kuechmann, Tim McDonough, Edward Nisley, Dick Sawyer, Robert Stek, and Mark Voorhees.

not be used with other controllers, and non-Apple-type drives cannot be used with an Apple controller.

The Apple drive hardware and software is discussed in considerable detail in the following books: Understanding the Apple II *by James Sather,* Understanding the Apple IIE *by James Sather,* Beneath Apple DOS *by Don Worth and Peter Lechner, and* Beneath Apple ProDOS *by Don Worth and Peter Lechner. All four books are available from Quality Software, Computer Book Division, 21601 Marilla St., Chatsworth, CA 91311.*

At one time, there were several sources for kits to convert industry-standard drives made by Shugart and MPI to work with the Apple controller. You might be able to use one of them to adapt drives such as the Remex 480 you mentioned. I know of only one source now: W.M. Enterprises, 266 Hillsmere Dr., Annapolis, MD 21403.—Steve

An Apple Coxswain

Dear Steve,

I have a rowing exercise machine hooked up to my Apple II using the game I/O connector SW2. It keeps track of the number of strokes I do, and, using the $\frac{1}{60}$ second interrupt on my mouse card, I can display the time, strokes per minute, required strokes per minute, and other calculations that I want.

I would also like to monitor my heartbeat and increase or decrease my required strokes per minute based on my pulse rate. I've seen several units that monitor your pulse using infrared sensors on either the finger (not good for rowing) or the earlobe.

I picked up an infrared phototransistor (TIL414) from Radio Shack and hooked it up to one of the paddle connectors. It works with a light source, giving different values as the distance from the light varies, but it isn't going to work on the earlobe or the finger the way it is. Can you give me some help with this?

Dave Partyka
Lorain, OH

You've already got about half of what you need to monitor your pulse. The other half consists of an infrared LED, which you can obtain from Radio Shack. You should connect the LED between +5 volts and ground using a series resistor with a value in the 100- to 500-ohm range.

If you place the LED on one side of your earlobe and the phototransistor on the other, you should be able to monitor pulse frequency. You may need to experiment with various series resistance values (varying LED brightness) to obtain the best results. Fastening the rig to your ear may be the biggest headache. Perhaps you could use a post-type earring, with the LED and phototransistor epoxied in position.

A more sophisticated method might use a photodiode buffered with an op-amp instead of the phototransistor. This would give you a faster response, but you may not need it for your application.—Steve

Love Me, Love My Imagewriter

Dear Steve,

I surrender! After a number of years as an Apple user, I have concluded that I *must* switch to an MS-DOS machine. However, I have developed a fondness for my 15-inch-carriage Imagewriter, and therein lies my question. Will my Imagewriter work using the standard serial port on IBM clones? Will I have problems using my Imagewriter with products such as Lotus 1-2-3, dBASE, and Microsoft Word? I live in Heidelberg, West Germany, and technical assistance (in English) is hard to come by. I hope you can help.

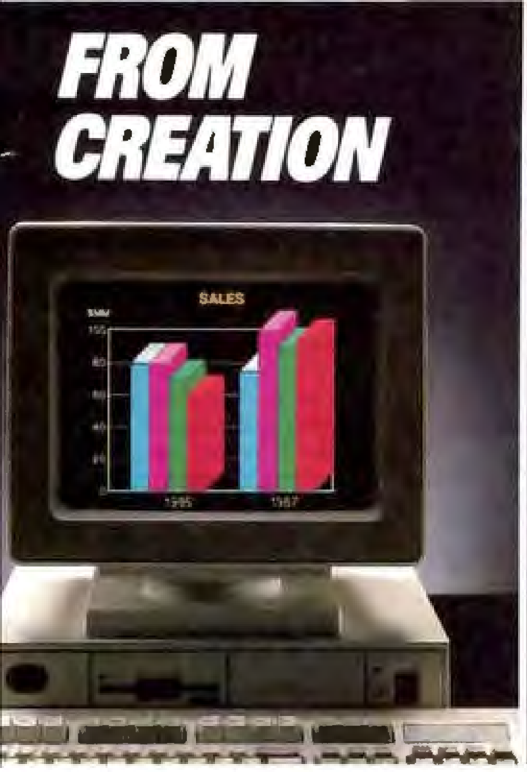
Alan P. Alborn
APO, NY

Your desire to keep your Imagewriter is understandable—it's an excellent printer that's worth holding on to. You can use it with an IBM-type computer with minimal effort. There is one potential problem that you may encounter, however, which leads us to the RS-232C follies. As many people have discovered, "RS-232C standard" is an oxymoron, like "harmonious discord."

The Imagewriter is configured for DTE operation. If the serial port on your IBM PC is also configured for DTE, the result will be a conflict between the two devices. The simplest solution is to configure your serial port for DCE operation (if possible). Some microcomputers come with two serial ports—a printer port wired for DTE and a modem port wired for DCE. Usually, you can alter configurations with shorting blocks or switch settings. Consult the documentation of whatever PC you obtain to determine the procedure for making the change. If you cannot configure the port suitably, you could use a null modem cable or adapter.

As with RS-232C, there is no such thing as a standard null modem cable. To simplify the confusion, let's assume you're using a cable with a DB-25 connector at each end. In all common variations, pin 2 at each end is tied to pin 3 at the other, and pin 7 connects straight through. The rest of the connections vary considerably. Some of the possibilities are as follows:

continued



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• Tie pins 5, 6, and 8 together at each end, then connect them as a group to pin 20 at the other end.
• Tie pins 4 and 5 together at each end; tie pins 6 and 8 together at each end, then connect to pin 20 at the other end.
• Tie pin 4 at each end to pin 5 at the other; tie pin 20 at each end to pin 6 at the other.

You can ignore pins that I haven't mentioned above. You may need a breakout box, and you'll certainly need a lot of patience to get things working. You can simplify the situation somewhat by using a straight-through connecting cable together with a prewired null modem adapter (both available from sources such as JDR Microdevices and Jameco Electronics—see the back of BYTE for their ads). It is usually easier to alter the connections inside an adapter than to rewire the cable itself. —Steve

Parts Is Parts

Dear Steve,

I enjoy building interface cards for my Apple II (I purchase bare boards for this). Usually, I have no problems locating the parts I need. However, I have now run into a brick wall. I am looking for a General Electric DS3D PC-mount nickel-cadmium battery and a TTLDM-100 time-delay IC. If you know where I can locate these components, please let me know.

Joseph E. Pratt
St. Ann, MO

It's always encouraging to hear from fellow "roll your own" types. In a field increasingly dominated by appliance users, putting together your own hardware can get pretty lonely. While I can make a number of suggestions regarding your quest for parts, it would be easier to be specific if you had provided more information (such as the number of pins, the width of the sought-after IC, and the voltage/amperage of the needed battery).

Your best bet for obtaining the nickel-cadmium battery (GE DS3D) you require is probably an industrial supplier in a major nearby city, such as St. Louis or Kansas City. You can probably obtain the battery (or its equivalent) through sources you should be able to locate in the phone book. Digi-Key Corp. (P.O. Box 677, Thief River Falls, MN 56701), a frequent advertiser in BYTE and other publications, carries a line of nickel-cadmium batteries in various sizes, although most are designed to be used in holders rather than soldered directly into a printed circuit board. You might be able to use one of these batteries with minor board modifications to accommodate the battery holder. It's important to match the battery's voltage, amperage, and charge/discharge rate if you make a substitution. You may also have to make slight circuit modifications to permit substitution of a nonrechargeable type (such as a lithium cell). The major component in such a circuit change is the addition of a diode such as a 1N914, to prevent charging (you may also need a resistor).

The IC designation you've given—TTLDM-100—doesn't match anything I've been able to find in my references. Perhaps it is a manufacturer's in-house number. —Steve

CIRCUIT CELLAR FEEDBACK

Remember the S-100?

Dear Steve,

Several of my friends and projects are on hold for lack of information. For the most part, I've exhausted local sources, so my roommate, Alex Pournelle, suggested I write and ask you.

At the moment, my main home computer is a CP/M Jade "Big Z" CPU card with a Z80 and one serial port, a Jade "Double D" 8-inch floppy disk controller and four 8-inch drives, a 64K-byte CMOS memory board (with the address range F000-FFFF hexadecimal locked out for the monitor/boot ROM and disk window), and a CCS 2830 six-port RS-232C card. All these boards are supposedly IEEE-696 compatible, and I have mangled the BIOS to support them. This system runs in an old 12-slot Problem Solver Systems cabinet with two internal 8-inch drives.

Over the years, I have reconfigured the system many times, but I always run into either power supply or slot-count limits. I have a number of S-100 peripheral boards on the shelf, and I have recently been given another complete CP/M system consisting of an ICOM dual floppy disk drive system, a Soroc terminal, and an IMSAI 8080 S-100 frame holding even more S-100 boards. I'd like to convert the IMSAI itself to IEEE-696, so that I can move my existing system into the IMSAI frame (which has a much larger power supply and 22 slots). My problem is that I have not been able to locate any information about updating old S-100 bus equipment.

I'm sure there are thousands of Altairs, IMSAIs, Vectors, and North Stars out there gathering dust. They only need updating to the IEEE-696 standard and adding some modern Godbout, Teletek, Lomas, or Advanced Digital S-100 boards

continued

Circle 274 on Reader Service Card →

to turn those computers back into contributing members of a computing society. Upgrading old S-100 equipment to IEEE-696 might make a good topic for an article.

I will probably buy an SB180 (September 1985 Circuit Cellar) if I can modify it two ways: adding 512K bytes for an expanded RAM disk, and interfacing an ST-506 drive to it (sacrificing the SCSI port if need be). My application is a process control system that must be able to survive a very dusty environment, will be 30 miles from the nearest road (i.e., infrequent service calls), and will be able to receive remote uploads via modem.

I plan to buy your Home Run Control System (April 1985 Circuit Cellar) or build my own. However, I'd like to add to it a receiver for X-10 codes so I can continue using my telephone responder and ultrasonic console (on different house codes to avoid undesired interaction). Have you considered this option?

My house was built in the late 1930s, and it's extremely difficult to run any kind of wiring inside the walls or the attic. (The current Heathkit catalog has an X-10 module designed to connect to dry contacts on a household alarm system to output an "all lamps on" command or "all lamps on" plus "one appliance module on" command. This transmitter, modified for only the "appliance module on" code, would be ideal, if I could set up the Home Run Control System so it would receive the signal and then respond accordingly.)

This is an idea for a future Circuit Cellar project: Many people (including myself) are still using daisy-wheel printers on printer buffers. Often, when I'm printing a large piece of correspondence, I use several different print wheels, depending on what symbol I want. I might use one wheel for text, another for italics, and another for mathematical symbols. I have not yet seen a printer buffer on the market that accepts a "pause code" (i.e., a series of bytes that I could send to the buffer, commanding it to pause so I can change print wheels, then push a Continue button on the box so that printing resumes).

Also, only one manufacturer that I have seen offers a buffer that allows you to select serial or parallel in and serial or parallel out, so that you can still use the buffer box even if you change your printer, your computer, or both.

Mike Morris
Arcadia, CA

Let me get this straight: Alex Pournelle's roommate is asking me for information? This sounds like Dear Abby get-

continued

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ting another letter from the lads at Yale!

I've got to admit that all my S-100 and CP/M knowledge is rather dated by now—and not having done anything with it for a while, the grisly details are fading fast. The current repository of such knowledge may be the S-100 Journal, *which you can reach at P.O. Box 1914, Orem, UT 84057. It's $14 for a year's worth of quarterly issues, $27 for 2 years. A letter to the editor of* S-100 Journal *might well turn up someone who knows the answers to your IEEE-696 questions.*

For the original SB180 design, 256K bytes is the upper limit on the RAM. The boot EPROM shows up in the lower 256K bytes of the total 512K bytes of address space and is not fully decoded. You could hack the board to "shadow" the EPROM and add more RAM on the expansion port, but it might be a little messier than you'd like, because we didn't really intend to expand the SB180's RAM. The newer SB180FX, which uses the same HD64180 as the SB180, allows up to 4 megabytes of RAM.

As far as hitching an ST-506 hard disk drive directly to the SB180 goes, I think you're wasting your time. Admittedly, the drive is cheap, but if you're figuring in any nonzero value for your time, the total cost is going to be a lot higher, particularly because this sounds like a one-time project.

If you're looking for reliability, you want a stock solution without little yellow wires hanging off the boards. It's always fun to mess around with (read "improve") someone else's circuitry, but is that really what your client wants? Remember, he's paying for results, not "clever" design.

Back to the SB180FX. It has a SCSI port on-board, so it's easy to add an external hard disk drive with an outboard SCSI controller, such as the XEBEC 1410A. (You can usually find someone advertising the XEBEC controller in the back of BYTE. This device allows a SCSI port to control an ST-506 hard disk drive.)

Concerning your remarks about an X-10 receiver, stay tuned for a few upcoming Circuit Cellar power-line projects. These projects should provide you with the X-10 control you appear to be longing for.

Another upcoming project is the Circuit Cellar SmartSpooler, which functions as a rather bright print spooler with all combinations of parallel and serial inputs and outputs. I'm setting it up to allow downloading custom software through the standard printer port, so you can tinker with this project to add a "pause" code.—Steve ■

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THE MS-DOS ENCYCLOPEDIA
Ray Duncan, editor

IBM PERSONAL SYSTEM/2 AND PERSONAL COMPUTER BIOS INTERFACE TECHNICAL REFERENCE

MEMORY RESIDENT PROGRAMMING ON THE IBM PC
Thomas Wadlow

THE MS-DOS ENCYCLOPEDIA

Reviewed by Bill Bourn

Microsoft Press, Redmond, WA: 1988, ISBN 1-55615-049-0, 1570 pages, $134.95

What do you call a single volume containing over 1500 pages, 15 appendixes, and 5 sections, one of which contains 20 distinct articles? Suppose that material came from 14 contributors and 64 technical advisers. Microsoft Press calls this massive collection *The MS-DOS Encyclopedia*. With its multitude of distinctively presented examples, written in both assembly language and C code, the book is closer to being a handbook, although you'd need Schwarzenegger's wrists to manage it with only one hand. I guess "encyclopedia" has become an unwelcome synonym for "comprehensive treatise" since Jiminy Cricket first defined the word.

In addition to the 20 articles written by such MS-DOS experts as Ray Duncan, Charles Petzold, and Van Wolverton, the book contains 240 pages detailing individual descriptions of MS-DOS user commands, 200 pages of usage descriptions for programming utilities, and 250 pages devoted to the description of DOS system calls via the INT instruction. Much of that material is already available in the respective user guides for the various software. Why repeat it all here?

There is, I suppose, a good reason, depending on your need: The descriptions in the book span all the versions and OEM suppliers of MS-DOS—pretty handy if, as a programmer, you don't have all the versions of all the DOS manuals from Compaq to Zenith at your disposal. Even though this material has been covered elsewhere, including it all in one volume (along with the possible error messages that you might get when using any command) turns that volume into the one to fetch for nearly all DOS-related questions.

The Articles

The most unique part of *The MS-DOS Encyclopedia* is the first section, whose 20 articles delve into those mysteries that have tantalized the intellectual DOS user. I was disappointed that the internal control structures are so lightly covered in the article on the components of MS-DOS; it's rather like describing a car as a chassis, engine, wheels, fenders, and passenger compartment. I want to know about the pistons, crankshaft, and oil pump inside the MS-DOS engine. That level of detail is denied us here.

Other articles deal with the structure of an application program; managing files, records, directories, and volumes; memory management; and several other topics—merely scanning the table of contents gives evidence of the breadth of coverage in this section. Nothing I read here (or elsewhere in the book) struck any discord with what I already knew about MS-DOS. I depend on the high caliber of the contributors for having checked the factual accuracy of the contents.

A few articles deserve specific mention. In his article "Terminate-and-Stay-Resident Utilities," Richard Wilton does a creditable job of classifying the kinds of trouble you could have trying to write a TSR routine for MS-DOS. After the "rules of the residency-road," he presents two TSR routines in complete form, with accompanying explanatory text. The first routine is a simple, passive TSR that merely says "Hello." The second TSR is a more useful routine that attempts to cover all the conditions under which a TSR might be invoked. This sample TSR is invoked from the keyboard, writes to disk, recognizes the status of pending hardware interrupts, and generally addresses all the other nitty-gritty details that appear to be required for a successful TSR.

Microsoft has yet to publish an official method or set of guidelines for using this DOS function, which has been in place since release 2.0. A myriad of useful routines have been published in that vacuum; all take advantage of the TSR capability but have widely varying degrees of compatibility with each

continued

Illustration by Len Kulberda

Profuse examples and minute details make The MS-DOS Encyclopedia's *coverage of debugging a must for any programmer who knows that even the purest of heart are visited by gremlins.*

other. *The MS-DOS Encyclopedia* takes a brave step into the resulting melee to give us these examples of "decent" TSR behavior. However, the volume includes a disclaimer: "Microsoft cannot guarantee that the information in this article will be valid for future versions of MS-DOS."

TSR programs come up again in an article on the Microsoft object linker program, as an example of using the linker to organize memory. This article and the preceding one on the structure of object files (also by Wilton) may well be unique among books on MS-DOS, and this is undoubtedly due to the extreme specialization of the topic. The articles go into great detail, which is welcome here, particularly if you need to know how to build some "food" for the linker program as a part of your large project. The feast includes analysis of every bit of every byte in any object module. Wilton must have been working with Microsoft's internal documentation to provide such a complete description.

Steve Bostwick's article, "Debugging in the MS-DOS Environment," vigorously attacks the problems facing a programmer whose program doesn't work. Bostwick presents a variety of techniques, ranging from simple eyeball examination to complex analysis using CodeView, which comes with Microsoft's high-level language compilers. In one example, he uses a TSR program to echo data from the serial port onto the screen. The article briefly discusses hardware debuggers, their capabilities, and the circumstances for their use, but it avoids discussion of specific non-Microsoft hardware products. Profuse examples and details down to the byte in error make this coverage of debugging a must for any programmer who knows that even the purest of heart are visited by gremlins.

What Could Be Missing?

Amid the wealth of information included in *The MS-DOS Encyclopedia*, it's hard to tell what might have been left out. Aside from a more detailed discussion of DOS's internal structure, I missed comprehensive discussions of networking and file-sharing. The first article, which describes the haphazard infancy of MS-DOS, includes a reproduction of a large scribbled diagram showing the original network support logic for MS-DOS 3.0, but the topic deserves an article of its own. (That first chapter, by the way, is of interest to all DOS users, not just programmers, and it's worth borrowing the book just to read.)

The book could stand to have a glossary and a bibliography, which are quite useful adjuncts to serious study—whatever the subject. It does have a two-part index that is unique; commands and system calls are listed separately from the other subjects. Getting used to this arrangement might take you a while.

The complete set of the examples from the book is available on two 5¼-inch floppy disks, or presumably one 3½-inch disk, for the exorbitant fee of $50. This seems to condone the use of the examples, but Microsoft should make its intentions clearer about the use of sample code in a reader's own products. In

continued

these days of copyright cupidity, I'd prefer to have a definite statement one way or the other.

The code examples are set off by both typeface and color to good effect. As a rule, the typography is clean and uncluttered throughout the book. However, the tables are labeled inconsistently; many identical typographic structures face each other on opposite pages, one with a table designation and the other without.

Similarly, the information about MS-DOS control structures is diagramed in two apparently arbitrary formats. One structure might appear in a table that lists field length and usage, while another is consigned to a more visual series of stacked rectangles, with descriptions inside.

The cross-references to other articles are sometimes awkward. Whereas references to an appendix title include the letter designation, references to articles don't carry the corresponding article number, so the page headings (which appear on odd pages and which carry both the number and title) are less helpful than they could be.

Do You Need It?

Why publish so extensive a work about MS-DOS now, on the verge of OS/2 ascendancy? Perhaps Microsoft thought that MS-DOS is now mature enough that *The MS-DOS Encyclopedia* won't soon go out of date. The preface claims 10 million copies of MS-DOS are working now. Does this book belong next to all of those systems? Emphatically not! The book's general editor, Ray Duncan, tags the book's audience as "the community of working programmers," but I have to wonder how many programmers are currently engaged in new MS-DOS application development with OS/2 just around the corner.

Is this book for you? Look at your shelf of software and manuals. Do you have a version of an 8086 assembler there? If so, you may be able to use this book. Doubly so if that assembler is dusty. I bet the examples and lucid explanations here will catalyze you to use both the book and your assembler to overcome your previous frustrations with the quirks and mores of the world's most popular operating system.

Bill Bourn is moderator of the ms.dos conference on BIX and president of the Central Connecticut PC User's Group. You can reach him at P.O. Box 964, Glastonbury, CT 06033, or on BIX as "billbourn."

IBM PERSONAL SYSTEM/2 AND PERSONAL COMPUTER BIOS INTERFACE TECHNICAL REFERENCE

Reviewed by Ben Myers

IBM Corp., Racine, WI: 1987, Publication 68X2260, Form S68X-2260, 214 pages, $75

For some time now, when I've had to refer to some detail about an IBM PC BIOS, I've found myself looking at several sources, none of them complete. Peter Norton's *Programmer's Guide to the IBM PC* has become somewhat dated by the author's original vision to produce a work that emphasized the IBM PC and PC XT, then predominant. Norton's book contains sketchy information about the EGA specification and few specifics about the AT BIOS. Until the PS/2 computers came along, Ray Duncan's *Advanced MS-DOS* was a well-organized reference for some BIOS calls, but it curiously omitted most of the information about disk BIOS services, and it included nothing about the system services (interrupt 15H) on the AT. Finally, descriptions of BIOS calling sequences are embedded

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within the assembly listings contained in the older PC and AT technical references published by IBM. All in all, this is a very haphazard collection of reference materials, but it was the best available until recently.

The *IBM Personal System/2 and Personal Computer BIOS Interface Technical Reference* gives the software developer a complete set of materials that describe how the various versions of the IBM PC BIOS work. IBM has not published assembly listings of the PS/2 BIOS; this reference documents the externally visible features of the BIOS as a programmer doing clean BIOS-level programming would see and use them.

The book covers the original IBM PC, PC XT, PC AT, PCjr, PC Convertible, and all announced models in the PS/2 product line. At $75, the *BIOS Interface Technical Reference* seems pricey at first, but no other single document today can match it for completeness in treating its subject. It comes with a hard three-ring slipcase binder, like most other IBM reference publications. The typeface is a small but very readable Helvetica, so a lot of information is crammed into its 214 pages. There are few typographical errors.

The meat of the book is the section that has detailed descriptions of all calls to BIOS services. If different models of the PC do not respond identically, the book lists exact differences by PC model and relevant BIOS date. For example, the printer BIOS (17H) section has six notes describing the actions taken by various models of PCs. The pages covering video BIOS (10H) describe the three VGA modes, as well as the other video modes. The system services interrupt 15H receives extensive treatment, including the multitasking services that are used by other parts of BIOS on the PC AT, PC XT Model 286, and PS/2. If another interrupt uses system services to relinquish control while waiting for completion of an external event, this information is also noted. The BIOS services are arranged in order by interrupt number, then by major function designation passed in the AH register value within interrupt, so everything is quite easy to find. For the money, it would have been nice if IBM had thrown in half a dozen blank thumb-index tabs, beyond the two labeled "BIOS" and "Supplement." Then, I could have set up tabs to get quickly to the sections I use most often.

In the section on data areas and ROM tables, the BIOS data area, extended BIOS data area, and disk drive parameter tables are laid out, byte by byte and bit by bit. The last section of the book, entitled "Additional Information," describes interrupt sharing, adapter ROM, video function compatibility, multitasking provisions, system identification, application guidelines, and scan code/character code combinations. I found the information on video function compatibility particularly useful, because it told me, step by step, how to test which video functions are present. Using the procedure described, I can determine which video adapter—VGA, EGA, MCGA, CGA, or MDA—is present. The text also describes video mode-switching procedures. There is a vacant section for future supplements to be issued. The book has a standard glossary and index at the end.

If you are an experienced software developer designing software that must interface with any version of BIOS, the *IBM PS/2 and PC BIOS Interface Technical Reference* is one of a kind and indispensable. It is not for the novice PC programmer, however, because it is almost entirely bereft of examples. In the personal computer industry, where it is fashionable to take potshots at IBM, the company is often overlooked as a source for complete, well-organized materials describing its products and, by logical extension, compatible products.

Ben Myers has more than 25 years of varied experience in the computer industry. He can be reached at 73 Westcott Rd., Harvard, MA 01451.

continued

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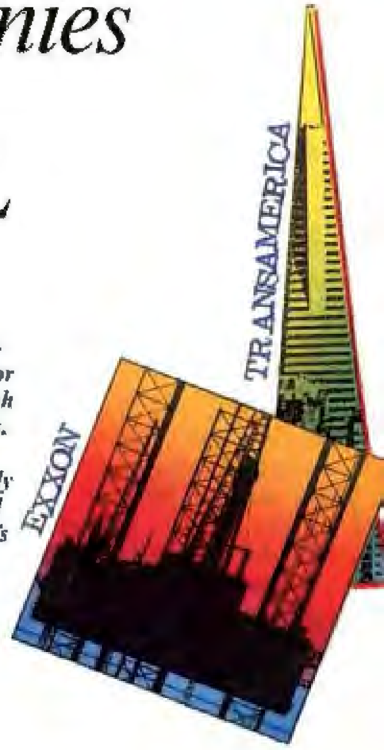

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Top companies according to the April 17, 1987 issue of *Business Week*

*U.S. suggested retail for DOS version. International prices slightly higher.

Circle 253 on Reader Service Card

MEMORY RESIDENT PROGRAMMING ON THE IBM PC

Reviewed by Ben Myers

Addison-Wesley, Reading, MA: 1987, ISBN 0-201-18595-2, 413 pages, $24.95

The subtitle of *Memory Resident Programming on the IBM PC* is "The Essential Guide to Developing Memory Resident Programs." The introductory chapters of the book cover programming in general, assembly language programming for the Intel 8088/8086 family, and writing an 8086 assembler program to display the interrupt vectors. Author Thomas Wadlow then defines a basic TSR program skeleton and provides several sample TSRs by way of explaining TSR writing. These include a keystroke expander, a clock, an instruction pointer (CS:IP) display, and TSR programs that display communications port values, set communications port parameters, list a directory, and browse through a file. The last four programs serve only as examples of TSR writing. Normal DOS programs would accomplish the same results with less effort.

Interrupts and Omissions

Unfortunately, Wadlow's book omits information that is necessary to write many important kinds of TSR programs. For example, if you have to read or write files while other programs are running, you need to know what to do to the current active PSP (program segment prefix) via DOS functions 50h and 51h. The interrupt multiplexer vector, interrupt 28h, is used to synchronize DOS operations among TSRs and other programs. Interrupt 22h (program termination), interrupt 23h (Control-C/Control-Break handler), and interrupt 24h (critical error handler) are essential to any well-written application, and doubly so for a TSR program. DOS treats functions 01h through 0Ch differently from the other function calls. None of these are explained in the book.

Similarly, if you write a TSR program that pops up on the screen, you need to be able to save and restore the screen area in which the pop-up occurs. That information is missing, as is any explanation of how a TSR program de-installs itself.

The concluding chapter, "The Roads Not Taken," is an often misleading explanation of TSR design trade-offs. Fully one-third of the book contains appendixes intended as reference material, though these, too, have some omissions. The first appendix, "IBM ROM BIOS Services," explains the BIOS calls for the IBM PC XT but excludes the ones for the IBM AT, EGA, VGA, MCGA, and PS/2. (Granted, omission of the last three is understandable, since they are fairly recent developments.) A "Hardware Interrupts" appendix covers only interrupts through 01Fh, and it includes some interrupts that are not for hardware, like the disk parameter table and high-order graphics table pointers. "IBM DOS Services" describes only the DOS functions for DOS 2.x, neglecting the DOS 3.x functions entirely. The final appendix, "Useful Books," gives a (very short) list of references used by the author in writing the book. These appendixes also have quite a few typos.

Useful, But Not Essential

The assembly language examples in *Memory Resident Programming on the IBM PC* are clear, and the accompanying explanations of programs are lucid and well written. If you want to get your feet wet writing simple TSRs, this book is an introduction to the subject, but you can find more complete examples of robust TSR programs elsewhere. The book does not meet its stated objective of being essential. You can write the bulletproof TSR programs that today's IBM PC marketplace demands without it. ■

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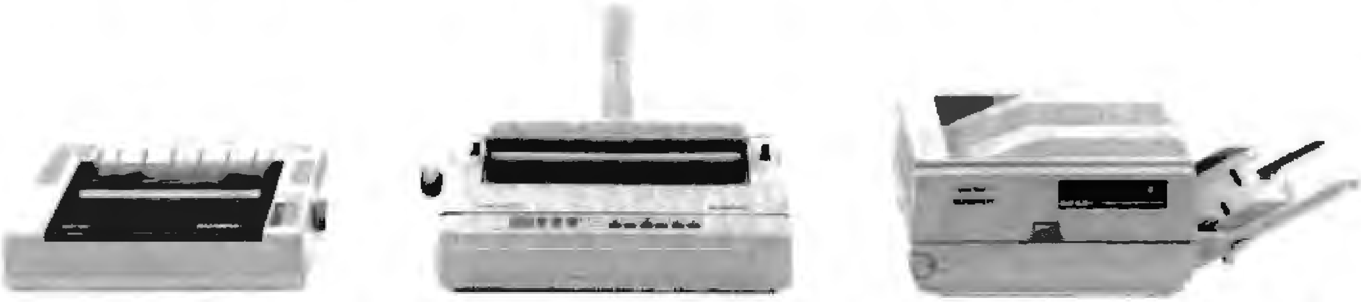

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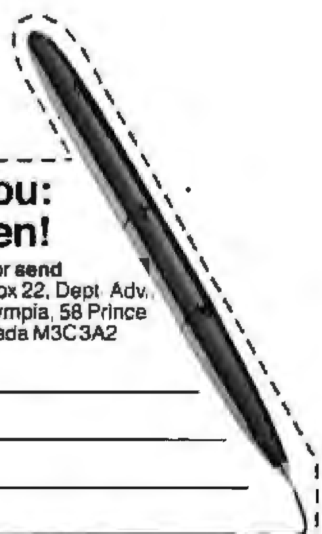

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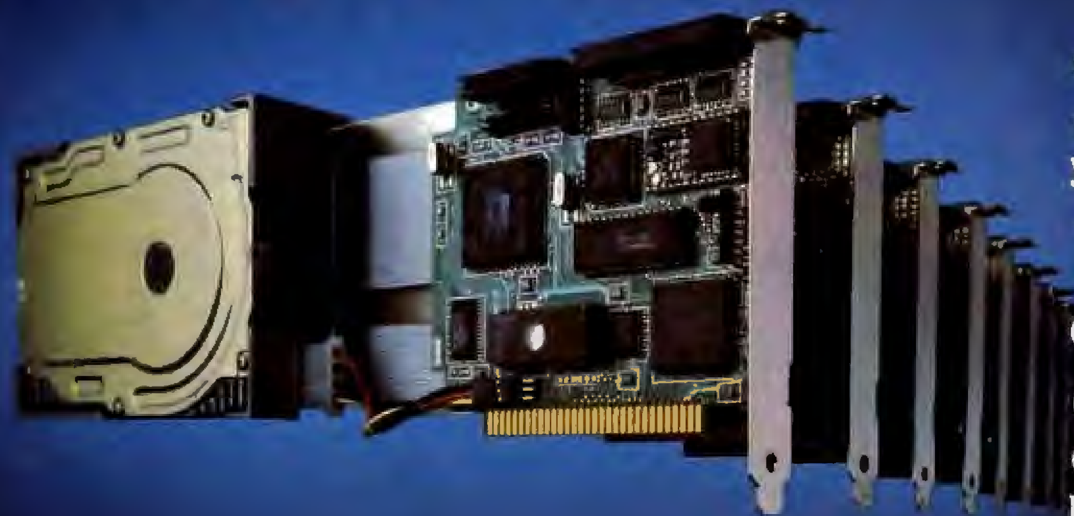

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Products in Perspective

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PROBE's menu bar and pull-down menus set a new standard for debugger interfaces.

POP registers up and down with a single key.

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You rack your brain, trying to figure something out. Is it a random memory overwrite? Or worse, an overwrite to a stack-based local variable? Is it sequence dependent? Or worse, randomly caused by interrupts? Overwritten code? Undocumented "features" in the software you're linking to? And to top it off, your program is too big. The software debugger, your program and it's symbol table can't fit into memory at the same time. Opening a bicycle shop suddenly isn't such a bad idea.

THIS DEBUGGER'S FOR YOU

Announcing the 386 PROBE™ Bugbuster,*from Atron. Nine of the top-ten software developers sleep better at night because of Atron hardware-assisted debuggers. Because they can set real-time breakpoints which instantly detect memory reads and writes.

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Then, so you can look at the cause of the problem, the 386 PROBE automatically stores the last 2K cycles of program execution. Although other debuggers may *try* to do the same thing, Atron is the only company in the world to dequeue the pipelined trace data so you can easily understand it.

Finally, 386 PROBE's megabyte of hidden, write-protected memory stores your symbol table and debugger. So your bug can't roach the debugger. And so you have room enough to debug a really big program.

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SYSTEMS

A Loaded 68020 System

Designed and built in England, the Omega is a full-featured 68020-based workstation that includes a 68881 math coprocessor and 1 megabyte of zero-wait-state nonvolatile static RAM. Also included is the OS9/68K real-time, multitasking operating system from Microware Systems.

With a processor running at 12.5 MHz, other standard features of the Omega include a fully buffered 16-bit data bus with 24 address lines, a 25.5-megabyte hard disk drive, a 1.2-megabyte floppy disk drive, four RS-232C serial ports, a parallel printer port, a bidirectional high-speed 16-bit parallel interface, and an RS-485 network node.

Hardware options for the Omega include higher clock speeds of 16.67, 20, or 25 MHz. There's also a 640- by 480-pixel by 16-color display controller, a 1- or 4-megabyte memory-expansion board, an intelligent network node controller, a prototyping board, an EPROM programmer, a 100-megabyte hard disk drive, and a tape backup unit. On the software side, there's a variety of language compilers, an applications generator, a cross assembler and debuggers, and several business applications.

Price: 12.5-MHz version, $4750; 16.67-MHz version, $4950; 20-MHz version, $5495; 25-MHz version, $6895.
Contact: Lloyd I/O Inc., Omega Sales Dept., 19535 Northeast Glisan St., P.O. Box 30945, Portland, OR 97230, (800) 227-3719.
Inquiry 754.

The Omega is a feature-packed system from England.

NEC's Desktop-Publishing System

If you have an urge to get into desktop publishing but feel constrained by your current display and controller, you can add NEC's MonoGraph System to your IBM PC or compatible and be ready to roll. A complete full-page display system, the Monograph System has a square-screen monitor; a controller board for the monitor's 1024- by 1024-pixel maximum resolution; a cable to connect the two; and driver, font, and diagnostic software.

The system's square-screen analog monitor has a 16-inch CRT with 100-dot-per-inch dot density, an aspect ratio of 1 to 1, and a flicker-free display. The monitor measures 14 by 14 by 17 inches and includes a tilt-and-swivel base.

The video-controller board requires a full-length 8-bit slot and features an Intel 82786 graphics processor running at 10 MHz. It has a CGA emulator that displays CGA-compatible software in double-scan mode, with twice the standard resolution and double the pixels per dot.

On the software side, the MonoGraph System comes with 15 fonts for both Aldus PageMaker and Ventura Publisher. Software drivers for Microsoft Windows and Ventura Publisher are also included, as is a full set of diagnostics.

Price: $1999.
Contact: NEC Home Electronics (U.S.A.) Inc., 1255 Michael Dr., Wood Dale, IL 60191, (312) 860-9500.
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Upgrade Your Zenith

A new upgrade kit from Zenith Data Systems (ZDS) lets you upgrade any Zenith Z-248 PC- or AT-compatible system to a 16-MHz, zero-wait-state, 80386-based computer with a 32-bit bus.

The ZDS SuperSet upgrade kit contains three 32-bit system boards (I/O, 1 megabyte of RAM, and the 80386 CPU board). ZDS claims it takes less than 30 minutes to install and that it works with any Z-248 system, including those supplied to the U.S. Department of Defense.

After you install the SuperSet upgrade, your system will become a Z-386 with five open bus slots, 1 megabyte of RAM (expandable to 16 megabytes), serial and parallel ports, and sockets for both 80287 and 80387 coprocessors. The Z-386 will support dual hard disk drives, dual floppy disk drives, and a tape backup unit.

Price: $2699.
Contact: Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025, (800) 842-9000, ext. 1.
Inquiry 756.

continued

PERIPHERALS

Laser-Quality Printing for Under $1000

Using drop-on-demand thermal ink-jet printing technology, Hewlett-Packard claims its new HP DeskJet printer gives laser-printer-quality output at a significantly lower price. The DeskJet prints high-resolution text in multiple fonts and full-page graphics, all at 300 by 300 dots per inch. There's also a draft mode that prints at a resolution of 300 by 150 dpi. It prints standard letter-quality text at 120 characters per second, and draft quality at 240 cps.

The DeskJet has an automatic cut-sheet feeder that holds up to 100 sheets and has Courier, Courier Bold, and Courier Compressed fonts built in. There are two accessory-cartridge ports that let you add additional fonts, expand the memory (up to 256K bytes), and provide Epson FX-80 printer emulation.

Because the DeskJet uses HP's own PCL printer language, it's compatible with most software packages that support the HP LaserJet printer. The unit comes with both parallel ports and a 16K-byte printer buffer. It measures 17.3 by 8 by 14.8 inches and weighs 14.3 pounds.

Price: $995.

Contact: Inquiries Manager, Hewlett-Packard, 1820 Embarcadero Rd., Palo Alto, CA 94303, or call the Hewlett-Packard Company sales office listed in your telephone directory's white pages.

Inquiry 757.

The Hewlett-Packard DeskJet prints laser quality for less.

POSTSCRIPT-COMPATIBLE LASER PRINTER

According to QMS, its QMS-PS 810 laser printer is the first Canon SX-engine-based laser printer that supports Adobe's PostScript page-description language.

The printer's built-in controller includes 2 megabytes of RAM (expandable to 3 megabytes) and 1 megabyte of ROM, and is built around a 68000 processor running at 16 MHz. The controller supports the 35 standard Adobe PostScript typefaces and also emulates the HP LaserJet Plus, HP 7475A plotter, and the Diablo 630.

The QMS-PS 810 outputs final copy at 8 pages per minute with 300- by 300-dpi resolution. It has a duty cycle of 5000 copies per month and a toner cartridge life of 4000 copies. There are two output trays: one for face-up copies; one for face-down. RS-232C, RS-422/AppleTalk, and parallel interfaces are standard.

Price: $5495.

Contact: QMS Inc., One Magnum Pass, Mobile, AL 36618, (205) 633-4300.

Inquiry 762.

An Ocular Mouse for the New Macs

If your new Mac's standard mechanical mouse is wearing out or wearing you out, MSC Technologies (formerly Mouse Systems) is offering an alternative. The A+ Mouse ADB optical mouse is fully compatible with the Macintosh II and Macintosh SE, as well as the Apple IIGS.

The mouse's LED reflects off a special grid pad and is read by an optical sensor. It then converts the grid-line count to movement on your screen.

According to the company, an optical mouse avoids the problems of slippage, wear, and dirt that can eventually cause problems with mechanical mice. At the same time it introduced the new mouse, MSC also dropped the price of its optical mouse for other models of the Apple from $119 to $99. All models come with a lifetime warranty.

Price: $129.

Contact: MSC Technologies Inc., 2600 San Tomas Expressway, Santa Clara, CA 95051, (408) 988-0211.

Inquiry 802.

A Duo of Drives for the PS/2

The comparatively high price and lack of availability of 5¼-inch drives for the IBM PS/2 has encouraged manufacturers other than Big Blue to enter the fray. Here are two.

The PRS-2 from Pacific Rim Systems is a 5¼-inch floppy disk drive that attaches directly to the drive B connector on the IBM PS/2 Models 30, 50, 60, and 80. It weighs a mere 3½ pounds and consumes just 4 watts of power without having to use any external AC connections. The company claims you can install the PRS-2 in about 5 minutes, and says the unit's rated time before failure is 11,000 hours.

Price: $300.

Contact: Pacific Rim Systems Inc., 2570 Barrington Court, Hayward, CA 94545, (415) 782-1013.

Inquiry 759.

Meanwhile, the XD-360 is SMT's version of the 5¼-inch external drive for the entire IBM PS/2 family. The company says the unit's footprint is half the size of the IBM drive. To install the XD-360, you insert the unit's cable into your PS/2's drive B connector. You then route the cable internally to the rear panel and insert it into an available slot.

Price: $325.

Contact: Systems Manufacturing Technology Inc., 1145 Linda Vista Dr., San Marcos, CA 92069, (619) 744-3590.

Inquiry 760.

Micro Channel Modem

If you own an IBM PS/2 Model 50, 60, or 80, you can now telecommunicate at 2400 bps with an internal modem for the Micro Channel bus. The Ven-Tel 24/2 internal modem comes with a configuration file that automatically sets it up for PS/2 operation. You don't need to set any option switches, and it supports communications ports 1 through 8.

Ven-Tel says the 24/2 is fully compatible with the AT command set and includes automatic fallback to 1200 or 300 bps, as well as extensive self-test capabilities. It has a jack for an external telephone, is covered by a 5-year warranty, and is available with Crosstalk XVI software.

Price: $549.

Contact: Ven-Tel Inc., 2121 Zanker Rd., San Jose, CA 95131-2177, (800) 538-5121; in California, (408) 436-7400.

Inquiry 761.

continued

PERIPHERALS

Numerikeys gives your portable computer a numeric keypad.

Numbers for Your Portable

Portable or desktop computers without dedicated numeric keypads can be a real pain if you need to enter large amounts of numeric data into your programs. Numerikeys, an auxiliary numeric keypad from Genest Technologies, solves the problem by connecting between your computer's parallel printer port and printer cable.

Numerikeys has all the keys you need for most spreadsheet applications, including separate numeric, cursor-control, symbol, and function keys. The unit doesn't interfere with your parallel port, and it works full-time, even while your computer is printing.

Price: $129.

Contact: Genest Technologies Inc., 1331 East Edinger Ave., Santa Ana, CA 92705, (800) 826-9641; in California, (714) 547-0880.

Inquiry 763.

Touch Your Keyboard

Honeywell's new TCE434 Series Touch Panel Keyboard is a flat-panel unit that's sealed so it's completely protected in environments where dust, grime, moisture, or liquid spills could create problems.

The 84-key keyboard uses membrane switches with metal snap disks and an embossed touch surface for tactile feedback. It's compatible with the IBM PC, AT, and compatibles, and automatically selects the correct interface.

The TCE434 includes its own dedicated 8-bit processor, ROM, RAM, I/O lines, timer/event counter, and electronic shift. To keep the throughput moving, the electronics include a 16-character FIFO buffer.

Price: $275.

Contact: Honeywell Inc., Keyboard Division, 4171 North Mesa St., Building D, El Paso, TX 79902, (915) 543-5503.

Inquiry 764.

Run PC Bus Card with the Micro Channel

A product called the TransFormer 2 is a converter board that lets you connect PC bus add-in cards into IBM's Micro Channel bus in PS/2 Models 50, 60, and 80. The board plugs into your PS/2, and you connect it via cable to your PC expansion bus.

The TransFormer 2 package includes the TransFormer board, a cable, and the ADC XI Card, a PC expansion interface board. You can also use the unit with Advanced Digital Communication's current bus expansion box. The company says you can also use it with all ADC Personal Network software, including Novell NetWare, and that it will be compatible with OS/2.

Price: $695.

Contact: Advanced Digital Corp., 5432 Production Dr., Huntington Beach, CA 92649, (714) 891-4004.

Inquiry 765.

Shades of Gray For Your Mac II

If you're using your Macintosh II for desktop publishing or other applications that require photo-realistic black-and-white images, the Viking Analog gray-scale monochrome monitor from Moniterm may be your ticket.

The 19-inch monitor uses square pixels that let it precisely match screen and laser-printed output at a screen resolution of 72 dpi. It comes with a controller that plugs into the Mac II's NuBus slot. A PC-compatible controller is also available.

Price: $2695.

Contact: Moniterm Corp., 5740 Green Circle Dr., Minnetonka, MN 55343, (612) 935-4151.

Inquiry 766.

A Hard Drive for the Amiga 500

Supra Corp., which has been making hard disk systems for Amigas since their introduction, now has a version of its SupraDrive hard disk system for the newest Amiga—the 500.

The SupraDrives are available in capacities of 20, 30, 60, and 250 megabytes, and are ready to be plugged in and used immediately. The drives plug into the Amiga 500's expansion connector and use Supra's own proprietary interface for high-speed data transfer. The data channel is capable of burst data transfers of over 250K bytes per second.

Each SupraDrive has an SCSI expansion port, and you can add plug-in RAM modules with either 1- or 2-megabyte capacities. Both the hard disk drives and any expansion RAM are powered by SupraDrive's internal power supply.

Price: $995 to $3995.

Contact: Supra Corp., 1133 Commercial Way, Albany, OR 97321, (503) 967-9075.

Inquiry 767.

continued

ECONOMICAL PORTABLE MODEM

Tiny transportable modems have recently become popular, but with an often considerable price difference over conventional modems. Now Delta Gold Computer Corp. has, at this writing, the lowest-cost full-featured portable modem.

The DM-1200 is a 300-/1200-bps Hayes-compatible modem that measures $2^3/_8$ by 1 by $3^1/_2$ inches—about the size of a pack of cigarettes—and weighs just eight ounces. The modem has 28 characters of nonvolatile configurable memory, remote ring, tone sensing, busy- and dial-tone monitoring, and a low-battery light. You can power the DM-1200 off a 9-volt battery, an automobile lighter adapter, or standard AC power.

Price: $99.

Contact: Delta Gold Computer Corp., 260 Forbes Blvd., P.O. Box 809, Mansfield, MA 02048, (800) 255-3358; in Massachusetts, (617) 339-5575.

Inquiry 768.

ADD-INS

Capture color for real-time processing with the DT2871.

Process Color Images In Real Time

The DT2871 from Data Translation is a PC AT-compatible plug-in board that captures color images from standard video sources for image processing. In addition to handling real-time color capture and display, the DT2871 performs real-time conversions between RGB and hue-saturation-intensity (HSI) images. According to the company, HSI representations are preferable to RGB because they allow high-speed image processing of color images.

Examples of hue-saturation processing made possible by the DT2871 are color identification, edge enhancement, desaturation/saturation, colorimetric analysis, automatic coloring of monochrome images, object definition, tinting, retouch, and other special effects. Intensity-processing capabilities include noise reduction, arithmetic and logic operations, frequency-domain analysis, and compression/ decompression.

The DT2871 handles 30 frames per second at 512- by 512-pixel resolution with over 16 million displayable colors. You can connect it directly to other Data Translation boards, such as the DT2858 Auxiliary Frame Processor or DT7020 Floating Point Array Processor, to speed up computation-intensive operations.

The DT2871 has 1 megabyte of frame store memory—enough to store a single color image in three 256K-byte buffers; the fourth 256K-byte buffer supports overlaying of text and graphics on color images.

Data Translation also provides a software library package called Aurora for controlling the DT2871. The library is callable from Microsoft Pascal, C, and FORTRAN.
Price: $2995; Aurora software, $995.
Contact: Data Translation Inc., 100 Locke Dr., Marlborough, MA 01752, (617) 481-3700.
Inquiry 769.

Supercharge Your Printers

The Printer Performance Card is an intelligent printer interface that fits into any IBM PC or compatible and lets up to three computers share up to seven printers. The card also has its own 256K-byte internal buffer (expandable to 512K bytes) that can store and feed documents to printers while freeing up the computers.

Equipped with its own dedicated microprocessor, the Printer Performance Card has six standard parallel and two RS-232C serial ports.

You can use the card in a network server, and it's shipped with memory-resident software that lets you pick the printer you want to use from a pop-up menu.
Price: $399.
Contact: Dresselhaus Computer Products, 8560 Vineyard Ave., Suite 405, Rancho Cucamonga, CA 91730, (800) 368-7737.
Inquiry 770.

LOW-COST HI-RES

CADcontroller is a new multifunction graphics card from GTCO that's designed especially for CAD applications on the IBM AT and compatibles. It displays color graphics in resolutions of up to 1024 by 768 pixels.

Although it's at its best when used with wide-bandwidth high-resolution monitors, you can configure CADcontroller to work with lower-cost (lower-bandwidth) monitors at either 1024- by 768-pixel interlaced or 800- by 600-pixel noninterlaced resolutions.

CADcontroller has a standard RS-232C serial port. A 1-megabyte RAM expansion board is also available.
Price: $777; RAM expansion, $495.
Contact: GTCO Corp., 7125 Riverwood Dr., Columbia, MD 21046, (301) 381-6688.
Inquiry 773.

Tape Interface for the AT

You can use industry-standard 9-track computer tape drives with your IBM PC, AT, or compatible with Catamount's interface cards. The cards are available in two different models: one for the IBM PC or compatible, the other for the IBM AT or compatible.

For the PC, The ATC-8 is an 8-bit FIFO interface on a half-slot card. For the AT, the ATC-16 is a full-length card with 16-bit I/O and 128K-byte buffering.
Price: ATC-8, $1095; ATC-16, $1295.
Contact: Catamount Corp., 2243 Agate Court, Simi Valley, CA 93065-1898, (805) 584-2233.
Inquiry 771.

Digital Sound From Your PC

Using the VP620E add-in board in your IBM PC or compatible, you can convert any audio signal in the 20-Hz to 7-kHz range into a digital signal for real-time recording and playback using your computer's disk. The ¾-length board uses ADPCM (Adaptive Differential Pulse Code Modulation) and takes its input via an RCA jack.

Using software, you can select a sampling rate of either 8 or 16 kHz. You can then manipulate or randomly access the digitized audio. Since the board operates in the background, it works at a maximum overhead rate of less than 20 percent. Since it has selectable interrupts, you can use multiple boards for applications such as stereo or simultaneous record/playback.
Price: $395.
Contact: Antex Electronics Corp., 16100 South Figueroa St., Gardena, CA 90248, (800) 621-0849, ext. 350; in California, (213) 532-3092.
Inquiry 772.

continued

e right mouse.

A Logitech mouse plus Logitech application software equals a complete solution (all prices include mouse, Plus Software, and application):

LOGICADD...$189. Turns your PC into a full-featured CADD workstation. Everything you need for dimensioned line drawing and CADD.

PUBLISHER PACKAGE ...$179. PUBLISHER software lets beginners and experts alike produce professional, high-impact documents. Design templates make page layout easy.

LOGIPAINT SET... $149. Eleven type fonts and a 16-color palette. Creates files that move easily into both LOGICADD and PUBLISHER documents.

THE ALL-PURPOSE MOUSE: SERIAL OR BUS

Most people find our standard mouse is still the best choice for their systems. It's available in both bus and serial versions, one of which is sure to fit perfectly with your hardware. And with all your favorite software—whether mouse-based or not.

It's hardly an accident that only Logitech offers you such a complete selection—we're the only mouse company to design and manufacture our own products. We make more mice, in fact, than anyone else. Including custom-designed models for OEMs like AT&T, DEC, and Hewlett-Packard.

The three mice pictured to the left come with all this expertise built right in. Which explains an interesting paradox: while you may pay less for a Logitech mouse, you'll surely get more in performance.

And in comfort. With a unique lightweight ergonomic design. Low-angled buttons for maximum comfort and minimum fatigue. An exclusive technology that guarantees a much greater life span. An exceptionally smooth-moving, dirt-resistant roller ball. And natural compatibility with all PCs, look-a-likes, and virtually any software.

All of which leads to an inescapable conclusion: if you want to end up with the right mouse, start with the right mouse company.

Logitech. We've got a mouse for whatever the task at hand.

For the dealer nearest you, call **800-231-7717** **(800-552-8885** in California). Or fill out and mail the coupon below to: Logitech, Inc., 6505 Kaiser Drive, Fremont, CA 94555. In Europe, call or write: Logitech Switzerland, European Headquarters, CH-1111 Romanel/Morges, Switzerland (++41-21-869-9656).

Logitech, Inc., 6505 Kaiser Drive, Fremont, CA 94555.
Logitech Switzerland, European Headquarters,
CH-1111 Romanel/Morges, Switzerland.

Yes! Please send me the name of the nearest Logitech dealer.

Name ______________________

Company/Title ______________________

Address ______________________

Phone ______________________

LOGITECH

Circle 149 on Reader Service Card (DEALERS: 150)

HARDWARE • OTHER

Analyze Those Waveforms

The MacSpeech Lab II is a complete system for speech, music, and waveform analysis using Apple's Macintosh II. According to GW Instruments, typical applications for the lab include the development and testing of audio equipment, voice and sound analysis by crime laboratories, speech disorder analysis, speech therapy, speech-recognition and speech-synthesis technology development, audiological testing and studies, and other assorted acoustic studies.

The heart of MacSpeech Lab II is the MacADIOS data acquisition board, along with the MacADIOS II antialiasing filter daughterboard. Also included are a microphone, speaker, record and play amplifiers, and MacSpeech Lab II software.

The system can digitize complex waveforms up to 4½ minutes long at sample rates of from 5 to 80 kHz. You can then view, play, analyze, edit, or print them. MacSpeech Lab II is available either solo or complete with a Macintosh II and Apple LaserWriter Plus,or with the Macintosh II without the printer.

Price: $6999; with Mac II and printer, $16,350.
Contact: GW Instruments Inc., P.O. Box 2145, Cambridge, MA 02141, (617) 625-4096.
Inquiry 774.

MacSpeech Lab II brings waveform analysis to the Mac II.

Companionship for Your Computer

Cybex Corp. stresses that it's not a network or multitasking device, but what its product—named Companion—can do is add an extra keyboard and monitor to your system up to 250 feet away from your system unit.

Companion uses a connector box and special circuitry to use a single ⅜-inch cable for both keyboard and monitor. It can be switched from "shared," which allows both local and remote keyboards and screens to be active, to "private," for when you don't want the remote screen visible.

According to its maker, Companion works with all IBM PCs and compatibles. If you're using monochrome or color monitors, you can get Companion in cable lengths of 25, 50, 100, and 150 feet.

Price: $199 and up.
Contact: Cybex Corp., 1860-B Sparkman Dr., Huntsville, AL 35816, (205) 830-1100.
Inquiry 775.

Serious Joy(stick)

The "ultimate control for flight-simulation software" is what CH Products calls its FlightStick joystick for the Apple II and IBM PC and compatible families. The FlightStick has a contour pistol grip, with both trigger and fire buttons. The IBM version also has a thumbwheel control for throttle control on both Microsoft's Flight Simulator and Electronic Art's Advanced Flight Trainer.

The FlightStick also has dual-axis trim controls, and a 5-foot cable with thumbscrews. CH Products says the internal potentiometers are rated at 4 million life cycles, and that its return-to-center accuracy is ±.5 percent.

The Apple model of the FlightStick works with the IIe, IIc, and IIGS. The IBM model is compatible with the PC, XT, AT, and compatibles, as well as the PS/2 series. On the IBM, you'll need a game port, and CH Products just happens to have its new Gamecard III Plus available. The board has a three-position switch that adjusts the gameport interface to three different values.

The company claims the board also lets you use joysticks and computer games with AT compatibles at up to 16 MHz.

Price: Apple version, $74.95; IBM version, $79.95; Gamecard III Plus, $59.95.
Contact: CH Products, 1225 Stone Dr., San Marcos, CA 92069, (619) 744-8546.
Inquiry 776.

Coprocessor Speedup

Due to the variation in speed rating of 80287 arithmetic coprocessor chips, most computer systems run these chips at only 66 percent of the speed of the 80286 processor. But a company called Semiconductor Physics has a solution. Its Co-Clock is an 80287 speedup board that's sold without the coprocessor chip.

Available in rated frequencies of 10 and 12 MHz, the Co-Clock operates at the precise rated frequency of the 80287. Installation is a simple matter of inserting the 80287 into the Co-Clock, and inserting the Co-Clock into your system's 80287 socket.

Price: $60.
Contact: Semiconductor Physics Inc., 639 Meadow Grove Place, Escondido, CA 92027, (619) 741-3360.
Inquiry 777.

FRIENDLIER THAN THE AVERAGE MOUSE

Mouse-Trak looks like a trackball, and it is. But it's compatible with a mouse. According to Itac Systems, Mouse-Trak is more accurate and requires less effort to use than your garden-variety mouse.

The essence of Mouse-Trak is a 2-inch polished phenolic ball. Using a DIP switch, you can set the onboard buttons for either momentary contact or toggle on/off. There's also a speed-control button that gives you a 4-to-1 change in cursor velocity.

Five versions of Mouse-Trak are available. The two standard RS-232C versions (two or three buttons) emulate both the Microsoft Mouse and the Mouse Systems PC Mouse, respectively. The three quadrature versions are replacements for mice that operate with systems ranging from Atari to Apple, to more powerful systems such as Sun, Apollo, VAX, and Tektronics.

Price: $119 to $179.
Contact: Itac Systems Inc., 1303 Columbia, Suite 217, Richardson, TX 75081, (800) 533-4822; in Texas, (214) 234-5366.
Inquiry 778.

continued

ANNOUNCING ORACLE® FOR 1-2-3. JUST IN TIME - $199

Spreadsheet growing too big and complex? You need a database. No time to learn a database? You need the ORACLE database add-in for Lotus 1-2-3.

If you have Lotus 1-2-3 and $199, you can now solve the six biggest spreadsheet problems:

1 Has your spreadsheet grown so complex you can't keep track of the formulas any more?

2 Have you had to break down your large spreadsheet into many smaller ones?

3 Do you have to manually re-enter data that's duplicated in several spreadsheets?

4 Do you have to manually manipulate rows into meaningful groups?

5 Is recalculation time for seldom-used reference variables eating you alive?

6 Do you wish you could simultaneously share spreadsheet data with other PCs, as well as with minis and mainframes?

Now, ORACLE for 1-2-3 turns your spreadsheet into the world-class database you already know how to use. And without learning a new database language, you can use the very same ORACLE that's the most requested DBMS by minicomputer and mainframe users. All for only $199.

ORACLE for 1-2-3 lets data relationships replace ever more complex spreadsheet formulas. No more time is wasted recalculating seldom-used reference cells. In short, ORACLE puts data back where it belongs. In a database.

With simple extensions to existing Lotus menus, ORACLE for 1-2-3 lets you create new database tables right from rows and columns in your spreadsheet. When you query the database from a cell, you immediately see current database information. Update a spreadsheet cell, and the database is simultaneously updated. A range of cells in your 1-2-3 spreadsheet could really be a window into an online micro, mini or mainframe database anywhere in the world. It's network ready, from LAN to WAN. All as easy as … 1-2-3.

ORACLE FOR 1-2-3: THE NEW STANDARD

ORACLE is the number one database for mainframes, minicomputers and workstations. Software Digest recently rated ORACLE the most powerful and versatile relational DBMS for the PC. And ORACLE is based on SQL, the data management standard endorsed by IBM, ANSI, ISO and the federal government. Now, there is a new standard: ORACLE for 1-2-3. It has the simplicity you've always had, with the power you've always wanted.

THE ADVANTAGES OF DATABASE TECHNOLOGY

If your data is in a database, your spreadsheet only has to deal with the data you're interested in. Which means spreadsheet performance is dramatically improved. But this is just the beginning.

Multiple users can share the same data. Different users can have different levels of security. Mainframe-class data integrity and error recovery mean never having to say "Ooops!"

• CREATE YOUR DATABASE FROM SPREADSHEET COLUMNS AND ROWS. Familiar menus and context-sensitive help guide you through the process.

• QUERY YOUR DATABASE AS EASY AS 1-2-3. Have the query built for you, or write SQL queries yourself. Learn why SQL is the industry data management standard

• UPDATE YOUR DATABASE AS YOU UPDATE SPREADSHEET CELLS. In update mode, changes in your spreadsheet become changes in your database. And if you make a mistake, you can …

• COMMIT OR UNDO CHANGES. Finally, an "UNDO" command for 1-2-3! When your database changes are complete, you can COMMIT them, or ROLLBACK your database *and* your spreadsheet.

• AROUND YOUR OFFICE OR AROUND THE WORLD, ORACLE for 1-2-3 is network ready for data distribution on LANs and WANs. So data on PCs, workstations, minis and even on mainframes appears as if it's on your local hard disk.

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Dear Oracle, ORACLE for 1-2-3 • Oracle Corporation
20 Davis Drive • Belmont, CA 94002

Yes, I have an ☐ 80286/80386 PC running ☐ DOS 3.0 + and ☐ Lotus release 2.01. I also have ☐ 640KB of RAM, plus either ☐ 1MB of extended memory or I'll reassign 1MB of my expanded (above-board) memory as extended memory. Please send me the database I already know how to use: The ORACLE Database Add-in for Lotus 1-2-3. Enclosed is my ☐ check, or ☐ VISA/ ☐ MC/ ☐ AmEx credit card authorization for $199. Hurry.

Print Name ____ Date ____

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Street (No PO boxes, please) ____

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Phone ____

Credit Card Number ____ Card Expiration Date ____

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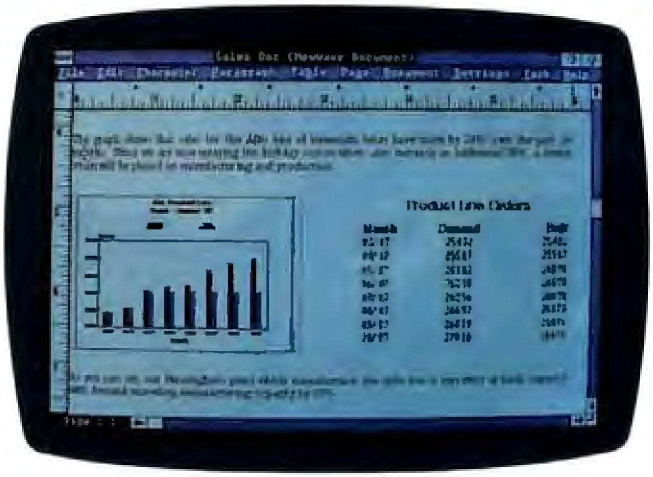
SOFTWARE • PROGRAMMING



HP's NewWave integrates data from multiple applications.

Windows Management Under QuickBASIC

QuickWindows is a window-management library for Microsoft's QuickBASIC. You can create windows, pop-up and pull-down menus, help windows, and data-entry screens, and you can access over 60 functions through BASIC with the CALL statement.

When you open a window, the program automatically saves the screen contents below. When you close the window, it restores the screen. You have control over the style, size, and attributes of each window. Each window also has its own cursor, so you can write text to a window, and the window scrolls when it becomes full.

QuickWindows is written in assembly language. It runs on the IBM PC, XT, AT, or compatible with a hard disk drive or two floppy disk drives and MS-DOS or PC-DOS 2.0 or higher. You need at least 320K bytes of available memory, and 512K bytes is recommended. You also need Microsoft's QuickBASIC and an EGA or CGA video board. The program also supports the Microsoft Mouse.

Price: $79; $99 with source code.

Contact: Software Interphase Inc., 5 Bradley St., Suite 10, Providence, RI 02908-2304, (401) 274-5465.

Inquiry 779.

HP's Icon-Based Application Environment

The NewWave environment combines object-management technology, artificial intelligence, and a graphical user interface. It lets you integrate data from multiple applications including text, graphics, voice, and scanned images. Hewlett-Packard reports that the data is linked seamlessly. "Hot connects" between applications make sure that when you modify one object, all others are updated as needed.

NewWave can run any MS-DOS application, but you need to write code to make it appear as a seamless object in the NewWave environment. You can run the MS-DOS application from within NewWave, represent the data from the application as an icon, or fully integrate the application into NewWave by hot connects.

A task manager (the Agent) is like a macro processor but can record comments applying to different MS-DOS applications. The Agent uses scripts written in the NewWave Task Language, and you can use it to automatically execute repetitive tasks at a particular date and time.

NewWave runs on the IBM PC, XT, AT, and compatibles with Microsoft Windows 2.0.

Price: $895.

Contact: Hewlett-Packard, P.O. Box 10301, Palo Alto, CA 94303-0890, (800) 367-4772; in California, (415) 857-1501.

Inquiry 780.

Application Modeling

Model-S lets you develop a working model of process-related applications. To create a model, you break the application into frames, such as menus, data-entry panels, and reports, which may include both text and data. You then link the frames into a working model, test it during development, and display the flow diagram; then you can export it to a database.

You can develop models with up to 200 frames, and for longer models you connect them to form super-models. Frame size is 60 rows by 160 columns, and you can have up to 200 titles and data fields. You can link it to as many as 60 other frames.

The program runs on the IBM PC and compatibles with a hard disk drive, one or more floppy disk drives, PC-DOS or MS-DOS 2.0 or higher, and at least 256K bytes of RAM. Color is supported.

Price: $149.

Contact: PC-Systems, 307 Barwynne Lane, Wynnewood, PA 19151, (215) 649-8981.

Inquiry 781.

TURBO PASCAL 4.0 LIBRARY AND COMMUNICATIONS UTILITY

Power Tools Plus 4.0 is a library of over 140 functions that enhance the Turbo Pascal 4.0 programming environment. You can install a Turbo Pascal procedure as an interrupt-service routine or an intervention code that can be automatically triggered at certain times of the day or when you press hot keys.

The utilities provide cursor control, screen attribute settings, multiple-display page support, scrolling, screen input and output, and fast video access. EGA and VGA are supported in text mode, including 43- and 50-line modes.

With Power Tools Plus, you can construct multiple windows with borders, attributes, and cursor control. You can also stack and remove them, or display them tiled or overlapped. You can also execute DOS commands from within your Turbo Pascal program.

Asynch Plus is another Turbo Pascal 4.0 utility. It lets you add asynchronous communication capabilities to your Pascal applications programs. Asynch offers simultaneous buffered input and output to both communications ports at up to 9600 bps, according to Blaise. It supports the XON/XOFF protocol and XMODEM file transfers. The routines drive most asynchronous devices via RS-232C ports. The utility includes low-level control and queue-maintenance functions written in assembly language, and high-level routines written in Turbo Pascal.

Both Power Tools Plus and Asynch require Turbo Pascal 4.0 and MS-DOS 2.0 or higher, running on the IBM PC, XT, AT, or compatibles, or the PS/2. The source code is also included with both products.

Price: $129 each.

Contact: Blaise Computing Inc., 2560 Ninth St., Suite 316, Berkeley, CA 94710, (415) 540-5441.

Inquiry 782.

continued

Perfect matches to DEC user needs. Hip. Hip. And Hooray.

One-size-fits-all is an attribute best reserved for inexpensive socks. In the realm of PC-based emulation and communications software for DEC mainframe users, it's important to match specific user needs with specific product attributes. We have.

SmarTerm® 240 features exact four-color emulation of a DEC® VT241 terminal. Along with delivering full-screen ReGIS® and Tektronix® 4010/4014 graphics, SmarTerm 240 offers precise VT220, VT102, VT100, and VT52 text emulation.

For non-graphics applications, SmarTerm® 220 duplicates virtually every SmarTerm 240 text, communication, and ease-of-use feature. Three error-free file transfer protocols, including Kermit and Xmodem, are provided. Downloading minimizes on-line time requirements to boost overall system efficiency. And an optional network package allows direct LAN access to shared modems, printers, as well as host mainframes.

As SmarTerm 240 and 220 focus on graphics and text, new SmartMOVE® makes PC-to-the-rest-of-the-World communications sharper than ever. Speed connect, auto redial, and background file transfer features make this VT100 emulator a loud and clear choice for advanced communications requirements.

Graphics, text, and communications. If you're looking for a perfect fit, seek the software sized and priced to match your needs. Persoft has it. Period.

See us at DEXPO West Booth 1024, visit your dealer, phone us at 608-273-6000, or use inquiry code 50.

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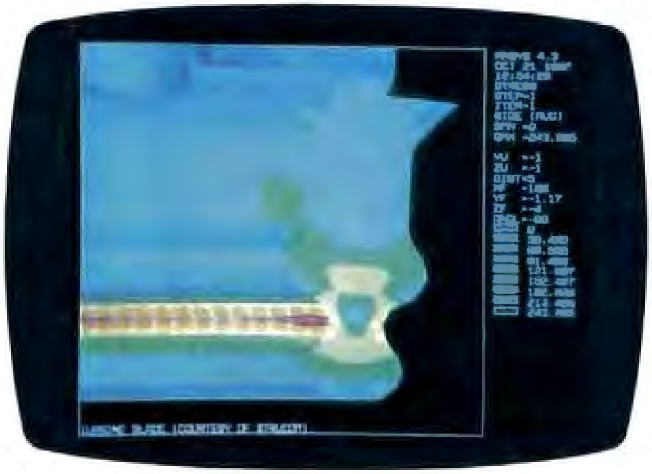
Ansys-PC for the Mac

Swanson Analysis has ported Ansys-PC/Linear 4.3 to the Macintosh II. PC/Linear is a finite-element analysis (FEA) program for static, modal, and dynamic response, and random vibration in one, two, and three dimensions. The analyses are performed on models built with a library that contains shell, solid, beam, pipe, gap, and other elements.

Other Ansys programs to be ported to the Mac include Ansys-PC/Thermal 4.3, a stand-alone program for steady-state and transient thermal analyses; Ansys-PC/Solid 4.3, an interactive preprocessor for building solid FEA models; and Ansys-PC/Opt 4.3, for design optimization.

Ansys programs require 2 megabytes of RAM, a 40-megabyte hard disk drive, and a 640- by 480-pixel 256-color monitor.
Price: $6400; $300 per month to rent.
Contact: Swanson Analysis Systems Inc., Johnson Rd., P.O. Box 65, Houston, PA 15342-0065, (412) 746-3304.
Inquiry 783.



A static analysis performed with Ansys-PC/Linear.

Viewing Computer-Aided Waveforms

CompView lets you view computer-aided waveforms using fast-Fourier-transform–based digital-signal analysis. The program is menu-driven and has built-in functions of sine, pulse, triangular, and modulated waveforms for plotting graphics in time and frequency domains.

CompView also has several ideal first- and second-order filters for plotting impulse and amplitude responses. You can edit data in ASCII format and save it to a disk.

CompView is not copy-protected. It runs on the IBM PC, XT, AT, and compatibles with PC-DOS or MS-DOS 2.0 or higher with 256K bytes of RAM and a CGA.
Price: $49.
Contact: Bsoft Software, 444 Colton Rd., Columbus, OH 43207, (614) 491-0832.
Inquiry 784.

Scientific Data Processing

Spectra Calc, a program for processing scientific data, displays up to 20 data files simultaneously and lets you expand data in real time with full axis labeling, according to Galactic Industries. A WYSIWYG mode lets you produce presentation-quality plots, the company reports. The plots can contain numerous font types, colors, axis labels, and other annotation tools.

The program has an optional arithmetic module that provides preprogrammed applications including smoothing, curve fitting, and Fourier domain filtering.

The program also includes an application language, which is designed to process arrays and is optimized for the 80x87 coprocessor. With expanded memory, the program can handle arrays as large as 2.4 megabytes.

A communications program within Spectra Calc lets you transfer data between it and any remote computer or instrument that supports a serial port. It supports standard ASCII file transfers, as well as Kermit and XMODEM protocols.

Spectra Calc runs on the IBM PC, XT, AT, and compatibles with at least 512K bytes of RAM. It also runs on the IBM PS/2s. The arithmetic module requires an 8087 or 80287 coprocessor. You also need an IBM CGA, Hercules monochrome, EGA, or IBM VGA adapter.
Price: $695; arithmetic module, $395.
Contact: Galactic Industries Corp., 417 Amherst St., Nashua, NH 03063, (800) 862-6004; in New Hampshire, (603) 881-7877.
Inquiry 785.

Ray Tracing

Tracer PC offers you ray-tracing capabilities with modeling and rendering features. Imagery includes reflections, refractions, spectral absorption, an unlimited number of multiple colored light sources, shadows, and variable levels of antialiasing. You can have the following features available: arbitrary viewer location, arbitrary center of view, variable lens length, and variable output resolutions; you can also simulate water equations.

The program's modeling capability lets you do surfaces of revolution, extrusion, and curved surfaces for complex parts, as well as quick primitives such as cones, spheres, cubes, cylinders, and arrows. You can also generate quick multiple views with hidden-line removal.

To run Tracer PC, you need an IBM PC with at least 640K bytes of RAM, a math coprocessor, a 40-megabyte hard disk drive, a mouse or digitizing tablet, and a Targa 24- or 32-bit graphics card or a Number Nine Revolution 32-bit graphics board.
Price: $3000.
Contact: Ray Tracing Corp., 2516 Via Tejon, Suite 316, Palos Verdes Estates, CA 90274, (213) 373-0520.
Inquiry 786.

Linear Design Tool

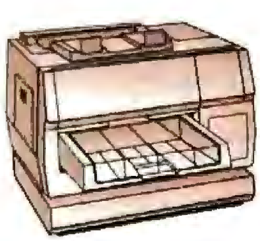
Unlike Spice-based linear-circuit-analysis programs, LCAS uses a single program with analysis, graphing, printing, file-management functions, and an integrated circuit editor. LCAS is command-driven from a spreadsheet-like menu, and the circuit editor is cell-based.

Basic circuit components include delay lines, transmission lines, microstrip, and phase-locked loop components.. Graphics functions let you plot, overlay, add, and subtract the magnitude, phase, and group delay responses of circuits. You can output graphs to disk files or to Epson or IBM graphics–compatible dot-matrix printers.

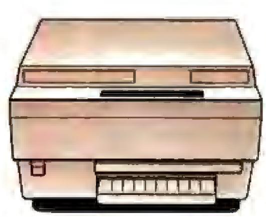
LCAS runs on the IBM PC, XT, AT, and compatibles with at least 640K bytes of RAM and a CGA or EGA video adapter. It will also use an 8087 or 80287, if available.
Price: $149.95.
Contact: Datum Systems, P.O. Box 4720, Santa Clara, CA 95054-0720, (408) 988-0858.
Inquiry 787.

continued

Inside thes
revolution

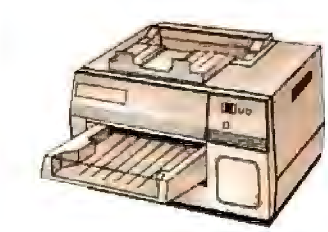


NBI, Inc. Model 908

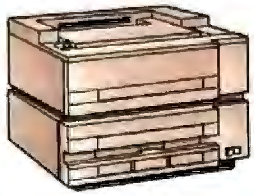


QMS-PS® 800
QMS-PS® 800+
QMS-PS® 800 II

Linotype Company Linotronic™ 100
Linotype Company Linotronic™ 300



Digital Equipment Corp
ScriptPrinter™



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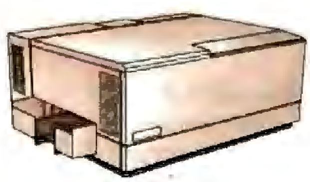

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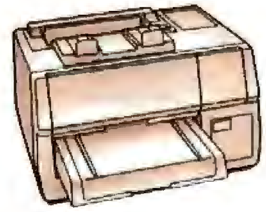
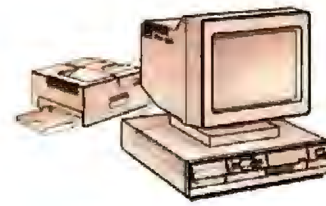
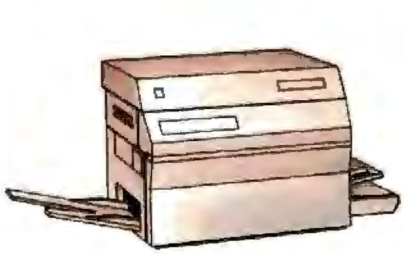


AST Turbo Laser®/PS

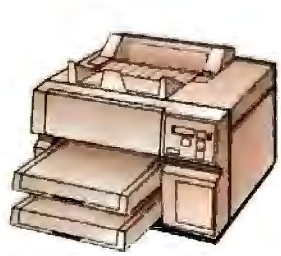


IBM 4216-020 Personal Pageprinte

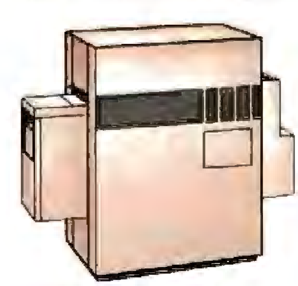
Texas Instruments OmniLaser™ 2108



Varityper VT-600

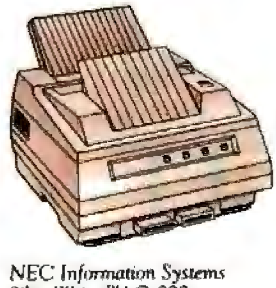


Wang LCS15™

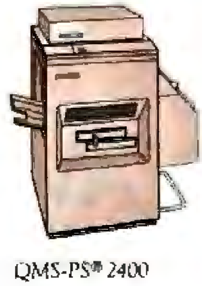


Agfa-Gevaert P400PS™

The Laser Connection PS Jet/PS Jet+™



NEC Information Systems
SilentWriter™ LC-890



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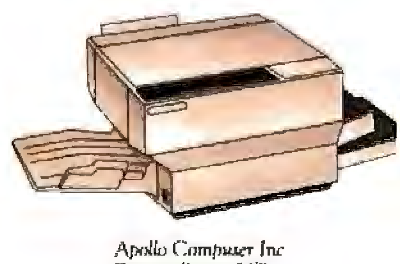

Apollo Computer Inc
Domain/Laser 26™

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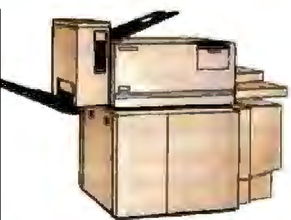
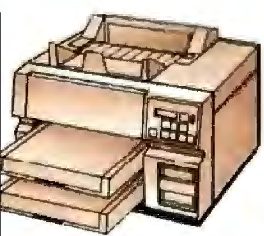
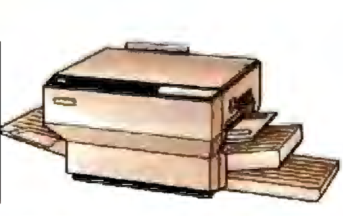


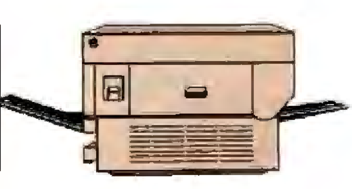
Digital Equipment Corp PrintServer 40™



Texas Instruments OmniLaser™ 2115



Dataproducts Corp. LZR™ 2665



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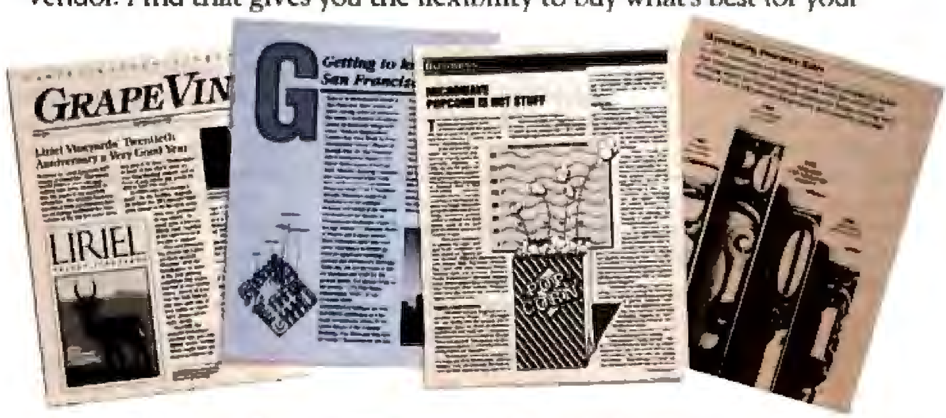

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SOFTWARE • SCIENTIFIC AND ENGINEERING

Modeling, Animating on the Amiga

Sculpt 3-D is a solids-modeling and ray-tracing program. Animate 3-D is an animation program. You can link the two together to produce animated designs and productions.

Sculpt 3-D is a stand-alone program that can use all 4096 colors of the Amiga palette. It offers mouse control, pull-down menus, and keyboard macros. Three windows show you standard architectural views of a three-dimensional space. A library of shapes includes spheres, cubes, and prisms. Tools such as spin, magnet, and extrude enable you to modify the object's shape.

You can change your point of observation, and, just as if you were using a 35mm camera, you can choose the lens view from wide angle to telephoto. You can also change the placement of light sources.

In quick check mode, which lasts for less than 1 second, you can create a wire-frame model image. Painting mode is for generating a solid model image quickly.

Snapshot mode renders a fast ray-traced image without the shadows, and photo mode gives you a detailed 4096-color ray-traced image with shadows.

Sculpt 3-D supports overscan and all the Amiga graphics modes, as well as NTSC and PAL video displays. Output is in the form of standard IFF files.

Animate 3-D requires Sculpt 3-D as its object editor. It lets you manipulate and control the motion of the objects you create with Sculpt 3-D. You can use segmented and cubic spline paths for objects, observer, and light sources. Animate also lets you preview character animation in real time.

You can also compress and expand images in real time.

A three-dimensional model created with Sculpt 3-D.

Animate lets you interface with single-frame controllers and film recorders.
Price: Sculpt 3-D, $99.95; Animate 3-D, $149.95.
Contact: Byte by Byte Corp., Arboretum Plaza II, 9442 Capital of Texas Highway N, Suite 150, Austin, TX 78759, (512) 343-4357.
Inquiry 788.

Modeling with DataCAD

DC Modeler works with DataCAD 3.5, adding three-dimensional design, editing, and modeling capabilities to the CAD program. The modeler includes an edit menu, which lets you edit drawings from any perspective. An entities menu gives you a variety of three-dimensional shapes such as cones, domes, cylinders, and slabs.

You can access DC Modeler from within the DataCAD menu. All changes you make are automatically made to the drawing file.

To run DC Modeler you need an IBM PC or compatible with 640K bytes of RAM, MS-DOS or PC-DOS 3.0 or higher, and DataCAD 3.5.
Price: $495.
Contact: Microtecture Corp., 617 West Main St., Charlottesville, VA 22903, (804) 295-2600.
Inquiry 789.

Numerical Analysis, Signal Processing, and Graphics

386-MATLAB (matrix laboratory) and 386/Weitek-MATLAB run in protected mode on 386 systems, breaking the 640K-byte memory barrier. The programs, which integrate numerical analysis, matrix computation, signal processing, and graphics, don't require dimensioning. A matrix interpreter accepts commands in standard mathematical notation.

The Weitek version of MATLAB offers floating-point support using the Weitek 1167 on the Compaq Deskpro 386/20.

386-MATLAB runs on 386-based personal computers with an 80287 or 80387 math coprocessor and MS-DOS or PC-DOS 3.1 or higher; 1 megabyte of RAM; and an EGA, CGA, or Hercules Monochrome card. The Weitek version requires the Weitek 1167 coprocessor option.
Price: 386-MATLAB, $1495; Weitek version, $1995.
Contact: Math Works Inc., 20 North Main St., Suite 250, Sherborn, MA 01770, (617) 653-1415.
Inquiry 790.

Mechanical Drafting with AutoCAD

Encodraft/Mechanical works with AutoCAD to automate a variety of mechanical drafting tasks. Encodraft/Mechanical has a setup feature that helps you create layers, establish standard drawing sizes, and select layer names and colors. The program can shift the drawing origin to any location automatically.

According to Encode, rules-based construction techniques facilitate geometric construction and ensure that the drawings will meet CAD industry standards. Encode reports that tangencies and other intersections are accurate to 16 significant digits.

A bill of materials extraction routine extracts data captured, and the information is exported to external databases.

The program runs on the IBM AT or PS/2s with AutoCAD 2.5 or higher.
Price: $500.
Contact: Encode Inc., 12 Cotton Rd., Nashua, NH 03063, (603) 882-4666.
Inquiry 791.

HyperCard Statistical Calculator

CLR StatCalc simulates a statistical calculator with a display, 7 standard functions, 12 statistical functions, and 3 memories. Functions provided include mean, standard deviation, standard error of the mean, correlation, regression, and probabilities. You can enter data in scrollable text fields, or you can read it in from text files.

The program runs on the Macintosh Plus and requires HyperCard.
Price: $22.50; 1-year site licenses for schools, $125.
Contact: Clear Lake Research, 5615 Morningside, Suite 127, Houston, TX 77005, (713) 523-7842.
Inquiry 792.

continued

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SOFTWARE • BUSINESS

Memory-Resident Spreadsheet

Datax calls QuickPlan the only memory-resident spreadsheet program for MS-DOS computers. The spreadsheet features a SideKick-like pop-up menu, 17 movable windows, cut-and-paste capability, and math functions.

With the cut-and-paste feature, you can export an area of the spreadsheet to other programs. The 28 built-in math functions and operators let you build worksheets. QuickPlan works with cell ranges, letting you construct formulas containing absolute, relative, or mixed-cell references. You can customize the format of any cell in the spreadsheet, and also change the number of decimals and cell width. QuickPlan's worksheet contains 588 cells in 14 columns by 42 rows.

QuickPlan is not copy-protected and runs on the IBM PC with at least 150K bytes of available RAM. It comes with TurboCalc, a 24-function calculator, and FileMaster, a DOS shell and macro processor.
Price: $79.
Contact: Datax, 470 12th Ave. N, St. Petersburg, FL 33701, (813) 894-7472.
Inquiry 793.

QuickPlan, the memory-resident spreadsheet.

Two on Taxes

ChipSoft's TurboTax and J. K. Lasser's Your Income Tax both take the 1986 tax reform act into account. They feature on-screen calculators and pin-feed 1040 forms (and don't require preprinted 1040s).

TurboTax offers pop-up instructions from the IRS booklets. A forms finder helps you locate the form you need by subject. TurboTax's data examiner checks over your return when you're done to see if you've missed anything.

Also included with TurboTax is Price Waterhouse's guide to 1987 and 1988 taxes. More than 35 schedules and worksheets are provided with the program. One last unique feature of TurboTax is its tax window, which lets you check your tax status at any point while filling out the forms. A version of TurboTax is available for professional tax preparers.

TurboTax runs on the IBM PC and compatibles with at least 256K bytes of RAM.
Price: TurboTax, $75; ProSeries/1040, $295.
Contact: ChipSoft Inc., 5045 Shoreham Place, Suite 100, San Diego, CA 92122, (619) 453-8722.
Inquiry 794.

Your Income Tax from J. K. Lasser has an interview system feature like the program Ask Dan about Taxes. It asks you questions and suggests the correct forms to use, based on your answers. The program can also compare your tax liability under various scenarios. And, like Turbo Tax, Your Income Tax has features for the professional tax preparer so you can work on forms for more than one client.

Your Income Tax also runs on the IBM PC and compatibles with at least 256K bytes of RAM.
Price: $69.95.
Contact: MicroServices, 200 Old Tappan Rd., Old Tappan, NJ 07675, (800) 624-0023; in New Jersey, (800) 624-0024.
Inquiry 795.

Tracking Sales Accounts

Maximizer is a general-purpose program for salespeople. It lets you keep track of information on your clients, write letters, track your own records, schedule appointments, and more.

Maximizer imposes no limit on the number of clients and no system limit on the number of contacts within a company.

You can define the number of attributes associated with each client, and the terms you use to describe the attributes are up to you. You can write notes and letters with the program's built-in editor.

A day-at-a-glance facility lets you record appointments and other scheduled activities. A telephone directory is created automatically from your records.

To run Maximizer you need an IBM PC with at least 512K bytes of RAM and MS-DOS or PC-DOS 3.0 or higher. It also runs on PS/2s.
Price: $495.
Contact: Pinetree Software Inc., 8100 Granville Ave., 9th Floor, Richmond, BC V6Y 1P3, Canada, (604) 270-3311.
Inquiry 796.

AI and Hypertext Application

Stock Expert is Knowledge Garden's first application that combines hypertext with an expert system. Based on guidelines set by the National Association of Investment Clubs, the program offers assistance in investment decision-making.

Hypertext explains industry jargon, and artificial intelligence is used in the expert system that makes investment recommendations. You can instruct the expert system to think in various ranges so you can adjust its recommendations to reflect your own experience, expertise, and preferences.

The system includes a stock checklist, selection guide, comparison guide, and company database. The checklist helps you analyze past stock growth. The selection guide includes information from Standard and Poor's or Value Line to help you predict stock price fluctuations over the next five years. The comparison guide compares and analyzes the performance of companies and makes predictions on gains. And, finally, the database lets you store historical information on companies. The database lets you search for sales growth, relative value, earnings-per-share growth, retained earnings, and payout.

Stock Expert is written in the KnowledgePro knowledge-processing environment. It runs on the IBM PC, XT, AT and compatibles with 512K bytes of RAM. It also runs on PS/2s.
Price: $249.
Contact: Knowledge Garden Inc., 473A Malden Bridge Rd., Nassau, NY 12123, (518) 766-3000.
Inquiry 797.

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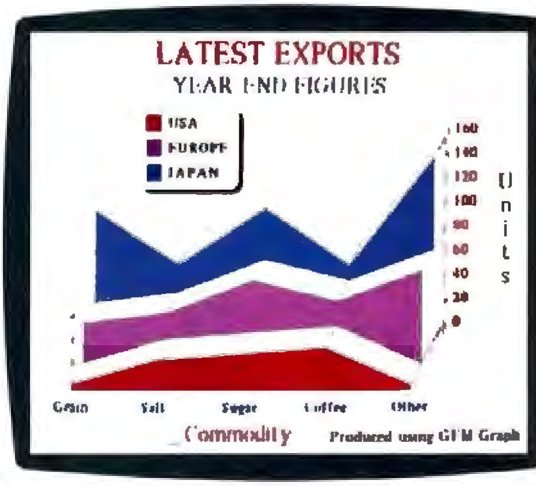

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SOFTWARE • OTHER

Resident Expert offers information on a variety of programming languages.

Programmer's Reference Guides

Resident Expert contains a memory-resident shell and reference modules that you can pop up as windows to get more information on commands, a summary of syntax, examples, or a cross-indexed list of related topics.

For example, if you forget the syntax for a command such as `BACKUP`, you activate the shell and press F for Resident Expert's `FIND` command to pull up a window showing a synopsis and overview. There's also a Related Topic feature and a Snapshot capability, which lets you freeze a window of information and continue typing.

Reference guides are available for Borland's Turbo C 1.0, Turbo Pascal 3.0, and Turbo Prolog 1.1; the Lattice C Compiler 3.2; Logitech's Modula-2 version 3.0, Mark Williams' Let's C 4.0, and Microsoft C. A PC Programmer's Guide is also available.

The program is a terminate-and-stay-resident utility that runs on the IBM PC, XT, AT, and compatibles. It uses 49K bytes of RAM and is compatible with other TSRs, according to Santa Rita. Each reference database uses 110 to 500K bytes of RAM.

Price: $19 for the shell, which includes MS-DOS and PC-DOS guides; prices of other guides range from $19.95 to $39.95.

Contact: Santa Rita Software, 1000 East 14th St., Suite 365, Plano, TX 75074, (214) 727-9217.

Inquiry 798.

Freehand Drawing on the Mac

Aldus Corp. acquired the rights to FreeHand from Altsys Corp. in August 1987 and plans to release the product early this year.

FreeHand is a drawing program that lets you create or trace graphics with basic drawing tools or advanced line- and Bézier-curve tools. You can manipulate objects and text using special-effects features such as graduated fills of text and objects; the ability to scale, rotate, reflect, and skew objects and text; and the ability to define beginning and ending colors for graduated fills. Drawing tools include lines, rectangles, rounded rectangles, and ellipses. PostScript line and curve tools are also included.

Text-handling capabilities include the ability to bend or shape a line of text along a baseline that you define. Automatic or manual kerning is available, as well as variable letter and word spacing and variable line spacing.

When you're in preview mode, FreeHand lets you edit. You have nine levels of magnification for viewing work on the screen. There are undo and redo options for the last eight actions you've performed. Other editing features include group/ungroup and lock/unlock commands, automatic alignment of objects and text, snap-to grids, rulers with measurements in increments you define, an on-screen information bar that shows you changes in mathematical increments, and the ability to break up rectangles and ellipses into separate paths.

FreeHand allows you to display up to 256 colors on your Mac II color monitor. The program also has a color-separation capability for the four process colors, spot color separations, or a combination of the two. You can also specify color screen percentages for printing color tints.

FreeHand can import and export files saved in Encapsulated PostScript, and you can also open and edit graphics files created in Adobe Illustrator. The program also supports Clipboard images, which you can bring in as traceable background elements.

FreeHand runs on the Mac Plus, SE, or II with two 800K-byte floppy disk drives or a hard disk drive, and any PostScript-compatible output device.

Price: $495.

Contact: Aldus Corp., 411 First Ave. S, Suite 200, Seattle, WA 98104, (206) 628-2375.

Inquiry 799.

Quips and Quotes

Salinon's quipster, called Off-The-Wall, generates one-liners from a library of over 70 patterns and a dictionary. You can add your own phrases to the library and control the placement of nouns, adjectives, adverbs, and verbs.

Off-The-Wall runs on the IBM PC and compatibles with at least 256K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher.

Price: $29.

Contact: Salinon Corp., 7430 Greenville Ave., Dallas, TX 75231, (214) 692-9091.

Inquiry 800.

A Print Spooler with Sideways Capabilities

Duet is a memory-resident print spooler that performs standard functions such as queuing and background printing of jobs. It also prints sideways and can print 1-2-3 or Symphony spreadsheet files.

Duet can intercept all output sent to the printer by other programs and put it on its print queue. You can reorder, delete, and schedule print jobs for a certain time of day, or put them on indefinite hold. Duet can automatically write the print queue and the spooled files out to disk, so if the power goes down, you won't lose your print jobs.

With sideways printing you have the choice of 12 predefined font sizes, ranging from 19 by 10 pixels to 9 by 6 pixels. A font generator is included that lets you customize the sideprint fonts or build your own fonts. Duet comes in four configurations: The largest version has both sideways printing and spreadsheet decoding; another version has sideprinting only; a third version has spreadsheet decoding only; and the last version is without sideprinting or spreadsheet decoding. All four have normal spooling operations.

Duet runs on the IBM PC, XT, AT, and compatibles with at least 256K bytes of RAM.

Price: $89.95.

Contact: Consumers Software Inc., 736 Chestnut St., Santa Cruz, CA 95060, (408) 426-7311.

Inquiry 801.

REGIONAL SECTION

PACIFIC COAST

Stand-Alone Modem

Merge—System A combines a Hayes-compatible modem with a telephone and includes up to 264K bytes of RAM. It allows you to communicate by both voice and data over the same line, send data unattended, and upload and download information without being connected to a microcomputer.

When hooked up to an IBM PC or compatible, Merge—System A supports communication at 300 or 1200 bps. You can store information from your computer in the modem's memory, and transfer data from the modem's memory to your computer. A two-line 80-character LCD screen is provided.

Merge—System A features a programmable alphanumeric keyboard with macros, a phone directory that can store 200 numbers, and auto-dial capabilities. Terminal emulation is also provided.

Price: With 40K bytes of RAM, $399; with 264K bytes of RAM, $499.

Merge—System A can upload and download unattended.

Contact: New Generation Technology, 16742 Gothard St., Suite 217, Huntington Beach, CA 92647, (714) 848-0871.

Inquiry 823.

Norton's OS/2 Reference Guides

The Norton On-Line Programmer's Guides to OS/2 Kernel API include about 800K bytes of information about DOSx (system and file functions), KBDx (keyboard functions), MOUx (mouse functions) and VIDx (video screen functions).

The memory-resident program provides both short and long entries, including calling sequences and programming examples. A reference section

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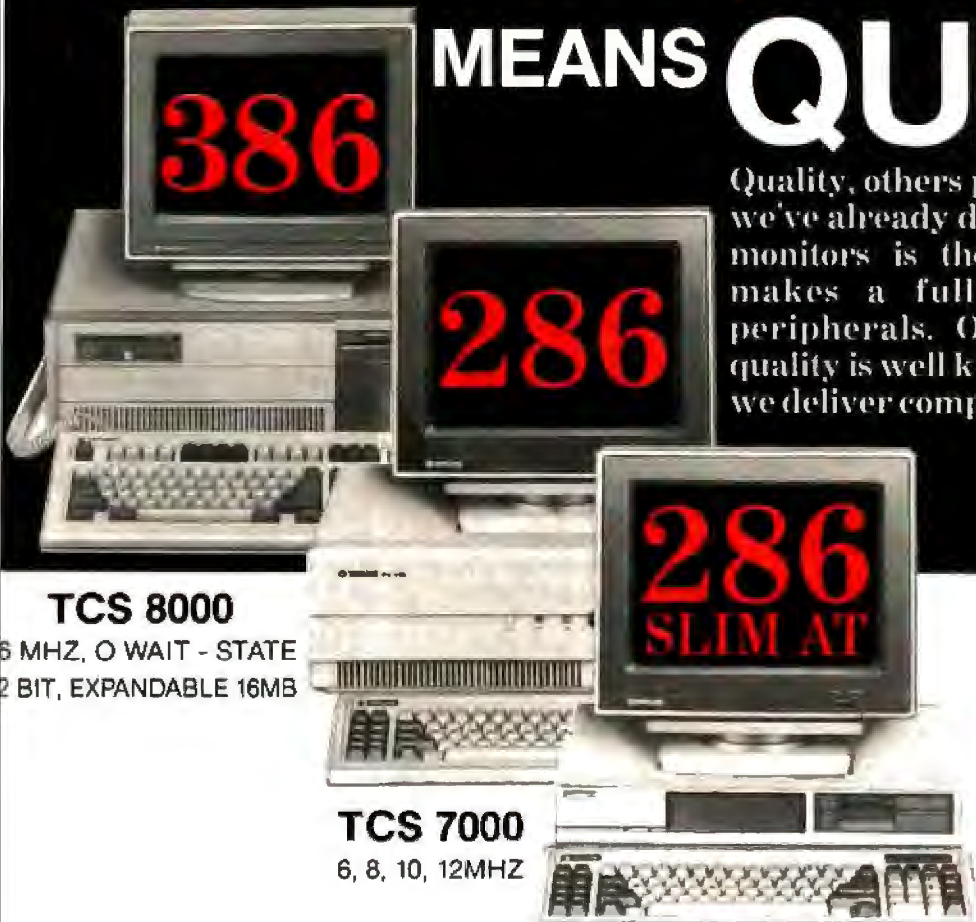

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includes an introduction to OS/2 and examples of programming techniques like pipe creation and using protected mode for running multiple processes. It also provides information on OS/2 data structures, ANSI escape sequences, and I/O control functions.

You invoke the program by pressing a hot key. It then presents you with a menu that provides expand and search functions; and kernel, tables, and reference areas. Each category includes a list of short entry descriptions. Once you find the appropriate short entry, you can open its corresponding long entry.

With the options menu, you can set screen colors, change the hot key, de-install the instant-access program from memory, and invoke the auto-lookup function, which enables you to automatically search for what your cursor is on when you invoke the program.

The Norton On-Line Programmer's Guides to OS/2 Kernel API enable you to create your own cross-referenced databases with menus and expandable entries.

The program runs on the IBM PC and compatibles with MS-DOS or PC-DOS 2.0 or higher or OS/2 (in the DOS compatibility box). A version that runs in OS/2 native mode is also available. The program takes up 72K bytes of RAM. It comes on both 3½- and 5¼-inch floppy disks. You can purchase it with or without the Norton Guides Engine instant-access program.

Price: $100 without Norton Guides Engine; $150 with Engine.

Contact: Peter Norton Computing, 2210 Wilshire Blvd., Suite 186, Santa Monica, CA 90403-5784, (800) 451-0303, ext. 40; in California, (213) 453-2361.

Inquiry 824.

Stackware Provides Videodisk Links

The Voyager Company's Laserstacks are among the first to take advantage of HyperCard's capabilities as a front end to large databases. A Laserstack turns the still photographs and motion pictures on existing videodisks into visual databases.

The hub of the series is VideoStack, which enables you to develop interactive videodisk applications with HyperCard. It provides more than 35 buttons controlling different functions. It allows you to automatically install video drivers into any HyperCard stack, define video events, and automatically activate the events.

The National Gallery of Art Laserguide is designed to work with The Voyager Company's National Gallery of Art disk that contains still photographs of the permanent collection on display at the National Gallery of Art in Washington, DC. You can organize works of art and present them according to artist, nationality, school, and other categories.

Laserguides are also available for Voyager's Vincent Van Gogh and Bio-Sci disks.

The Laserstacks series runs on the Macintosh Plus, SE, and II with HyperCard and a videodisk player.

Price: VideoStack, $49.95; National Gallery of Art Laserguide, $49.95; Vincent Van Gogh Laserguide, $39.95; Bio-Sci Laserguide, $99.95.

Contact: The Voyager Company, 2139 Manning Ave., Los Angeles, CA 90025, (213) 475-3524.

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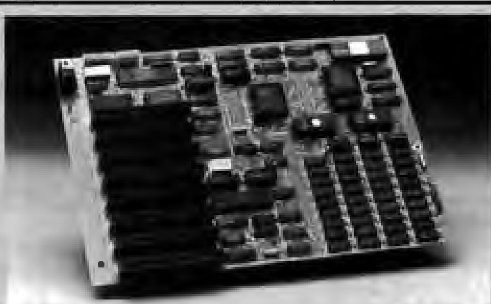

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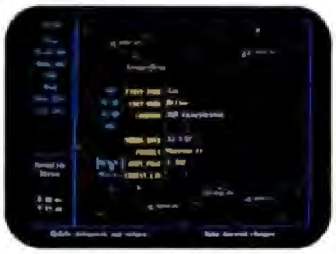

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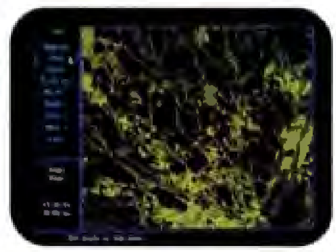

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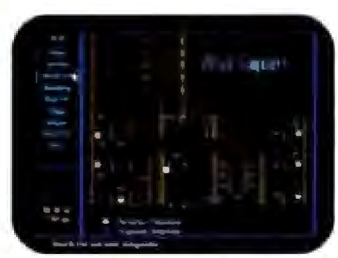

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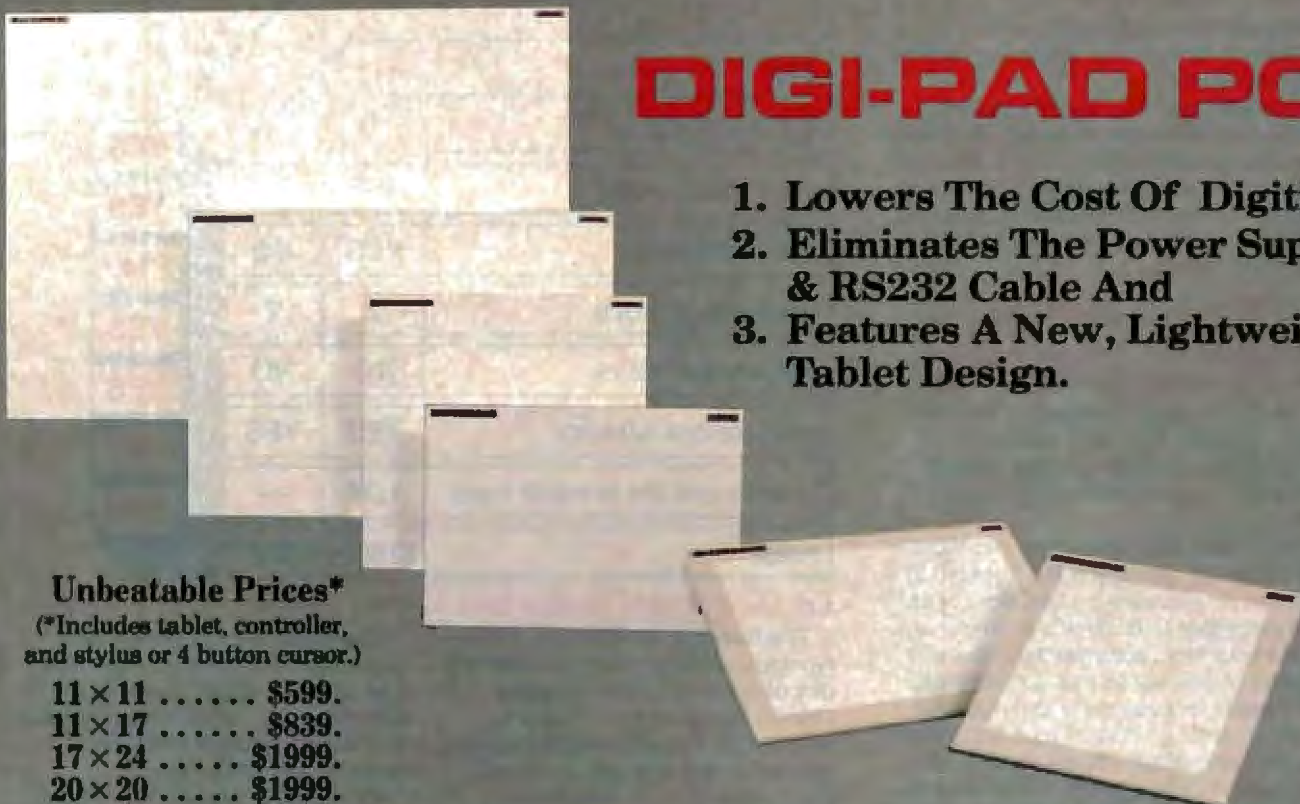

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BYTE editors offer hands-on views of new products.

A New SideKick

Experienced SideKick users will feel like kids in a candy store when they begin using **SideKick Plus.** The program is so packed with features that Borland's biggest problem may well be convincing current SideKick customers that the program is in fact a completely new program, not simply an upgrade of an existing product. Comparing the nearly 400-page SideKick Plus manual needed to document the program with the original 86-page SideKick manual underscores this.

SideKick Plus (SK+) has a memory-resident Notepad (text editor), a Calculator, and an ASCII table. Although greatly expanded in capabilities, these modules, and many other SK+ features, should be familiar to current SideKick users. However, SK+ also includes a disk organizer (File Manager), an outline processor (Outlook), a calendar (Time Planner), and a full communications package (Phonebook). The program is modular in that you can customize SK+.

To save on memory and enhance performance, I set up my version to include only the applications I thought I'd use the most—File Manager, Notepad, Phonebook, and Calculator. Using a standard IBM PC with a Plus Hardcard 20, I focused on those features that I frequently use—the text editor and communications module.

There were two things that I particularly liked about the SK+ Notepad: the ability to have up to nine windows open at a time, and the size of the files that you can have in each window (up to 54K bytes). I loaded nine chapters of a project I'm currently working on (the largest chapter was 49K bytes), switched from one chapter to another (by pressing F6),

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SIDEKICK PLUS COMMAND SUMMARY

File Manager
Directory (for any disk or path), Search (for files or text strings within files), Mark Entries (for further processing), Copy, Delete, Move, Rename, Print, (change) Attributes, View (files), Prepare (format) Disk, Create Directory, Order (sort directories)

Notepad
File, Reformat, Search, Block, Insert, Delete, Go to, Marker, Options, Insert Mode, Auto Indent, Graphics, Hard Tabs, Margin Release, Right Margin, File

Outlook (outliner)
Line Spacing, Indent, Hidden Text, Attached Notes, Structured Output; also, all the Notepad's commands

Phonebook
Search (for entry), Attach Note, Edit Entry (uses the Notepad's commands), Insert Entry, Delete Entry, Communications (a full telecommunications module), Glossary, Print, Options, New Phonebook

Time Planner
New Book, Search (for an entry), Insert, Edit (uses the Notepad's commands), Print, (set) Alarm, Resolution (set appointment book's increments, in minutes), Begin Day, End Day, Default Times, Go to

Calculator
Edit Tape, Variables, Functions, Memory, Block, Options, Type (of calculator: Scientific, Business, Programmer, Formula)

ASCII Table
Control Characters, Edit Paste Buffer, Paste Options, Go to

Services
Edit Clipboard (uses the Notepad's commands), Window Control, Copy from, Paste from Clipboard, Quick Paste, Setup, Memory Sizes, Unload SideKick Plus

Vogon Poetry
A just-for-fun item. In the beta version we tested, this command (from the opening menu) called up a game—a clone of Space Invaders.

edited them, and copied and pasted text without any problem. At the same time, I loaded the same 49K-byte file into WordStar 3.3, and I found that I could move around the file faster with Notepad than with WordStar. (Executing a Control-Q-C to get from the top to the end of the file took SK+ about 2 seconds; with WordStar, it took about 9 seconds.)

The system Clipboard made it very easy to cut, copy, and paste information between SK+ applications. A feature called Quick Paste, which bypasses the Clipboard, let me paste text directly to the current cursor position in the WordStar file. The Notepad also uses WordStar-like dot commands and Control-key sequences to support almost all standard word-processing features.

The Phonebook is a powerful communications program that supports background communication, auto-log-on, scripts, and other advanced features. Its Learn feature was nice; I easily created a BIX log-on script by turning Learn on, going through the standard dial-up and log-on sequence, and turning Learn off. I then edited the script to delete everything but prompt and response statements before finally activating it. It worked fine the first time. To test background communication, I logged onto a remote bulletin board system and, using XMODEM CRC protocol, downloaded a 7K-byte file. During the download, I switched back to DOS, loaded WordStar, created and edited a document, then switched back to my background downloading. It worked great, and the complete file was received with no errors. Although background communication capability uses about 20K extra bytes of RAM, I know I'll use it a lot.

One SK+ feature that users may find troublesome is that the program is complex and has a confusing array of features that you can reach from Control-key sequences, function keys, and menus. You'll have to decide for yourself if the complexity of the program is worth the effort; I think it is.

Another feature I found bothersome was the length of time it takes SK+ to appear on the screen—about 4 seconds to load and another 4 seconds to unload. The reason for the time delay is the method used to swap resident applications and data on and off the disk. There are ways to speed up the loading process, including an installation option that eliminates disk swapping, the use of a RAM disk or an Above Board, or the creation of an abbreviated customized version of the program (my option). Borland also indicated that speed optimization will continue to be a prime objective.

Overall, I think I'll be one of many dedicated SideKick users who give up the simplicity of the original program for the power of SideKick Plus.

—Jonathan Erickson

Lotus's Outliner/Word Processor

The Facts:

Manuscript 2.0
$495
(Pre-2.0 copies purchased on or after December 1, 1987 can be upgraded to 2.0 for free. Copies purchased before that date can be upgraded for $75.)

Lotus Development Corp.
55 Cambridge Parkway
Cambridge, MA 02142
(617) 577-8500
Inquiry 854.

Requirements:
Runs on MS-DOS computers (version 2.0 or higher) with at least 512K bytes of RAM, a hard disk drive, and a 5¼-inch or 3½-inch (1.44-megabyte) floppy disk drive; works with CGA, EGA, VGA, Hercules Monochrome, InColor, Toshiba T3100, and Compaq Portable III displays. Includes software drivers for most popular dot-matrix and laser printers.

Manuscript 2.0 is easier to use, more powerful, and faster than version 1.0.

Word-processing additions include macros; named text libraries for rapid insertion of boilerplate copy; multiline headers and footers; inclusion of Microlytics' Word Finder thesaurus, with definitions as well as synonyms; a new spelling checker from SoftArt, and integration of spell-checking with the editor rather than as an external utility; the ability to see page breaks while in the editor; sorting of tables, using any column as the sort key; and automatic saving of an edit document at predefined time intervals. You can include Lotus 1-2-3 worksheets in a document by file reference and update them by command (the latest numbers from a worksheet are read into the document).

Formatting and printing the six-page sample document, which contained three graphs, two equations, and two tables, took 59 seconds with version 1.0, while a prerelease version of 2.0 took 47 seconds. The final version will be still faster, according to Lotus. (Lotus reports it plans to ship Manuscript 2.0 in the first quarter of this year.)

Previewing is also faster in version 2.0, thanks to an intermediate storage format for graphics images and changes in the product's overall memory management scheme. The edit document now remains in memory while the editor, print formatter, and previewer are swapped in and out.

Manuscript 2.0 also includes some major enhancements and new features in the area of page layout and format: winding columns of text (one to nine columns); financial tabs, so numbers are properly aligned even when followed by symbols such as percent and minus signs; named blocks; full user control of parameters for hyphenation and microjustification; and logic for page and column breaks.

I think Manuscript 2.0 should have broad appeal as a complete editing and layout system for large documents. It looks like a workable alternative to the traditional approach of using typesetting and layout services to create printable documents.

—George A. Stewart

continued

Search and Cut/Paste Facility for dBASE Files

The Facts:
Friendly Finder
$99

Proximity Technology Inc.
3511 Northeast 22nd Ave.
Fort Lauderdale, FL 33308
(305) 566-3511
Inquiry 856.

Requirements:
IBM PC, XT, AT, or compatibles with DOS 2.0 or higher (DOS 3.0 required with the IBM PC AT); 75K bytes of free memory; hard disk drive (recommended).

If you've ever needed information from a database while working in another application, you know that exiting the application, opening the database, and then finding the record can be frustrating.

Using the patented search algorithm Proximity-Scan, **Friendly Finder** lets you search and retrieve information from dBASE files while working in other applications. Friendly Finder also works with fixed-length ASCII files, but it's primarily for use with files in dBASE format (DBF). You can use Friendly Finder with other database programs, such as Paradox or R:base, by first converting the data to DBF format, but then you have to reconvert your data every time you update the database.

You can run Friendly Finder from the DOS prompt, but you would probably want to operate it in memory-resident mode (it takes up 75K bytes); this is really more useful because you can then access databases from within other applications.

To invoke Friendly Finder in memory-resident mode, you press the default key combination Control-Right-Shift, or any other combination that you specify. Friendly Finder appears in a small window at the top of your screen with a list of available databases. You select the database you wish to search and enter your query. Friendly Finder finds all records that match the string in your query. Once you've found the record (or records) you're looking for, you can paste the data into your application, one field at a time.

I tested Friendly Finder on an XT with an Orchid TurboEGA card and an Intel Above Board. With the Above Board, I was able to copy my database files to a RAM disk in expanded memory. While Friendly Finder is pretty fast on a hard disk, its performance is virtually instantaneous on a RAM disk. A search for a unique record in a 1000-record

continued

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In Canada contact **Kao-Didak Ltd.** P.O. Box 41, 10 Didak Drive, Arnprior, Ont. K7S 3H2 (613) 623-7901 Fax (613) 623-2886 Telex 0533548
In Europe contact **Kao Corporation GmbH** Infosystems Division, Wanheimer Str. 57, 4000 Dusseldorf 30, F.R. Germany 0211-4176-0 Fax 0211-413559 Telex 8587565 kaoe d

database took a few seconds on the hard disk but completed almost instantly on the RAM disk.

To customize Friendly Finder using its special customization program, you add submenus that appear when you invoke Friendly Finder. The customization program also lets you set up fixed-length ASCII files for use with Friendly Finder. You have to specify a field width and field name for each field in the fixed-length record. The fixed-length file can then be queried just like a DBF file.

Friendly Finder is an extremely useful utility for database users. I hope that Proximity Technology will eventually make Friendly Finder available for other database formats.

—Nick Baran

Recordkeeping Software Shows Potential of Macintosh HyperCard

The Facts:

Focal Point
$99.95

Activision Inc.
P.O. Box 7286
Mountain View, CA 94039
(415) 960-0410
Inquiry 857.

Requirements:
Macintosh Plus or equivalent, HyperCard 1.0.1 or higher, and a second floppy disk drive or a hard disk drive.

One of the most alluring promises of Apple's HyperCard is the possibility of quickly storing, retrieving, changing, and cross-referencing "stacks" of whatever information you use regularly. **Focal Point** is a collection of 18 interrelated stacks that help you organize job-related phone, project, and billing data.

The most valuable thing about Focal Point is that information needed in multiple places shows up automatically after you have entered it once. For example, when you dial a number from the Directory and Dialer stack, Focal Point creates a new record in the Outgoing Phone Log, filling in the fields for the date, time, person called, and phone number.

The scheduling stacks include the Appointment Book, To Do List, Monthly Calendar, and Deadlines. In the To Do List, you can sort entries by priority; at the end of the day, pressing one button copies all pending items to the next day. The Deadlines stack shows all the project-related deadlines you've set, sorted by date.

There are also project stacks that you can use to interrelate clients, vendors, and projects. The phone-support stacks include the Directory and Dialer stack, and the Incoming and Outgoing Phone Log stacks. For billing purposes, you can record the length of a call in both Phone Log stacks just by clicking on a call-finished button. And finally, there are expense accounting stacks.

Focal Point is an excellent product, but as stackware, which sits "on top of" HyperCard rather than a directly executable file, it has advantages and disadvantages. For example, if you don't like the way it works, you can modify it (with some difficulty) by changing the underlying HyperTalk scripts. On the other hand, it executes some actions slowly and has odd conventions, like wanting you to hit Tab or Enter but not Return when you finish a data item (this is an idiosyncrasy of HyperCard).

You really need a hard disk drive, MultiFinder, and at least 2 megabytes of memory (Focal Point is most useful when it is already in memory and can be called up in several

continued

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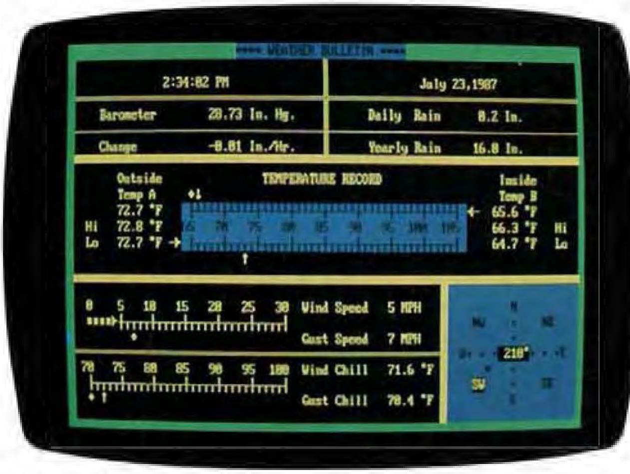
Circle 174 on Reader Service Card

seconds). The full set of stacks takes up 1051K bytes of disk storage, although you can make do with less. Although Focal Point's price is too high and it has a few drawbacks, I think it's a worthwhile product.

—Gregg Williams

A Weather Station for Your PC



The Facts:

PC WeatherPro
$575

Technology Marketing Group Ltd.
4000 Kruse Way Place, Building 2, Suite 120
Lake Oswego, OR 97035
(503) 635-3966
Inquiry 855.

Requirements:
IBM PC, XT, AT, or compatible; DOS 2.0 or higher.

A full-fledged weather monitoring system, **PC WeatherPro** is based on a half-length plug-in card with a spiffy 80-pin custom IC developed specifically to process weather data. Packed into the chip is an A/D converter, a processor, memory, a real-time clock, a custom solid-state barometric pressure transducer, and the microcode that ties it all together. Since keeping the board powered up at all times is critical, a separate plug-in power supply keeps PC WeatherPro running even when your computer is powered down.

But the board is only the beginning. It's what you hook up to it that counts, and that includes both internal and external temperature sensors, an electronic rain gauge, an anemometer, and a wind vane. Obviously, installing and hooking up all this stuff requires a certain amount of ambition, time, and skill. You'll need to plan wire runs and crawl around on your roof to mount the wind sensors and rain gauge. And you'll need both boiling and freezing water to calibrate the temperature probes, as well as access to accurate barometric pressure to calibrate the on-board sensor.

The software that keeps PC WeatherPro happily keeping track of conditions runs in the background, as you'd expect. You can call up the master Weather Bulletin screen at any time by pressing a hot key. The real power in PC WeatherPro, however, is its ability to log and plot all that weather data. At regular intervals, all the weather parameters that the system measures are written to a disk file. You can call them up at any time, and, with the press of a couple of keys, either display

continued

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or print out graphs of the data. You can also set alarms to go off when certain conditions that you've preset—such as low or high temperatures or wind—occur.

With its $575 price tag, PC WeatherPro is for dedicated weather freaks or those with a real need to keep track of current and past weather information. It is kind of a pain to set up, but it's one of the few PC accessories that give you the guilty pleasure of having fun and doing something ostensibly useful at the same time.

—Stan Miastkowski

Technical Graphing for Lotus 1-2-3

The Facts:

Tech*Graph*Pad 2.1
$275

Binary Engineering Inc.
100 Fifth Ave.
Waltham, MA 02154
(617) 890-1812
Inquiry 858.

Requirements:
IBM PC, XT, or AT with 440K bytes of free memory, DOS 2.0 or higher, and CGA or EGA.

Tech*Graph*Pad is a stand-alone technical graphing program that can read directly from Lotus 1-2-3 or WKS-format files. The version that I tested (2.1) had several serious bugs and an extremely clumsy interface for such an expensive piece of software. The program does, however, have many features that engineers and scientists need in a graphing program. It supports log-log and log-linear plot types, as well as polar coordinates. You can use up to eight data sets of 500 points each, which you can generate in ASCII format or WKS files. In addition, Tech*Graph*Pad supports a set of curve-fitting algorithms, including polynomial, power, spline, logarithmic, Bézier, and Savitsky-Golay. A host of other features for scaling, labeling, and customizing your graphs are also included. You can also convert data from Tech*Graph*Pad into multiple or merged PIC files if you need to use the Lotus PrintGraph facility.

In the bugs department, Tech*Graph*Pad printed the x-axis coordinates incorrectly when I changed to an integer format (it printed one coordinate twice and put a minus sign in front of the 0 coordinate). Also, the built-in line editor for editing data files did not work properly, introducing extraneous characters when I attempted to move the cursor or use the PageUp or PageDown keys.

While bugs can be corrected, Tech*Graph*Pad suffers from more basic design problems in its user interface. Tech*Graph*Pad uses a series of pop-up menus, some of which have selections in columns. Unfortunately, you can't move the cursor horizontally from one column to the next. You have to scroll vertically to the bottom of one column and then start at the top of the next, even if you only want to enter commands in a single row. In addition to the menu problems, Tech*Graph*Pad does not support the Extended ASCII character set, so you can't label your plots with standard Greek mathematical symbols such as θ or Σ, for example.

Tech*Graph*Pad's most important feature is its ability to read WKS files. However, you can't view the data from the WKS file when you are prompted to enter cell ranges for each data set. This means that you have to write them down on paper while in Lotus 1-2-3 before you load Tech*Graph*Pad.

There is a need for a program with Tech*Graph*Pad's features. However, I think that the implementation of these features in Tech*Graph*Pad version 2.1 is seriously flawed. ■

—Nick Baran

 Circle 255 on Reader Service Card

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Circle 45 on Reader Service Card

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PETITION OUT ON A LIM.

Enhanced EGA and VGA Boards

Curtis Franklin Jr.

Should you buy a VGA or will an enhanced EGA fill the same purpose for less money?

The joy of a good video standard is that you want to use the available graphics. EGA graphics have become the standard for business applications, offering 640- by 350-pixel by 16-color resolution and text that is readable for extended periods of time. During the last year, companies pushed that standard higher by offering enhanced EGA boards with 640 by 480 or higher resolutions.

IBM has since given the world a new graphics standard, the VGA, and early indications are that it is a good standard indeed. People who make graphics boards recognize this, and so the rush is on to get VGA-compatible graphics adapters to market. In this mad rush, unfortunately, the word "compatible" takes on several shades of meaning. I looked at 22 boards and found that, in many cases, compatibility is in the eye of the marketing chief.

In broad terms, the boards in this review fall into two categories: VGA-compatible boards and enhanced EGA boards that happen to have modes that coincide with one or more of the new VGA modes. Table 1 lists characteristics for the 14 enhanced EGA boards I looked at, and photo 1 shows a sampling of these boards. Table 2 lists the 8 VGA boards, and photos 2 and 3 show what these boards look like. In both groups of boards, I found that performance and features varied widely from board to board.

Sorting Out Standards

The original EGA boards used a 16.257-MHz timing crystal to drive the display at the 640 by 350 resolution. This satisfied users until multiple-scan-rate monitors, like the NEC MultiSync, appeared. These monitors allow a much higher resolution, and people soon realized that simply adding a faster crystal would give them an EGA display with 640 by 480 resolution (now the standard for enhanced EGAs). Some manufacturers are going beyond the new standard to 800 by 560 and higher resolutions.

VGA arrived on the scene with the IBM PS/2 computers in April 1987. It brought five new BIOS display modes (two text and three graphics) and a new requirement for monitors. EGA (and earlier) graphics use TTL monitors for their display. The increased bandwidth of the VGA signals would require a TTL cable roughly the diameter of your thumb, so IBM engineers decided to switch to analog display technology.

With an analog display, fewer wires are required to carry the signal from the display adapter to the monitor. Most multiple-scan-rate monitors allow switching between analog and TTL input, so upgrading from EGA to VGA will not, for many users, require buying a new monitor, as did the switch from CGA to EGA.

Most of the interest in VGA has centered on the graphics modes. The three new ones are mode 11H, 640 by 480 by 2-color; mode 12H, 640 by 480 by 16-color; and mode 13H, 320 by 200 by 256-color. Modes 12H and 13H display their colors from a palette of more than 256,000 colors.

You may have noticed that the resolution of modes 11H and 12H matches the resolution of many enhanced EGA boards. This does not mean that all boards with 640 by 480 resolution are VGA-compatible. The BIOS entry locations are different for EGA and VGA, even at the same resolution. Some manufacturers solve this problem by offering software that switches the board between EGA BIOS and VGA BIOS.

If you have specific needs for a particular mode or resolution, you should read the specifications of the board and its attendant software carefully. Photos 4 and 5 show the difference between EGA and VGA resolution. (For a detailed discussion of the VGA standard, see "PS/2 Video Programming" by Richard Wilton in BYTE's Fall 1987 *Inside the IBM PCs.*)

Wringing Them Out

I used nine tests to check the features and compare the performance of the boards. The machine I used was an 8-MHz IBM PC AT with 2.5 megabytes of RAM, a 40-megabyte hard disk drive, and an NEC MultiSync XL monitor. The tests I used were the following:

1. TORUS.BAS: A QuickBASIC 4.0 program that draws a torus (doughnut) on the screen at the highest available color/resolution, then cycles the colors.
2 and 3. Two QuickBASIC programs that checked for support of VGA mode 13H.
4. VGADiag: This program comes with the SigmaVGA board and checks for support of all EGA modes, enhanced EGA (640 by 480), and all VGA modes.
5. Windows Draw: I measured the time to redraw the USA.PIC file that was supplied with Microsoft Windows Draw.
6. Windows Write: I measured the time needed to scroll from the top to the bottom of a file that measured approximately 40K bytes. For both Windows tests, I used Microsoft Windows version 1.03 (which was the latest version available at the time of this writing) and the Windows driver supplied with the individual board unless otherwise stated.
7. DOS `DIR`: The time needed to display a 53-entry directory using the `DIR` command of DOS 3.2.
8. AutoCAD: I timed a regeneration (REGEN) of the STPAULS file supplied with AutoCAD version 2.52 with ADE 3 extensions. I used the AutoCAD driver supplied with each board to perform this test.

continued

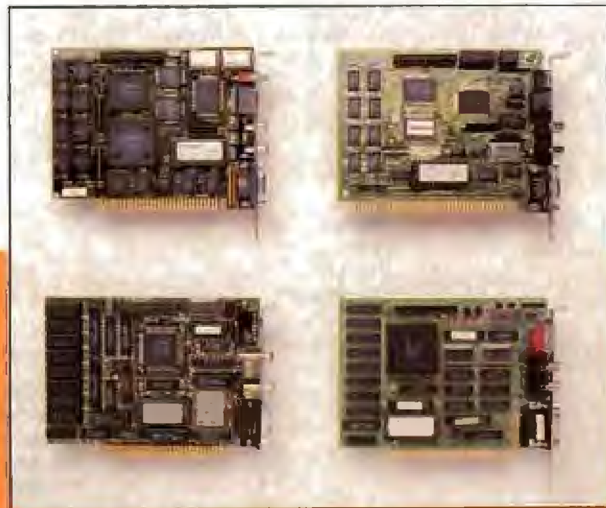
Curtis Franklin Jr. is a technical editor for BYTE. He can be contacted at BYTE, One Phoenix Mill Lane, Peterborough, NH 03458, or on BIX as "curtf."

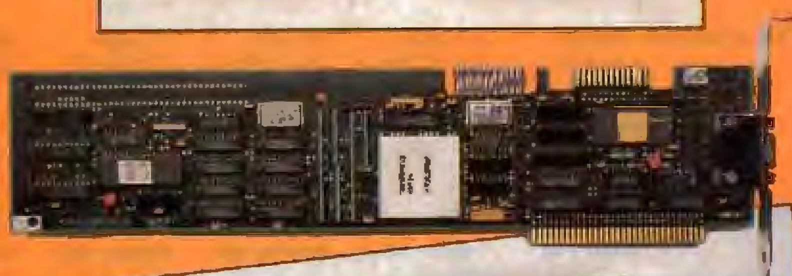
EGA

Boca Research MultiEGA
Genoa SuperEGA HiRes +
IGC EGAcard
Logitech EGA
Mitac SEGA
NSI Smart EGA Plus
Paradise Autoswitch EGA480
Quadram Quad ProSync!
SCOA Star PGA
SMT Pro-EGA
Tatung 900 OmniCard
Tecmar EGA Master 800
Thomson EGA Ultra Version
Tseng EVA480

VGA

ATI VIP VGA
Tatung Platinum Card
Compaq VGC Board
IBM PS/2 Display Adapter
SigmaVGA
STB VGA Extra
Video Seven VEGA VGA
Zenith Z449





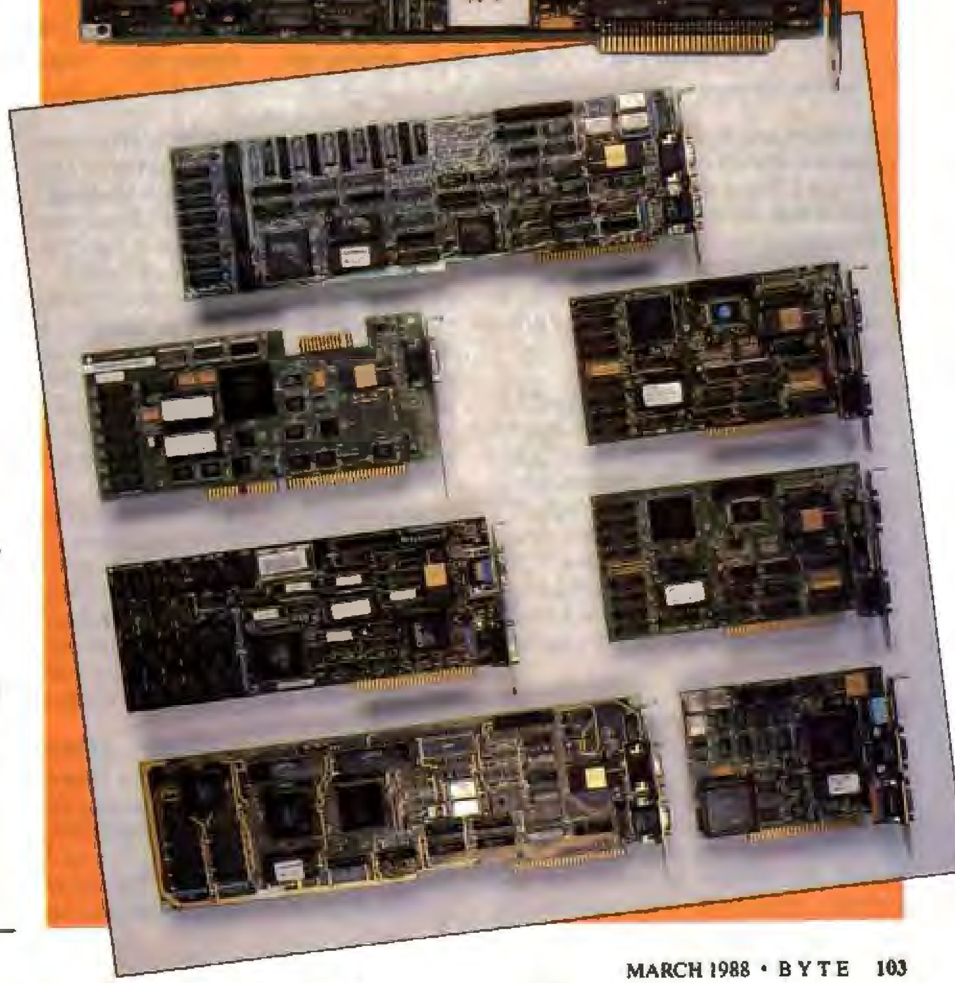


Photo 1: *The NSI Smart EGA Plus, Thomson Enhanced Graphics Adapter Ultra Version, Paradise Autoswitch EGA480, and Quadram Quad ProSync! are typical of the half-slot enhanced EGA boards.*

Photo 2: *IBM's Personal System/2 Display Adapter, the standard by which most other VGA boards are judged.*

Photo 3: *The first crop of VGA boards include the ATI VIP VGA, Compaq Video Graphics Controller Board, SigmaVGA, STB VGA Extra, VEGA VGA, Tatung Platinum Card, and Zenith Z449.*

Table 1: *Enhanced EGA boards.*

Product	Boca Research MultiEGA	Genoa SuperEGA HiRes +	IGC EGAcard	Logitech EGA	Mitac SEGA	NSI Logic Smart EGA Plus	Paradise Autoswitch EGA480
Maximum resolution	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors
VGA modes supported	None	Modes 0, 1, 2, and 3	None	None	None	None	None
Drivers supplied	Windows, AutoCAD	Windows, AutoCAD, GEM, Lotus 1-2-3, Framework II, Ventura Publisher, Volkswriter 3	AutoCAD	Windows, AutoCAD GEM	Windows, AutoCAD, Lotus 1-2-3	Windows, AutoCAD, GEM, Lotus 1-2-3, Ventura Publisher, Symphony, WordStar, Framework II, WordPerfect	Windows, AutoCAD, GEM Lotus 1-2-3, Ventura Publisher, Symphony, WordStar, Framework II, WordPerfect
Size	5½ × 4"	5½ × 4"	7 × 4"	6½ × 4"	5½ × 4"	5½ × 4"	5½ × 4"
Special features			TTL and 9-pin analog output; cable	Comes with three-button mouse and mouse driver software		Compatible with drivers for other EGA boards	
Documentation	46-page *Owner's Manual*	57-page *User's Manual*	25-page *User's Manual*	47-page *Installation Manual*	28-page *Guide to Operations*	39-page *User's Guide* 4-page addendum	35-page manual 31-page *Software Manual*
Price	$299	$489	$450	$399	$199	$499	$349
	Inquiry 924.	**Inquiry 925.**	**Inquiry 926.**	**Inquiry 927.**	**Inquiry 928.**	**Inquiry 929.**	**Inquiry 930.**

All drivers supplied used the ADI driver hooks available in AutoCAD.

9. Lotus 1-2-3: I timed the drawing of a graph within the spreadsheet. The graph was a stacked bar chart of 48 data points in 1-2-3 version 2. I used the 1-2-3 graphics driver supplied with the board or the Lotus EGA driver if no graphics driver was supplied.

The applications (Windows, AutoCAD, and Lotus 1-2-3) test the performance and features of a graphics board/driver combination. I used the highest-resolution driver available in each case. The performance of the board with a lower-resolution driver might be much different. Figure 1 shows the benchmark results for the enhanced EGA boards; figure 2, the results for the VGA boards.

Boards Beyond EGA

All boards in this category support at least 640 by 480 by 16-color graphics, driving them on a TTL monitor. Some of the boards provide BIOS hooks for VGA software in certain modes, but most simply list themselves as enhanced EGA boards. In addition to the drivers and software listed with each product, the boards generally include software to display the version and date of the motherboard ROM, a program to change video modes in software, and a program to allow games that auto-boot to run. The boards are listed in alphabetical order.

The *Boca Research MultiEGA* ($299) is a PC-bus half card. The MultiEGA uses the Chips and Technologies EGA chip set and the Boca Research BIOS, and it contains one switchblock and three jumpers for setting mode and monitor type. It includes drivers for AutoCAD and Windows and a screensaver.

Its performance places the MultiEGA solidly in the top tier of the enhanced EGA boards, taking 22.77 seconds to regenerate the STPAULS file in AutoCAD, the fifth fastest time, and 95.98 seconds to scroll through the Windows Write text file, the second fastest time. Boca does not claim that the MultiEGA emulates any VGA video modes.

The *Genoa SuperEGA HiRes +* ($489) is a half-length board that uses a Genoa EGA chip set and EGA BIOS to provide enhanced EGA functions and compatibility with VGA text modes 0, 1, 2, and 3 through a TTL video port. The board provides VGA BIOS entry points, but the tests I ran showed that the VGA emulation is not perfect. For example, the TORUS program gave an initial display of EGA-type colors, but it would not cycle the colors. In addition, a large green band ran down the right side of the screen.

Genoa includes drivers for AutoCAD, GEM, Windows, Lotus 1-2-3, Framework II, Ventura Publisher, and Volkswriter 3. With each test program, the SuperEGA HiRes + brought up the display on the far left side of the screen and then shifted it to the center after about ½ second. The jumping display was disconcerting but did not seem to have any effect on the performance of the programs. This board had the worst performance in Lotus 1-2-3, taking more than twice the time of the next slowest board. In other programs, it scored in the middle.

The *Intelligent Graphics Corp. EGAcard* ($450), based on the Chips and Technologies chip set and Phoenix BIOS, has a number of features that make it stand out from the rest of the boards in this group. The EGAcard does not include VGA BIOS hooks or emulation, but it does have (9-pin) analog output in addition to the standard EGA TTL. IGC even included a 9-pin to 9-pin cable with the

Quadram Quad ProSyncl	SCOA Star PGA	SMT Pro-EGA	Tatung 900 OmniCard	Tecmar EGA Master 800	Thomson EGA Ultra Version	Tseng Labs EVA480
640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	800 × 560 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors
Modes 11H and 12H	None	None	Modes 11H and 12H	Modes 11H and 12H	None	None
Windows, AutoCAD, GEM, WordStar, WordPerfect	Windows, AutoCAD, GEM, CADVance, Lotus 1-2-3, WordStar, Symphony, Ventura Publisher	Windows, AutoCAD, GEM, CADVance, Lotus 1-2-3, WordStar, Symphony, Ventura Publisher	Windows, AutoCAD, Lotus 1-2-3, WordStar	Windows, AutoCAD, GEM, Lotus 1-2-3, Ventura Publisher	AutoCAD	Windows AutoCAD
5½ × 4"	5½ × 4"	5½ × 4"	5½ × 4"	5½ × 4"	5½ × 4"	13¼ × 4"
Driver upgrade for VGA: $10					Microsoft InPort connector and mouse driver	25-pin RS-232C port, Hercules emulation
52-page *Operations Manual*; 30-page driver appendixes	60-page *User's Manual*	60-page *Instruction Manual*	45-page *Operations Manual*	70-page user's guide; 38-page cover removal guide	44-page *User's Guide*	51-page *User's Guide*, 35-page *Driver Notes*
$395	$399	$249	$399	$595	$395	$480
Inquiry 931.	**Inquiry 975.**	**Inquiry 976.**	**Inquiry 977.**	**Inquiry 978.**	**Inquiry 979.**	**Inquiry 980.**

board. While other boards in this review concentrated on the VGA standard, IGC designed this board to work "in series" with its PGC (Professional Graphics Controller) compatible adapter. According to the manual, connecting the two boards allows the EGAcard to provide PGC colors at EGA resolution.

A driver for AutoCAD was included with the board but, unlike the drivers for the other boards I looked at, this one didn't work. When I tried to install it, I got an Unknown Hardware error. The AutoCAD timing test was run using the AutoCAD EGA driver.

The *Logitech EGA* ($399) comes with a three-button Logitech mouse and a mouse port. The Logitech EGA is based on the Chips and Technologies chip set and Logitech BIOS, and it uses one switchblock and two jumpers to set video mode and monitor type. The board comes with drivers for Windows, GEM, and AutoCAD and drives all three at 640 by 480 resolution. I did not test the mouse or its drivers. The Logitech EGA board

continued

Photos 4 and 5: *Microsoft's Windows 1.03 running under EGA (left) and VGA (right) modes illustrates the increased resolution that VGA offers.*

Table 2: *VGA boards.*

Product	ATI VIP VGA	Tatung Platinum Card	Compaq Video Graphics Controller	IBM Personal System/2 Adapter	SigmaVGA	STB VGA Extra	Video Seven VEGA VGA	Zenith Z449
Maximum resolution	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors	640 × 480 × 16 colors
VGA modes supported	All	All	All	All	All	All	All	All except mode 13H
Drivers supplied	Windows, AutoCAD, GEM, Lotus 1-2-3, Ventura Publisher	Windows, AutoCAD, GEM, Lotus 1-2-3, Ventura Publisher	None	None	Windows, AutoCAD, Lotus 1-2-3, WordStar, GEM	Windows, AutoCAD, Lotus 1-2-3, Symphony	Windows, AutoCAD, Lotus 1-2-3	Windows, AutoCAD, GEM, Symphony, Lotus 1-2-3
Size	7½ × 4"	7½ × 4"	9 × 4"	13½ × 4"	13½ × 4"	10 × 4"	5½ × 4"	13½ × 4"
Special features				Also supports EGA, CGA, Hercules, and MDA		Loads video ROM into RAM	Also supports EGA, CGA, Hercules, and MDA	
Documentation	49-page *Operations Manual*	49-page *Operations Manual*	29-page *Installation and Operations Guide*	21-page *Installation Instructions;* 22-page addendum to *DOS Guide*	63-page *Installation and User's Guide*	57-page user's manual	52-page *User's Manual*	24-page *Installation Guide;* 20-page *Driver Installation Guide*
Price	$449	$445	$599	$595	$499	$395	$499	$499
	Inquiry 981.	**Inquiry 982.**	**Inquiry 983.**	**Inquiry 984.**	**Inquiry 985.**	**Inquiry 986.**	**Inquiry 987.**	**Inquiry 988.**

worked flawlessly and turned in a better-than-average performance.

The *Mitac SEGA* ($199) is built around the same Chips and Technologies chip set and Phoenix BIOS as many of the other boards, but it deserves special note as the least-expensive board I looked at. The SEGA performed as a standard enhanced EGA, with one exception: In the VGA-Diag test, where all other boards gave a full-size screen for both the 320 by 200 by 16-color and 640 by 200 by 16-color tests, the SEGA gave split screens, with identical half-size images appearing in the top and bottom halves of the screen. In all, the Mitac board looks like a good bet if your needs are confined to the capabilities of an enhanced EGA.

The *NSI Logic Smart EGA Plus* ($499) supports VGA modes 11H and 12H through its TTL video port. The documentation also lists other boards that this NSI chip-set- and BIOS-based board is compatible with. According to the documentation, this board is compatible with, and can use the drivers from, the Paradise Autoswitch EGA480, Video Seven VEGA Deluxe, Quadram Quad ProSync!, and PCG Photon Mega. In addition to this bounty of drivers, the Smart EGA Plus comes with drivers for Windows, 1-2-3, Symphony, and AutoCAD.

The major flaw of this board was the noticeable and very annoying flicker in the Windows and AutoCAD displays. The Smart EGA Plus was the only board to have a problem with severe flickering.

The *Paradise Autoswitch EGA480* ($349) is a half-length card that uses the Paradise single-chip EGA and Paradise BIOS to provide enhanced EGA capability. This board offers the same basic functionality as the other boards in this group, and it provides software drivers for Windows, GEM, AutoCAD, Ventura Publisher, 1-2-3, Symphony, Framework II, WordStar, and WordPerfect.

The most outstanding feature of the Autoswitch EGA480 is its documentation, which is well written, professionally presented, and clearer than any other board's documentation on how the installation procedure for each driver works, including the response shown on the screen at each step. The quality of the documentation make this board good for users who do not have a lot of experience installing boards and drivers.

The *Quadram Quad ProSync!* ($395) supports VGA modes 11H and 12H, as well as enhanced EGA modes. When I tested the board, which uses a Chips and Technologies chip set and the Phoenix BIOS, I found that on TORUS I got VGA colors, but no color cycling, indicating limits to the completeness of the emulation. The Quad ProSync! comes with drivers for 1-2-3, Windows, AutoCAD, GEM, WordPerfect, and WordStar.

My only problem with the board came in using AutoCAD. When STPAULS first appeared, the colors were dramatically different than those of other boards, with red replacing blue, and green replacing white. When I regenerated, the colors corrected themselves, but throughout the AutoCAD session, random characters would occasionally appear at the top of the menu section.

The *SCOA Star PGA* ($399) confused my poor little brain. First, the box said "Intelligent EGA." Next, while I would assume that "PGA" related to the IBM PGC board, this is simply another enhanced EGA board that uses the Chips and Technologies chip set and the Phoenix BIOS. There was nothing unusual in the operation of the board, but it was the only product I looked at that had no switches set at the factory. Most of the boards came set up for EGA graphics on a standard EGA monitor, but this board simply came with all switches on.

The *SMT Pro-EGA* ($249) is a half-length card that uses the Paradise chip set

continued

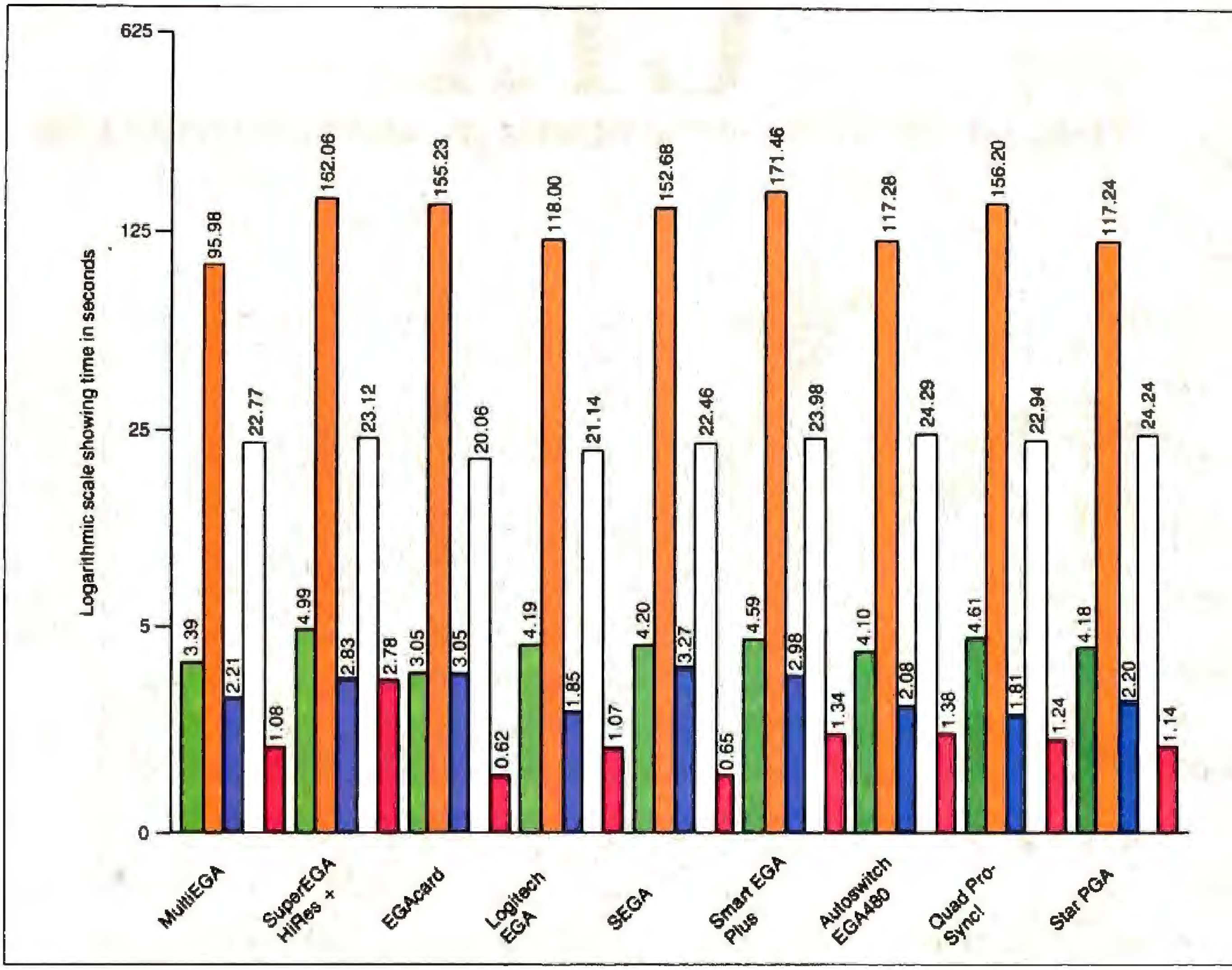


Figure 1: *In the tests for the enhanced EGA boards, Boca Research's MultiEGA and Tseng's EVA480 were the top performers.*

and BIOS. The Pro-EGA has one switchblock and three jumpers on the board, and it comes with drivers for Windows, GEM, AutoCAD, CADVance, Ventura Publisher, Symphony, 1-2-3, and WordStar. This board is one of the few that warranted a word about color; the driver for AutoCAD produced a weak red, while the Windows driver gave one of the richest reds of any board in the review.

The *Tatung 900 OmniCard* ($399) uses the Chips and Technologies chip set and a Tatung BIOS to provide both VGA BIOS entry points and enhanced EGA resolution up to 800 by 560 by 16 colors. Tatung provides drivers for Windows, GEM, AutoCAD, 1-2-3, and Symphony. I tested the board using the 800 by 560 mode and found the display to be quite crisp and readable. Unfortunately, the screen in Windows and 1-2-3 was drawn too large (vertically) for the display, especially annoying in Windows, when important information (like the name of the working file) was drawn off the screen.

The *Tecmar EGA Master 800* ($595) is an enhanced EGA half-length card that has software for enabling BIOS hooks for VGA modes 11H and 12H. The Tecmar board has a Genoa chip set and Tecmar BIOS, and it comes with drivers for Windows 1.03, GEM, 1-2-3, AutoCAD, and Ventura Publisher. I was surprised to find that, in addition to the 70-page manual for the board, Tecmar includes a 38-page *Guide to Cover Removal and Replacement*, showing how to take the cover off scores of personal computers.

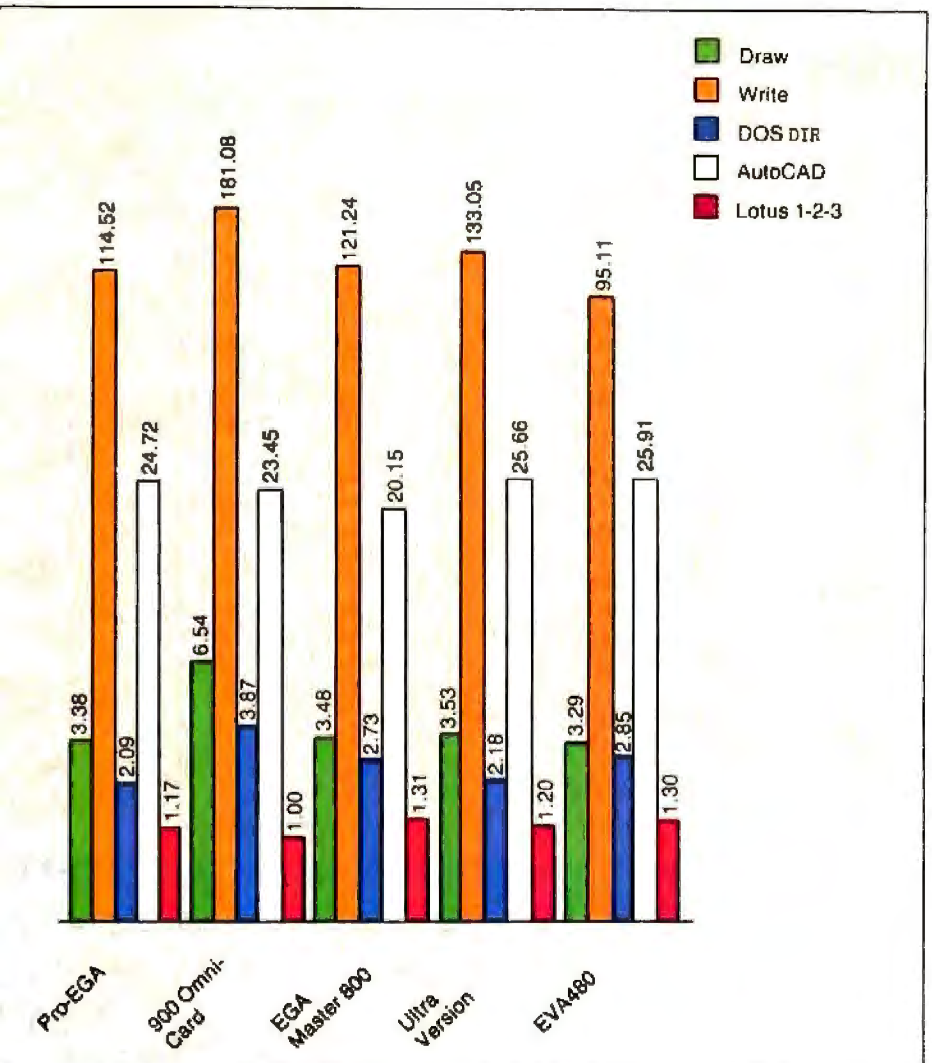
The *Thomson Enhanced Graphics Adapter Ultra Version* ($395) is a half-length card that comes with a driver for AutoCAD and a mouse driver for the Microsoft InPort Mouse adapter on the card. Because of the presence of the InPort, the EGA Ultra Version has more switches than most of the boards, with three switchblocks and four jumpers. The board is built around the Renaissance BIOS and chip set.

The *Tseng Labs EVA480* ($480) has a number of unusual features that set it apart from the other boards. Tseng offers a piggyback board to allow complete Hercules emulation and includes a 25-pin serial port with the EVA480. This is a full-length board that uses a Tseng proprietary chip set and BIOS.

There are drivers for 1-2-3 and AutoCAD with the board, and I found files that appear to be Windows drivers. There were, however, no instructions for installing the Windows drivers, so I used the enhanced EGA driver supplied with Windows 1.03. The AutoCAD driver had the interesting feature of changing the menu characters to double size whenever they were accessed. The sudden leap in size was a bit jarring.

And on to VGA

The eight boards reviewed that fall into the true VGA category are the first ones



available. I found that the levels of performance and features among this group varied far more than did the features and performance of the enhanced EGA boards. As before, the boards are (with one exception) listed in alphabetical order.

The *ATI VIP VGA* ($449) and *Tatung Platinum Card* ($445) are listed together because they are one board sold by two different companies. ATI manufactures the boards using a Chips and Technologies chip set and ATI BIOS. Both supply drivers for GEM, Ventura Publisher 1.0, 1-2-3, AutoCAD, and Windows.

Both boards support all VGA modes, and both had the same problems with drivers. In AutoCAD and Windows, the display was drawn much too large (vertically) for the monitor to display. In AutoCAD, both the coordinates at the top of the screen and the current command at the bottom of the screen were invisible. In Windows, the blue bar with the working filename at the top of the screen and the green icon bar at the bottom were both drawn out of the display area.

The *Compaq Video Graphics Controller Board* ($599) emulates the IBM VGA to the extent of including precisely as many drivers as the IBM: none. Once I got past that, the Paradise chip-set-based board worked well, but with a lot of noise; not the video noise that causes "snow" on the screen, but real audio noise over the computer speaker. There was a definite hum throughout the operation of the board. The hum's pitch would change as different items were drawn on the screen. It was kind of fun to close my eyes and guess what was happening on the screen by the sound it made, but I think that the hum would get on my nerves in a big way over time.

The *IBM Personal System/2 Display Adapter* ($595) is, of course, the standard against which all other VGA boards are judged. In most ways, it's not a hard standard to meet. It comes on a Micro Channel form-factor with a PC-bus connector. The board includes no drivers. Its documentation is complete, but not exhaustive. In order to get VGA graphics, I used the drivers from the SigmaVGA board, which worked with every package but AutoCAD. I ran the AutoCAD test using the EGA driver that was packaged with AutoCAD.

The *SigmaVGA* from Sigma Designs ($499) is a full-length board that packs a lot of graphics compatibility into a single slot. Not only does the SigmaVGA support all VGA modes, it emulates EGA, CGA, Monochrome Display Adapter (MDA), and Hercules as well. With one of these and a multiple-scan-rate monitor, graphics-incompatible software would be few and far between. Drivers for AutoCAD, 1-2-3, Windows, GEM, and WordStar are included with the board. I've tried to think of some criticism of the board, but frankly, I can't.

The *STB VGA Extra* ($395) is the least-expensive VGA board, but it's also the board with the most problems. The full-length Chips and Technologies chip-set-based board includes drivers for 1-2-3, Symphony, Windows, and AutoCAD. It also has a 57-page photocopied user's manual.

The problems arose in Windows and 1-2-3. The screen display in Windows was drawn too large for the monitor, with areas of the screen getting shoved off the top and bottom. In 1-2-3, the problem arose when I exited the package. After leaving 1-2-3, the screen stopped redrawing. In other words, a DOS CLS command would take the cursor to the top left corner of the screen but would not blank the old image. It took rebooting to get redrawing back.

The *VEGA VGA* from Video Seven ($499) came very close to getting a no-buy recommendation. The first VEGA VGA board that I looked at had some serious problems. In AutoCAD, large vertical white lines would flash across the screen any time the mouse was in motion. No amount of regenerating, redrawing, or rebooting solved this problem.

Fortunately for Video Seven, I had received three of the boards, and I decided to look at another, to see if the problems were endemic to the VEGA VGA or particular to one board. I'm glad I did, because the problems seem to have been with one board, and the VEGA VGA does a couple of nice things. First, Video Seven has put VGA graphics into a half-length card format, which makes it the smallest board of the VGA group. Next, the company provides software that can automatically load the ROM code into faster RAM for better performance.

continued

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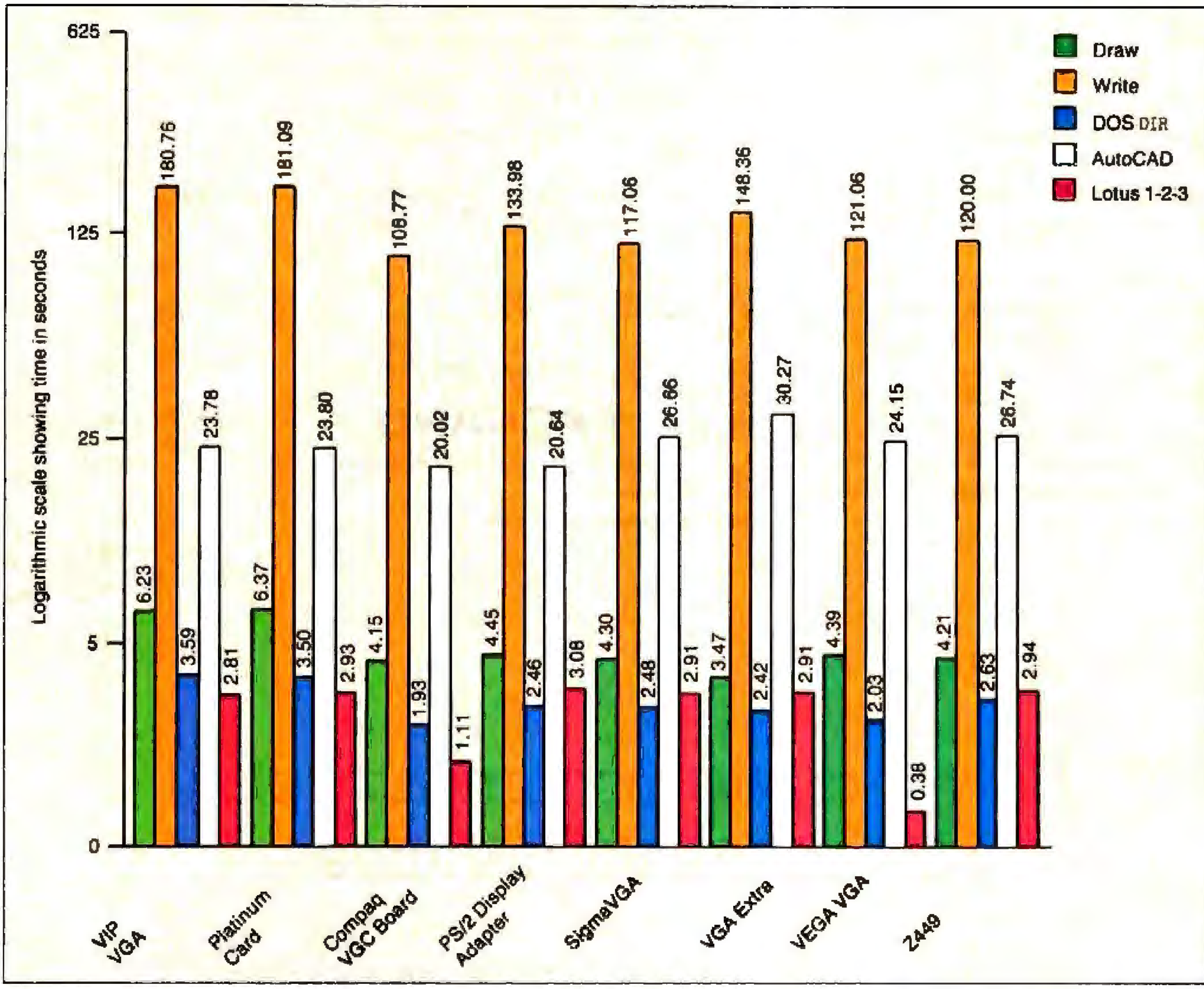

Figure 2: *Compaq's VGC Board scored best on the benchmark tests for VGA boards, followed by Video Seven's VEGA VGA.*

Video Seven includes drivers for AutoCAD, Windows, and 1-2-3 with the board. The experience with the first board left me a bit leery of the VEGA VGA, but based on the performance and features of the second board, this product's a winner.

The *Zenith Z449* ($499) is a full-length VGA board that supports all but one of the VGA modes. Unfortunately, the mode left out (mode 13H) is the 256-color mode that helps make the VGA standard so nice. The Z449, based on the Chips and Technologies chip set, tries to make up for the missing mode by providing lots of backward compatibility, offering EGA, CGA, MDA, and Hercules support. It almost succeeds. In addition to the hardware features, Zenith shows nice attention to detail by being the only manufacturer to provide its drivers for AutoCAD, GEM, 1-2-3, Symphony, and Windows on both 5¼- and 3½-inch disks. If it weren't for the missing mode, this would be the top board of the group.

The Best of a Big Bunch

If an enhanced EGA board with no pretensions to VGA is all you need, the Mitac SEGA board is the clear winner on the basis of price. If you feel that high-quality, detailed documentation is important, by all means check out the Paradise board. Other than these two, the enhanced EGA boards offer a lot of similarities across a wide range of prices and secondary features. There were none that I would warn against. And given the current lack of software that supports VGA, these boards may be more than adequate for most applications.

On the VGA side of things, one fact became quite clear: If you need VGA, buy VGA, not an enhanced EGA board that happens to have a mode or two that coincides with VGA. For one thing, you really need an analog display to take advantage of VGA, and with the exception of the Intelligent Graphics EGAcard, none of the enhanced EGA boards offer analog. For another, the quality of the "VGA emulation" provided by the enhanced EGA boards simply wasn't up to the standards of the "real" VGA boards.

Finally, most of the VGA boards reviewed here claim BIOS-level versus register-level compatibility with VGA. Since I began this review, many companies, including Paradise, Sigma, and others mentioned here, have announced boards that claim to be hardware-compatible with VGA and so able to more fully support future VGA software and offer faster performance.

But if I were in the market today for a VGA board, the SigmaVGA would be my choice. It offers complete VGA implementation and a nice variety of drivers in a well-documented package. The VEGA VGA from Video Seven is also a top-notch board, with good features and performance. If you need VGA and have only a half-length slot open, the VEGA VGA is the way to go. ■

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The Z-386 backplane design features an unusual approach to high-speed bus expansion. In this design, the backplane, or system board, serves as a power and bus connection system into which you plug other circuit boards. One advantage to this is that if a part fails, it is likely to be on a removable circuit board. The Z-386's backplane has two 8-bit slots, two AT-compatible 16-bit slots, and six 32-bit slots.

The Z-386, at the high end of Zenith's MS-DOS desktop computers, combines the speed of a 32-bit 80386 processor with IBM PC AT compatibility.

The basic system comes in two models, differentiated by the amount of hard disk space: The Model 40 ($6499) contains a 40-megabyte hard disk drive, and the Model 80 ($7499) has an 80-megabyte hard disk drive. Both models include a 16-MHz 80386 processor, which requires one 32-bit slot and has a socket for either an 80287 or 80387 math coprocessor; a Z-505 memory board containing 1 megabyte of two-wait-state 100-nanosecond RAM (it requires one 32-bit slot); a 1.2-megabyte floppy disk drive and one of the hard disk drives (the disk controller requires one 16-bit slot); an I/O board containing one serial port and one parallel port (the board requires one 32-bit slot); a 31.5-kHz video display board, which occupies one 8-bit slot and includes EGA, CGA, and Hercules hardware and software support; and five additional expansion slots—one 8-bit, one 16-bit, and three 32-bit slots. The basic system also includes MS-DOS 3.2 and Microsoft Windows/386.

You can expand memory in either 1-megabyte increments with the Z-505 memory card ($699) or 4-megabyte increments with the Z-515 memory card ($2199); each card of either kind requires one 32-bit slot. You can provide the Z-386 with a maximum of 16 megabytes of RAM by filling the three remaining 32-bit slots with Z-515s and substituting another Z-515 for the Z-505 that comes with the basic system.

You can add Zenith's optional Z-525 64K-byte, zero-wait-state, 40-ns cache-memory board ($599), which requires a 32-bit slot, and you can add another 1.2-megabyte or 360K-byte floppy disk drive, as well as another hard disk drive. The Z-386's 195-watt power supply and disk controller provide all the power and cabling necessary to support two floppy disk drives and two hard disk drives without upgrading or requiring additional expansion slots.

The system I reviewed was a Z-386 Model 80 with a 1.2-megabyte 5¼-inch floppy disk drive, an 80-megabyte hard disk drive, the Z-449 video display board, and Zenith's excellent ZVM-1380-C 13-inch EGA color monitor ($799). The review system also came with the optional 64K-byte cache memory board to cache the entire address space. Adding this optional board boosts system performance, as the benchmarks will show.

The Hard Facts

The Z-386 has a modular design based on Zenith's familiar "backplane," with plug-in components including the CPU, system memory, disk controllers, and standard I/O services. Most 80386 microcomputers feature at least one 32-bit expansion slot into which you can add fast peripherals such as memory. However, many slot designs are proprietary, and 32-bit hardware designed for one system can't be used with another. Much of the time, you can use these 32-bit slots only with special 32-bit circuit boards; if you are running out of slots, you may not be able to use a standard IBM PC or AT peripheral device in an unused slot.

While the 32-bit bus layout for the Z-386 is also proprietary, it is designed to be an extension of the AT's 98-pin connector. The 16-MHz, 32-bit, 160-pin slots can accept Zenith peripheral boards as well as AT-compatible boards. Those AT boards containing descenders—that is, portions of the board that drop down beyond the edge connector to gain more board space—won't fit, because the descenders hit the connector on the Z-386.

continued

Ed McNierney is a principal engineer at Lotus Development Corp. You can contact him at 54 Pleasant St., Groton, MA 01450, or on BIX as "mced."

Zenith Z-386 Model 80

Company
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 699-4800

Components
Processor: 16-MHz Intel 80386; socket for optional 80287 or 80387 math coprocessor
Memory: 1 megabyte of two-wait-state RAM, expandable to 16 megabytes; 64K bytes of cache memory optional
Mass storage: One 1.2-megabyte 5¼-inch floppy disk drive; one 80-megabyte hard disk drive; expandable to one more floppy disk drive and one more hard disk drive
Display: MDA, CGA, Hercules, EGA, Enhanced EGA, and VGA
Keyboard: Modified 101-key enhanced keyboard layout
I/O interfaces: One serial port; one parallel port; five free slots: one 8-bit slot, one 16-bit slot, and three 32-bit slots
Other: Real-time clock/calendar with battery, 195 watts; 110-/220-volt switchable power supply; one year carry-in warranty

Size
6½ by 21 by 16½ inches; 38 pounds

Software
MS-DOS version 3.2; Microsoft Windows/386; Video Drivers software support

Options
80287 math coprocessor: $525
80387 math coprocessor: $1199
Z-505 1-megabyte RAM expansion: $699
Z-515 4-megabyte RAM expansion: $2199
Z-525 64K-byte cache memory: $599
40-megabyte hard disk drive: $1699
80-megabyte hard disk drive: $1999

Documentation
130-page *High-Performance Workstation Owner's Manual*; 475-page *MS-DOS Version 3.2 User's Guide and User's Reference*; 20-page *Video Drivers Installation Guide*; 46-page *MS-DOS Version 3.2 Quick Reference Guide*

Price
Model 40: $6499
Model 80: $7499

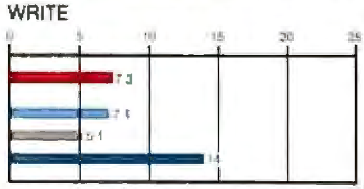
Inquiry 885.

Test	Z-386 Model 80 no cache, no FPU	Z-386 Model 80 cache, no FPU	PS/2 Model 80 80387-16	Compaq 386 80387-16	IBM PC AT 80287-8
Dhrystone*	3821	4136	3626	3748	1590
Fibonacci	53.17	49.43	57.26	53.11	126.22
Float	35.70	33.45	1.62	1.43	10.98
Savage	314.06	280.89	9.49	8.95	37.30
Sieve	5.84	5.38	6.45	5.98	24.60
Sort	8.02	6.92	7.74	5.58	43.17

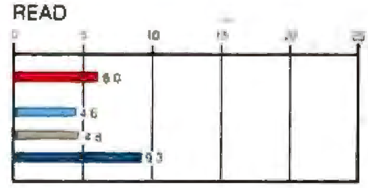
* For the Dhrystone test only, higher figures denote faster performance.

DISK ACCESS IN BASIC (IN SECONDS)

WRITE

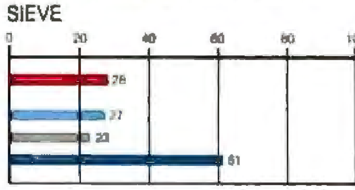


READ

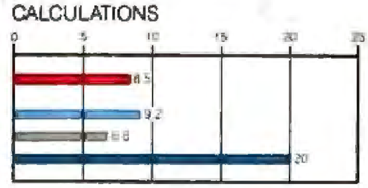


BASIC PERFORMANCE (IN SECONDS)

SIEVE

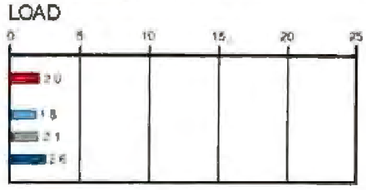


CALCULATIONS

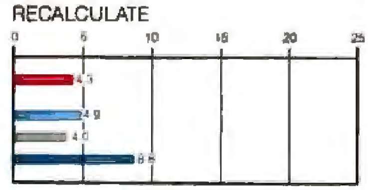


SPREADSHEET (IN SECONDS)

LOAD

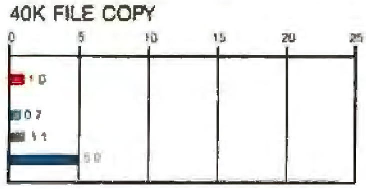


RECALCULATE



SYSTEM UTILITIES (IN SECONDS)

40K FILE COPY



ZENITH Z-386
IBM PS/2 MODEL 80
COMPAQ DESKPRO 386
IBM PC AT (8 MHZ)

The table contains the results of C language benchmarks (see "A Closer Look" by Richard Grehan in the September 1987 BYTE). All times are in seconds, except for the Dhrystone, which is in Dhrystones per second. The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The Spreadsheet tests load and recalculate a 100-row by 25-column Multiplan (1.06) spreadsheet. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. All BASIC benchmark programs were run with MS-DOS 3.20 and GWBASIC 3.20 on the Zenith Z-386 Model 80; PC-DOS 3.3 and BASICA 3.3 on the PS/2 Model 80 and PC AT; and Compaq DOS 3.1 and Compaq BASIC 3.11 on the Deskpro 386.

However, most AT boards will fit, and the added flexibility is convenient.

The Z-386 features standard EGA-compatible graphics that can send video output to a variety of different monitors. In addition to supporting MDA, CGA, Hercules, and EGA monitors, the Z-449 video adapter can drive a 31.5-kHz analog monochrome or color monitor, such as those supported by IBM's PS/2 computers. The Z-449 directly supports a special EGA-like 480-line display on VGA analog monitors, and Zenith provides a disk of video drivers to support the 480-line mode in Lotus 1-2-3, Lotus Symphony, AutoCAD, GEM, and Microsoft Windows. [Editor's note: *For further discussion of the Z-449, see "Enhanced EGA and VGA Boards" by Curtis Franklin Jr. on page 102 of this issue.*]

On the rear of the system unit are two sockets for monitors: one for a VGA or compatible monitor and one for the other supported monitors. The sockets are easy to differentiate, however: The VGA monitor socket has 15 pins in three rows, and the other has 9 pins in two rows. In other words, the plug on your monitor will fit only in the appropriate socket, so there's no chance of mixing them up.

When I connected the monitor to the system unit, it displayed only a solid white screen. Even though the review system came with an EGA monitor, Zenith configured the system at the factory to support an analog VGA monitor. I solved the display problem by setting off video DIP switch 6 (accessible from the outside of the unit)—but only after searching the documentation for the solution and finally finding it in Chapter 4 of the owner's manual. I think Zenith should include information addressing common setup problems in the "Getting Started" chapter at the front.

The on/off switch for the monitor is on the front; it is a push button labeled "1/0." The monitor also has a feature I haven't seen before: On the front is a three-position dial that lets you choose either the standard color output (black and white for text at the default settings) or monochrome output in amber or green.

Zenith's enhanced 101-key keyboard closely emulates the 101-key layout used on IBM's PS/2 and AT computers, and it has a soft touch with an audible clicking feedback system in the keyboard unit itself. Zenith has made one change to the IBM layout: Instead of placing the backslash (\) key to the left of the single-width Backspace key, as IBM does, Zenith has enlarged the Backspace key to double-width and placed the backslash key to the right of a truncated right Shift key. It's a small change, but I find it difficult to switch between layouts.

On the positive side, the Z-386's keyboard features a well-designed accelerated key-repeat feature. When you press a key and hold it down, it begins to repeat at a standard rate; but the longer you hold it down, the faster it repeats, making long cursor movements convenient and rapid.

You can use the keyboard with either AT- or XT-compatible computers; there is an AT/XT switch under the nameplate on the upper left. The keyboard comes set up for AT compatibility, and if you wish to use XT compatibility, you need to add appropriate firmware and change the switch setting.

The Software Scene

In addition to MS-DOS 3.2 and Microsoft Windows/386, the Z-386 comes with a ROM-based Monitor program that provides access to: a Setup/Configuration program that lets you configure your system from the keyboard; a Test program that has extensive disk-read, keyboard, base-memory, expansion-memory, and power-up diagnostic tests; a series of debugging tools, including `E`*`address`* (examine memory), `I`*`port`* (input from port), `R[`*`register`*`]` (examine register), `T[`*`count`*`]` (trace program), and `U[`*`range`*`]` (unassemble program), where brackets denote an optional parameter. To activate the Monitor program, you press Ctrl-Alt-Insert.

The Z-386 provides a flexible disk-boot mechanism. The Setup/Configuration program lets you tell the system where to look for its bootstrap record; you can choose to boot automatically from the floppy disk or the hard disk, or from the floppy disk when it is mounted and from the hard disk when it isn't. You can also choose to have the system come up displaying the Monitor program's prompt, at which time you can boot from whatever drive you wish with the boot command `B[`*`parameters`*`]`.

Although the Z-386 comes with Zenith's version of MS-DOS 3.2, the operating system is not preinstalled on the hard disk. When I first powered up the review system (after setting the DIP switch), the screen displayed the error message `Not a bootable partition`. The "Getting Started" section of the owner's manual explained that at this point you reset the computer with the Ctrl-Alt-Insert combination to go to the Monitor program. From there, you mount the first MS-DOS disk and enter `B F` (which stands for "boot from floppy"). The boot sequence on the floppy disk initiates the MS-DOS `SETUP` utility.

This reveals a couple of problems that Zenith could easily have avoided. First, `SETUP` is not the same as the Setup/Configuration program, but Zenith doesn't tell you that there are two different programs involved. This is confusing; you think you're going to enter the Setup/Configuration program, but you aren't. So, any attempt to jump ahead can easily put you in the wrong place. For instance, if at the monitor prompt you select the option for the Setup/Configuration program, you have actually bypassed the `SETUP` utility, and your hard disk has not been formatted. Thus, you can find yourself in quite a mess. A different name for one of the programs would have avoided this confusion.

Second, Zenith has set the system to automatically try to boot up on the hard disk. This doesn't make much sense when you consider that the hard disk doesn't contain an operating system; in fact, it isn't even formatted. It would make more sense to set the initial system default to boot from the floppy disk.

The `SETUP` utility formats your hard disk and transfers your system to it, if you wish, through a user-friendly conversational interaction. The hard disk comes unformatted with one partition. If you want more than one, you can use the MS-DOS `PART` utility to set them up. `SETUP` tells you when to exit and execute `PART`, and the two utilities give you instructions on all the procedures you need.

You can also use some other MS-DOS utilities if you need to modify the hard disk organization and protections. You can use `DSKSETUP` and `ASGNPART` to create more than one MS-DOS partition and assign disk drive letters to those partitions. Then you can format the partitions with the MS-DOS `FORMAT` command to make them usable and bootable.

The `DSKSETUP` utility adds a convenient feature to the hard disk layout: format protection. With `DSKSETUP`, you can protect each partition on the hard disk from accidental reformatting; only another `DSKSETUP` command can release the protection and allow the disk to be reformatted. `ASGNPART` lets you assign the connections between MS-DOS disk drive letters and the logical disk partitions created by `DSKSETUP`. Partitions can all receive flexible name assignments.

Zenith's version of MS-DOS includes a number of custom software utilities, including `APPLY` (to execute a command repeatedly while varying a specific parameter); `CONFIGUR` (to tell the system the correct protocol to use for a serial or parallel device and display the system configuration); `FC` (to compare two files and send any differences it finds to the screen or to another file); `RTCLOCK` (to read the real-time clock and set the MS-DOS clock to that date and time, and reset the real-time clock); `SEARCH` (to scan a disk

continued

and display all files that match the input specification); ZCOM (to use a modem or direct serial communications to transfer files between two computers); and ZSPOOL (to create a print buffer in either conventional or expanded memory).

In addition, the Expanded Memory Specification device driver, EMM.SYS, comes on the MS-DOS distribution disk. You can set up as much of your memory as you wish to be EMS memory, as long as your first memory card reserves at least 640K bytes as system memory.

The Z-386 is completely AT compatible, running all the tested software and hardware without any problems, including Microsoft Windows version 1.03, Lotus 1-2-3 version 2.01, SideKick version 1.56A, the Microsoft bus Mouse version 6.10, the Everex Evercom 1200-bit-per-second modem, and Lotus Manuscript version 1.0. As is common with 80386 systems, the Z-386, via the Setup/Configuration program, lets you select one of three operating speeds: Slow, which is a constant 8-MHz operation; Fast, a constant 16-MHz operation; or Smart, in which the CPU runs at 16 MHz for processing and slows to 8 MHz for disk I/O operations. The default mode, Smart, lets you install (and deinstall) copy-protected software, such as Lotus 1-2-3 version 2.01, on the hard disk without difficulty.

[Editor's note: *While we were working with the Z-386, the system hung on two separate and unrelated occasions. We could enter nothing, and we got no response; we couldn't even reboot. We had to turn the machine off and then on again to free it. We also couldn't re-create the situations. Thus, we have no idea whether this is a recurring problem or a fluke.*]

On the Bench

Zenith's literature claims a 40-millisecond average access time for the 80-megabyte hard disk drive, but Core International's Coretest utility measured a much more respectable 27-ms average seek time, with track-to-track seeks requiring only 4.3 ms. The drive also performed well on the disk-transfer-rate test, with a transfer rate of 205.5K bytes per second.

The EGA display system ran all tested graphics software, including Microsoft Windows versions 1.03 and 2.0 and PC Paintbrush Plus version 1.0, with no problems. Video memory required 30 wait states for each access, but this is not unusual for an EGA board running in a 16-MHz 80386 machine. As 32-bit machines become more common and users become more demanding of graphical interfaces, EGA-compatible hardware will need to be redesigned for higher speed, so that it fits more appropriately with the performance of the rest of the system.

BYTE's BASIC benchmarks show that the Z-386 without its optional cache memory is generally comparable to other 80386 machines; its performance is slightly slower in some tests and slightly faster in others.

The Z-386 becomes more impressive in the C benchmarks, which are more indicative of computing power and ability among the 80386 machines. Without its optional cache, the Z-386 exceeds the performance of the IBM PS/2 Model 80 by 5 percent on the Dhrystone test, and it beats that of the 16-MHz Compaq Deskpro 386 by 2 percent. With the cache memory, these figures jump to 14 percent over the PS/2 and 10 percent over the Compaq (and an 8 percent increase over the Z-386 without the cache).

On the Fibonacci test, the Z-386 shows a slight edge over the Model 80 and a speed equal to the Compaq's. Adding the cache boosts performance by about 8 percent. The review system didn't have a floating-point coprocessor, so the Float and Savage benchmarks indicate only that if you do many floating-point or transcendental calculations, you will want one.

On the Sieve test, the Z-386 shows a 10 percent improvement over the Model 80 and a small (2 percent) improvement over the Compaq. The Sort benchmark is the only one in which the Z-386 falls behind the others. It lags behind the Model 80 by 4 percent, and behind the Compaq Deskpro by a whopping 44 percent. The cache memory boosts the Z-386's Sort time by 16 percent, however.

Coupled with Zenith's reputation for service and reliability, the benchmarks overall indicate that the Z-386 is an excellent machine to use as an 80386 computing platform. They also indicate that the additional expense of the Z-525 64K-byte cache memory board is well worth the performance boost it provides.

An Outstanding Machine

The Zenith Z-386 is a powerful machine and a sound value for your computing dollar. Its compatibility with the PC AT is flawless, and its performance is among the best in its class. Its raw computing horsepower is made even more useful by Zenith's unusually helpful assortment of ROM and MS-DOS utility software.

The manual could be better organized and some of the setup choices more logical. However, these things bothered me partly because the Z-386 is such an outstanding machine: It's frustrating to have a terrific machine at your fingertips and then have a struggle setting it up. Take the instructions slowly and carefully, and don't try to jump ahead, and I think you'll avoid the troubles I had. ■

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Circle 191 on Reader Service Card

NEC PowerMate 2 and HP Vectra ES/12

John Unger

Two mature AT-compatible designs that offer higher speed and greater reliability

The NEC APC IV PowerMate 2 and the Hewlett-Packard Vectra ES/12 represent two of the best of a generation of microcomputers that are based on IBM PC AT compatibility and the 80286 CPU. Both NEC and HP apparently believe that computers based on the 80286 have not reached the end of their development. The companies offer the PowerMate 2 and the Vectra ES/12 as the best price/performance solution for many business and personal needs.

The Vectra and the PowerMate both have dual-speed 80286 processors: The PowerMate can be switched between 10 MHz and 8 MHz, and the Vectra runs at 12 MHz or 8 MHz. The machines are more than adequate for nearly all the needs of the average microcomputer user. Furthermore, they are compatible with the multitude of software and hardware developed for the IBM PC AT.

The NEC PowerMate (left) and HP Vectra (right).

The PowerMate I reviewed had 1 megabyte of 120-nanosecond and 150-ns RAM; the Vectra had 640K bytes of 120-ns and 100-ns RAM. They both came with EGAs and monitors and high-performance hard disk drives: The PowerMate had a 67-megabyte drive, and the Vectra had a 40-megabyte unit. The PowerMate also came with an optional 1 megabyte of extended RAM. In these enhanced configurations, the PowerMate costs $5595, and the Vectra $5535.

The basic version of each computer comes with one 1.2-megabyte 5¼-inch floppy disk drive, a floppy disk/hard disk drive controller card, and 640K bytes of RAM. In these versions, the PowerMate costs $2595 and the Vectra is $2995.

Internal Circuitry

Both computers use very-large-scale integration (VLSI) chips from Chips and Technologies (C&T). The Vectra uses five of these surface-mounted packages on its motherboard, and the PowerMate uses six. The optional EGAs that were part of my review systems each used two of these C&T packages. VLSI packages reduce the total chip count in the computers and allow a cleaner design. Like many other AT clones, both use Phoenix Technologies' ROM BIOS—firmware well known for its compatibility with the IBM operating-system ROM.

In addition to five 16-bit and two 8-bit expansion slots (the disk controller occupies one of the 16-bit slots, and the EGA card fills one of the 8-bit slots), the Vectra's motherboard holds a special expanded memory slot, which can only be used for an optional Vectra ES expanded memory card. This slot looks like an 8-bit slot, but the board connector has been moved forward on the motherboard. The slot can't be used for standard PC expansion boards. You can populate the expanded memory board with up to 8 megabytes. The slot runs at 12 MHz, rather than 8 MHz like the other slots on the expansion bus; this factor gives the Vectra faster memory I/O for those applications that use expanded memory.

The PowerMate has six 16-bit expansion slots and two 8-bit slots on its motherboard. The PowerMate's disk controller card occupies one of the 16-bit slots, and the EGA card fills one of the 8-bit slots. The optional NEC memory board that I installed in my review machine fits in one of the 16-bit slots. This board comes with 18 256K-bit by 8-bit 120-ns RAM chips soldered to it, for a total of 512K bytes of additional memory. Three more memory kits consisting of 18 256K-bit RAM chips may be added for a total of 2 megabytes of RAM for each board. You can add a total of five fully populated boards to each PowerMate.

The PowerMate features a zero-insertion-force (ZIF) socket for its 80286 pin-grid-array CPU. This makes removing or replacing the chip very easy.

Both systems let you switch speeds either from the keyboard or with simple software commands. I had no difficulty switching speeds on either computer, even in the middle of a program. The

continued

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PowerMate has a convenient LED indicator on the front panel that lights when the computer is running in the high-speed or 10-MHz mode. The Vectra gives one beep when you shift to 8 MHz, and two beeps when you go to 12 MHz. Each computer's motherboard has a socket for an optional 80287 numeric coprocessor.

Storage

The PowerMate's larger size provides room for five half-height storage devices. The Vectra has a more conventional layout, with space for three half-height storage devices.

The hard disk drive that came with my PowerMate was NEC's D5452, a high-performance 67-megabyte model with a data transfer rate of 247.4K bytes per second, an average seek time of 25.3 milliseconds, and a track-to-track time of 6.3 ms, according to the Coretest program. Vectra's 40-megabyte Seagate ST-251 hard disk drive is only slightly slower: It has a data transfer rate of 244.7K bytes per second, an average seek time of 26.7 ms, and a track-to-track time of 10.5 ms.

Because MS-DOS 3.2 does not support a logical disk drive larger than 32 megabytes, I partitioned the 67-megabyte drive into two 32-megabyte drives and one 3-megabyte drive. The utility setup and formatting programs that came with the Vectra and the PowerMate were easy to follow, and getting the hard disks set up properly was not difficult.

The Vectra comes with HPCACHE, a disk-caching utility program for the computer's hard disk. This versatile program lets you set aside either normal or EMS memory as a cache. Disk-cache routines such as HPCACHE can improve the overall performance of your system, particularly if you use software that frequently accesses the hard disk—such as a program that uses overlays or a compiler that stores and retrieves intermediate temporary files as it compiles source code. In use, the cache provided a 10 percent to 40 percent improvement in the benchmark results.

The Vectra and PowerMate disk controller cards come with cabling and connectors for a total of two floppy disk drives and two hard disk drives. This setup gives you a variety of possible combinations of hard and floppy disk drives for the systems. Both systems' software and hardware support the addition of 3½-inch floppy disk drives; the Vectra can handle either 720K-byte or 1.4-megabyte drives, while the PowerMate only has the option of adding a 720K-byte drive. The Vectra's disk controller card also contains the logic for the serial and parallel ports. On the PowerMate, the two DB-9 serial

NEC PowerMate 2, Model APC-H503C

Company
NEC Information Systems Inc.
1414 Massachusetts Ave.
Boxborough, MA 01719
(617) 264-8000

Components
Processor: 10-MHz Intel 80286; socket for optional 80287 math coprocessor
Memory: 1 megabyte, expandable with 2-megabyte expansion boards to 10.6 megabytes
Mass storage: One 1.2-megabyte 5¼-inch floppy disk drive; 67-megabyte hard disk drive
Display: MultiSync monitor and EGA card
Keyboard: 101 full-size keys with 12 function keys and separate editing keys and numeric keypad
I/O interfaces: Two 8-bit and six 16-bit expansion slots; two RS-232C ports (DB-9); one parallel printer port (DB-25)

Size
6⅓ by 21⅓ by 17 inches; 41 pounds

Software
MS-DOS 3.2; GWBASIC 3.2

Options
Color graphics adapter board: $225
Advanced Graphics Board plus PowerMate MultiSync monitor: $1350
Memory expansion board with 512K bytes of RAM: $395

Documentation
69-page *PowerMate 2 Owners Guide*; 407-page *GWBASIC User's Guide*; 468-page *MS-DOS User's Guide*

Price
Model APC-H503C (unit reviewed): $5595
Model APC-H500K (no hard disk drive or monitor): $2595
Model APC-H501D (40-megabyte hard disk drive and EGA monitor): $4345

Inquiry 884.

Hewlett-Packard Vectra ES/12, Model 42

Company
Hewlett-Packard Corp.
3000 Hanover St.
Palo Alto, CA 94304
(415) 857-1501

Components
Processor: 12-MHz Intel 80286, socket for optional 80287 math coprocessor
Memory: 640K bytes of RAM on motherboard standard; up to 8 megabytes on optional Vectra ES expanded memory card
Mass storage: One 1.2-megabyte 5¼-inch floppy disk drive; 40-megabyte hard disk drive
Display: EGA card standard; 13-inch enhanced color display
Keyboard: 101 full-size keys with 12 function keys and separate editing keys and keypad
I/O interfaces: Two 8-bit and five 16-bit expansion slots; one expanded memory slot; one RS-232C port (DB-9); one parallel printer port (DB-25)

Size
6½ by 16¾ by 15½ inches; 34 pounds

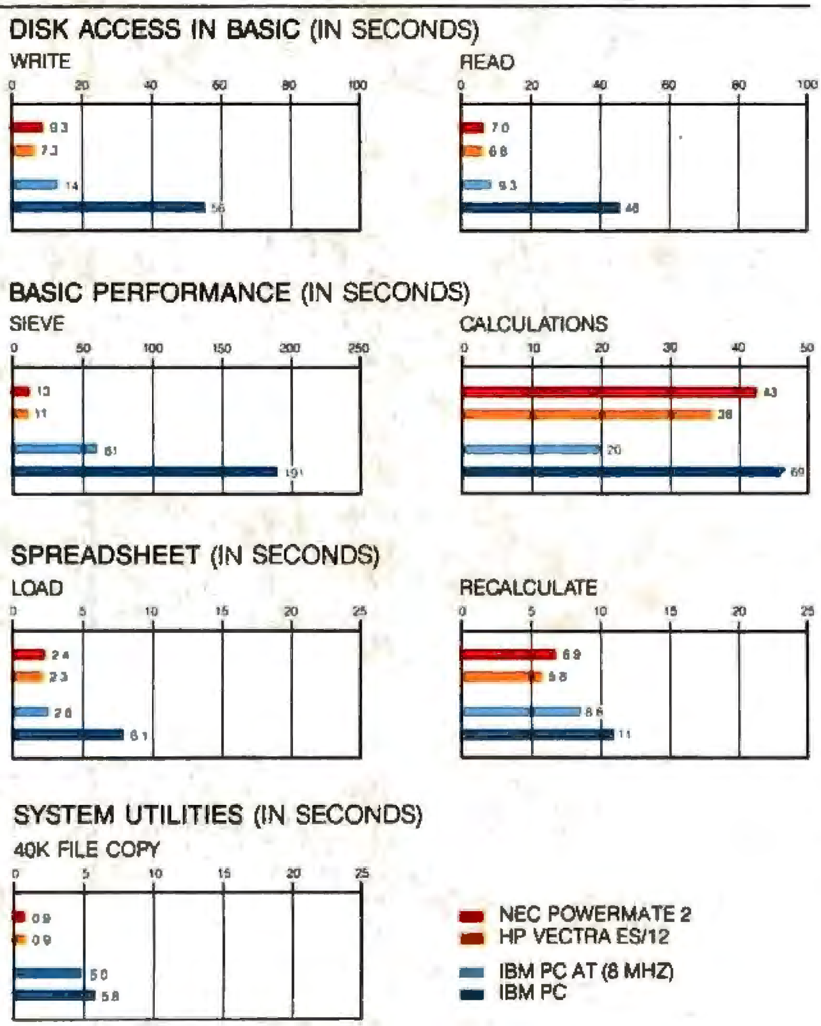
Software
MS-DOS 3.2; HP utilities and system diagnostics, including Personal Applications Manager, DOS shell, terminal-emulation program, disk-cache program

Options
3½-inch 1.44-megabyte floppy disk drive: $325
5¼-inch 360K-byte floppy disk drive: $225
80287-8 math coprocessor: $450
Monochrome monitor: $325
Enhanced graphics monitor: $845
Expanded memory card with 2 megabytes of RAM: $1695

Documentation
120-page *Vectra MS-DOS 3.2 Vol. 1, Introduction*; 585-page *Vectra MS-DOS 3.2 Vol. 2, User's Reference*; 245-page *Setting Up the Vectra ES*; 110-page *HP Terminal Program User Manual*; 146-page *Using Personal Application Manager*; 112-page *Using the Multiple Character Set Utilities*

Price
Model 42 (unit reviewed): $5535
Model 10 (640K bytes of RAM and one 1.2-megabyte 5¼-inch floppy disk drive): $2995
Model 20 (same as Model 10, plus a 20-megabyte hard disk drive): $3195
Model 40 (same as Model 10, plus a 40-megabyte hard disk drive): $4195

Inquiry 883.



The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The Spreadsheet tests load and recalculate a 100-row by 25-column Multiplan (1.06) spreadsheet. The BASIC benchmarks were run with MS-DOS 3.2 and GWBASIC 3.2 on the NEC PowerMate and HP Vectra; tests on the IBM PC and PC AT were run with PC-DOS 3.3 and BASICA 3.3.

ports and the DB-25 parallel port are part of the motherboard's circuits.

Externals

The most obvious difference between the two computers is their size. The PowerMate is about 4 inches wider than the Vectra and uses this extra space to provide two more half-height slots for storage devices.

Both computers have keyboards patterned after the IBM enhanced keyboard. The feel of both keyboards is good, even though they are rather different. I fell in love with the PowerMate's the first time I used it. It has a rather light touch, with a mechanical click built into the keys, and it is good for fast typing. The Vectra's keyboard is a bit stiffer, but it has a similar feel, with a definite break before the key actually enters its character. I just can't seem to type as fast on it as I can on the PowerMate's. The key click on the Vectra comes from software rather than from the keyboard, and you can easily change its amplitude or remove it altogether by using the Control, Alt, and Plus (+) keys.

The EGA boards and monitors on both computers performed flawlessly, and the colors and resolution of the displays were good. You might expect this from the PowerMate; the "Advanced Color Display" sold with this system is the popular NEC MultiSync, which has received well-deserved praise in many reviews. Mitsubishi manufactures HP's enhanced graphics display. It has a fine screen and great color, and it automatically selects scan frequencies between 15.75 and 21.85 kHz. I give the edge to the PowerMate 2's display; it is crisper, and the character set used by NEC is easier on the eyes. Because of its 35-kHz maximum scan frequency, the MultiSync monitor also has the advantage of upward compatibility with VGA cards' higher-resolution graphics modes.

Performance and Compatibility

There are no mysteries when comparing these two computers. As the benchmark results show, the Vectra's 12-MHz mode gives it a 3 percent to 27 percent performance edge over the PowerMate running at 10 MHz. The Vectra's performance edge increases when it is run with the disk-caching program in place.

Although it is not explicit from their specifications, both of these machines operate with one wait state and therefore give up a slight speed advantage. Both computers are probably in the top 10 percent of all AT clones in terms of calculating speed; the only 80286 machines that outperform them are those few that run at

continued

10 or 12 MHz with zero wait states. The high-performance disk drives add to the overall speed of the two systems.

I had no problems running my normal stock of software, which includes WordPerfect 4.1, Reflex 1.1, Condor 3, Multiplan 1.06, a variety of C compilers (Turbo C 1.0, Microsoft C 4.0, and DeSmet C 2.5), and the C-terp 3.00 interpreter, on either computer at its highest speed setting. Most of the games I ran—Jet, Starflight (which needs an EGA patch), Pinball Construction Set, and Flight Simulator—functioned reliably.

Warranty, Service, and Quality

HP has a well-deserved reputation for making reliable and well-designed computers. Its dedication to quality carries over into its Vectra series; my review system was a well-built, well-designed piece of hardware. HP offers a limited one-year warranty that covers carry-in service at an authorized dealer or the manufacturer.

The first microcomputer I reviewed for BYTE was the NEC APC III, a predecessor to the PowerMate reviewed here. The qualities that impressed me in the APC III—its design, construction, and graphics—are even more apparent in the APC IV PowerMate, and this time the system is 100 percent compatible with the IBM PC AT. NEC has a one-year warranty for its machines that is similar to HP's. Service should be easy to find due to NEC's extensive national network of dealers.

Up to Snuff, and Then Some

The 80286 AT-compatible market is now at a mature stage. This means that potential buyers of this class of microcomputer must look at small, perhaps even subjective, features when comparing different machines. The NEC and HP systems have an advantage over most of the no-name AT clones now flooding the marketplace because they are backed by companies with large, well-known sales and service groups. The Vectra ES/12 and the APC IV PowerMate 2 are both going to be supported for years to come. The amount and quality of documentation is also quite good—an important point for less-experienced users to keep in mind.

If you want a high-performance AT-compatible computer with excellent expansion capability, either of these machines will do the job for you. Obvious differences are the Vectra's lead in computing performance and the PowerMate's larger expansion chassis. My choice would be the PowerMate, because of the feel of its keyboard and the extra serial port, and because it is available at highly discounted prices from many dealers and so is simply a better value at retail street prices. ■

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Performance Chart
(execution times in seconds)

	Power C	MS C	Turbo C
1) fib*	23.8	47.0	26.4
2) sieve*	27.8	40.2	25.5
3) tdbl*	3.5	9.0	9.6
4) diskio*	13.5	14.2	14.3
5) report**	11.0	86.3	60.7
6) drystone**	36.6	38.2	31.8
Compile/Link	73.9	187.6	81.4
EXE File Size	25120	29008	27184

Benchmarks from Dr. Dobb's Journal* & Computer Language**. First four programs test 1) function calling, 2) loops/integer math 3) floating point math, & 4) disk I/O. Programs 5 & 6 simulate typical applications. Tests compiled from command line using Make supplied with each compiler. Tests run on 8 MHz AT with medium model of Power C 1.0, MS (Microsoft) C 4.0, & Turbo C 1.0.

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Total Cost with Source	$29.95	N/A	$249.95

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CLEO

The Tandy 1400 LT

David Satz

This portable strikes a sensible balance between basic performance and economy

At $1599, the Tandy 1400 LT is less expensive than most other portables and laptops. It enters the field of IBM PC-compatible laptop computers in the middle in terms of processor power and portability, and near the bottom in terms of price. The speed of its 8088-compatible NEC V20 is software-switchable between 7.16 MHz and 4.77 MHz, placing its top speed between those of the 4.77-MHz IBM PC and the 8-MHz IBM PC AT. At 13½ pounds, it is lighter than some portables (the Compaq Portable 386, for example, weighs in at 20 pounds) and heavier than others (the Toshiba T1000 weighs only 6½ pounds).

The Tandy 1400 LT has 768K bytes of RAM, two 720K-byte 3½-inch floppy disk drives, and a backlit supertwist LCD screen. As configured by Tandy, the 128K bytes of memory beyond the 640K-byte DOS limit is set up as a RAM disk. Unfortunately, however, its contents are not maintained when you shut the power off. The Tandy's user-replaceable and rechargeable internal nickel-cadmium battery pack gives 4 to 5 hours of service per 13-hour charge cycle. An AC adapter also comes with the machine. An optional internal 300-/1200-bit-per-second (bps) Hayes-compatible modem card is available for $199.95.

To the Rear

The rear access panel contains all external power and data connectors, including one serial port and one parallel port, RGB-intensity (RGBI) and composite video outputs, a keyboard input, and a socket for an external floppy disk drive. Also, the rear panel has a slot for an internal modem and an unlabeled access panel. The motherboard has a socket for an optional 8087-2 numeric coprocessor.

The system ROM contains the Phoenix BIOS, and the system software includes MS-DOS 3.2 and Tandy's version of GWBASIC 3.2. The system also contains a setup mode from which you can alter system parameters at any time. For example, the F7 option lets you change the system clock speed from the default 7.16 MHz to 4.77 MHz, if you should need to for program compatibility.

The rear panel is protected by both a plastic door flap and two sets of protruding ridges that let you stand the computer safely on end. You can connect an IBM PC-compatible external keyboard, as well as an external RGBI monitor; a tiny slide switch on the back panel allows you to specify either the LCD screen or an external monitor as the default display. In addition, you can also connect an external 5¼-inch floppy disk drive; there is another tiny slide switch on the right side of the case that lets you select the internal or external disk drive as the default boot device.

Stand By

Standby mode in the Tandy 1400 LT is the timed, automatic shutdown of the screen electronics, including the battery-eating fluorescent backlighting. It is triggered when the computer has been waiting for keyboard input for a specified length of time—10 minutes as configured by Tandy, but you can set this interval to any number of hours and minutes up to 3:59 with the setup mode.

The computer most often waits for keyboard input at the DOS prompt. However, keyboard-driven applications programs such as word processors can also be left suspended while waiting for the next command; their execution then resumes along with screen illumination as soon as you press any key to continue operation.

The value of this feature is in preserving battery-charge life and sometimes (especially in cases of user oversight) important program data. The normal battery charge lasts only about 4 hours in active mode, while the standby mode, which uses less than half as much current, can preserve the contents of memory and the status of a running program for up to 11 hours on a fully charged battery, provided that you don't turn off the power switch in the meantime. A green LED in front of the B drive lights up when you are in standby mode.

continued

David Satz (118 State St., Apt. C, Brooklyn Heights, NY 11201) is a classical musician and recording engineer. You can reach him on BIX as "dsatz."

Tandy 1400 LT

Company
Tandy Corp./Radio Shack
1800 One Tandy Center
Fort Worth, Texas 76102
(817) 390-3011

Components
Processor: 4.77- /7.16-MHz NEC V20; socket for Intel 8087-2 math coprocessor
Memory: 768K bytes of RAM; 16K bytes of ROM (Phoenix BIOS)
Mass storage: Two 720K-byte 3½-inch floppy disk drives, optional 5¼-inch external floppy disk drive can be used
Display: Backlit supertwist LCD, 25 lines by 80 columns, 640- by 200-pixel color graphics (partially simulated by shading); 4⅛- by 9⅜-inch screen; optional external RGBI monitor can be used
Keyboard: 76 keys, including 12 function keys; special editing-key cluster, embedded numeric keypad in ASCII keyboard; optional external keyboard can be used
I/O interfaces: RS-232C serial port; Centronics-compatible parallel port; external floppy disk drive port; RGBI video output (IBM PC-compatible); composite video output; external keyboard port; telephone line and instrument
Other: Built-in clock/calendar; internal nickel-cadmium battery pack, A/C adapter; carrying handle

Size
14½ by 12⅜ by 3½ inches;
13½ pounds

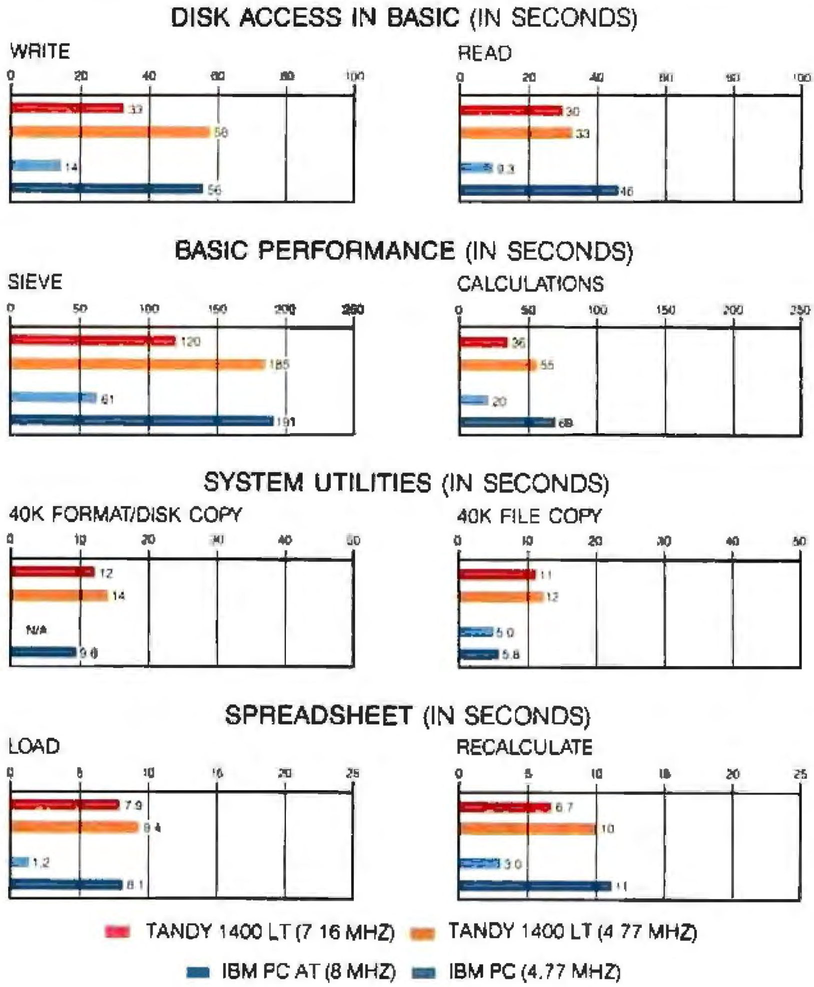
Software
MS-DOS 3.2; GWBASIC 3.2

Options
300-/1200-bps Hayes-compatible CMOS internal modem: $199.95
Additional nickel-cadmium battery pack: $79.95
Carrying case: $39.95
Intel 8087-2 math coprocessor, $250
MS-DOS/GWBASIC Reference Guides, $29.95

Documentation
77-page *A Practical Guide to the Tandy 1400 LT*

Price
$1599

Inquiry 895.



The Disk Access benchmarks write and then read a 64K-byte sequential text file to a blank, formatted floppy disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The 40K Format/Disk Copy formats and copies a 40K-byte file with the system utilities. This test was not performed on the PC AT because the computer had only one floppy disk drive. The 40K File Copy benchmark copies a 40K-byte file from one floppy disk to the other. The Spreadsheet tests load and recalculate a 25-row by 25-column Multiplan (1.06) spreadsheet. All benchmark programs on the Tandy 1400 LT were run with MS-DOS 3.20 and Tandy's version of GWBASIC 3.20; tests on the IBM PC and PC AT were run with PC-DOS 3.2 and GWBASIC 2.02.

Screen and Keyboard

The lid containing the 4⅛- by 9⅜-inch LCD screen hinges from the center of the main chassis and is adjustable to any viewing angle from upright to nearly flat. Be careful, however, not to let it fall shut on your fingers or on disks that you haven't fully inserted into the drives.

The 80-column by 25-line screen is only half as tall as it is wide, and there is no margin at all between the descenders of one line of characters and the ascenders of the next. But the font is a well-chosen mixture of double- and single-dot thicknesses, and it has sufficient contrast to be easily legible under all normal ambient lighting conditions—or even in total darkness. A contrast control on the right side of the case sets the shading for the royal-blue characters and the silver-gray background, a combination I found extremely readable and easy on the eyes.

The plastic-film surface coating over the screen tends to reflect some glare, but you can usually adjust the screen tilt to avoid any problems. The fluorescent backlighting also "sings" noticeably at about 660 Hz when energized, but this sound is disturbing only in quiet surroundings. The fluorescent panels have an estimated life of 3 years; Tandy computer-service personnel can replace them.

The Tandy 1400 LT simulates the CGA 640- by 200-pixel graphics mode. By varying the refresh cycle of the LCD pixels, you can obtain four degrees of shading: the basic silver-gray background, royal blue for fully darkened pixels, a dull brownish foreground shade, and a lighter background shade.

The slow darkening characteristic of supertwist LCD pixels is observable here just as it is on the NEC MultiSpeed (see my review "The NEC MultiSpeed" in the September 1987 BYTE). But due to the Tandy's slower processor, the smearing effect that you get when you scroll text (e.g., disk directory listings) is less pronounced. You can also see a slight downward ripple effect, particularly when the background setting is on the dark side. This ripple is not a product of interference from other lighting; it is visible in total darkness as well.

Keyboard preferences are even more intensely subject to personal tastes and acquired habits than screens are. The Tandy 1400 LT's keyboard arrangement features 12 function keys in three groups across the top, the Escape key to the left of the numbers row, and minor punctuation character keys to the left and right of the space bar. The cursor-control cluster is at the extreme bottom right, and you must combine cursor keys with a left-hand Function key to produce commands such as PageUp, PageDown, Home, and End. This arrangement conserves space on the keyboard, but not in the mind. It results in four different shift-type keys: Shift, Control, Alt, and Function. It also makes you use three fingers, as well as extra eye motions, to generate several of the most common word processor commands, such as PageUp (Ctrl-Fn-PgUp) or End (Ctrl-Fn-End). Even CapsLock, the purpose of which is to free your hands, ironically requires both hands to set or reset (Ctrl-Fn-CapsLock).

The keyboard action provides some resistance and requires a firm touch—a slight punching action. Getting used to the touch required to depress the keys is easier than getting accustomed to the keys popping up when you release them. They make a hollow popping sound both when you depress them and when you let them go. The keyboard is not conducive to quiet typing or to an extremely light typing touch. On the other hand, you're not likely to enter extraneous characters by mistake; these keys require a definite keystroke to produce a character.

You can use an alternative keyboard, if you wish, by plugging it into the keyboard socket provided on the rear panel.

Modem, Size, and Battery

I installed the optional 300-/1200-bps Hayes-compatible modem card with very little difficulty. To use it, you must select the F4 option in the setup mode and switch from the default `RS232C` to `MODEM`. The modem functioned flawlessly on both local and coast-to-coast connections. It lets you use acoustic cups at both 300- and 1200-bps speeds, making it useful in hotels and pay phones where direct access to modular phone sockets may not be available. The modem's implementation of the AT command set includes all the normal S register controls and the extended verbal/numeric result codes.

Overall, the computer is neither as small as the Toshiba T1100 Plus (or any of the Toshiba laptops, for that matter) nor as large as the NEC MultiSpeed. The Tandy 1400 LT is light enough to carry across a large airport terminal, but it is heavy enough to cause eventual discomfort, rather like an early-model portable electric typewriter. The weight is mostly at the rear of the computer. This is understandable: The keyboard is in the front, and the boards and disk drives are in the rear. However, taking the Tandy 1400 LT at its name, I tried it as a laptop, balanced on my knees. Its rear weight and slightly longer footprint (14½ inches versus 12 inches for the Toshiba T1100 Plus and 13½ inches for the NEC MultiSpeed) gave it a tendency to slip off my lap.

The nickel-cadmium battery pack comes in its own externally accessible compartment, so you can easily replace it with an optional extra battery pack. This will be good news for travelers and those of us who never quite seem to get the long-life performance that modern, properly cared-for nickel-cadmium batteries are supposed to offer. The battery power supply takes over automatically if it contains an adequate operating charge and the AC power supply is removed or interrupted. However, you can't change the battery safely while the computer is active or in standby mode. The manual instructs you to turn off the power and disconnect all peripherals and accessories first.

Checking Out the Software

A single 3½-inch floppy disk contains a complete implementation of MS-DOS 3.2, including the hard disk drive-oriented utilities such as `BACKUP`, `RESTORE`, `JOIN`, and `SUBST` (although no hard disk drive is available). GWBASIC 3.2 comes on the disk as well.

Up-to-date versions of `MOUSE.COM` and `MOUSE.SYS` are included to support a Microsoft serial Mouse if you wish to add one. The DOS disk also has the programmer-oriented utilities `LINK`, `LIB`, and `EXE2BIN`, and a bunch of lesser-known DOS utilities. These would have sent me running to the DOS manual to see what they're good for if the Tandy 1400 LT had come with one. But it didn't; the manual is an optional extra.

The Tandy 1400 LT showed no software- or hardware-compatibility problems with Flight Simulator 2.13, Turbo Pascal 3.01a, SideKick 1.56a, MEX.PC 1.65a, Microsoft Word 3.1, or QuickBASIC 2.01. However, I did have trouble with version 4.0 of Microsoft Word. Earlier versions of Word worked perfectly well; however, due to the increased default key-repetition rate in version 4.0, you get a runaway-keyboard condition that you can stop only by rebooting. To prevent this problem, you must use the `DOS DEBUG` utility to patch a single location in the `MW.INI` file in the `WORD` directory. (Microsoft's customer service is aware of this problem and can advise you of the precise patch.) The Microsoft serial Mouse (original style) worked perfectly well with the supplied version of `MOUSE.COM`.

The softcover manual, *A Practical Guide to the Tandy 1400 LT*, devotes 28 pages to DOS concepts and functions, but the explanations are so concise that I wonder whether many nontechnical readers could really profit from them. Another strange aside: The manual contains *two* indexes—one at the end of the hardware section (48 pages into the manual), and another at the end of the DOS section, which is at the end of the book. So, if you're looking for something to do with the hardware, you won't find it in the index at the end of the book, where you'd normally look.

Testing the Tandy

I tested the 720K-byte floppy disk drives with the Coretest, which showed an average access time of about 225 milliseconds; this is typical of the drives on current-model laptops. The operating noise level of the disk drives is higher than average, although, like the noise of the screen, it should be disturbing only in quiet environments, such as libraries or classrooms.

I also ran BYTE's BASIC benchmarks with Tandy's version of GWBASIC 3.2 and MS-DOS 3.20. Disk Read and Write, Sieve, Calculations, and Spreadsheet Load and Recalculate all give the Tandy

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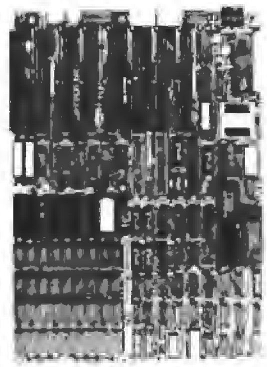

1400 LT at 4.77 MHz the edge over the 4.77-MHz IBM PC. The formatting and copying tests, however, are a different story. On the 40K Format/Disk Copy, the IBM PC is more than 40 percent faster than the Tandy 1400 LT (9.6 seconds for the PC and 13.5 for the 1400 LT); and on the 40K File Copy, the IBM leaves the Tandy in the dust, with more than a 98 percent advantage (5.8 seconds for the IBM versus 11.5 for the Tandy).

When you compare the Tandy 1400 LT at 7.16 MHz with the 4.77-MHz IBM PC, the results change, as you would expect. The Tandy shows a significant advantage on the Disk Write and Read, the Sieve, and the Calculations tests. Then the advantage dissolves. The 4.77-MHz IBM PC outperforms the 7.16-MHz Tandy 1400 LT on the 40K Format/Disk Copy by more than 20 percent (9.6 seconds for the IBM and 11.6 for the Tandy). And the IBM continues to blow the Tandy away on the 40K File Copy by 88 percent (5.8 seconds versus the Tandy's 10.9). On the Spreadsheet Load, the 1400 LT at 7.16 MHz performs at almost exactly the same speed as the 4.77-MHz IBM PC, although the megahertz advantage does show up in the Recalculate figures (the Tandy outperforms the IBM by 64 percent: 6.7 seconds versus 11 seconds). Needless to say, the 8-MHz IBM PC AT steals the speed awards by a healthy margin.

Little New Ground

Tandy, with its massive distribution network of Radio Shack stores, has the power to make waves with any serious computer product it introduces. The Tandy 1400 LT is a solidly designed laptop that breaks little new ground, but—if you accept its keyboard feel and layout and slow disk drives—it avoids any serious design flaws. Its hardware capability will be particularly noteworthy if a reasonably priced expansion chassis and a hard disk drive become available in the future.

The Tandy 1400 LT's processor power and backlit LCD screen make it a low-cost alternative to the successful Zenith Z-181 ($2399). The Z-181 screen is taller but is hinged from the back of the case, making it harder to use on most airplane or train seat backs. If you need compactness, processor power, and battery life, you may prefer the somewhat higher-priced Toshiba T1100 Plus ($1999)—or the NEC MultiSpeed ($2195), a backlit LCD machine that is more powerful than either the Tandy 1400 LT or the Toshiba T1100 Plus. However, at $1599, the Tandy 1400 LT achieves a sensible and moderate balance between good basic performance and economy. ■

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TURBO C COMPILER	100	65
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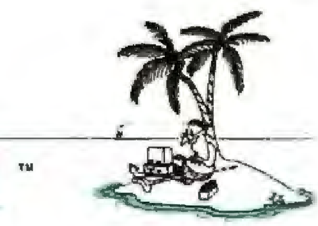

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Screening Macintosh II Color Monitors

Joel West and Neil Rhodes

A look at the PCPC II, the SuperMac Color Trinitron, and the Machroma C2D monitors

The Macintosh II (unlike its predecessor, the Mac Plus) was designed without a built-in video display device. This means that you can select display hardware (monitors or video cards) that are suitable for the specific demands of your work—color or gray scale, or larger monitors with more pixels.

Apple's Mac II video board gives you a 640- by 480-pixel display with 16 colors or gray scales for $499, and up to 256 colors or grays if you add extra video memory to the board (for an additional $149). For displays, Apple offers a choice of a 12-inch gray-scale monitor for $399 or a 13-inch color monitor (which was in short supply last year) for $999.

Since the Mac II's introduction, third-party vendors have brought out alternative monitors for it, including larger monitors displaying more pixels to meet the needs of those doing extensive CAD/CAM or graphics work. We evaluated some of the first available Mac II displays: two large-screen monitors from Personal Computer Peripherals Corp. (PCPC) and SuperMac Technology, and a standard-size monitor from 4Site Technologies.

The Mac II architecture supports display formats of arbitrary resolution; the video card's configuration ROM supplies the screen dimensions and pixel depth to the operating system when the computer starts up. Both SuperMac and PCPC take advantage of this flexibility by supplying video boards that provide more pixels than the standard Apple display.

The PCPC II [Trinitron] uses a 19-inch color Trinitron monitor and a video board that displays 1027 by 768 pixels. This combination costs $5295. SuperMac Technology offers a 19-inch color Trinitron monitor and the Spectrum 1000/8 video board, which provides a 1024- by 768-pixel display. This monitor and video board combination costs $5190. Both companies offer alternative lower-cost 19-inch displays (discussed later). 4Site Technologies' Machroma C2D is a 14-inch color monitor that can display 926 by 580 pixels and costs $895. It does not use its own video board; you can use Apple's Mac II video board or another third-party video board. (For a look at IBM-compatible multiscan-type monitors that can be used on Mac IIs, such as the Sony Multiscan and NEC MultiSync, see "Multiscan Color Monitors" by George A. Stewart in the February BYTE).

We noted qualitative impressions of the monitor/video card combinations during normal use, including testing with various Macintosh software packages. We used our own Colorizer software package, several MacApp demonstration programs from Apple's Advanced Technology Group, and Spinnaker, a Palette Manager test program by Art Cabral of Apple. In addition, quantitative results were obtained at the laboratories of Microvision, which used its SuperSpot 100 CRT analysis system on the three monitors. For reference purposes, we compared these systems with Apple's AppleColor color monitor and the Mac II video board.

The Monitors

The PCPC and SuperMac monitors are based on the 19-inch Trinitron manufactured by Sony, the GDM 1950 monitor (termed the GDM 1952 when equipped with a tilt/swivel base). The PCPC is available only with the tilt/swivel base. The two monitors appeared to function identically during normal use, although testing showed a few subtle differences.

These monitors are very bulky and heavy; in fact, under Federal Occupational Safety and Health Administration employee guidelines, they require two people to move them. Due to their weight, you can't place them directly on top of a Mac II, as you can with smaller monitors. Thus, you need either more desk space or a stand that's sturdy enough to support 84 pounds of monitor (the tilt/swivel base increases this load to 90 pounds). SuperMac offers a tilt/swivel stand to support its monitor; it costs $250.

According to the manufacturer, the Trinitron can display 1280 by 1024 pixels, but the nominal resolution with both of the supplied video boards is 1024 by 768 pixels. This provides approximately 250 percent of the screen pixels of the standard 640- by 480-pixel Apple Mac II monitor, and 450 percent of the Macintosh Plus and SE's 512- by 342-pixel displays. The pixel density is approximately that of the standard displays, so the net effect is a lot more screen area to work with when positioning application windows. This is particularly useful when working with MultiFinder, where the windows of all running programs must share the screen. A larger screen area lets you place application windows where you can bring them to the foreground at a mouse click instead of needing to pull down the desk accessory menu.

The 4Site Machroma C2D monitor is based on the Magnavox Professional 8CM873 monitor. It has a 14-inch screen with a 13-inch viewing area. Combined with Apple's video card, it offers a display of 640 by 480 pixels. It is slightly taller than the Apple monitor and is 5 pounds lighter.

The Machroma is the only one of the

Joel West is president and Neil Rhodes is manager of software development for Palomar Software Inc. (P.O. Box 2635, Vista, CA 92083). They are coauthors of the firm's Colorizer software package for the Macintosh II.

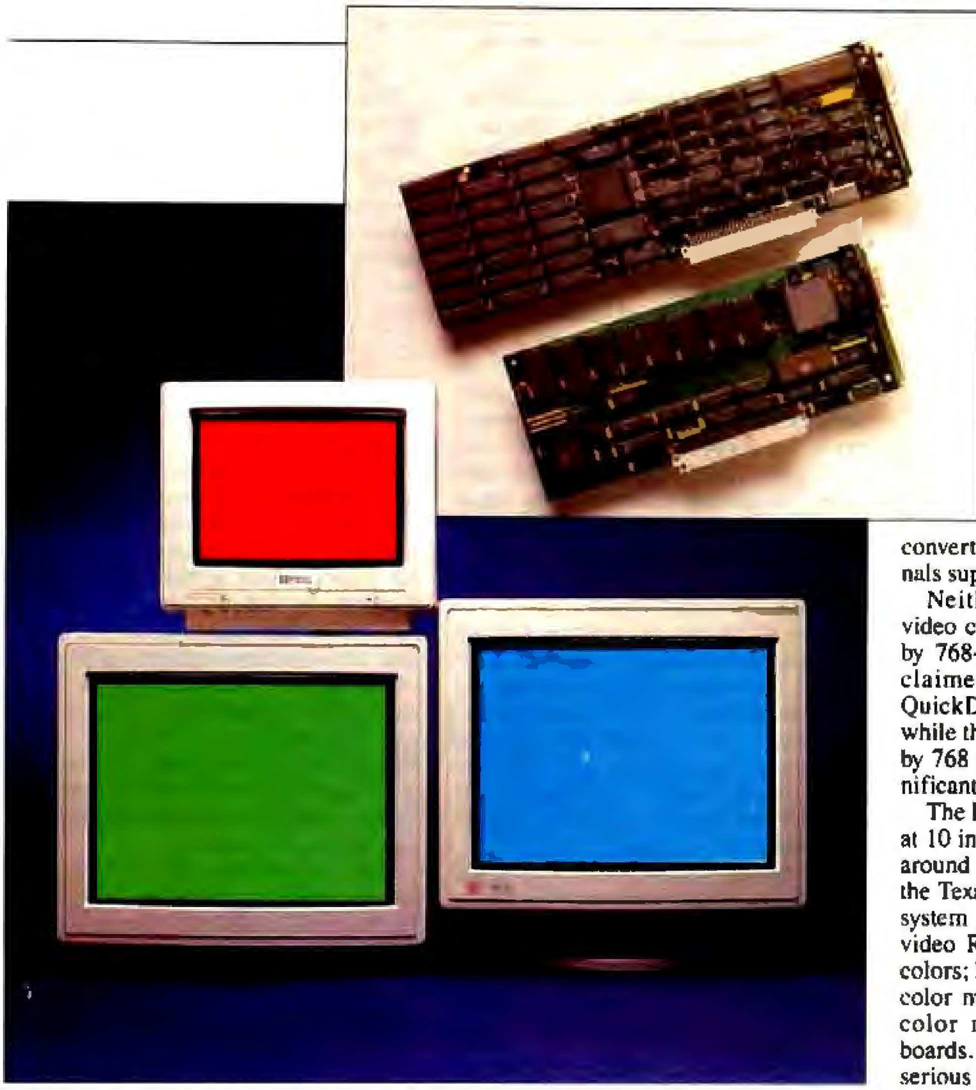


Photo 1: *The three monitors reviewed. Top: 4Site's Machroma C2D. Bottom left: The SuperMac Color Trinitron. Bottom right: The PCPC II [Trinitron].* **Inset:** *The video boards for the large monitors. Top: The SuperMac Spectrum 1000/8. Bottom: The PCPC CGC/1.*

four monitors to include a 3-inch speaker and an audio input jack. It also has a Text switch that turns off the red and blue inputs, producing a black-on-green display with the Mac II.

The AppleColor High-Resolution RGB Monitor, which we used for reference, uses a 13-inch Trinitron tube with Apple electronics.

All the monitors except the AppleColor have a nonreflective coating, which is an advantage in normal and bright office lighting. Both of the large screens are switch-selectable for 220/240 volts AC, although different fuses are required for the different voltages. The AppleColor monitor automatically adjusts to higher voltages, while the Machroma was supplied in the 120-V version only.

PCPC and SuperMac each offer another 19-inch model, made by Mitsubishi and Ikegami, respectively. The PCPC II [Mitsubishi] costs $4995; the SuperMac Standard Color Monitor costs $2995. SuperMac also sells a 16-inch Trinitron that displays the same number of pixels at a higher density and costs $2495, and a 19-inch gray-scale monitor that costs $1695.

Video Cards

To use one of these monitors, you must install a NuBus-compatible video card in the Mac II chassis. Opening up the Macintosh and installing the card may seem foreign to owners of earlier Macs, but it's a simple task, accomplished in less than 5 minutes. No DIP switches are present on any of the boards: Following the NuBus standard, it's up to the board's configuration ROM to provide the computer with the necessary information and driver code.

The output device for all the video cards is a RAMDAC by Brooktree Corp. This IC passes a digital value retrieved from video RAM to three built-in D/A converters that drive the RGB analog signals supplied to the monitor.

Neither PCPC's nor SuperMac's video cards supported exactly the 1024- by 768-pixel display their manufaturers claimed. The PCPC board provided QuickDraw with 1024 by 767 pixels, while the SuperMac board supplied 1016 by 768 pixels. Neither variation was significant in actual use.

The PCPC video board is the smallest, at 10 inches long. The board is designed around the 75-MHz Brooktree 458 and the Texas Instruments TMS 34061 video system controller. It has 768K bytes of video RAM, allowing it to display 256 colors; however, it supports only the 256-color mode and not the 2-, 4-, and 16-color modes available on the other boards. The lack of a 2-color mode is a serious limitation, since a number of programs (e.g., MacPaint 1.5, SuperPaint 1.0, and TMON) expect a 1-bit deep (2-color) display; otherwise, they garble the screen image. With other video boards, the easiest fix for this problem is to set the display to the 2-color mode. Since the PCPC board doesn't have a 2-color mode, you're stuck until a new generation of programs arrives that can properly handle a 256-color display. PCPC is aware of the situation and says it will have a video board that supports a 2- and 256-color mode by the time you read this.

The SuperMac is the longest of the three boards at 13 inches. It uses the same TMS 34061 and a 66-MHz Brooktree 453. It also uses 768K bytes of video RAM to provide 256 colors. The tested board included version D11 of the SuperMac ROMs—the third revision offered, correcting problems with the 4- and 16-color display modes. This version was made available to all customers late last year, according to the company.

The SuperMac board demonstrated a minor (but annoying) display defect. When we changed the standard QuickDraw color table, the top display line noticeably flashes to black before showing

continued

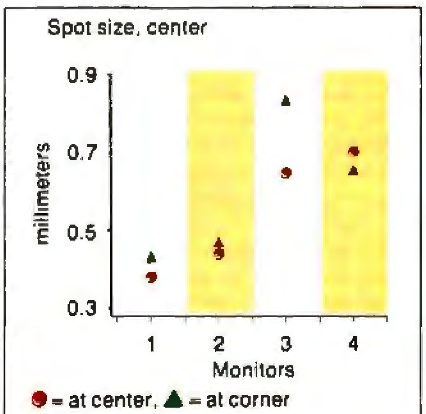
Company Information

Personal Computer Peripherals Corp.
6204 Benjamin Rd.
Tampa, FL 33634
(813) 884-3092

SuperMac Technology
295 North Bernardo Ave.
Mountain View, CA 94043
(415) 964-8444

4Site Technologies Inc.
Machroma Division
200 Seventh Ave.
Suite 120
Santa Cruz, CA 95062
(800) 634-7483

Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010



the proper color. However, before this article went to press, SuperMac sent us a new version (1.0B1) of the configuration ROM that corrects this problem.

For comparison, the 12-inch Apple Macintosh Video Card uses a 40-MHz modified version of the Brooktree 453. The board is built around a custom frame-buffer chip instead of the Texas Instruments controller. It supports 2-, 4-, and 16-color modes standard, while the optional expansion kit (or its third-party equivalent) is needed for a 256-color mode. As shipped, the board comes with eight video RAMs and sockets for eight more. The additional RAM (sold by Apple as the Mac II Video Card Expansion Kit) is required for a 256-color display.

Monitor Tests and Results

A series of 10 tests was performed at the offices of Microvision in Campbell, California. The tests were run using the firm's SuperSpot 100 CRT analysis system. The standard SuperSpot test patterns are available only for MS-DOS machines, so we wrote a comparable program for the Mac II using Color QuickDraw calls and MacApp.

The tested hardware included the AppleColor High-Resolution RGB Monitor; video cards from PCPC and SuperMac and their monitors; and two Mac II Video Cards, with the optional video expansion kits, to drive Apple's monitor and the Machroma monitor.

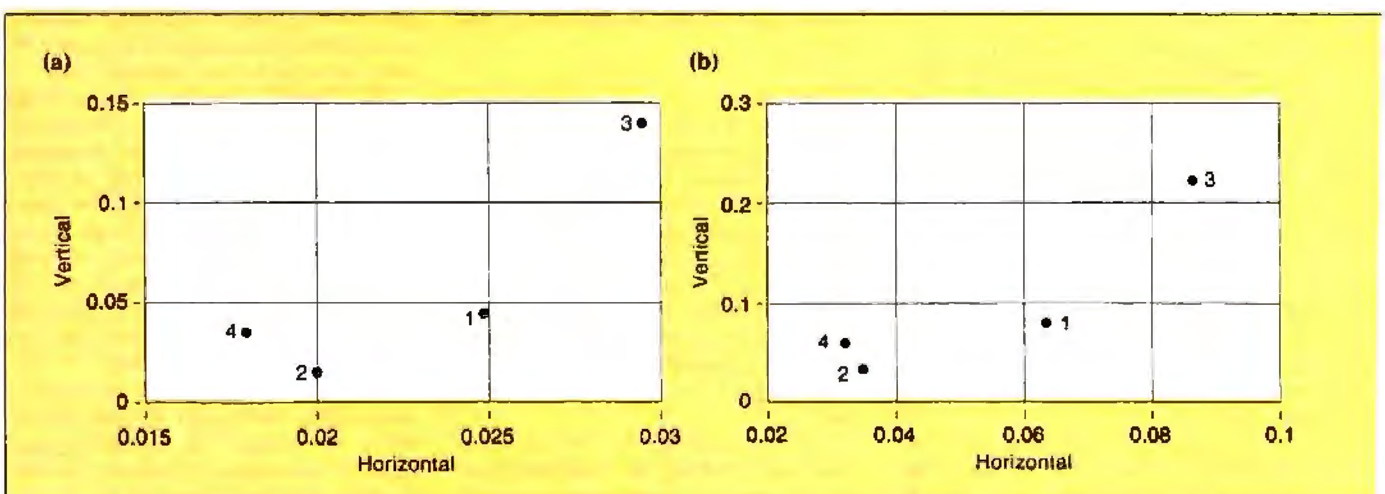
The monitors were allowed to warm to operating temperature (about 30 minutes), and the brightness level was adjusted for best definition. The entire screen was flooded with green, since the sensor was most sensitive to this color, and the intensity was measured. The light levels in foot-lamberts for each monitor were as follows: PCPC, 19; SuperMac, 16.7; Machroma, 17; and AppleColor, 15. The tests measured the spot size; time variance effects such as jitter, swim, and drift; misconvergence; and voltage regulation.

Spot size is the minimum size that can be illuminated by the electron beam. The tests provide separate readings for horizontal and vertical dimensions. Measurements were made in the center and the corner of the screens. The square root of the sum of the squares of the horizontal and vertical measurements provides a single number that corresponds to the length of a diagonal line across a spot. Spot size shows the fineness of the display beyond the nominal dot-pitch specification. The spot sizes are shown in figure 1; they have been normalized for a screen size of 13 inches.

The two 19-inch Trinitron monitors did not perform identically. The spot size for the PCPC monitor was measurably smaller than that of the SuperMac monitor—in fact, it was the smallest for the monitors tested. This result was repeated when testing the PCPC monitor with the

◀ **Figure 1:** *Measured spot sizes for the monitors in millimeters.*

Figure 2a: *Jitter measurement.*
Figure 2b: *Swim measurement.*
Figure 2c: *Drift measurement.*
All measurements in millimeters. ▼



SuperMac card. Other measurements, such as line variation, were better for the SuperMac; this suggests sample-to-sample variations in factory adjustments. The Machroma monitor had the largest spot size and the largest variation between the center and the corner of the screen.

Time variance measures undesirable fluctuations in the beam position. *Jitter* is high-frequency movement (measurements were made over half-second intervals), *swim* is medium-frequency movement (measurements were made over 10-second intervals), and *drift* is low-frequency movement (measurements were made over 60-second intervals). Jitter can cause eyestrain; large amounts of drift can make precision graphics or CAD work difficult.

Microvision measured horizontal and vertical variance separately. Maximum variance and average variance for jitter, swim, and drift were recorded. Measurements were made only in the center of the screen. Again, linear measurements have been adjusted for a 13-inch screen. Figures 2a, 2b, and 2c present the results for average variance of the three measurements. The SuperMac and Apple monitors had the lowest time variance, and the Machroma monitor had the highest.

Misconvergence measures errors in the electron beam/phosphor dot alignment; these errors cause color fringing. Misconvergence was measured at the center of the screen (usually best case) and the upper left corner (usually worst case). The amount of error in the red-green, blue-green, and red-blue convergence in horizontal and vertical directions was measured separately. Linear measurements were adjusted for screen size. (See figures 3a and 3b.) There were no clear winners here, but the SuperMac had the best horizontal convergence, and the Machroma had the best vertical convergence.

You can gauge the quality of a monitor's voltage regulation by how much a line's position is displaced when the screen is black versus when the rest of the screen is filled with white. Ideally, the line shouldn't move. We compared a horizontal line's position on the screen when the rest of the screen was black, and then when the screen was white; a vertical line was similarly compared. Again, the results were normalized for screen size. Figure 4 shows the voltage regulation test results presented as horizontal and vertical displacements. The AppleColor monitor showed exceptionally good voltage regulation. The Machroma monitor was the only one of the four to show poor high-voltage regulation; the test pattern moved noticeably as the number of displayed pixels changed.

The Price of a Large Screen

None of the three rival monitors was quite as good subjectively as the AppleColor

continued

Key to Charts

1	PCPC II	3	Machroma
2	SuperMac	4	AppleColor

All measurements are normalized for a 13-inch screen.

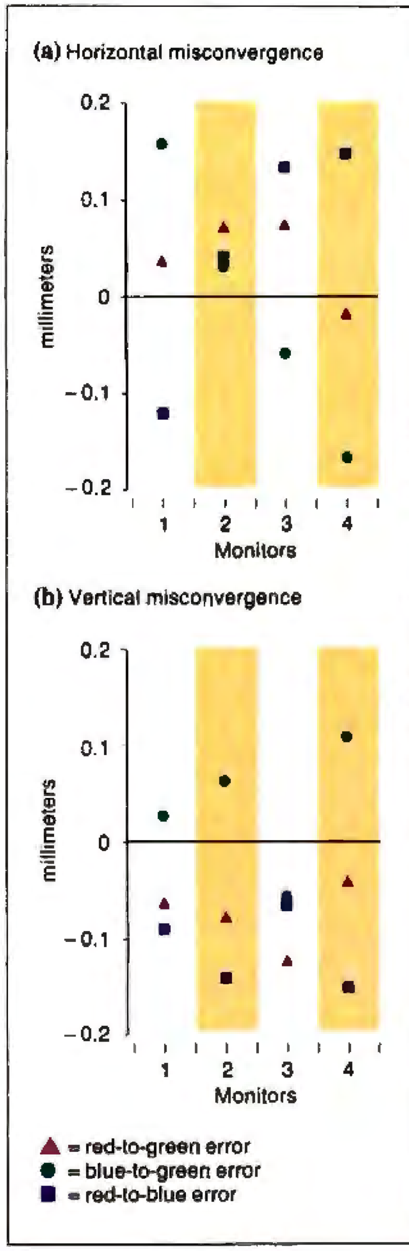


Figure 3a: *Horizontal misconvergence at center, in millimeters.*
Figure 3b: *Vertical misconvergence at center, in millimeters.*

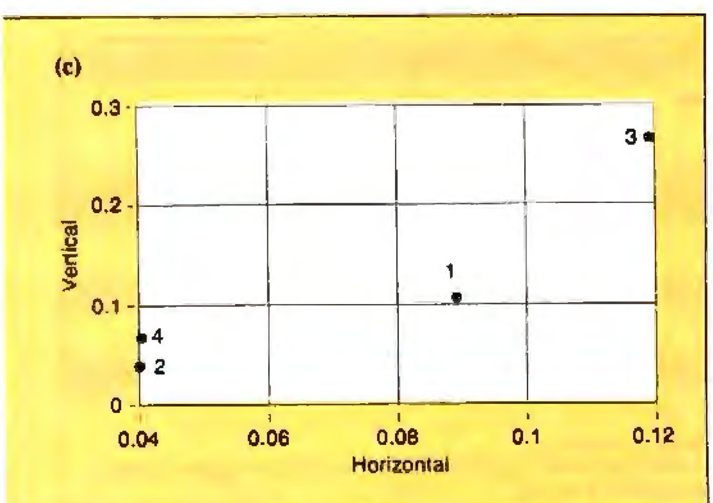
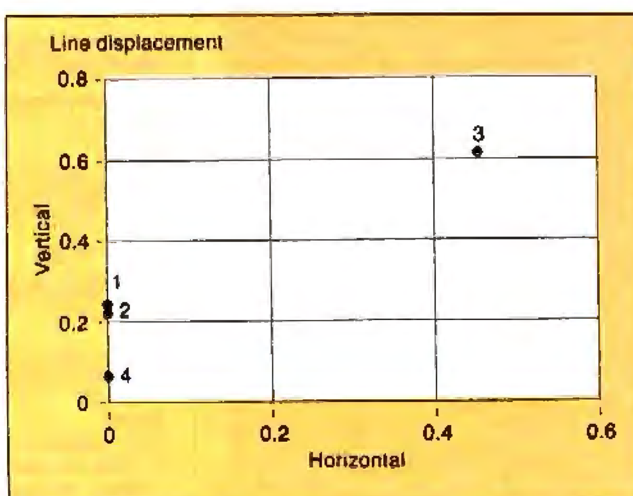


Figure 4: *Line displacement in millimeters.*



Monitor	PCPC II [Trinitron]	SuperMac Color Trinitron	4Site Machroma C2D	AppleColor High-Resolution RGB Monitor
Screen size	19 inch	19 inch	14 inch	13 inch
Resolution[1]	1024 by 768	1024 by 768	926 by 580	640 by 480
Display area[1] **(in mm)**	360 by 270	360 by 270	250 by 180	235 by 176
Aspect ratio	1.33	1.33	1.39	1.33
Dot pitch	0.31 mm	0.31 mm	0.31 mm	0.25 mm
Scanning frequencies[1]	49 kHz by 60 Hz	63 kHz by 60 Hz	35 kHz by 60 Hz	35 kHz by 66.7 Hz
Bandwidth	100 MHz	100 MHz	25 MHz	23 MHz
Power consumption	220 W	300 W	132 W	160 W
Power input	100/120 V 220/240 V	100/120 V 220/240 V	120 V	85/270 V
Antiglare	Yes	Yes	Yes	No
Signal connector type				
Video	3 BNC male	3 BNC male	DB-9 female	DA-15 female
Audio	N/A	N/A	RCA jack	N/A
Dimensions	19 by 21 by 19	18 by 21 by 19	13 by 14 by 15	12 by 14 by 15
Weight	90 pounds	84 pounds	29 pounds	34 pounds
Tilt and swivel	Standard	$250	$35	$89
Warranty	1 year	90 days	1 year	90 days
Price	$5295[2]	$5190[3]	$895	$999
	Inquiry 888.	**Inquiry 889.**	**Inquiry 890.**	**Inquiry 891.**

Notes:
1. Horizontal by vertical.
2. Includes price of video board (video board and monitor sold as a set).
3. Price of monitor and video board (monitor alone is $3695).

Board	PCPC CGC/1	SuperMac Spectrum 1000/8	Apple Macintosh II Video Card
Resolution[1]	1016 by 768	1024 by 767	640 by 480
Scanning frequencies			
Horizontal	49 kHz	48.2 kHz	35 kHz
Vertical	60 Hz	59.3 Hz	66.7 Hz
Connector	DB-9 male	DA-15 female	DA-15 female
Board length	10 inches	13 inches	12 inches
Warranty	1 year	1 year	90 days
Price	$1595	$1495	$648[2]
	Inquiry 892.	**Inquiry 893.**	**Inquiry 894.**

Notes:
1. As measured; horizontal by vertical.
2. Price includes 256K-byte video RAM upgrade for 256 colors (without upgrade, price is $499, and card displays only 16 colors).

monitor. The tests indicate that although the AppleColor's convergence and spot size is not as good as that of the larger monitors, the low time-variance measurements and the superior voltage regulation probably contribute to the favorable impression.

From the standpoint of display quality, the two 19-inch monitors were very good. The colors were as good as the AppleColor's, although the displays did not appear to be quite as sharp. The much larger display area is a decided advantage for many applications. Remember, however, that since there are more pixels to update, the two 1024- by 768-pixel monitors are considerably slower than the 640- by 480-pixel screens. Of course, whether the bulk, weight, and price of these monitors is likely to rule them out must be up to you.

The Machroma C2D was disappointing in comparison to the other three monitors. The display did not appear to be as sharp as the others, and the contrast was low. This observation was confirmed objectively by the test results. In addition, the white had a marked greenish tint. The saturation of pure colors was poor, particularly for red. We found little reason to recommend the Machroma monitor. If you're looking for a medium-size monitor other than the Apple, then you should consider one of the better multiscan monitors reviewed in the February BYTE, such as the Sony CPD 1302 or the Taxan 770 Plus.

Among video cards, the Apple board again set the standard: It worked flawlessly, and it supported the 2-, 4-, 16-, and 256-color modes without any problems. The PCPC video board showed no real problems, but the lack of a 2-color mode made it incompatible with the TMON debugger and SuperPaint. Also, all software works considerably faster when updating 87 percent fewer video bits in a 2-color mode (1 bit instead of 8). We run our Mac II monitors in the 2-color mode for development work a significant portion of the time, and a board like the PCPC that does not support this would be unacceptable for our own purchase. The 4-color mode is rarely of use, but the 16-color mode frequently proves to be an acceptable compromise between speed and color fidelity.

The SuperMac video board performed capably, but only after the problems with the configuration ROM were corrected. If you decide to buy the SuperMac board, we recommend that you check to see that it has the latest version of the configuration ROM. ■

ACKNOWLEDGMENTS

David Buckstad of Microvision performed the quantitative tests on the four monitors at his company's facilities. David Gelphman of Adobe Systems lent his Mac II and Apple monitor for use during those tests. ■

Pushing the Mac SE

Laurence H. Loeb

The MacMemory Turbo SE board (left), and the Radius Accelerator board (right).

Macintosh SE accelerator boards plug into the SE's single expansion slot to let SE owners upgrade their computers to near-Macintosh II power without buying a new and more expensive machine. The two accelerator boards examined here, the Radius Accelerator ($995) and MacMemory's Turbo SE ($599), claim to more than double the Mac SE's processing power.

The idea of a plug-in board that bypasses the Mac SE's processor is not a new one. In a previous review (November 1987 BYTE), I looked at two of the first accelerator boards for the SE: the Prodigy SE from Levco and the HyperCharger 020 from General Computer Corp. (GCC). These two boards boost the Mac SE's computing power by supplying a 16-MHz 68020 processor and 1 megabyte of 32-bit memory that replaces the computer's original 8-MHz 68000 processor and 1 megabyte of 16-bit memory.

The Radius Accelerator and Turbo SE, however, use different approaches to enhance the Mac SE's performance. While the Radius accelerator has an on-board 16-MHz 68020, it uses 32K bytes of zero-wait-state 32-bit-wide cache memory. The MacMemory board uses a 16-MHz 68000, clocked at twice the speed of the SE's processor, but it still uses the Mac SE's 16-bit memory for program storage. Like the Prodigy SE and HyperCharger, both of these boards have a socket for an optional 68881 floating-point unit (FPU).

The Radius Accelerator
The first board I examined was the Radius Accelerator. I looked forward to evaluating this product because it offered a reasonably priced board with a 68020 processor and the 68881 FPU socket (the review unit contained the 68881).

The installation documentation that came with the board was abysmal: It consisted of a single sheet of paper with text printed on each side. The documentation cautions that only a Radius authorized dealer should install the board. There's good reason for this: Its design results in an installation procedure that, with some bad luck, could damage your Mac SE motherboard.

The SE motherboard is hinged on one side. To remove it, you shift the motherboard along its axis, then swivel it out of its locked position (much like pulling up on a door before swinging it open). The Radius daughterboard contains a connector that coincides with a hole in an internal metal strut when the board is installed on the Mac SE motherboard. The connector implements Radius's "MagicBus," an expansion bus for additional hardware add-ins. Currently, it connects only to Radius's Full Page Display.

The MagicBus connector prevents you from reinstalling the motherboard in the same way that you took it out (i.e., you can't swing the door shut, then let it drop down). Radius's installation notes say that "you will not be able to slide the Macintosh board back into the chassis and will have to pop it back into place by putting first one edge into the side rail and then prying with a flat blade screwdriver to pop the other edge into the side rail." In almost a year of product reviews, this is as close as I have come to cracking the Mac SE's motherboard in half. Until this installation procedure is changed, I recommend that your Radius

continued

Radius Accelerator	**Turbo SE**
Type Macintosh SE accelerator board	**Type** Macintosh SE accelerator board
Company Radius Inc. 404 East Plumena Dr. San Jose, CA 95134 (408) 434-1010	**Company** MacMemory 2480 North First St. San Jose, CA 95131 (800) 862-2636 (408) 922-0140
Features 16-MHz 68020 processor; socket for 68881 math coprocessor; 32K bytes of zero-wait-state cache memory; connector for Radius Full Page Display	**Features** 16-MHz 68000 processor; socket for 68881 math coprocessor; uses memory already in Mac SE; adds 128K bytes of memory for use by video and sound circuitry; connector for The Big Picture video display from E-Machines; Turbo881 INIT file for 68881 support
Size 8½ by 4¼ inches	**Size** 8½ by 5 inches
Hardware Required Macintosh SE	**Hardware Required** Macintosh SE
Software Required System 3.2/Finder 5.3 or higher	**Software Required** System 3.2/Finder 5.3 or higher
Documentation Two-page *Installation Guide*; 12-page *User's Manual*	**Documentation** 57-page *Turbo SE Installation and Owner's Manual*
Options 16-MHz 68881 math coprocessor: $395	**Options** 16-MHz 68881 math coprocessor: $399 4 megabytes of 120-ns RAM: $1798 (price varies)
Price $995	**Price** $599
Inquiry 886.	**Inquiry 887.**

dealer install the board, even if you are technically competent. Once installed, the accelerator board doesn't require any further adjustments via the Control Panel or a desk accessory.

A 12-page user's manual provides tips on using the board. It shows you simple things such as how to tell when the accelerator is active (it displays a start-up screen) and how to turn the accelerator off (hold down the mouse button after you power up the computer—you can turn it off from a preferences panel that appears). If you use MacWrite 4.5, you don't have to add a special compatibility file, as some accelerator boards require, because the Radius board patches the offending TRAP vectors automatically. This feature is of limited value if you're using MacWrite 4.6, which works correctly with all Macintoshes.

A yellow insert in the package advises you to back up your hard disk before installing the Accelerator because some formatting software "has exhibited incompatibility problems with the Accelerator, destroying data on start-up." Radius also provides a list of tested hard disk drives. Backing up the hard disk drive is a good idea before doing any major hardware change.

The Radius board requires that you power down the Mac SE to switch between the 68020 mode and the 68000 compatibility mode. Some users may find fault with the need to power down the Mac to change modes, but I never found this procedure necessary because I encountered no software incompatibilities.

The latest versions of all the software I normally use worked with the Radius's 68020 mode. Several programs that use the 68881 floating-point processor also worked just fine, including beta versions of Borland's Eureka for the Mac and Super-3D by Silicon Beach Software. Red Ryder 10.3 worked well with the board, too, although version 9.4 of the program had caused problems with the Prodigy SE and HyperCharger boards. This indicates that software vendors have tried to make their code 68020- and 68881-compatible since the Mac II's introduction.

Fast Cache Memory

The problems with installation should not blind you to the immediate benefits of using the Radius Accelerator: Programs run noticeably faster, and the screen refreshes itself faster. One example is returning to Finder from an application. With a hard disk, Finder can take a few seconds to redraw all the icons on a crowded desktop. Maybe it's my Type A personality, but waiting for this redraw annoys me. With the Radius board installed, this redraw time is decreased to acceptable levels.

A significant factor in the Radius's performance is its one unique feature: cache memory. Unlike the Prodigy SE or HyperCharger boards, the Accelerator doesn't have a megabyte of 32-bit memory to store the executing program. It has 32K bytes of zero-wait-state 32-bit cache memory, of which 22K bytes is used to store the memory-mapped screen (one of the reasons the board appears to work fast is the quick screen-refresh time), 8K bytes is for program data, and 2K bytes is for "housekeeping" information. When a cache miss occurs, the program code (which is in 16-bit memory) is simultaneously executed and copied into the cache, avoiding a separate copy operation that would slow the processor down.

As a result, the computer stores the most recently used parts of the program (whether executing code or Macintosh ROM calls) in cache memory. This minimizes the Mac SE's number of slower 16-bit memory accesses and allows the 68020 to do fetches from cache memory at the maximum data transfer rate. Radius's 32K bytes of cache memory is faster than the HyperCharger's and Prodigy's 1 megabyte of memory because these boards' memories always run at one wait state, while Radius's always runs at zero wait states.

The Turbo SE

MacMemory takes a completely different approach in its Turbo SE board. It uses a 16-MHz 68000 processor clocked at 15.8 MHz (from the C16M signal present in the SE) to speed things up. The company says it took this approach (which none of the other boards uses) to offer compatibility with all existing Mac software. (However, as I stated earlier, I didn't find software incompatibility with the 68020 to be a problem.)

continued

Table 1: *As these benchmarks show, the Radius board outperforms the Turbo SE and boosts the Mac SE's performance to close to that of the Mac II. All times are in seconds, except the Dhrystone, which is in Dhrystones per second.*

	Prodigy SE	Hyper-Charger 020	Standard Mac II	Radius Accelerator	MacMemory Turbo SE	Standard Mac SE
Dhrystone*	3125	3125	2631	2941	1470	887
Fibonacci	51.81	52.08	58.9	59.78	126.7	203.1
Float	17.98	27.54	14.4	32.57	24.32	123.0
Savage	52.08	52.69	226.2	457.2	43.79	1927
Sieve	10.58	10.63	11.9	9.87	26.88	46.22
Sort	18.56	18.60	19.6	18.35	41.67	74.10
Open spreadsheet	N/A	N/A	8.59	11.24	14.36	21.9
Recalculate spreadsheet	N/A	N/A	1.99	1.99	2.67	4.90
Scroll	N/A	N/A	111	100	149	273
Price, with 68881 FPU (for boards only)	$1499	$1699	N/A	$1390	$2796 with 4 meg of 120-ns RAM	N/A

*For the Dhrystone test only, higher numbers denote faster performance.

Notes:

1. The Radius tested had 1 megabyte of memory and 32K bytes of fast hardware cache memory. The Turbo SE had 4 megabytes of 120-ns memory. The HyperCharger used the SE memory as a 1-megabyte RAM disk and had an additional 1 megabyte of 32-bit memory. The Prodigy had 1 megabyte of SE memory and 1 megabyte of 32-bit memory. The Mac SE and Mac II had 1 megabyte of memory each.
2. For details on the C language benchmarks, see "A Closer Look" by Richard Grehan in the September 1987 BYTE.
3. The Spreadsheet tests open and recalculate a 25- by 100-cell Excel 1.04 spreadsheet. Scroll shows how long it takes to scroll through a 40K-byte MacWrite 4.6 text file from beginning to end.

The Turbo SE also installs differently from the others. One of the ways that MacMemory achieves its low price is to use the 16-bit memory of the Mac SE—which makes sense because its 68000 processor can't use 32-bit-wide memory. But you must take the SIMMs (single in-line memory modules) from the motherboard and put them into the accelerator card. This is not beyond what a technically competent user can do, especially with the 21-page well-illustrated installation section in the Turbo SE manual (which is the best such manual I have seen so far).

MacMemory also recommends that you take the two Mac ROMs and place them in sockets on the Turbo SE daughterboard. They work faster that way, but jumper blocks on the board let you leave the ROMs on the motherboard if you don't want to move them.

MacMemory supplies two 64K-byte SIMMs that you plug into the now-vacant SIMM3 and SIMM4 motherboard memory sockets. The Mac then uses this memory for the video display, leaving the remaining memory for other uses. According to the company, these changes "increase screen drawing speed by almost 50 percent above the speed gained by doubling the Mac SE's clock speed."

Once you have installed the ROMs and SIMMs, the board inserts into the SE expansion connector without problems. The two plastic retainers that connect the accelerator and motherboard are the best way of providing mechanical support that I have seen in all the boards I have reviewed. They are much easier to install and remove than the plastic post and the metal-screw-with-nonremovable-lock-washer system that Radius uses.

The last step of the installation process is to set the on-board jumpers to the correct positions for the RAM/ROM configuration installed. The board can accept up to 4 megabytes of 120-nanosecond (ns) memory, although the Mac SE's memory (which will go on the Turbo SE board unless you buy new SIMMs) is 1 megabyte of 150-ns memory.

The Turbo SE's manual is clearly designed to assist the technically competent user in installing the board. But, like Radius, MacMemory insists that only certified technicians should do the installation, to keep from voiding AppleCare coverage and any Apple warranties.

The Turbo SE's options include E-Machine's Big Picture video display (which connects to a socket on the board) and the 68881 floating-point coprocessor, which was installed on the board I reviewed. MacMemory provides a software INIT file to patch the calls from the Apple SANE (Standard Apple Numerics Environment) to use the 68881. This allows Excel, for instance, to recognize that the 68881 is present even though a 68020 isn't. To install INIT, drop it into the System Folder of your start-up disk (whether a hard or floppy disk), then restart your Mac using this disk.

Ranking Performance

Once installed, how do these boards stack up? To get an objective measurement, I ran BYTE's set of C benchmarks with both boards, using Lightspeed C 2.01. I also checked the boards' performance on a couple of applications-oriented tests with Excel 1.04 and MacWrite 4.6. For the Excel and MacWrite tests, the System Folder had no unnecessary INIT and cdev files, and there was no caching from the Control Panel. To measure its maximum performance, I tested the Turbo SE with 4 megabytes of 120-ns (one-wait-

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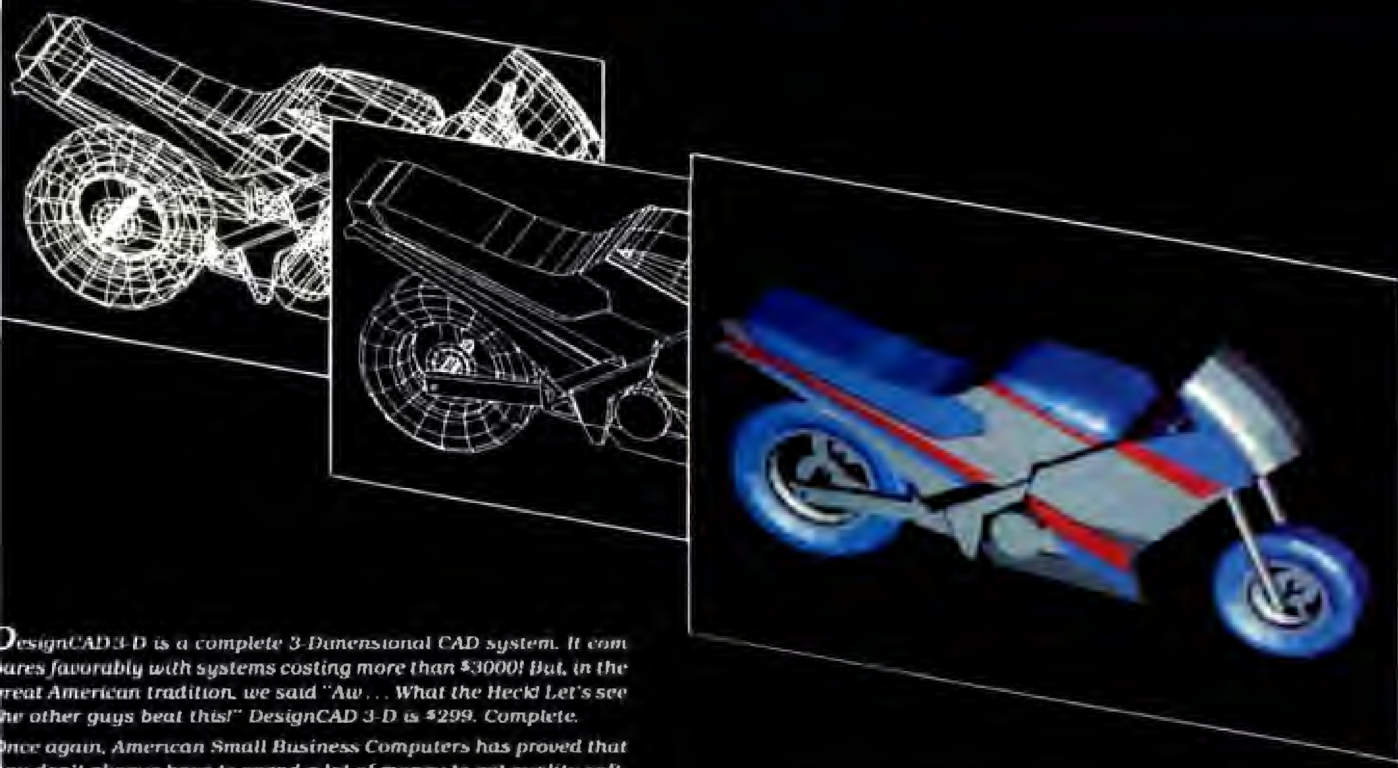

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state) memory. All four accelerator boards had a 68881 installed.

In all the tests except the Float and the Savage, the Radius board outperformed the Turbo SE, turning in times from 50 percent to almost 300 percent faster (see table 1). The Turbo SE outranked the Radius board in both the Float and the Savage; the Turbo SE's performance on the Savage benchmark was more than 10 times better than the Radius's.

True to the company claims, both accelerator boards significantly outperformed the Mac SE. In all but the Float and Savage benchmarks, the Radius board matched or topped the Mac II. The Turbo SE beat the Mac II in the Savage only, falling short on the other tests.

Neither the Radius Accelerator nor the Turbo SE matched the Dhrystone performances of the Prodigy SE and the HyperCharger 020. However, the Radius Accelerator approached their performances in several of the tests. The Turbo SE came close to or beat their performances in the Float and Savage benchmarks only.

The times for the Savage benchmark deserve some interpretation and qualification. The Radius board does poorly (457.2 seconds) because it uses the SANE routines to calculate the transcendental functions that the Savage benchmark emphasizes. The HyperCharger's time of 52.69 seconds is achieved with the use of GCC's numerics package, which is less accurate than Apple's SANE, but much faster. (The SANE package, based on an IEEE floating-point arithmetic standard, is much more precise than most applications require—the GCC numerics package has an error of 6×10^{-14} compared to the SANE's result.) Note that when the HyperCharger uses the SANE package, it achieves a time of 458.91 seconds—virtually identical to the Radius's result.

A spokesperson at Radius said that the company is now testing its own faster math package, which may be available by the time you read this. Like the HyperCharger, the Levco Prodigy uses a numerics package that's less accurate but faster than SANE; it offers no option for using SANE, however.

Most Bang for the Buck?

Although the Radius Accelerator has a risky installation procedure, I prefer this board to the Turbo SE. Its increase in performance is worth the extra $400 (or less, depending on street prices) over the base price of the Turbo SE.

If you're really on a tight budget, the Turbo SE with 1 megabyte of 150-ns memory offers an improvement over an unenhanced Mac SE. However, if you buy 4 megabytes of 120-ns SIMMs from MacMemory for maximum performance, the price of the Turbo SE jumps to about $2796—about $1400 more than the cost of the Radius board. Keep in mind, though, that MacMemory's SIMMs are pricey; you can buy less expensive ones from other vendors.

Overall, though, the performances of the Levco Prodigy SE and the GCC HyperCharger 020 make them still better choices—even over a Mac II—if you can afford them. ■

ACKNOWLEDGMENT

I would like to thank Rich Siegel, customer support representative of Think Technologies, whose help with 68881-related matters contributed to the background of this review.

Laurence H. Loeb is an electrical-engineer-turned-dental-surgeon and is co-moderator of the macintosh conference on BIX. He can be reached at PBC Enterprises, P.O. Box 925, Wallingford, CT 06492, or on BIX as "lloeb."

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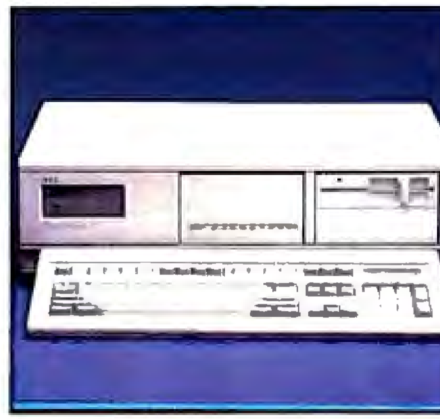

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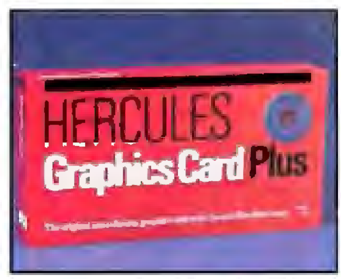

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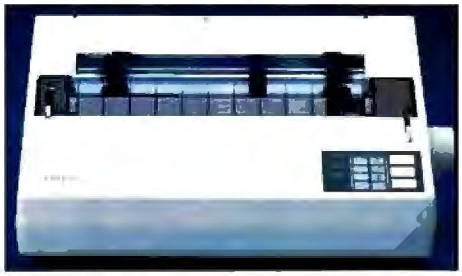

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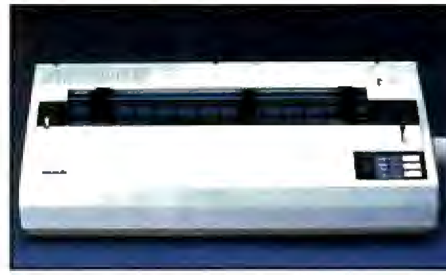

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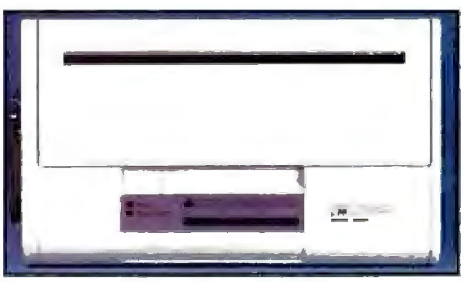

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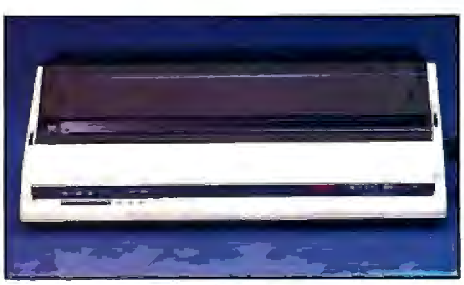

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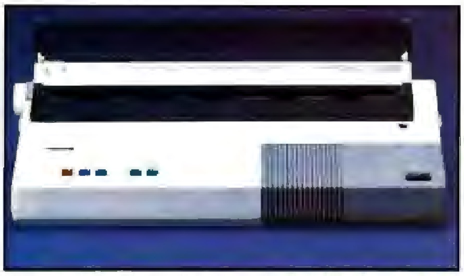

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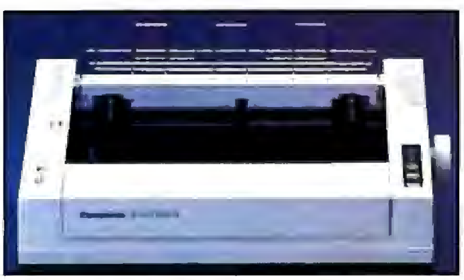

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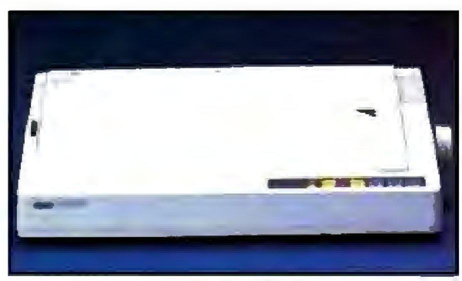

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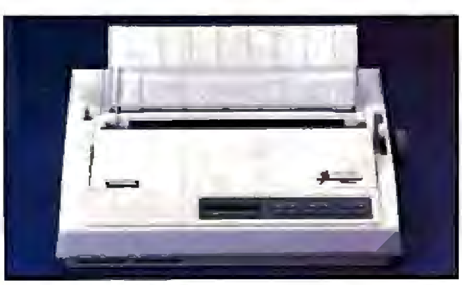

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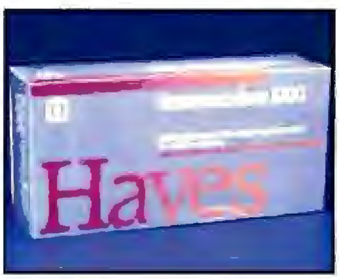

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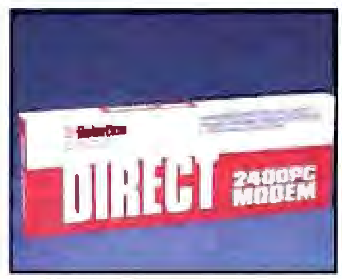

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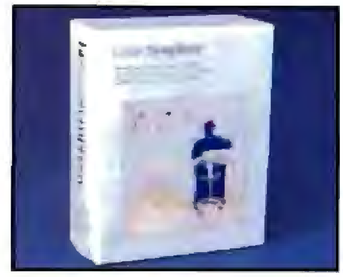

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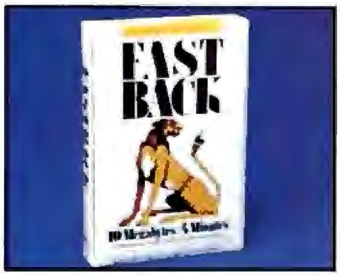

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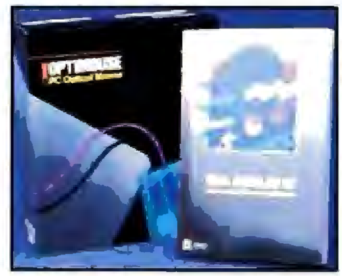

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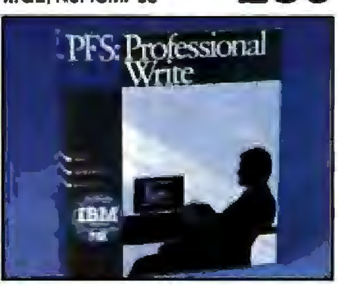

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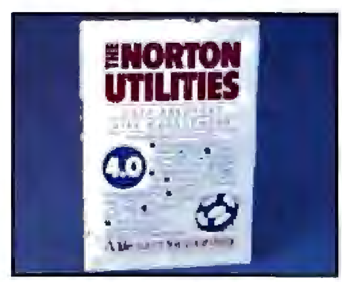

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Trilogy: A New Approach to Logic Programming

Alex Lane

An alternative to Prolog, with windows and other interesting twists

Trilogy version 1.15 ($99.95) from Complete Logic Systems (CLS) is a new logic programming language that combines the best features of logic, procedural, and database programming. Trilogy is an example of the current trend in logic programming languages, which centers on the introduction of types (domains), constraints, I/O annotations, arrays, and reassignable variables. (For a discussion of this trend, see the Prolog-related articles in the August 1987 BYTE.)

As a logic programming language, Trilogy most resembles Prolog. Both languages are based in mathematical logic, support lists, and are capable of manipulating symbolic variables. Running programs in either language consists of asking questions (called executing a query). The programming language can use backtracking to find alternative ways to satisfy a query. Trilogy improves upon the blind backtracking approach of Prolog, however, by incorporating constraint logic.

Program source code reads a lot more like Pascal than Prolog; Trilogy supports arrays, enumerated types, and subrange declarations, and provides `if...then ...else` and case control structures. You can express and compile procedures straightforwardly into nonbacktracking modules. While Trilogy provides no explicit control structures for iteration or looping, it conserves stack and heap space by performing tail recursion optimization (a technique for saving space and time in recursive programs) on nonbacktracking modules (procedures and subroutines).

Finally, Trilogy provides a set of relational database operations for creating, updating, and querying database files. Database files may have variable record sizes, and you can place these records anywhere within a file or insert them in order. You can store anything (e.g., a list, a tree, or an array) as a field. You can insert, delete, and update records anywhere in a file. The database predicates work with both Trilogy database files and ASCII DOS files.

The package requires an IBM PC, XT, AT or compatible with 512K bytes of RAM running DOS 2.0 or higher. You can run Trilogy from dual floppy disk drives, but a hard disk drive is highly recommended. I used a 4.77-MHz IBM PC XT with 640K bytes of RAM, a hard disk drive, and an 8087 coprocessor. The operating system I used was PC-DOS 3.1.

The Trilogy package consists of a spiral-bound user's manual and two 5¼-inch floppy disks that contain an installation program, the Trilogy compiler, source and object files for system modules, a number of sample programs, and a supplemental documentation file.

Language Features

Trilogy is a fairly compact language, having only 22 reserved words and 12 reserved names. The standard system modules `math.l`, `files.l`, `strings.l`, and `windows.l` add support for, respectively, mathematical functions, file-access functions, functions for manipulating strings, dates and times, and windowing functions. Unlike Pascal or C, Trilogy is case-sensitive. In a reversal of the Prolog naming convention, Trilogy variables and symbols start with lowercase letters, while the names of procedures start with uppercase letters.

Trilogy is a strongly typed language. Its four fundamental types are long (32-bit) and short (16-bit) integers; real numbers; and strings denoted by `L`, `I`, `R`, and `S`, respectively. Typed variables buy you faster execution and source code that's easier to read. However, the greatest benefit of using typed variables lies with Trilogy's ability to use *decision procedures* that modify *constraints* associated with the variables. Constraints are pieces of information that Trilogy places in the environment as it computes a solution.

The programming language associates different constraints with different data types. For example, the constraint conditions put on a short integer variable x are

```
x op n
x op var + n
```

where op is a relational operator (i.e., =, <, and >), `n` is a short integer, and `var` is a short integer variable. Whenever Trilogy encounters an expression with short integers and a relational operator, it attempts to transform the expression into one of the short integer constraints by using algebraic rules. If Trilogy cannot get the expression into one of these forms, it will backtrack in an attempt to calculate a value for one of the variables, and if this fails, it will flag the error with a message such as `too many backtracks`.

Consider the query `all x::I & y::I & x>0 & y>0 & x = 3*y +9`. Translated, this says: "Find all values of x and y when both are short integers, both are greater than zero, and x = `3*y +9`." This query will fail because the system cannot transform the expression x = `3*y + 9` into one of the constraint forms for short integers; nor can Trilogy find a finite number of values for either `x` or `y`. If, however, we add the condition that y = 2, then the query has a solution.

Constraints for long integers are more complex than those for short integers:

```
t1*v1 + t2*v2 + ... + tn*vn op m
```

continued

Alex Lane is a knowledge engineer for Technology Applications Inc. and moderator of the prolog conference on BIX. He can be reached at 6621 Southpoint Dr. N, Suite 310, Jacksonville, FL 32216, or on BIX as "a.lane."

Trilogy 1.15

Type
Programming language

Company
Complete Logic Systems Inc
741 Bluendge Ave.
North Vancouver, BC
Canada V7R 2J5
(604) 986-3234

Format
Two 5¼-inch floppy disks

Language
C and assembly

Hardware Required
IBM PC, XT, AT, or compatible with 512K bytes of memory and a hard disk drive (recommended)

Software required
DOS 2.0 or higher

Documentation
229-page user's manual

Price
$99.95

Inquiry 899.

where t1, t2, . . ., tn and m are long integer values and v1, v2, . . ., vn are long integer variables. If, in the previous example, you declare x and y to be long integers, you don't have to put a value on y for the query to succeed because the expression x = 3*y +9 fits the constraint decision procedures for long integers.

You can use Trilogy's pairing operator on the four basic types (I, L, R, and S) to construct other data structures. A pair consists simply of any two terms separated by a comma, optionally set off with parentheses for clarity. You can create a list data structure by pairing the basic types with the symbol Nil.

Trilogy also lets you declare your own types, including enumerated types and unions (similar to Pascal case-variant types). The user's manual uses the convention of appending t to all user-defined types. Type declarations can be Pascal-like subranges, like Digit_t = [0..9], or tuples like

```
Date_t = (year:I, month:[1..12],
    day:[1,31])
```

where you can select the individual fields year, month, and day by, for example, declaring a variable anniversary to be of type Date_t and using the terms anniversary.year, anniversary.month, and anniversary.day.

Advocates of typeless programming need not feel left out of Trilogy. Every data type in what is called the Trilogy universe belongs to a universal data type (denoted by U). Using the U data type in predicates (denoted as pred) lets you write predicates that take terms of any type as parameters. Having a universal type also makes possible conversions from one data type to another via coercion (which is an automatically occurring mechanism) and casts (which the programmer specifies).

Predicate Classes

Trilogy provides three classes of predicates: true predicates, procedures, and subroutines. Like predicates in Prolog, a true predicate in Trilogy expresses a quality, property, or relationship possessed by a term or a group of terms. In Trilogy, only true predicates exhibit backtracking (i.e., nondeterministic) behavior. The system doesn't perform tail recursion optimization for pred because of the uncertainty involved in satisfying constraints. Unlike Prolog, there are no extralogical operations (i.e., predicates that lie outside the logic programming model). Some examples of extralogical predicates are predicates for user I/O, for interaction with the operating system, and for program manipulation such as the cut, assert, and retract predicates.

While backtracking is a powerful resource in logic programming, it becomes a handicap when executing once-through procedural code. To permit efficient procedural programming, Trilogy provides the procedure (proc) predicate. Because there can be no possibility of backtracking inside a procedure, the manual specifies several rules for coding a procedure. For example, you can't use a logical or, symbolic parameters, or symbolic local variables in the procedure body, and the procedure cannot call any true predicates without using the all construct.

Like true predicates in Trilogy, proc predicates can fail. Prolog veterans will recognize this behavior as that of "deterministic predicates." You can view a procedure, whose last parameter is an output mode parameter, as a function, and you can (using functional notation) use it as a term in an expression.

The third and most important class of Trilogy predicate is the subroutine (subr). Subroutines are special procedures that access data external to the Trilogy environment (e.g., system time and user input). It is this access that distinguishes subr predicates from proc predicates in Trilogy. Were it not for this distinction, Trilogy would fail to maintain its logical integrity. Since the behavior of subroutines is unpredictable, you cannot call them from either proc or pred predicates, but only from other subr predicates or directly from a query.

Variable Modes

Unlike traditional Pascal-like programming languages, where only a variable's type is declared up front, variables in Trilogy are declared in terms of both type and mode. The mode tells the Trilogy compiler what, if anything, is known about a variable's value upon entry to a predicate. Trilogy has four variable modes: symbolic, input, output, and I/O.

Symbolic mode (denoted by :: in the variable declaration) is used exclusively in predicates, where little or nothing is known about the value of a variable passed as a parameter to a nondeterministic predicate. You use input and output modes in proc and subr predicates to denote whether to expect a value upon entry to or exit from such predicates.

For example, the expression x:<L declares x to be a long integer whose value the system will know upon entry to a predicate. Analogously, the expression x:>L says that you will know x upon successful exit from a predicate.

The major difference between symbolic-, input-, output-, and I/O-mode variables is that you cannot reassign the first three types. You can, on the other hand, reassign I/O variables, which conserves memory use.

Trilogy's Windows

Trilogy provides a window-oriented interface that lets you edit, compile, and run programs and build, query, and update databases. Available functions are listed at the top of the screen: Options, Query, Modules, Files, Library, and DOS. Context-sensitive help is available for both general information and errors encountered when running programs.

From the Options menu you can choose your screen colors and activate or deactivate the error-bell tone. You can also enable or disable the generation of .MOD files when compiling queries and determine whether these .MOD files will generate code that makes direct calls to the 8087 or only emulate it. In addition, you can choose to back up or restore libraries, or call the editor to edit a non-Trilogy file.

As with Prolog, a prior familiarity with the code you're going to run is necessary. You run programs by entering a query using the name of a predicate statement like ZebraAnsw(a, b) into a one-line query window near the top of the screen and pressing the F2 key to compile the query. If the compiler detects an error, the machine beeps and places the cursor at the spot where the compiler detected the error. Here, pressing F1 accesses a context-sensitive help window that attempts to explain the problem.

In general, I found Trilogy's help screens to be an invaluable aid in learning the language. Sometimes, however, the displayed message made no apparent sense. For example, when I executed the mistaken query

```
all Append ((1,1,Nil):<I,(2,3,
   Nil),a)
```

the system gave me an error message that a right parenthesis was missing.

Trilogy comes complete with a librarian that keeps track of what modules rely upon which others. You can add, modify, or delete modules from the library.

The editor included with Trilogy is modeled after the IBM PE editor. To use the editor, I had to learn an entirely new set of editing commands. I would like to see the next release offer the option of using your own programming editor with Trilogy.

By selecting the DOS function from the top of the screen, you exit from the Trilogy environment. This version of Trilogy does not provide a means of getting a directory from inside Trilogy.

Table 1: *Trilogy and Turbo Prolog are fairly evenly matched in their ability to manipulate lists, perform recursion, and read and write files, except for Trilogy's problem with running out of stack or heap. The Zebra Puzzle shows how use of constraints gives Trilogy a decided advantage in solving logic problems. The 8087 emulation in the Floating Point test is essentially the same for both products; however, Turbo Prolog outperforms Trilogy in the 8087 emulation of the Transcendental tests. Trilogy provides 8087 support, whereas Turbo Prolog does not. All times are in seconds.*

	Trilogy 1.15	Turbo Prolog 1.1
Floating Point	32.19 (3.68)[1]	30.83
Sieve	0.11	2.89
Disk Write (64K)	16.98	29.73
Disk Read (64K)	—[2]	15.85
Transcendental		
Sqrt	142 (0.7)[1]	5.19
Logs	87 (1.0)[1]	13.58
Exp	166 (1.3)[1]	24.24
Atan	388 (1.5)[1]	15.46
Sin	156 (2.0)[1]	16.18
Factorial	2.25	21.86
List Reversal	11.92	11.27
Tower of Hanoi		
5 rings	2.2	2.69
7 rings	14.2	10.87
10 rings	—[3]	87.71
Zebra Puzzle	2.19	9.45

[1] Time using the 8087 coprocessor chip
[2] Time for reading a 32K-byte file was 9.2 seconds
[3] Insufficient stack/heap

Note: Tests were conducted on an IBM PC XT with 640K bytes of memory, an 8087 coprocessor, and a 20-megabyte hard disk drive.

Documentation

Because Trilogy is a new language, the quality of the documentation is very important. The 229-page manual is divided into three sections: a tutorial, a system manual, and a programmer's manual. The tutorial provides a step-by-step introduction to the Trilogy programming language. It assumes you have some experience with programming languages like BASIC or Pascal, but you don't need to have background in logic or database programming.

The system manual describes the Trilogy system and environment, including use of the windows, function keys, and editor. The bulk of this part explains how to edit, compile, and query.

The programmer's manual resembles a collection of appendixes that cover the formal language definition. Short supplemental chapters are devoted to topics such as mode coercion, type conversion, and constraints.

All the examples presented in the manual are included in two source code files. I like this touch, since it saves much time getting acquainted with the language. Of the other sample programs included with the package, including a pattern matcher for ASCII files and several examples in a demonstration program, the file that interested me most was the so-called "zebra puzzle." This classic logic problem involves five men of different nationalities that own different pets, drink different drinks, smoke different brands of cigarettes, and live in different-colored houses. The goal is to find out "who owns the zebra." I used this program as one of the benchmark tests.

A supplemental READ.ME file on the distribution disk gives a terse description of the assembly and C language interfaces. The file LINKMOD.EXE is a utility that links .OBJ files generated by assemblers and C compilers into .MOD object files that Trilogy can use. The LINKMOD utility does not work as described. Instead of the command line LINKMOD MODNAME OBJFILE, I found I had to type LINKMOD MODNAME and then wait for the prompt to enter the object filename.

The supplemental file also covers other topics, such as a discussion of tail recursion optimization, heap management, and some partially implemented Trilogy features.

Benchmarks

Because Trilogy and Prolog appear to be "competitors" in the logic programming arena, I compared Trilogy to Turbo Prolog version 1.1 (see table 1). Of interest is the ability to manipulate lists, perform recursion and garbage collection (reclamation of memory that has been allocated to now-abandoned structures), and solve logic problems. Here, Turbo Prolog and Trilogy run approximately even, except for the solution of logic problems, where Trilogy has a decided advantage that is attributable to injection types and relation variables.

Although neither package performs garbage collection, Turbo Prolog appears to perform better because it considers free memory to be one large heap. Trilogy, on the other hand, has a disadvantage in that modules must confine their activities to a 64K-byte segment. This problem affected performance in the Tower of Hanoi and Disk Read benchmarks.

Trilogy ran the Sieve benchmark test, which finds all primes between 1 and 100, about 20 times faster than Turbo Prolog. The Floating Point test repeats a series of four basic operations 5000 times, and for this test, Trilogy and Turbo Prolog are about the same with 8087 emulation. The transcendental tests calculate the function in question 1000

continued

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times, while the factorial benchmark determines how fast 10 factorial (10!) can be calculated 1000 times. Benchmarks that exercise a logic programming language's capabilities for finding prime numbers and calculating transcendental functions are of limited interest. It is clear from the results for Trilogy that you can obtain dramatic improvements by installing an 8087.

As far as disk I/O is concerned, although Trilogy could write a 64K-byte data file, I got an `insufficient stack` error message when trying to read this file. Because the stack and heap share the same 64K-byte segment, recursively reading a 64K-byte file blew the segment. I modified the test program to write and read a 32K-byte file, and this worked fine. (While writing the initial version of the Disk Read test, I neglected to put in a check for end-of-file. Instead of giving a run-time error and halting execution, the machine froze and required a cold boot.)

The stack/heap problem reared its ugly head again when I was writing the program for reversing a 50-element list. The system blew the segment again after 11 iterations, regardless of how much free memory was available prior to loading the Trilogy compiler. However, I was able to write a predicate that would assemble a 50-element list and perform the reversal 10 times. In turn, I wrote the query to run this predicate to backtrack three times, so that 30 reversals were performed overall. Despite the additional overhead of having to assemble a 50-element list from a 10-element "building-block" three times (Trilogy balks if a 50-element list is presented in one chunk), Trilogy is nearly as fast as Turbo Prolog.

The Tower of Hanoi is a classic example of recursive programming. At the five-ring level, both Trilogy and Turbo Prolog are about neck and neck. However, at the seven-ring level, Trilogy begins to lag seriously. One explanation is that Trilogy spends much time churning out text to the screen. This is borne out by removing the `Print()` statement from the code—the performance increase is dramatic. I ran across the stack/heap problem trying to run the Tower of Hanoi benchmark with 10 disks.

Recalling the Zebra Puzzle from the previous discussion, it turns out there are nearly 25 billion ways of combining nationality, pet, drink, smoke, and house. A generic Prolog program will, if necessary, test all combinations of them to find an answer. Inherent in Prolog's backtracking mechanism is the "uninstantiation" of previously bound variables whenever it encounters a failure. In effect, Prolog "forgets" anything it learns

continued

every time it backtracks. Progress toward finding a solution occurs in one quantum leap when all variables happen to satisfy all the declared facts. On the other hand, Trilogy uses relation variables and injection types in conjunction with its built-in constraints to carry forward increments of the final solution. Relation variables express some relation that exists between objects, and injection types never have the same value for different sets of arguments. The result of this approach is that the Trilogy program to solve the Zebra Puzzle backtracks only 17 times before obtaining a solution. [Editor's note: *The Trilogy source code (BMARKS.L) for the benchmarks is available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement. See "Program Listings" in the table of contents. To "find" source code in the Listings areas on BIX and BYTEnet, search by article title, author, or issue date.*]

Worth Taking a Look

As an experienced Prolog programmer, I have found one of the practical problems of writing procedural code in that language is the awkward mind-set that must be adopted to tame the language's tendency to backtrack. Trilogy addresses this by offering programmers the flexibility to write both logic and procedural code.

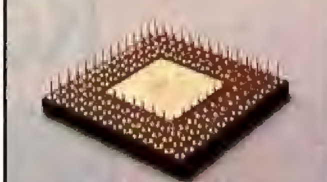
I am generally impressed with this package, although minor things about it bother me. For example, I wish I could exit to DOS to view a directory or file without having to exit Trilogy completely. (According to the company, a toolkit containing a graphics module and a DOS module along with utilities will be available for $50.) I would like more detail in the user's manual concerning the nuts and bolts of the language.

In terms of hands-on use, the editor was not the best I've used. Also, having to learn a new set of editing commands was inconvenient. (Of course, those people familiar with the IBM PE editor will not have this problem.) When running a query, it shouldn't be so easy to run out of stack or heap—and it would be nice to have a subroutine that could report on the status of those resources, too.

Trilogy is a unique product. It's the only product I have seen that combines logic programming with procedural and database concepts. The Pascal-like syntax makes it easier for people familiar with Pascal and C to learn Trilogy than Prolog. The stack/heap problem shows that the product perhaps isn't mature, yet new languages often have a few initial kinks. I cannot see Trilogy taking the microcomputer world by storm, but for $99.95, it's worth taking a look at if you are interested in logic programming. ■

POWER

The FlexCache™ 386 series from Advanced Logic Research



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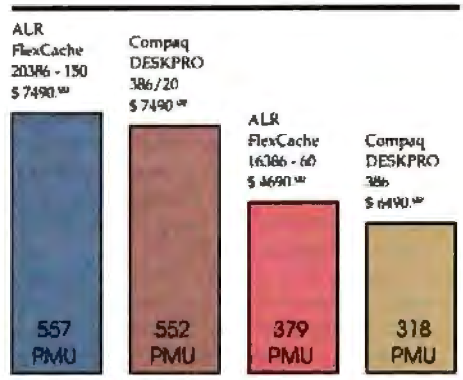

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The FlexCache 20386 will give you an extra 45,000 pages of document disk storage for free.

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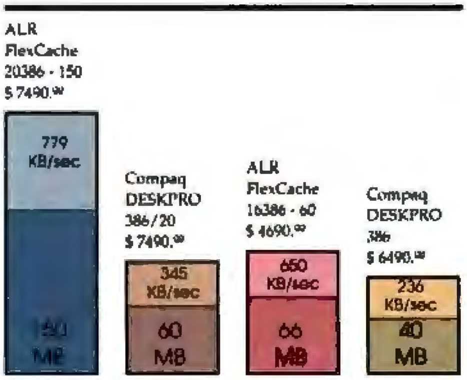

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- 80386 CPU with 16MHz system clock
- 80387 support with 16MHz clock
- 100Mbyte <30ms hard disk

FlexCache 20386 Model 100 ...$6490.00

- FlexCache 386 series specifications
- 80386 CPU with 20MHz system clock
- 80387 support with 20MHz clock
- 100Mbyte <30ms hard disk

FlexCache 20386 Model 150 ...$7490.00

- FlexCache 386 series specifications
- 80386 CPU with 20MHz system clock
- 80387 support with 20MHz clock
- 150Mbyte <23ms, track buffered, ESDI hard disk

FlexCache 20386 Model 300 ...$9990.00

- FlexCache 386 series specifications
- 80386 CPU with 20MHz system clock
- 80387 support with 20MHz clock
- 300Mbyte <20ms, track buffered, ESDI hard disk

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Excel Extraordinaire

Rich Malloy

Microsoft's Macintosh spreadsheet shines on the IBM AT, but is it fast enough?

In two words, Excel does. Microsoft has moved its popular Macintosh spreadsheet over to the IBM PC AT with all features, such as windows, pull-down menus, dialog boxes, and multiple fonts, still present. The new version also has features that were not present on the Macintosh version. These include better keyboard, font, and auditing support. Speed is the only remaining question. Is the 80286 architecture overtaxed by the superb graphics, and is the program overly slow as a result? Common sense and conventional wisdom suggest that the program's performance will suffer for its graphical largesse. But a detailed look at benchmark results yields some dramatic surprises.

The new Excel for IBM systems, officially called Excel 2.0 ($495), follows the original Macintosh version by about 2 years. On either the Macintosh or the AT, Excel is the paragon of bells and whistles. It does so many things, in so many different ways, that it tempts you to spend countless hours merely exploring.

You might quickly conclude that the program is huge. It comes on five 1.2-megabyte 5¼-inch floppy disks or seven 720K-byte 3½-inch floppy disks (you can order a set of 360K-byte floppy disks by a special card). By the time you finish loading the program, you gobble up 3.6 megabytes of hard disk space. When the program is executed, it takes up the lion's share of the 640K bytes of memory that it nominally requires, yet even that is not enough. The program must frequently swap overlays into and out of memory from the hard disk. The frequency of the overlays increases as the size of your spreadsheet increases.

Although the package is popularly called Excel for the PC, Microsoft specifically states that the software requires an IBM PC AT or compatible. Several non-AT compatible machines, such as the AT&T PC 6300, are supported, however. The program can use a CGA graphics card, but an EGA, VGA, or Hercules adapter is highly recommended. In the same way, a mouse is not required but is well worth the additional investment. (Excel supports any mouse compatible with Windows version 2.0.) Since Excel uses up such a large amount of memory, an expanded memory card (Expanded Memory Specification version 4.0) is also recommended.

As for software, Excel comes with its own run-time version of Windows 2.0. If you have a full copy of Windows 2.0, however, you can have Excel interact with other Windows applications.

The Mac Interface on an AT

The most dramatic distinction between Excel and a horde of other spreadsheet programs for the IBM PC is its user interface. Thanks to the run-time version of Windows 2.0 that comes packaged with the spreadsheet, Excel functions almost exactly like its cousin on the Macintosh. In some ways (e.g., keyboard and font support), it is actually better than the Macintosh version.

Excel's keyboard support lets you access every one of Excel's multitudinous commands and functions without ever touching a mouse. In most cases, the keyboard is fairly efficient—in some cases more efficient than the mouse.

Each menu or dialog box you choose contains an underlined letter. You can quickly choose an option by pressing that letter, or by pressing the letter in concert with the Alt key. The alternative is to press the Tab or Down Arrow key to cycle through the selections.

One problem with this technique occurs in cases where several choices begin with the same letter. The designers did, however, provide a number of shortcuts for keyboard users, and generally, the keyboard support is very good for a mouse-based product. You don't really need a mouse, but if you get one, you'll find it is icing on a very rich cake.

Ironically, the one major fault with the interface is not with the keyboard but with the mouse support. I asked a very experienced Macintosh user to try Excel on the IBM to see his reaction. He faulted the general "feel" of the mouse, saying it was too sensitive. (He was using the most recent Microsoft Mouse.) Excel apparently bypasses the Control program that comes with the mouse and offers only limited control over the mouse sensitivity: normal, high, or very high. The program defaults to the high selection. But even at the normal selection, the mouse seemed too sensitive; it was easy to overshoot a target area. Microsoft claims the problem is the sensitivity of the mouse and that you can adapt to the new mouse in about a week. Maybe so, but I hope they can fix this problem soon.

Excel for the IBM also has better font support than its Macintosh cousin. The Macintosh version allows only one font in a document at a time, with three variations on it: plain, bold, and italic. The IBM version allows four different fonts.

Dyed-in-the-wool Lotus 1-2-3 users could adapt to Excel fairly quickly. One possible problem might be the general command style of Excel. In 1-2-3, you use a verb-object command structure (e.g., `Copy A1..B5 to C4`). Excel uses an object-verb structure (e.g., `A1:B5 Copy to C4`). This takes some getting used to.

Macros Do Menus

At Excel's introduction, Microsoft officials said that they were using Excel to

continued

Rich Malloy is a BYTE senior technical editor. He can be contacted at BYTE/McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020, or on BIX as "rmalloy."

Excel 2.0

Type
Spreadsheet program with graphics and database support

Company
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
(206) 882-8080

Format
Five 1.2-megabyte 5¼-inch floppy disks or seven 720K-byte 3½-inch floppy disks

Language
C

Hardware Required
IBM PC AT or compatible with 640K bytes of RAM, graphics support, and a hard disk drive. Hercules, EGA, or VGA graphics card and mouse are recommended.

Software Required
MS-DOS 2.1 or higher; Windows 2.0 is recommended.

Documentation
775-page *Reference Manual*; 395-page *Functions and Macros Manual*; 38-page *Getting Started* booklet; 82-page *Sampler*

Price
$495
($250 for network user packs)

Inquiry 898.

build prototypes of new applications software. What makes this possible is Excel's extensive support for macros. With the program's exhaustive list of macro commands, you can set up a whole new system of menus and dialog boxes and even control other Windows applications.

Excel boasts many macro commands. However, most of these commands are merely other ways for you to execute Excel menu commands. But even if you only look at true macro commands (i.e., commands that perform a function that could not be performed by any other means) you would still find that Excel has an impressive number of commands.

One of the reasons that Excel has so many macro commands is that it processes macros in a unique way. Most other spreadsheets treat macros as strings of keystrokes. For example, a 1-2-3 macro to copy a cell to the right and move to the next row might have seven keystrokes:

/c~{right}~{left}{down}

where ~ represents the Return key, and {right} the right arrow key. Excel, however, converts the keystrokes into a series of commands. The copy operation would require six keystrokes (Alt-E, Alt-C, right, Enter, left, down) but would be represented by six commands:

```
=COPY()
=SELECT("RC[1]")
=PASTE()
=CANCEL.COPY()
=SELECT("R[1]C[-1]")
=RETURN()
```

Were it not for the equal signs (which differentiate a macro command from a comment), the macro would look like some odd variation of BASIC.

Excel's approach leads to large macros, but the macros are easy to understand. And in cases where you may just want to play back some keystrokes, there is a `SEND.KEYS` command.

It would be very difficult to describe the power of Excel's macros in this small space. Like a programming language, it would fill a book. Instead, let me provide a few examples.

The `ADD.BAR` command lets you replace the main menu bar of the program with your own. If you are so disposed, you can probably replace the menu bar with a 1-2-3-style menu bar.

The `ADD.MENU` command lets you add pull-down menus to the preexisting menu bars or to your new menu bars. These menus can have commands that are grayed out or checked, just like Excel's menus.

The `DIALOG.BOX` command lets you construct a dialog box containing scrolling lists, radio buttons (a menu of choices that lets you have only one choice active at one time), and other Macintosh goodies.

The `EXEC` command can execute Excel itself, or another Windows application. Once open, Excel can communicate in various ways with another application. If the application supports DDE (the Dynamic Data Exchange message-passing protocol), you can use an `INITIATE` command to open a DDE channel to it. If DDE is not supported, you can use the clipboard or the `SEND.KEYS` command to send keystrokes to that application.

Two commands, `CALL` and `REGISTER`, let you access all functions in Windows' dynamic libraries. Microsoft has very little detailed information on this but hopes to have more information available for developers soon.

Excel has `FOR...NEXT` and `WHILE...NEXT` loops, too. You can set up auto-start and auto-close macros that execute each time you open or close a particular worksheet. You can also have macros execute at a particular time of day, or when you choose a particular command.

As in most programming languages, you can insert comments anywhere and single-step through the execution of the macros. And unlike most programming languages, you can highlight areas of the macro with various fonts and shading. Your code may look as impressive as it performs.

Mac-Style Data-Entry Forms

Excel has a good complement of database features that are similar to those of 1-2-3. Excel also has a good data-entry-form feature. Data-entry forms greatly ease the process of getting information into a database. With Excel you can create not just a database form, but a Macintosh-style database form. That is, you can use radio buttons and scrolling lists just like Excel itself does. These forms are a little difficult to set up, and they run a little slower than Excel's normal dialog boxes, but they are impressive nonetheless.

Excel supports data tables in much the same way as 1-2-3 does, which is to say it does not make the job excessively easy. However, once a data table is set up, Excel lets you set up recalculation for everything but the table, thereby greatly speeding up operation.

Finding Your Mistakes

In any worksheet larger than a single screen, auditing becomes very important. Excel lets you give cells meaningful names that you can use in formulas and lets you attach notes to particular cells. It also lets you highlight all cells that are dependents or precedents of a particular cell.

One of the most interesting features of Excel is its Info window. You can set up this window to sit in the background and report various pieces of information about any cell you select. It will tell you the formatting, the precedent or dependent cells, and any notes that attach to the cell. With the Info window set up, you can easily scroll around a worksheet and check this information.

No Three-Dimensional Graphics

Excel can generate a good selection of graphs. These include the obligatory bar, area, line, and scatter graphs, as well as the old favorite pie chart. One advantage of Excel is its ability to do several variations on each of these common themes. The program also features high-quality text fonts and the ability to paste the graphs into Windows Write, the word processor that comes with Windows version 2.0. Macintosh users may be happy to know that macros can now access all the graphics commands.

Unfortunately, Excel cannot do three-dimensional graphs. These graphs are increasingly popular and are included in some of the competing new spreadsheet programs, such as Surpass and Quattro.

This review just barely scratches the surface of Excel's features. I should also mention that color is available, if you have an EGA or VGA. The program is not copy-protected, and it includes the ability to print wide worksheets sideways.

Head-to-Head: Excel Versus 1-2-3

After reading about all these features, you might conclude that Excel just has to be slow. But is it? And if so, by how much? To find out, I tested Excel on an AT clone with a 6-MHz clock speed, 640K bytes of RAM, and a 20-megabyte hard disk drive. The system was also equipped with a Hercules-style graphics card, a monochrome monitor, and the new Microsoft Mouse. The only software I ran with Excel was MS-DOS 3.1, the mouse driver, and the mouse control panel. For each test, the program and the benchmark worksheets were "maximized" to their largest sizes.

For comparison, I tested 1-2-3 (version 2.01) on the same machine. I was tempted to use 1-2-3 with Lotus Development's Speedup add-in program, since this program can dramatically speed up 1-2-3. But in these benchmarks, where each cell is dependent, the add-in actually has the effect of slowing the program down by a small amount. Thus, I did not use this feature.

The tests I used were the same as those used in the article "Spreadsheets" in BYTE's *Applications Software Today* (Summer 1987). Three of the tests involved a simple 100- by 25-cell worksheet, where each cell was a multiple of the previous cell. The fourth test was the so-called Savage benchmark, which measures floating-point accuracy and performance by using logarithmic and trigonometric functions.

As you can see by the results in table 1, Lotus's 1-2-3 is still number one in the Simple Recalculate and Insert Row tests. Excel was only 60 percent as fast as 1-2-3 in simple recalculations and was even worse when inserting rows. However, the other two tests yielded surprising results. In the Scroll Right test, where the character-based 1-2-3 should have had a hands-down advantage, Excel was 18 percent faster. In addition, in the Savage test, both programs had approximately the same results and the same error (approximately 10^{-8}).

Excel still has some catching up to do when it comes to simple recalculations. But it is interesting to note that, as you might expect, you can make Excel go faster by decreasing the size of its viewing windows. When I decreased the size of the benchmark window to 2 by 2 cells, the Recalculate speed increased by 48 percent. Also, I was very amused and intrigued when I found that Excel's results on the AT clone matched pretty closely with those measured on the Macintosh last year. For each test, the difference is less than 10 percent.

Documentation Goes Electronic

The most exciting thing about Excel's documentation is a program called the Feature Guide. This is a Windows application that runs in conjunction with Excel and communicates with it by DDE. The Guide functions sometimes as a slide show, showing graphics and displaying various worksheets and charts. In certain practice sessions, it lets you try out a particular feature and advises you when you make a wrong keystroke. This is an impressive program and a necessary introduction to a feature-rich product such as Excel. It also is a good example of what can be done with the DDE channel of Windows.

The rest of the documentation is two fairly conventional three-ring binders; one is a general reference, and the second is on functions and macros. A small booklet shows a short introduction and has instructions on how to get started. A fourth, thin book (with disk) is a "Sampler" of very interesting applications. Included, for example, is a worksheet for a new business plan and a set of macros for solving simultaneous equations.

Table 1: *In the head-to-head benchmark comparisons of Excel and Lotus 1-2-3, 1-2-3 still maintains supremacy in the Simple Recalculate and Insert Row tests. But, surprisingly, Excel is 18 percent faster in the Scroll Right test. Both programs are in a dead heat in the Savage test. All times are in seconds.*

Test	Excel	1-2-3
Simple Recalc	4.48	2.68
Insert Row	4.06	1.75
Scroll Right	47.38	55.81
Savage	33.02	33.55

I might suggest that the company add more examples to the *Functions and Macros Manual*. Several of the macro commands are intricate, and examples of each command would be helpful.

A Rare Product

The only things I might fault in Excel are the less-than-stunning recalculation speeds and the mouse support. But in view of the power and flexibility provided by the program, these criticisms seem empty.

This rare product combines extreme ease of use and exceptional power. It is one of the first products to establish a common interface across the AT and the Mac. I heartily recommend it—for both novice and expert—on both machines. ■

Microsoft Works

Nicholas M. Baran

An integrated program for the IBM PC and compatibles, Microsoft Works 1.00 ($195) offers word-processing, spreadsheet, database, and communications modules. The package also includes a chart facility for creating graphs from spreadsheet data and a separate memory-resident macro-command processor.

Though sufficient for most tasks, Works's modules do not quite measure up to full-featured, stand-alone applications packages. The word processor module includes all the text-handling functions required for basic text processing, but it does not have the sophisticated graphics or document management capabilities of Microsoft Word. The spreadsheet module is a basic Lotus-compatible spreadsheet without the Lotus macro language, and the database module is a nonprogrammable, single-table file manager or "flat file" system. The communications module is fine for dialing bulletin boards or conferencing systems and downloading and uploading files, but it does not include a programming or command language.

While Works is primarily intended for novice users, it has adequate capabilities

continued

Microsoft Works 1.00

Type
Integrated software package with word processor, spreadsheet, database manager, telecommunications program, and separate macro-command processor

Company
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
(206) 882-8080

Language
C and assembly

Hardware Required
IBM PC, XT, AT, PS/2, or compatible with 384K bytes of RAM, two 360K-byte floppy disk drives or one 720K-byte floppy disk drive (or a hard disk drive), and a CGA, EGA, VGA, or Hercules graphics adapter card; mouse, modem, and printers are optional

Format
Eight 5¼-inch floppy disks and four 3½-inch floppy disks

Documentation
578-page *Microsoft Works Reference Manual*, separate appendixes covering printers, modems, using a mouse, and MS-Key macro processor; Quick Reference card; keyboard guide

Price
$195

Inquiry 897.

for experienced users and offers the advantage of complete integration between these four basic software applications at a reasonable price.

The package requires 384K bytes of RAM, MS-DOS 2.0 or higher, two 360K-byte or one 720K-byte floppy disk drive, and a CGA, EGA, VGA, or Hercules graphics adapter card. The program can use a Microsoft Mouse and Hayes-compatible modems.

I tested Works version 1.00 on an IBM PC XT with a Microsoft Mouse and an Orchid TurboEGA card. The program is easy to install and uses the standard setup system found in all Microsoft applications for the IBM PC. Works comes on eight 5¼-inch floppy disks and four 3½-inch floppy disks. It includes a spelling checker and an extensive on-line tutorial. Without the tutorial, Works requires about 1 megabyte of hard disk storage; with the tutorial, the program requires 1.8 megabytes.

You can configure Works to operate with the mouse or keyboard. With the mouse option installed, you can still use all available keyboard commands and functions. However, the macro processor cannot incorporate mouse actions into recorded macros. Works also supports a wide range of printers and, by default, supports Hayes-compatible modems for communications. You can, however, configure Works for use with other types of modems.

Works uses a pull-down menu interface that is consistent throughout the four modules. You access the menus by pressing the Alt key and then selecting the command or simply pressing Alt followed by the first letter of the command. A description of the command you select appears at the bottom of the screen, and, in most cases, a dialog box appears for making additional selections or entering command parameters. With a mouse, you can point to and click on menu options and dialog boxes, and you can block off text or scroll through files.

I often pressed the Enter key at the wrong time in dialog boxes and discovered through trial and error that the Tab key was required to move to the next command parameter.

Works truly qualifies as an integrated package. You can access any of the four main application modules at any time. It assigns default file extensions to different file types so that it automatically knows which application to load with an existing file. For example, if you save a script file for a communications session, Works automatically assigns it a .WCM file extension. The next time you load the file, Works will automatically invoke the communications module. Similarly, special file extensions are assigned to spreadsheet, word-processing, and database files. You can override the assigned file extensions if you wish. Works also lets you temporarily exit to DOS.

Works lets you open up to eight files at one time. Even though you can work only on one file (i.e., the active file) at a time, you can switch from one file to the next with a single command. You can cut and paste data interchangeably between text documents, spreadsheets, graphs, and database files. The ease with which you can move data from one application to another is one of Works's most impressive features.

For example, to copy data from a spreadsheet into a word-processing file, you define the block of data in the spreadsheet, copy the data into a buffer, open the word-processing document, move the cursor to the desired location for the spreadsheet data, and press the Enter key. You can do the same between databases and text documents and also between spreadsheets and databases, provided the data formats are consistent.

Word Processor

The Works word processor is the closest of the four modules to what I would expect of a stand-alone word-processing program and is really the best part of Works. I used the BYTE standard tests to get a feel for the performance of the word processor and was impressed with the results. [Editor's note: *See "Word Processors" by Phillip Robinson in BYTE's* Applications Software Today, *Summer 1987.*] The BYTE 4000-word benchmark file loaded very quickly. A global search and replace of a word that was found 400 times throughout the document took only 5 seconds to complete. Resetting the margin and subsequent document reformatting occurred almost instantaneously. Converting the file to ASCII format took about 20 seconds, and saving it as a Works document took about 8 seconds.

I also worked with a 20-page document converted from WordPerfect. The Works word processor handled all editing functions admirably within the large document. You can convert Works's text documents to straight ASCII format with linefeeds at the end of each line (e.g., suitable for transfer via modem), or into a text format with carriage returns at the end of each line, which other word processors can read. You cannot load Works documents directly into Microsoft Word; you have to save the document as a text file first.

The Works word processor includes automatic pagination and reformatting. I found the reformatting function a bit distracting when I was inserting text into an existing document. From the corner of my eye, I could see the lower text constantly repositioning itself; however, this is a characteristic I could get used to.

The formatting commands for page layout, headers and footers, italics and underlining, and so on, are all easily accessible from the pull-down menu bar on the top line of the screen. You can also switch between windows and work on different open documents.

Works shows page numbers but does not provide line numbers or cursor position and also has no facility for obtaining a word count. The spelling checker includes 80,000 words and is similar to other word processor spelling checkers, such as the one used with WordPerfect.

Perhaps the best feature of the word processor is the ease with which you can merge text from the database module for

continued

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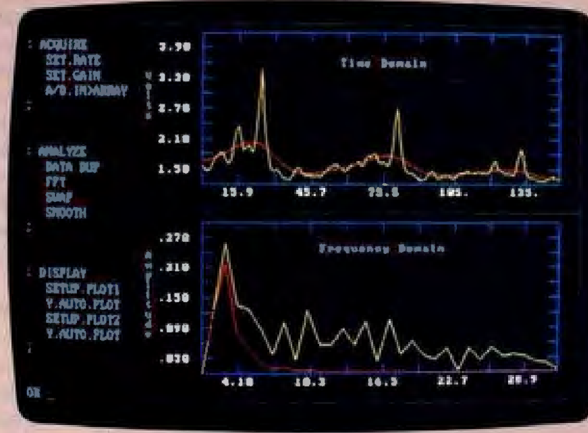

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The Works spreadsheet does the job, but it is the weakest module. It takes almost 1 minute to load a 1000-row by 5-column spreadsheet.

form letters and printing mailing labels. You simply select the `Insert Field` command from the Edit menu and select and locate the appropriate field names from your database. When you print the document, Works automatically inserts the database data, one record at a time, generating as many documents as there are records in the database. You use the `Print Labels` command to generate the labels from the database.

The word processor is more than adequate for most straightforward writing tasks. I would not hesitate to use it for most of my writing requirements. The mail-merge facility is actually quite a bit easier to use than comparable mail-merge utilities in some of the high-end word processors, such as Microsoft Word or WordPerfect. The word processor is also the easiest to learn of the four modules. I'll discuss ease of use in greater detail at the end of this article.

Database

The Works database is a simple flat-file system and is adequate for maintaining straightforward databases, such as mailing or contact lists or simple financial and statistical tables. A single Works database table can contain up to 4096 records and 256 fields. You can work with a database in form or list mode. In list mode, records are displayed in rows on the screen. In form mode, one record at a time is displayed on a screen form, which you design when you define the database.

To define a database, you simply set up a form on the screen, similar to the procedure in PFS:File or Symantec's Q&A. However, I did find Works's use of the Enter key confusing. Pressing the Enter key defines the form rather than a single field. I kept losing defined fields by pressing the Enter key at the wrong time. Once I got the hang of it, however, it was simple to define fields and also to customize the form. Works provides functions for moving fields around the form and performing modifications to the data structure. The Works database supports text and numeric formats, as well as date, time, and logical data types.

In spite of its simplicity, the Works database includes a good query facility and options for embedding formulas in fields. Field formulas can reference other field values in the database. The database uses the same library of functions as the spreadsheet module. The report generator includes options for specifying breakpoints and formatting and selecting specific data values. As mentioned in the section on the word processor, it is very simple to transfer database field values to the word processor for form letters.

As with the word processor, I ran some of BYTE's standard tests and found the performance of the database to be better than I expected for such a low-priced product. While the Works database does not include an indexing or key-field scheme, sorting a 1000-record file took only about 4 seconds. Searching the same file for a value in the last record took about 5 seconds.

My main complaint about the database is that you can't change the field delimiters if you want to save the database in ASCII format. This means that quotes surround all field values when saved in ASCII delimited format. There should be a facility for changing the delimiter to a blank or a space. On the positive side, the Works database provides a range of operations for formatting database fields and forms.

The database is quite easy to learn, though it takes a bit more effort than the word processor.

Spreadsheet

The Works spreadsheet does the job, but it is the weakest of the four modules when it comes to performance. It takes almost 1 minute to load a 1000-row by 5-column spreadsheet, and then the screen hangs temporarily (i.e., keystrokes are not recognized) until Works gets its bearings again. Another quirk is that the spreadsheet status line reports that recalculation is completed about 30 seconds before it really is. It was disconcerting to try to move on to another task and then realize the spreadsheet was still recalculating.

Actual performance of the BYTE standard tests [Editor's note: *See "Spreadsheets" by Rich Malloy in BYTE's* Applications Software Today, *Summer 1987*] was comparable to other spreadsheet programs. A compounded calculation involving the 1000-row by 5-column matrix and using a formula where each cell multiplies the value of the immediately previous cell by 1.001 produced an insignificant error of 2.14^{-8} over the total calculation. This result is a good indicator of the accuracy of the spreadsheet compiler. The compounded calculation took about 60 seconds, while a recalculation of a 100- by 25-cell spreadsheet took about 12 seconds. Cursor speed is also comparable to other spreadsheets, requiring about 24 seconds to traverse 100 columns.

The spreadsheet includes a standard library of arithmetic, financial, and logical functions and produces files in Lotus .WKS file format. While files are interchangeable with Lotus 1-2-3, the Works spreadsheet does not support Lotus macros or the Lotus database functions (understandably, since Works has its own database).

The spreadsheet's charting function produces the basic graph types (e.g., line, pie, bar, and area). You first select spreadsheet ranges and then assign them to the axes of the chart. The chart facility provides the normal formatting and labeling functions found in most business graph utilities.

The spreadsheet seems fine for modest-size applications, but the false completion signal with the 1000- by 5-cell spreadsheet makes me hesitate to recommend Works for large spreadsheet applications.

Communications

I tested the communications module by logging onto the BYTE Information Exchange (BIX) and uploading and downloading files. The communications module includes a handy script-file recorder for saving sign-on or log-on sequences. It recorded my log-on sequence to BIX, and from then on, I just opened the Works window and called up the BIX communications file; Works then dialed BIX and logged on.

The Works communications program supports both text and XMODEM file-transfer protocols. File transfers and captures worked without a hitch. Documents from Works' word processor saved in plain-text format transferred perfectly.

While the communications package does not include a command language, it is perfectly adequate for most users logging onto bulletin boards or conferencing systems. However, it took trial and error to get the communications system to work properly. At first, I couldn't figure out what should go in the "Modem Type" field of the dialog box. As it turns out, if you have a Hayes-compatible modem, nothing should be entered in that field. I found this out by trying various alternative values for about half an hour. Selecting different modem types is covered in the appendixes to the Microsoft and MS-Key macros reference, a separate manual included in the package.

As with the other functions of Works, once I got the hang of it, the communica-

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Print samples were created using Microsoft Word, Microsoft Excel, and Aldus PageMaker tions module was easy to use and did the job.

Macro Processor

I worked with the macro processor only briefly. Called MS-Key, the macro processor is a separate module invoked from the DOS prompt. It can run from a disk or as a memory-resident program. You can adjust the amount of RAM used by MS-Key, and you can deactivate it. I had WordPerfect's Repeat Performance keyboard enhancer (version 2.0) already loaded when I first tried MS-Key and hung up the system. So, you may have to experiment a bit if you want to run MS-Key with other memory-resident programs.

MS-Key can record any sequence of keystrokes used in Works. It includes a special macro editor for modifying previously recorded key sequences. As mentioned earlier, it does not recognize operations that the mouse performs.

The MS-Key macro processor is definitely useful for executing repetitive tasks. I tested it by recording a sequence of commands for loading a particular document and performing some search functions. With MS-Key loaded, an additional macro menu appears in the Works menu bar for executing, editing, and recording macros. Since MS-Key is really a separate program, instructions on its use are provided in a separate appendix to the Works user manual.

Ease of Use

Microsoft's sales pitch is that Works is an absolute snap for first-time users to learn and that in no time at all, novice users will be blazing through form letters, invoices, and mailing lists and downloading stock quotes from Dow Jones. I would dispute these ease-of-use claims.

The package does include a good on-line tutorial that lets you work through all the capabilities of Works. You can even start up the tutorial from within an application that you are working on. Works also includes a large on-line help facility with a topic index, explaining the various functions and commands in Works.

In contrast to the impressive on-line tutorial, the *Microsoft Works Reference Manual* is mediocre. I spent almost an hour trying to figure out how to log onto BIX or to find some information on the "Modem Type" field. There is no mention whatsoever of field delimiters in the database section. The index does not include a topic on data types. There is no direct information on how to obtain a directory of files that don't have Works file extensions. I figured out that you use *.* for that purpose. I don't think a novice user would necessarily figure that out. Many of the technical details not covered in the reference manual are in the appendixes manual.

While this criticism may seem a bit heavy-handed, it is important not to mislead new users into thinking that Works represents a revolutionary breakthrough in ease of use. This is simply not the case. While it is easier to learn than WordPerfect, Word, or Paradox, Works requires considerable effort from the novice in understanding its concepts and capabilities.

Working Opinion

In spite of the criticisms regarding its ease of use, Works is overall an excellent package for the money. The mail-merge facility alone may be worth the money to many users who don't want to struggle with the control codes and other confusing mail-merge commands found in most word processors. The Works word processor is competitive with many standalone word processors, as long as you don't need document summaries or WYSIWYG (what you see is what you get) text formats on the screen. The communications and database modules do the job, and, in spite of its quirks with large spreadsheet files, the spreadsheet does the job, too. I recommend Microsoft Works. ■

Nicholas M. Baran is an associate technical editor for BYTE. He can be reached at 425 Battery St., San Francisco, CA 94111, or on BIX as "nickbaran."

Reflex Plus for the Macintosh

Charles Spezzano

When it comes to relational database managers for the Macintosh, Reflex Plus is the fastest and easiest to use that I have seen. It lets you create relational databases from which you can link files to allow cross-accessing of information. Although it does not let you create custom menus and dialog boxes to shield the end user from the underlying structure of the program and create the illusion of a custom-designed program, it has few other shortcomings. Reflex Plus version 1.0 runs on any Macintosh with at least 512K bytes of RAM and 800K bytes of floppy disk or hard disk storage.

Reflex has evolved in three stages. It began as a program called Interlace, which was a good program from the start. Then Borland bought it, renamed it Reflex for the Macintosh, and removed the copy protection while also improving the highly visual interface. The company upgraded Reflex further and called it Reflex Plus: The Database Manager. The changes are far more than nominal.

The entry forms now allow default fields, calculated fields, and display-only fields. The calculated fields automatically perform a variety of calculations during data entry. You can also create multiple entry forms for each database. One entry form might display data one record at a time, while another displays all records at once in a tabular format. Report design has also been improved with new functions such as `GROUPBY`, which shows records grouped by common values in fields.

Reflex for the Macintosh could have records with a maximum size of only 1000 characters. That is the default maximum record size in Reflex Plus, but if you need more space for each record in a file, you can select `Configuration` from the Apple menu and then select a new maximum size of 2000 or 4000 characters. The number of characters you can enter in a single text field is limited only by the 1000-, 2000-, or 4000-character record limit minus the number of characters in other fields in the record. The program's other structural aspects are unchanged: 254 fields per record, as many records in a file as your disk can hold, and up to 15 files open simultaneously.

The new `Paste Choice` function serves a dual role. It lets you quickly define formulas by pointing and clicking with a mouse; and it can be used to copy a formula or field, with its attributes, from a database into another entry or report form. When defining a formula, you can create an entire path name by selecting a database file, expanding the file to see its fields and links, clicking on a linked file

continued

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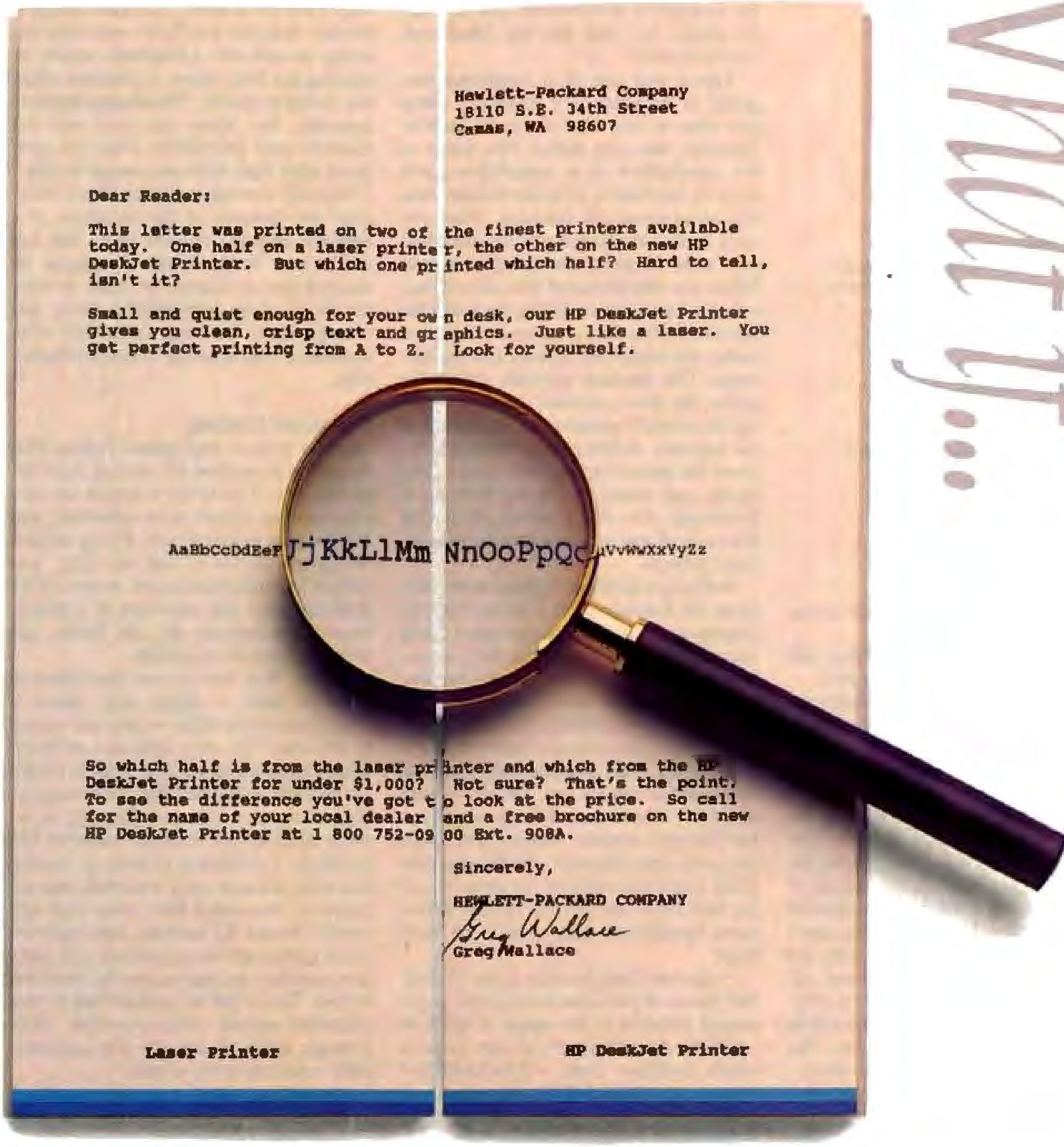

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Type
Relational database manager

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Scotts Valley, CA 95066-9987
(408) 438-8400

Format
Three 3½-inch floppy disks

Language
Assembly

Hardware Required
Any Macintosh with at least 512K bytes of RAM and 800K bytes of floppy disk or hard disk storage

Documentation
576-page *Reflex Plus User's Guide*
180-page *Learning Reflex Plus*

Price
$279; upgrade for Reflex owners, $95

Inquiry 896.

and expanding it to see its fields and links, and clicking on a field in a file.

Other changes in the program take care of annoying features in the previous version. In Reflex, for example, if you selected `Show Header` but did not put anything in the header, space was still reserved for that header. To remove the blank header, it was necessary to select the header and choose `Clear` from the edit menu. In Reflex Plus, by contrast, if you don't create a header, the command displayed is `New Header`. If you don't place anything in the header, it does not officially exist, and the command remains `New Header`. Only after you actually place something in the header does the command become `Show Header`. The two-step process is identical for footers.

You pay a lot for those improvements. Reflex used to be the greatest bargain in the Macintosh database market, retailing for $99.95. The suggested retail price for Reflex Plus is $279. Reflex owners can upgrade for $95. In comparison with the competition—most of which sell for just under $500—Reflex Plus is still a good buy, if not a great bargain.

Easy and Flexible

Reflex Plus is the easiest to use of the top five fully relational Macintosh databases (including Omnis 3 Plus, dBASE Mac, 4th Dimension, and Double Helix II). Many users could probably muddle their way through setting up a simple name and address database without reading the new improved reference manual or the tutorial learning guide. That's because much of the program is self-evident, and its overall design fits well into the Macintosh environment.

Typing and use of a command language is minimal. For example, when you want to use one of the 55 built-in functions that give Reflex Plus many of the capabilities of a spreadsheet, you click on the field to write the formula that will incorporate the function. Then you click in the formula panel in the place that you want to paste the function name. When you choose `Paste Function Name`, a dialog box appears, listing the available functions. You then click on the function name you would like to paste into the formula. The program not only pastes the name, but also a generic template showing the correct syntax of the arguments of the function. At this point, you have to replace the generic syntax with actual field names and values before the formula is functional, but that's about all Reflex Plus asks of you in this ordinarily complicated process.

Building a database is just as easy. You name the database, and a screen appears displaying the database name and a blank space under it for the first field name. You type the field name, press Return, and then type the next field name. In a simple name and address database, nothing else would be required before data entry. Reflex Plus automatically sets all new fields to contain text. But if you want to specify other types of fields, six others are available: number, integer, date, logical, time, and sequence. Reflex automatically checks for data of the correct type for each field, and you can further define more specialized data checks for each field.

A number field provides up to 15 decimal places of precision and accepts exponential notation in the range of E308 to −E324. An integer field can contain whole numbers from −2,147,483,647 through 2,147,84,647. If you specify a field as a sequence field, Reflex Plus automatically assigns consecutive numbers to the records you enter in a database. A file can contain only one sequence field.

Every database file must include at least one key field or you cannot save the design. There can, however, be multiple key fields in a record. Taken together, the key fields of a record constitute the *key* of that record. This is an important concept in Reflex Plus, since there are no indexes. The key for each record is unique, and Reflex Plus automatically sorts records by the key fields and displays the records in that sorted order. That can be a problem if you want to go back and check the last record entered in a database, but it makes searches very fast. It is also a very flexible system. You can change a nonkey field to a key field, even after entering records into a database, simply by moving the field above or between other key fields in the list. The change happens instantly, but when you next save the database and quit Reflex Plus, the program must then write the change to disk.

Equally flexible is Reflex Plus's tolerance for changes in the structure of a database that has records in it. You can add a new field, delete or rename an existing one or change its type, reorder the fields on an entry/display form, and change links between files—all with automatic restructuring of data by Reflex Plus.

Relational Linking

Another feature that makes Reflex Plus special is its method of creating links between files. This is the essential test of a program that claims to be relational, and Reflex Plus passes it with flying colors. When you decide to link two files, you simply add link fields to the images of the database files that you want to connect, draw a line between the link fields, and specify a type for each link.

Reflex Plus lets you set two different types of links: a single link, where a record in one file links to only one record in the other file; or a collection of links, where a record in one file links to multiple records in another file. For example, if you connect a customer file with an invoice file, the link from the customer file would be a collection of links to invoice records, because one customer record might be associated with more than one invoice record. By contrast, any single invoice record will be associated with only one customer record, so the link from the invoice file would be a single link to one customer record. Once you link files, changes made in one file are automatically reflected in the others.

In addition, when you look at a record in one file, such as the customer file used in the previous example, and you want to find information in another linked file, such as an invoice file, simply select `Show Linked Record` from the utility menu. This displays the record (or records) in the other database file that link to the current record in the current file.

Once data is in your files, Reflex Plus provides powerful search and sort capa-

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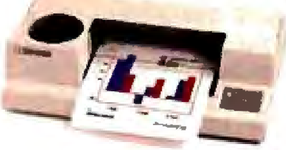

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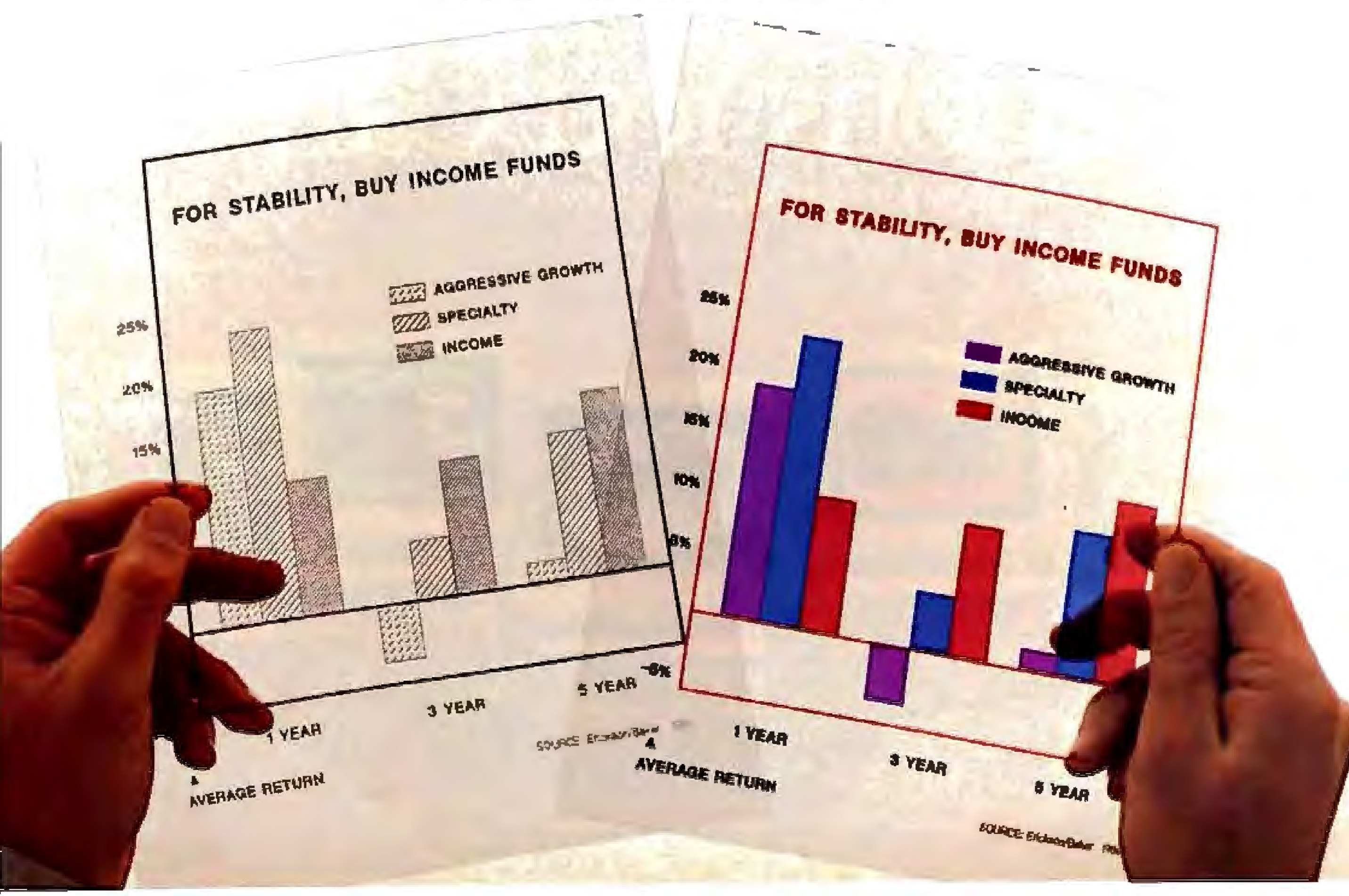

Table 1: *In the benchmark tests, Reflex Plus was much faster than Double Helix II. (All times are in minutes:seconds.)*

	Reflex Plus 1.0	Double Helix II 1.0
Search for last record	:05	1:13
Search for nonexistent record	:05	1:14
Index a field	<:01*	2:08

*Time does not include updating the disk, which took 1 minute upon exiting from the program.

bilities. You can use the "FormulaBuild" dialog box to easily retrieve records based on qualifications of values in fields combined with `AND` or `OR`. By pointing and clicking, you can paste the operators `Equal`, `Not Equal`, `Less`, `Less or Equal`, `Greater`, `Greater or Equal`, `Starts With`, and `Includes` into the query formula. As with constructing calculation formulas, the FormulaBuild feature lets you set up complex searches without having to memorize search formula syntax.

Unlike some relational databases, Reflex can also serve as a text-oriented database. The 4000-character maximum field size is large enough for comments on a client or the abstract of a journal article. The `Start With` and `Include` operators can handle key word or phrase searches adequately. Even with these capabilities, text entry could be cumbersome, because you move from one field to the next by pressing the Return key. That could preclude creating separate paragraphs within a field, but Reflex Plus gets around this potential problem by letting you insert line breaks in a text field by pressing Shift-Return.

Formulating Reports

The Reflex Plus report generator is as simple and sophisticated as the rest of the program. There are two ways to create a report. The quickest is to use the built-in table-style report that shows one record per row. Customized reports let you place fields wherever you like on the report form. You can create free-form reports that combine data from several different databases.

Finally, you can also use custom report forms to create spreadsheet-style reports where you use calculated fields to automatically perform operations on the values you enter. You might, for example, set up a tax form in which you enter values into some fields, and Reflex plus automatically calculates the value of other fields from those values you enter.

Formulas allow the inclusion of summary fields in reports for such statistics as counts, sums, averages, minimums, maximums, and standard deviations. Nesting lets you create sophisticated reports that show hierarchies of records and that can use data-file links and the contents of other reports. Unlike Reflex, Reflex Plus lets you sort on as many fields as you want, in any way you want.

When Borland transformed Interlace into Reflex, one of the improvements was to build in support for nonstandard sizes of paper. When you use the Apple Imagewriter—not the LaserWriter—you can change the width and height of the paper on which Reflex Plus prints your documents. This capability lets you use a broad variety of different sizes of paper, envelopes, and labels. Reflex Plus improves further on Reflex's report-printing capability by letting you select several fonts from those you have available, whereas Reflex lets you select only the first 16 fonts that appear in your fonts menu.

Fast Performance

I ran some benchmark tests comparing Reflex Plus version 1.0 to Double Helix II version 1.0, a well-known relational database manager for the Macintosh (see table 1). I ran the tests on a Macintosh 512E that had been upgraded to 1 megabyte of RAM with a Dove 524S MacSnap memory board and SCSI port upgrade. Attached to the SCSI port was a SuperMac DataFrame 20 hard disk drive.

The test file I used consisted of approximately 900 records with 10 fields of data. This file, originally created with Double Helix II, was tested first on Helix and then exported from that program as an ASCII text file and imported into Reflex Plus. The importing process was straightforward and flawless.

With the first test, I searched for the last record in the database on a nonkey (Reflex Plus) or nonindexed (Double Helix II) field. Then I ran a search on that same field for a nonexistent record—one that, if it did exist, would be at the end of the file. Double Helix II took about 14 times as long as Reflex Plus to perform both tests.

Finally, I indexed that field (Double Helix II), or turned it from a nonkey into a key field (Reflex Plus). Here, Reflex Plus had a built-in advantage. Helix indexed the records permanently on disk, while Reflex Plus, which loaded all 900 records into memory, only had to manipulate the order of records in RAM. However, it took only a few seconds to save the reindexed Helix database. By contrast, when I tried to quit Reflex Plus, it asked if I wanted to save the changes. The only change was that I made a field into a key field. It took 1 minute to make that change on disk. At first Reflex Plus seemed slow, but it is still faster than Helix with a database this size.

What doesn't Reflex Plus do? Besides custom menus and dialog boxes, Reflex Plus still doesn't have graphic fields, macros, or a programming language. It is not a multiuser program and, probably for that reason, does not offer password security. However, if you can get by without these features, Reflex Plus is a fast, easy-to-use, highly visual, fully relational Macintosh database program that retails for about $200 less than its competition. ■

Besides custom menus, Reflex Plus still doesn't have graphic fields, macros, or a programming language.

ACKNOWLEDGMENT

The author gratefully acknowledges the help of Rick Larson of North American Services Software Division in Denver for his help in obtaining the benchmarks.

Charles Spezzano is the author of "Database Managers" in BYTE's Applications Software Today *(Summer 1987). He can be reached at 950 East Harvard Ave., Denver, CO 80210.*

Transparent Conversions? Hah!

Jerry Pournelle

QuickBASIC 4.0 vs. Turbo BASIC and "Jerry's Choice" Awards for 1987

It has been quite a month, what with getting *Prince of Mercenaries* finished, going off to New York to make speeches and confer with my editors about *Wrath of God*, keeping up with the columns, and so forth. Meanwhile, it's time for my annual purely subjective awards for last year's most useful products.

The New York trip was fun. Ed Yourdon hosts an annual gathering for authors who write books for the Yourdon imprint at Prentice-Hall, and he wanted someone to talk about modern technology, writing, and the future. The neat part was that he had some other speakers, so I learned a lot about publishing.

I'd meant to have this column written by now. I even set aside the whole weekend to get it done. Alas, the fates intervened. For my sins, I decided to translate a GWBASIC program into both Microsoft QuickBASIC 4.0 and Borland Turbo BASIC before I started. That shouldn't have been hard, right? I mean, the program ran fine in interpreted BASIC; how hard could it be to compile it?

Hah. I soon learned, and if I never see another GOTO statement, it will be too soon.

A Simple Job

What happened was that a couple of years ago we decided to turn Mrs. Pournelle's reading instruction system, which then existed as a series of paper workbooks, into a program for the IBM PC and compatibles.

This was long enough ago that I was still very much a BASIC enthusiast. I had the notion that it ought to be a fairly simple job, and that BASIC was the obvious choice of language. After all, once it was written, Roberta could learn enough BASIC to modify and maintain it, and I wouldn't be wired into the loop. We did an analysis of the program requirements, and it didn't look complicated; indeed, it all seemed pretty simple.

Alas, time went by, and I never got a chance to do the program, but people kept asking us about it. Clearly, something had to be done.

That was when we asked Bruce Tonkin of T.N.T. Software to help us. Bruce writes all his software in BASIC and has done some amazing things with it. He's got a wide variety of products, all at low cost. His My Word! text editor competes in features and ease of use with some of the expensive ones, but it sells for less than $50. You can even buy the source code (in BASIC). It's always worth having Bruce's latest catalog. Anyway, Bruce took Roberta's notions and her paper worksheets and turned them into a GWBASIC program that presented the lesson elements quite well.

Just about then we got interested in the Atari ST, and Alex Leavens—"alexl." on BIX—did a C version that makes use of the GEM interface on that machine. No one had time to work on the IBM PC version until the Atari ST version was done; but just this month the Atari version was finished.

The PC version hadn't been completely neglected. Our friend Joyce Jumper plugged away at it. In particular, she added a bunch of visuals clipped from the various Fontasy libraries. The Fontasy art folders have a wide variety of interesting sketches and drawings, ranging from people working to bundles of firecrackers going off. The visuals are mostly intended for printing by desktop publishers, but they look fine on a PC screen.

Joyce set things up so the program can use the illustrations as rewards when the students get things right. She also added a number of tunes that the machine will play. (Naturally, we set it up so nothing interesting happens if the pupils get things wrong: after all, you don't want them to make mistakes just to see the error messages. . . .)

Meanwhile, Roberta had learned a lot from finishing off the Atari ST version of her program. No matter how much planning you do, when you actually get a program out there in testing, you'll find you've left out a number of things, and some of them, particularly in the user interface, will be important.

Naturally, Roberta wanted to incorporate her new features into the PC version. Unfortunately, interpretive BASIC isn't really ideal for as large and complex a program as this had become. Roberta is pretty new to programming, and this was just too much.

There was also the problem of marketing a program written in GWBASIC. Not everyone has BASIC. If your program is in interpreted BASIC, you have no choice but to distribute the source code. This may be no tragedy, but publishers don't see it that way. Also, GWBASIC can be pretty slow. It was clearly time to do something about it.

At this point, I must have taken leave of my senses. "I'll take care of it," I said. "I'll just translate the program into a compiled BASIC. Shouldn't take long." Hah.

Conversions

I suppose I should have known better, but after all, the program was running fine on Atilla the Honey, Roberta's AT&T PC 6300 Plus. It takes scads of files: as it's set up at present, there are some 65 lessons, and each lesson has a lesson-text file, a banner file that contains an illustration used to begin the lesson, and a reward file with more illustrations.

continued

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future.

Clearly, the files should be consolidated, but that's no great trick. Transferring all those files took time, but that wasn't a problem either. Eventually, everything, including the ASCII GWBASIC source code, was on one high-density floppy disk, and I was ready to get started.

The next step went well, too. I copied all those files onto Fast Kat, the Kaypro 386, brought up Turbo BASIC, imported the GWBASIC source code, and told Turbo BASIC to begin compiling. There was one error, a missing REMARK symbol. Turbo BASIC's integrated editor dropped me out precisely where the error was. In seconds that was fixed, and in less than a minute, the program had compiled just fine. Turbo BASIC compiles *fast*.

Running it was a different matter. The program started fine, but then it left out great hunks of the lessons. There weren't any reward illustrations, nor any tunes played. When the first lesson was done, it told me I'd completed the entire reading program. Clearly, there were a few more problems than I'd anticipated. Still, this couldn't take long. After all, I started with a working program.

Terminate the GOTO

The first thing was to get inside the program. It couldn't be too hard to understand, because the program itself is simple: it puts up text on the screen to be read by the instructor (who can be any literate person); then it puts up simple exercises for the student who's trying to learn to read; and, depending on the student's answers, it gives more instructions and more exercises. That shouldn't be too hard to follow. . . .

Alas, I'd reckoned without the GOTO statement.

Back when I first began writing this column, we had a considerable debate about GOTO: should the statement exist in modern computer languages? I took the view that it wasn't inherently bad and sometimes was the cleanest way out of a complex nest of conditionals and loops. These were times not so long after Edsger Dijkstra wrote his now famous piece, "GOTO Seen Harmful," and the craze for structured programming began. I believed in top-down structure, but I wasn't ready to give up GOTO.

I am now. Bruce Tonkin is probably as good a BASIC programmer as there is today, and the code he wrote works flawlessly in interpreted BASIC. He provides plenty of comments. Even so, I found it nearly impossible to follow the program flow without making extensive flowcharts and diagrams. Every time I thought I'd found a program thread, I'd come across something like the code in listing 1.

Incidentally, line 10070 was the one that caused the only compiler glitch: it needed a ' after the last colon and before TEACHER'S TEXT. Anyway, there were dozens of statements terminating in GOTO. It was clear they were part of the lesson parsing system, and if I looked at the code long enough, I could sort of see what was going on; but it wasn't easy.

It was also clear that this was the block where the program was going wrong. For some reason, Turbo BASIC was taking those instructions and doing something entirely different from what interpreted GWBASIC was doing.

There were also statements like 54140 IF ANSWER$ = CHR$(0)+CHR$(80) THEN RETURN:ELSE BOX = 7:GOSUB 52000. The Turbo BASIC manual says that's illegal. To be exact, it says: "The following statement will not compile: IF *a* < *b* THEN *c* = *d* : ELSE *e* = *f*."

That's all well and good, but 54140 didn't upset the compiler at all. That was a bit frightening. If it wasn't even supposed to compile, there was a good chance that the program wasn't doing anything like what I wanted it to do. Time to see. I turned on Trace.

The result was a disaster. Our program draws things on the screen. Trace tries to put numbers and messages on the screen while the program is running. The result was a colossal mess: our data and Trace's statement numbers all mixed together. I didn't learn a thing.

All right, time to do some rewriting. In particular, the code in listing 2 not only will compile, but it will accomplish what the interpreter does with the original statement. It's also a lot easier to read. I used the Turbo BASIC editor to find every instance of ELSE and rewrote each of those statements. There were a lot of them.

When I was done restructuring the ELSE statements, the program worked better, but it still did very odd things. By then, I was about out of time. Then I remembered something. I'd recently received a production copy of Microsoft QuickBASIC 4.0 to replace the beta-test copies. If anything would compile a Microsoft BASIC program, it ought to be a Microsoft BASIC compiler. The only reason I hadn't used it in the first place was that Turbo BASIC was already on my hard disk. I'd have to install QuickBASIC 4.0 eventually; why not now?

Listing 1: *The section of the GWBASIC code where the conversion problem was discovered.*

```
10040 IF FLAG=1 THEN GOSUB 54000:BOX=7:GOSUB 52000:GOTO
            11000:'SCREEN COMMAND
10060 IF FLAG=0 OR FLAG=9 THEN GOSUB 54100:GOTO 11000
10070 IF FLAG=5 THEN BOX=2:LSET SMALL$(LINE.COUNT):GOSUB
            54300:GOTO 11000:TEACHER'S TEXT
10080 IF FLAG=4 THEN X=1:WHILE X<LEN(S$(LINE.COUNT)):GOSUB
            51000:WEND:GOTO 11000
```

Listing 2: *An example of an* IF. . .THEN. . .ELSE *statement rewritten for Turbo BASIC.*

```
54140 IF ANSWER$ = CHR$(0)+CHR$(80) THEN
          RETURN
      ELSE
          BOX = 7
          GOSUB 52000
      END IF
```

QuickBASIC 4.0

Microsoft QuickBASIC 4.0 (which I'll call QB4 from here on) comes with a *lot* of files and libraries and such, and the program needs access to all of them. Putting all that stuff in one subdirectory makes intolerable clutter; it's better to break things up into a number of subdirectories.

Turbo BASIC has a configuration option that makes it easy to tell the program where to find the auxiliary files it needs. Alas, QB4 doesn't have that feature. You have to put the locations of your libraries and such in the PATH, and changing the PATH requires editing AUTOEXEC.BAT. When I did that, I discovered that my PATH command was now longer than a logical line, so I had to find things to eliminate from it. There were more annoyances like that, but eventually I had QB4 installed.

continued

Listing 3: *The final working version of the* IF *statement.*

```
10070 IF FLAG=5 THEN             ' THIS IS TEACHER'S TEXT
        BOX=2
        LSET SMALL$(LINE.COUNT)
        GOSUB 54300
        GOTO 11000 ' 11000 is SCREEN command
     END IF
```

First thing, then, was to feed in the original program that ran under GW-BASIC. It wouldn't compile. QB4 kept telling me I had a duplicate definition of a variable named TEACHER. This made so little sense I wanted to sit down and cry. The program doesn't have a variable named TEACHER. There was a TEACHER$, but . . .

Then I remembered something. Turbo BASIC wouldn't compile the program because it expected a remark delimiter; suppose QB4 saw things differently? Looking up variables in the QB4 documents index, I discovered that the $ at the end of the variable isn't part of its name; in other words, QB4 won't permit you to have both TEACHER and TEACHER$ as two different variables, and it was interpreting that TEACHER in 10070 (listing 1) as some kind of variable reference, probably a function call. Putting the REM delimiter in the appropriate place cured that problem, and the program compiled just fine.

When I ran the program under QB4, I got *exactly* the same errors I'd gotten with Turbo BASIC. The same parts of the lessons were omitted, no tunes were ever played, and the same garble appeared in the same place on the screen.

Since the two programs were reacting in the same way, it seemed reasonable to feed QB4 the new source code as I'd modified it for Turbo BASIC. Not only did that compile without a glitch, proving that Turbo BASIC and QB4 use pretty much the same syntax, but when I ran it I got the same result: the cleaned-up code ran better, but there were still plenty of errors.

By then, two things had happened: I'd used up a whole day, and I had the suspicion that both Turbo BASIC and QB4 were interpreting single-line IF statements one way, and Microsoft BASIC was interpreting them in another. The way to prove that was with Trace. I hadn't read anything about QB4 Trace, so I didn't expect much, but it couldn't hurt to try.

Now That's a Trace!

QB4's Trace doesn't work anything like Turbo's, or for that matter, BASIC Trace. When Trace is on, QB4 swallows the program screen and flickers to the edit screen, where it highlights the statement now being executed. If there's new output to the program screen, it toggles back there.

The whole thing goes in slow motion, so that if you've got big loops, it can take forever, but the simple answer to that is to put TROFF (Trace Off) and TRON (Trace On) statements around places that you're sure work properly. Alas, in my case, there were so many GOTO statements scattered throughout the code that this was nearly impossible, so I was forced to sit there and watch the program draw lines and boxes a character at a time. The effort was worthwhile, though; in an hour, I had figured out what was wrong.

It was indeed those IF statements. There was no quick fix: I'd have to do some editing. A couple of hours later, it was done. All the IF statements had been broken up to look like those in listing 3, which, if nothing else, are a lot easier for humans to read. It seems to be easier for the compiler, too: once I'd done that, the program ran fine.

There were a couple of bugs I didn't much care for, but when I told Roberta about them, she said they were in the interpreted version, too. I spent a couple of hours cleaning them up. When I was done, the program ran better than it ever had; and now that it's all laid out in pretty print, it won't be so hard to change. There are still blocks of GOTO spaghetti, but I was able to convert some of those blocks into subroutines and replace others with functions. After a while, the code looked pretty clean.

Once I got the program running in QB4, I fed the code back to Turbo BASIC. QB4 and Turbo BASIC use the same syntax for subroutines, so those were not a problem. Functions are handled in about the same way, but the syntax used to define them is different; it took a few minutes to make the conversions. After that, the program ran fine in both Turbo BASIC and QB4.

The moral of the story is simple: it may be efficient to pack lots of statements on each line, and certainly that saves memory; but it's not good practice. Neither is extensive use of GOTO statements, even when you're using them to structure the code. Edsger Dijkstra was right. GOTO is harmful.

The Great Compiler War

Competition is a wonderful thing. For years, Microsoft didn't have a BASIC compiler. The only real competition was CBASIC, which "compiled" to a kind of p-code and interpreted that. Then Gordon Eubanks began developing a true compiler for CBASIC, and shortly thereafter Microsoft announced BASCOM.

BASCOM went through a couple of improvement cycles, none spectacular, and emerged as QuickBASIC 2.0. QB2 wasn't as good as compiled CBASIC, but it wasn't bad, and it did have the merit of letting you develop programs in interpreted BASIC before compiling them. Compiled CBASIC could have given BASCOM/QB2 some real competition, but it was about then that Digital Research went into a funk and let all its languages languish, suffer, and darned near die.

Then Borland began development of Turbo BASIC. The word was that it would have an integral editor (as all Borland language products do) and a lot of other features that QB2 didn't have.

Microsoft's response was interesting: The company put not one, but *two* teams of first-class programmers on the job. Team One was told to develop the best BASIC compiler they knew how to write.

Team Two had an unenviable assignment: come up with enough kludges to QB2 to let Microsoft hold some kind of defensive position when Turbo BASIC came out. It seems clear to me that Microsoft was afraid Turbo BASIC would do to BASIC what Turbo Pascal has done to Pascal: dominate the market so thoroughly that the BASIC compiler Team One was developing wouldn't have a chance.

Team Two finished QB3 just about the same time that Borland was able to ship Turbo BASIC; and while QB3 was, at bottom, a kludge, it wasn't all that bad a kludge. It didn't have all the features of Turbo BASIC, but it did have an integral editor, and overall it was good enough to keep Microsoft in the ball game.

As it happens, Team One finished sooner than anyone had expected, so that QB4 followed close on the heels of QB3, close enough that it looked like it might be no more than an improved QB3; but that wasn't the case. Microsoft QB4 is an entirely new and different product, written by a different team, and has very little to do with QB3.

It does fix most of QB3's mistakes. As

continued

an example, whereas QB3 had an entirely different version to compile programs for systems with math chips, QB4 simply uses the math chip if it's available and otherwise does without.

More importantly, QB4 has many features QB3 didn't attempt. QB4 supports recursion. It can handle modular compilation: you don't have to recompile everything every time. It has good data structures, including records.

Probably the most spectacular new features are the debugging routines. QB4's Trace is enormously powerful. You can stop the program, make minor changes, and resume it. If you try to make too many changes, the program warns you that you'll have to recompile and start over, but it gives you a chance to abort the changes.

You can set multiple breakpoints to temporarily stop the program. There's a History routine that preserves information about where the program had been before it was stopped. There's a Watch Window, where you can observe the changing values of specified variables. All told, the QB4 debugging tools are the most powerful I've ever seen for any BASIC.

The other fundamental difference is that QB4 "compiles" the code as you write it. Of course, you have to write it within the QB4 editor to get that feature, but that's no great hardship: the editor is well-designed and, unlike the Borland editor, works with a mouse (my Logitech Mouse worked fine).

If you really want to use your own programming editor, QB4 will compile the program as it reads it in—although if my experience with the "duplicate definition" is any indication, it isn't all that good at locating syntax errors. If you use the QB4 environment to write your code, you won't get any syntax errors: QB4 parses each line before "compiling" it.

This isn't true compilation: what QB4 is doing is translating your code into a Forth-like threaded code, not assembly language. The resulting threaded code isn't as fast as true compiled code, but it has the great merit of being easily traced. When you're finished with the program, you do an entirely different operation that produces real assembly language code, so that you end up with a stand-alone program.

QB4 really is a new product, written from scratch. There are inevitable bugs, which I have no doubt that Microsoft will correct; I expect QB4.1 by spring. So far, I haven't encountered any serious bugs, but I've heard of some.

It mildly bothers me that the "compiler" that produces memory code isn't the same as the compiler that produces the final product you'll eventually run, and I wonder if there are any hidden traps there. After all, I have good reason to know that just because a program will compile, that's no proof that it will do what you want it to. On the other hand, it doesn't bother me enough to keep me from using QB4.

I haven't done any tests on the final output of QB4 versus Turbo BASIC. The fact is that I have both compilers, and once I've developed Roberta's program, I'll try it with both; their syntaxes are sufficiently close to make that simple. Then I'll test them and see which is fastest, has the smallest code, and so forth. Whichever produces the best final code, though, there's no contest about which is the best programming environment. Microsoft wins that hands down because of the debugging tools. QB4 is a serious language, quite good enough to develop any program you like.

At the moment, then, Microsoft is winning the BASIC battle in the Compiler War. I'd recommend that serious BASIC programmers get both compilers.

continued

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It's Flat!

I don't suppose anyone is happy with CGA. Everyone *wants* higher resolution and better graphics. Now we have several ways to get them.

The opening move was made by NEC when that company brought out the MultiSync, a monitor that works on anything from simple monochrome to the Professional Graphics Controller (PGC). I've had one of those attached to the Golem, the huge CompuPro system that practically runs Chaos Manor, for several years now, and it has given me yeoman service. It's also the test monitor when we get new video boards.

After the MultiSync came others, and for a while it looked as if multiple-sweep-frequency monitors were the wave of the future as more and more programs were written for the EGA standard.

Then Orchid, and later Zenith, came up with a new philosophy: instead of putting the smarts in the monitor, put them in the video board. That way you can get the best monitor you can afford, add a multiple-choice video board, and run programs that output monochrome, CGA, EGA, and PGC all on the same system without hassles.

Orchid chose to let its TurboPGA board run with any multiple-sweep-frequency monitor.

Zenith, long one of the industry leaders in monitor technology, had another approach. The company designed its board to run with its flat tension mask (FTM) monitor and made that monitor run on 31.5-kHz *analog* signals, while the board can digest anything from monochrome through VGA.

The result is pretty spectacular. The FTM monitor can be tuned so that the screen is absolutely black. Colors are just gorgeous; they really stand out against that black background.

Everyone who's come upstairs since I set up the FTM monitor with the Z-449 video board has been impressed. The colors are really striking. Oddly enough, though, most think the screen is concave. That's an illusion: it really is flat, but we're so used to convex screens that bulge out at us that at first the ZCM-1490 FTM monitor really does appear concave. The illusion vanishes after you work with it awhile.

The ZCM-1490 has a 14-inch screen, but the images are so crisp that it appears bigger. It is certainly good enough to sit and work at all day. Larry Niven is about to buy a new computer system—I've recommended the new Zenith Z-386—and he very much likes my Electrohome Color Display ECM 19 (19-inch multiple-sync monitor). Before I let him spend the money, though, I'm going to have him look at the ZCM-1490. He may get the Electrohome monitor anyway, but then, he can afford it.

The highest resolution from the Zenith Z-449 video board isn't as sharp as the best from the Orchid TurboPGA, but it's close.

I had the traditional problems with the Zenith manuals, trying to figure out the switch settings; the board didn't come with the right defaults, and when I first powered things up, it wouldn't automatically switch from EGA to CGA, so that CGA was squished into two images on the screen. Fifteen minutes spelunking the Z-449 manual fixed that, and now everything works fine.

There is one problem with the ZCM-1490 monitor: it doesn't have a degaussing button. Both my Electrohome and Intecolor high-resolution monitors have that feature, and the ZCM-1490 needs it.

If you leave the monitor on long enough, especially in an electronically noisy environment (such as next to the Z-248 with its cover off), ugly patches in inappropriate colors appear on-screen. They're easily removed by turning the monitor (but not the computer) off for 30 seconds to a minute. This won't happen more than once a day. Degaussing takes about 10 seconds on my other monitors, so the time loss isn't significant; but I do wish Zenith had put the degaussing feature into the monitor.

Other than that, I love it. So will you, when you get used to having a screen that looks concave.

The Year's Most Useful

It's time for my annual awards. Do understand: these are purely subjective, and they're from Pournelle, not from BYTE. The ground rules are simple: something I acquired this year (no matter when it first came out), used a lot, and found to be the most useful thing in its class.

First, the Year's Most Useful Computer: the Kaypro 386 wins by a land-

continued

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In a recent AT compatible product comparison, *Infoworld* (4/87) stated *"...for overall best machine in power, the Proteus 286e is the clear winner. It offered the best CPU and hard disk random read/write performance of any machines tested, is remarkably easy to set up, and boasts the best support around. We recommend it."*
EDITOR'S CHOICE

"...There are so many nice aspects to Proteus and the company that makes it, there isn't room to cover them all."
Business Computer Digest (3/87)

PROTEUS SYSTEMS

MODELS	286E	286F	286GTX	386A
INTEL CPU	80286-10	80286-10	80286-12	80386
CLOCK SPEED	6/10MHz	6/10MHz	6/12MHz	6/16MHz opt. 20MHz
NORTON SI	10.1	11.5	15.3	23.5 opt. 31.6
BASE MEMORY	1024K	1024K	1024K	1024K to 4MB
WAIT STATES	ONE	ZERO	ZERO	ZERO
KBD SELECT SPEEDS	NO	YES	YES	YES
CLOCK, CAL/BATTERY ONBD	YES	YES	YES	YES
COPROCESSOR SOCKET	80287	80287	80287	80287/387
SERIAL PORTS	TWO	TWO	TWO	TWO
PARALLEL PORT	ONE	ONE	ONE	ONE
I/O SLOTS	EIGHT	EIGHT	EIGHT	EIGHT
HARD DISK-FD CONTROLLER	YES	YES	YES	YES
FLOPPY DISKS	1.2MB	1.2MB	1.2MB	1.2MB
360K OR 3.5" FD CHOICE	YES	YES	YES	YES
KEYBOARD TYPE	84 KEY	84 KEY	101 KEY	101 KEY
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slide. It isn't that the Kaypro is all that much better than other 386 machines; indeed, Kaypro has completely upgraded its 386 line so that the Kaypro 386 you can buy now is much better than the one I have. The important thing, though, is the 386, which is to the 286 what the 286 is to a CP/M 64K-byte 8080 system. I'm very fond of my Zenith Z-248, which is as good an AT system as I know of; but it can't match a 386 for utility. Fortunately for Z-248 owners, Zenith recently announced a 386 upgrade kit.

One reason 386s are so superior is DESQview 2.01, which wins my award for the Most Useful Software of the Year. DESQview will greatly improve a 286 machine provided that you have an AST RAMpage AT board; but the *real* improvement comes when you run DESQview with a 386. DESQview and the Kaypro 386 haven't quite solved all my problems—I still want more memory-resident programs than the system will handle—but it beats everything else I've tried, and I've tried a *lot* of things. Learning DESQview is no trivial task, but it has been a lot more than worth it to me. It doesn't hurt that the people at Quarterdeck pay a lot of attention to bug reports and fix things fast.

The Most Useful Portable is the Zenith Z-183 with hard disk drive, and although at 15½ pounds it's too heavy by half, I wouldn't be without it. The supertwist backlit screen is readable in any light, the machine is rugged as all get-out, and the keyboard is wonderful; I've written a couple of hundred thousand words on that machine this year. I showed the machine to my friend Norman Spinrad, and he decided to get one to serve as his only computer. The Z-183 has EGA video output he's feeding into a Zenith EGA monitor, and he got a DataDesk Turbo-101 (101-key) keyboard: there's an input jack for that on the Z-183.

I don't know what the category is, but DataDesk keyboards have been about as useful as anything I've gotten this year. I now have Turbo-101 keyboards on just about every machine in the house—including the Macintosh Plus. The Mac version of the Turbo-101 comes with some nifty software to define function keys and the like. I've had several people do double takes when they see what looks like an AT keyboard attached to my Mac, and the notion of function keys on a Mac startles just about everyone.

The Most Useful Software for Portables is LapLink, which transfers programs from desktop to portables and back. It's painless and extremely fast, and if you have a PCompatible portable, you simply can't afford to be without it.

continued

Items Discussed

Color Display ECM 1910........$2795
Electrohome Ltd.
809 Wellington St. N
Kitchener, Ontario
Canada N2G 4J6
(519) 744-7111
Inquiry 901.

Fontasy............................$69.95
Prosoft
7248 Bellaire Ave.
P.O. Box 560
North Hollywood, CA 91603-0560
(800) 824-7888
(818) 765-4444
Inquiry 902.

Megatrend
EGA version $1895
Intecolor Corp.
225 Technology Park
Norcross, GA 30092
(404) 449-5961
Inquiry 903.

MultiSync
II.....................................$899
Plus..............................$1395
XL.................................$3195
NEC Home Electronics (U.S.A.) Inc.
Computer Products Division
1255 Michael Dr.
Wood Dale, IL 60191
(800) 323-1728
(312) 860-9500
Inquiry 904.

My Word! $49
T.N.T. Software Inc.
34069 Hainesville Rd.
Round Lake, IL 60073
(312) 223-0832
Inquiry 905.

QuickBASIC 4.0 ....$99
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
(800) 426-9400
(206) 882-8080
Inquiry 906.

Turbo BASIC.....................$99.95
Borland International
4585 Scotts Valley Dr.
Scotts Valley, CA 95066
(408) 438-8400
Inquiry 907.

TurboPGA $1599
Orchid Technology
45365 Northport Loop W
Fremont, CA 94538
(415) 490-8586
Inquiry 908.

ZCM-1490...........................$999
Z-449 ....$499
Z-386 ....$6499
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 699-4800
Inquiry 909.

The Most Useful Writer's Tool is the Amdek Laserdrive/Microsoft Bookshelf CD-ROM package. Putting all those reference works on a single CD-ROM was a stroke of genius. I predict that within 5 years, professional writers will find Microsoft Bookshelf—or a similar CD-ROM reference library—as indispensable as we now find word processors.

Probably the most subjective award of the lot is the Text Editor of the Year. Writers don't just use editor programs, they have relationships with them. I've certainly had my ups and downs with mine; but the winner this year is Q&A Write, which, despite its faults, is the most transparent editor for text creation I've tried. XyWrite III Plus, WordPerfect 4.2, and Microsoft Word 4.0 are close competitors, and each has features that put it ahead of Q&A Write in some areas; but on balance I found Q&A Write clearly ahead in the critical particulars.

Fair warning: Gordon Eubanks and Brett Walters of Symantec have been extremely responsive to my suggestions, so that in part Q&A Write has been modified to suit my fancies. They've added a splendid word/line/paragraph count command, they're changing some of the print features, and they're doing some other stuff I wanted, including making it work well with Microsoft Bookshelf. It would be surprising if I didn't consider this my favorite text editor.

Any serious computer user needs not only a text-creation editor, but a programming and general-purpose editor: something to use to alter `CONFIG.SYS` and `AUTOEXEC.BAT` and that sort of thing. The General-Purpose Editor of the Year is Logitech's Point. This comes with the Plus Package, as well as with the Publisher Package, both of which include the Logitech Mouse. I'm fond of the Logi-

continued

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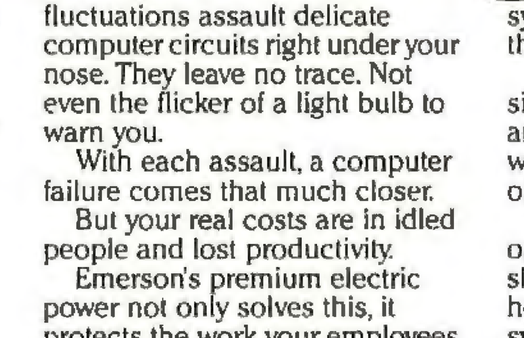

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Santa Ana, CA 92702

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★ "Jerry's Choice" ★ Awards for 1987 ★

☆ ***Most Useful Computer:***
Kaypro 386........................ $3995
Kaypro Corp.
533 Stevens Ave.
Solana Beach, CA 92075
(619) 481-4300
Inquiry 910.

☆ ***Most Useful Software:***
DESQview 2.01 ....$129.95
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica, CA 90405
(213) 392-9701
Inquiry 911.

☆ ***Most Useful Portable:***
Zenith Z-183...................... $3199
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 699-4800
Inquiry 912.

☆ ***Most Useful Software for Portables:***
LapLink $139.95
Traveling Software
19310 North Creek Parkway
Bothell, WA 98011
(800) 343-8080
(206) 483-8088
Inquiry 913.

☆ ***Most Useful Something:***
Turbo-101 Enhanced Keyboard $149.95
DataDesk International
7650 Haskell Ave.
Van Nuys, CA 91406
(818) 780-1673
Inquiry 914.

☆ ***Most Useful Writer's Tool:***
Amdek Laserdrive.................$995
Amdek
1901 Zanker Rd.
San Jose, CA 95112
(408) 436-8570
Inquiry 915.

Microsoft Bookshelf CD-ROM................$295
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
(800) 426-9400
(206) 882-8080
Inquiry 916.

☆ ***Text Editor of the Year:***
Q&A Write..........................$199
Symantec Corp.
10201 Torre Ave.
Cupertino, CA 95014
(408) 253-9600
Inquiry 917.

Runners-up:

XyWrite III Plus $445
XyQuest Inc.
44 Manning Rd.
Billerica, MA 01821
(617) 671-0888
Inquiry 918.

WordPerfect 4.2 ....$495
WordPerfect Corp.
288 West Center St.
Orem, UT 84057
(801) 225-5000
Inquiry 919.

Microsoft Word 4.0 ....$450
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017-9717
Redmond, WA 98073
(800) 426-9400
(206) 882-8080
Inquiry 920.

☆ ***General-Purpose Editor of the Year:***
Point, which comes bundled with the **Logitech Mouse** in the following packages:
Plus Package.........................$119
Publisher Package..................$179
Logitech Inc.
6505 Kaiser Dr.
Fremont, CA 94555
(415) 795-8500
Inquiry 921.

☆ ***Game of the Year:***
Wizard's Crown $39.95
Strategic Simulations
1046 North Rengsdorf Ave.
Mountain View, CA 94043
(415) 964-1353
Inquiry 922.

Runner-up:

Strategic Conquest Plus $59.95
PBI Software Inc.
1163 Triton Dr.
Foster City, CA 94404
(415) 349-8765
Inquiry 923.

tech 3-button mouse anyway; the neat part is that when you buy the mouse, you get some really useful software as well.

The Game of the Year is Wizard's Crown from Strategic Simulations. It's certainly the one I've spent the most time with. A close runner-up is Strategic Conquest Plus for the Macintosh. They're both pleasant ways to waste more time than I have available.

No More Eyestrain

The problem with naming the "thing of the year" is that a lot of good stuff doesn't fall into neat categories, and sometimes you can't pick just one. For example: 1987 was the year I finally solved my eye problems. First, I got an EGA board and the Intecolor Megatrend 19-inch EGA color monitor. That was more than good enough; indeed, when Larry Niven buys his new computer, he's going to get a 386 system, an EGA card, and either the Intecolor Megatrend or the Electrohome monitor.

Next, I installed the Orchid TurboPGA board and the Electrohome 19-inch multiple-sync color monitor. The Electrohome is perhaps not quite as crisp in EGA mode as the Megatrend, but it's hard to tell the difference; and, of course, this combination will perform with software that outputs monochrome, Hercules, CGA, EGA, and PGC, all more or less automagically. The PGC graphics are amazingly good.

Now we have the Zenith Z-449 board and Zenith's 14-inch ZCM-1490 FTM monitor. For years, I've been saying that 19 inches is just a tad large and 13-inch monitors are too small. My first monitor was a 15-inch Hitachi monochrome for my CP/M system; I'd have thought a 14-inch monitor would be too small, but the Zenith 14-inch isn't. Combined with my new computer glasses—focal length 28 inches—I can see that screen fine.

I'll stick with the 19-inch because when Niven and I work together, it's handy if we can both see the screen from a distance; but the 14-inch Zenith would really be good enough. So how do I pick a "year's best" out of that group? I'm not going to try. I'll just say that if you do much writing with computers, any one of these will help you a lot. You can't be too kind to your eyes.

Fair Warning

Every now and again I see computers—usually offshore-constructed clones—run at amazing speeds, but when I look inside, the critical parts are ordinary chips. "We select the good ones," one exhibitor told me at COMDEX. "Try a lot until we find parts that work."

That sounds right, but it isn't, at least not in the case of Intel chips. I've been talking to a former Intel designer, and he tells me that Intel has very elaborate test equipment.

When Intel makes a batch of expensive parts—say, 386 or 387 chips—they're put into the automated test setup and run at the highest possible speed. Most of them fail those tests; the few that pass are then certified for that speed and sold at a premium.

The rest of the parts are tested again at lower speeds. Those that pass get certified; the others are tested at still lower speeds and become the "ordinary" stock. A few don't pass tests at even the minimum speed and are discarded.

The point is, every "ordinary" chip Intel sells has *failed a test* at higher speeds. That's guaranteed. The failure the part experienced may not be critical. Intel has excellent test equipment and can find failures that may never show up in ordinary use—but how could you know what the failure was? It might be in a little-used area, but even little-used features can be critical. So while it's fun to crank up the speed on your system, it's guaranteed that if you run Intel parts much above their certified speed, you'll get failures. Murphy's law will take care of the rest.

Winding Down

As usual, I'm out of space long before I have run out of material. I spent the day installing an AST RAMpage board in the Zenith Z-248 so I could run DESQview. It all works, but I sure learned a lot. Then too, from here I can see Paradox and Condor, two relational databases; Quattro, Borland's new spreadsheet; a bunch of communications programs; stacks of stuff for the Macintosh; Turbo Tax for the IBM PC; and a partridge in a pear tree. There are also two large Federal Express boxes from BYTE in New Hampshire.

The most important package, though, is a new Unix system for the AT&T PC 6300 Plus. I want to compare it to OS/2. I've never been a great Unix fan because Unix is big and slow and takes up so much room on a hard disk—18 megabytes for the on-line manuals alone—but OS/2 seems no smaller or faster, while hard disk capacity per dollar has grown so fast that 100-megabyte systems will soon cost less than OS/2.

With luck, I'll know more about that next time. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on BIX as "jerryp."

"It's 6:33 pm. The lines are down. And she's the closest thing I've got to a technician.

Meanwhile, I've got a sales guy here waiting to close a half-million-dollar deal, and he's screaming 'why didn't my order go through.' I have no clue. My technical staff is home watching the game. And all I keep thinking is whatever happened to that word reliability? If I could have anticipated the problem, at least I would have had a chance. As far as I'm concerned, somebody at headquarters better start talking to AT&T about getting a network management system. Or they can find themselves a new whipping boy.

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Annual Revelations

Ezra Shapiro

A plea for smarter computers, and Ezra's annual list of favorite things

In some ways, owning computers is like being a parent. I often find myself wishing my "children" had more memory, did their chores faster, and required less nagging. And I upgrade my system with add-ins, add-ons, and accessories with the same sinking feeling in the pit of my wallet that a parent experiences buying clothing for a rapidly growing infant.

I can't push this analogy too much further; I don't know a single family that sells off its kids every couple of years to buy new ones (though I've heard more than a few parents mutter wistfully that they'd like the opportunity to do so).

The frustration of computer ownership, however, is worse in one respect. There are at least some certainties to raising children; you know that in a predictable number of years, they'll grow out of infancy, out of adolescence, move away, and probably start cleaning up their own rooms. In contrast, I keep waiting for my machines to show signs of increasing maturity, but nothing seems to happen.

Once a year, I write a column that catalogs my own extremely personal choices in software and hardware, and this is the month for it. I strongly believe that confessing my prejudices provides a necessary foundation to the column; if you know I use WordStar, for example, you'll be able to take my dislike of some other word processors with a grain of salt.

As I began compiling my list, I noticed that although there have been major changes in my computing environment, the nature of the tools has changed very little in the past few years. Sure, everything has gotten faster and more powerful, but the systems have not gotten perceptibly smarter. I'm still telling my electronic children what to do in words of one syllable, and I'm still picking up after them.

So I offer the following challenge to the computer industry: You've proved that you can design systems that follow orders perfectly. Now give us systems that can anticipate them.

Software that senses the presence of video boards and numeric coprocessors is a step in the right direction. So are natural-English query languages. But I want more.

I want a computer to say to me, "Ah. I see from the filename that you're writing your BYTE column. I'll just go ahead and load all the desk accessories you normally use for that." Or, "You seem to make typos involving transposed characters more frequently than other spelling mistakes, so I'll look for the transpositions first." Or, "When you set margins for your letterhead, the document almost always gets sent to the laser printer. Articles usually get sent as ASCII files via the modem. I'll just load the appropriate drivers for you."

To do this sort of thing today, I have to spend hours with installation and macro programs. I want my computers to be able to figure it out for themselves. I don't want to have to say a thing.

Right now, everyone is excited about adding graphics interfaces and programming languages to the environment, be it HyperCard or SQL. To me, that's just another way of phrasing the orders. Why not provide tools with some smarts? It's time to help the kids grow up.

The Soft Set

On the MS-DOS side of my computer table, I'm now using three word processors, so help me. For short documents, I'm back to WordStar, my old favorite. The upgrade to 4.0 convinced me to start using it again, and it's more than adequate for my basic needs. For longer pieces, or ones where I need computational or database operations, I'm still using Framework II. After 2 years of Framework, it's comfortable—and as Mac-like as I need.

When I've got arcane manipulations to perform, I switch over to XyWrite III Plus. I was reluctant to try it, but it's the quickest of the three editors, extremely adept at block operations, and marvelously programmable. Even if I have to haul out the manuals, I find it easier to program XyWrite than to program Framework.

My set of memory-resident programs hasn't changed at all in the past 12 months. Aside from device drivers, I use Cruise Control, Revolution Software's magnificent program to optimize cursor speed and action depending on the foreground task; MemoryMate, Michael Fremont's free-form text database with a reminder tickler; and Ready!, the outliner from Living Videotext.

For big-league database functions, I like Borland's Reflex and Paradox. Reflex is great for analytical jobs, but it's limited to database files that fit in RAM. Paradox is the big guy for large projects. I've changed spreadsheets from Framework II to VP-Planner Plus. Now that VP-Planner is macro-compatible with Lotus 1-2-3 and features simplified menus, I'm satisfied with it. For telecommunications, I'm using Mirror II.

Over on the Mac, Microsoft Works is my primary writing tool, equipped with Lundeen & Associates' WorksPlus Spell and WorksPlus Command. WorksPlus Spell adds the best spelling checker I've ever used, and WorksPlus Command is a full macro environment—not only does it record and play back keystrokes and mouse movements, it also generates editable Pascal-like code.

continued

Ezra Shapiro is a consulting editor for BYTE. Contact him at P.O. Box 146069, San Francisco, CA 94114, or on BIX as "ezra." Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

Items Discussed

Cruise Control $29.95
Revolution Software Inc.
715 Route 10 E
Randolph, NJ 07869
(201) 366-4445
Inquiry 934.

Desktop Express $149
Dow Jones & Co. Inc.
P.O. Box 300
Princeton, NJ 08450
(609) 452-2000
Inquiry 935.

Excel (Mac)........................... $395
Microsoft Works (Mac)............ $295
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
(206) 882-8080
Inquiry 936.

4th Dimension $695
Acius Inc.
20300 Stevens Creek Blvd.
Suite 495
Cupertino, CA 95014
(408) 252-4444
Inquiry 937.

Framework II........................ $695
Ashton-Tate
20101 Hamilton Ave.
Torrance, CA 90502-1319
(213) 329-8000
Inquiry 938.

GraphicWorks 1.1.............. $79.95
Mindscape Inc.
3444 Dundee Rd.
Northbrook, IL 60062
(312) 480-7667
Inquiry 939.

MacCalligraphy................. $149.95
Enzan-Hoshigumi (USA)
P.O. Box 131
Still River, MA 01467
(617) 456-8255
orders: (800) 962-6686
Inquiry 940.

MemoryMate $69.95
Broderbund Software Inc.
17 Paul Dr.
San Rafael, CA 94903
(415) 492-3200
Inquiry 941.

Microphone $149
Software Ventures Corp.
2907 Claremont Ave.
Suite 220
Berkeley, CA 94705
(415) 644-3232
Inquiry 942.

Mirror II $89.95
SoftKlone Distributing Corp.
1210 East Park Ave.
Tallahassee, FL 32301
(904) 878-8564
Inquiry 943.

More.................................. $295
Ready! $99
Living Videotext Inc.
2432 Charleston Rd.
Mountain View, CA 94043
(415) 964-6300
in California: (800) 443-4310
orders: (800) 822-3700
Inquiry 944.

PageMaker $495
Aldus Corp.
411 First Ave. S
Suite 200
Seattle, WA 98104
(206) 622-5500
Inquiry 945.

Paradox 1.1 .... $495
Reflex Plus (Mac) $279
Borland International
4585 Scotts Valley Dr.
Scotts Valley, CA 95066
(408) 438-8400
Inquiry 946.

PowerStation...................... $59.95
Suitcase $59.95
Software Supply Inc.
599 North Mathilda Ave.
Suite 210
Sunnyvale, CA 94086
(408) 749-9311
Inquiry 947.

QUED/M $119
Paragon Concepts
4954 Sun Valley Rd.
Del Mar, CA 92014
(619) 481-1477
Inquiry 948.

QuicKey $99.95
CE Software
801 73rd St.
Des Moines, IA 50312-1051
(515) 224-1995
Inquiry 949.

SuperGlue......................... $89.95
SmartScrap and
The Clipper $59.95
Solutions
29 Main St.
Montpelier, VT 05602
(802) 229-0368
Inquiry 950.

SuperPaint $149.95
Silicon Beach Software Inc.
9580 Black Mountain Rd., Suite E
San Diego, CA 92126
(619) 695-6956
Inquiry 951.

TOPS/DOS (MS-DOS)............. $189
TOPS for the Macintosh $189
TOPS FlashCard (PC AppleTalk card)................................ $239
TOPS
2560 Ninth St., Suite 220
Berkeley, CA 94710
(415) 549-5900
Inquiry 952.

VP-Planner Plus $179.95
Paperback Software International
2830 Ninth St.
Berkeley, CA 94710
(415) 644-2116
Inquiry 953.

WordStar Professional 4.0........ $395
MicroPro International Corp.
33 San Pablo Ave.
San Rafael, CA 94903
(415) 499-1200
Inquiry 954.

WorksPlus Command $99.95
WorksPlus Spell $59.95
Lundeen & Associates
P.O. Box 30038
Oakland, CA 94604
(415) 893-7587
Inquiry 851.

XyWrite III Plus $395
XyQuest Inc.
44 Manning Rd.
Billerica, MA 01821
(617) 671-0888
Inquiry 852.

Occasionally, when I'm working with ASCII files, I'll shift over to QUED/M from Paragon Concepts, a nifty programmers' editor that implements the full Unix wild-card search system. I keep Microsoft Write around on the hard disk merely to convert MacWrite files into something usable.

My databases are in Reflex Plus, though I'm building an accounting system in 4th Dimension. Excel is the spreadsheet of choice. For graphics, I usually use SuperPaint, but I occasionally play with both MacCalligraphy and GraphicWorks. My favorite layout program is PageMaker 2.0a.

Communications are handled with Software Ventures' Microphone 1.1; I use Desktop Express from Dow Jones to communicate with MCI Mail. Is an outline conceivable without More from Living Videotext? Of course not. I'm also high on SuperGlue (the print-to-disk driver from Solutions), and I use SmartScrap and The Clipper, desk accessories from Solutions that simplify using graphics fragments in other programs.

In the past few months, I've picked up a number of new utilities for the Mac. Suitcase lets me cram my menus with far more desk accessories and fonts than Apple allows. PowerStation is a Finder replacement that I find extremely useful in the confusing maze of windows generated by MultiFinder. Both are from Software Supply.

I've just purchased QuicKey, from CE Software, which lets me assign mouse movements, menu selections, and text to keyboard commands of my own choosing. I haven't worked with it long enough yet to tell if I really like it.

The Hard Set

There's been a lot of hardware activity in the past 12 months; 1987 was a year for replacements. My old Compaq portable made way for a Tandon PCA-40, a 286/EGA box with a 40-megabyte hard disk drive and a single high-density floppy disk drive. I've added a Logitech Bus Mouse and MicroSpeed's FastTRAP trackball device, and I switch between the two depending on mood. I'm being won over by the trackball, but since it uses my one lonely serial connector, I switch to the Bus Mouse when I know I'm going to need the port.

One of the Tandon's slots has an AST Premium RAMpage board, and another holds a TOPS FlashCard AppleTalk board. The Compaq lives on, by the way. Since I haven't gotten around to installing a 360K-byte drive in the Tandon, I use the Compaq to format disks—a lowly fate for a machine that provided flawless performance for 2½ years of nearly continuous use, including 15 months spent running a bulletin board system.

The real excitement has occurred on the Macintosh side of my worktable. The Mac Plus and DataFrame 20 combo has been lent to a rabid computerphobe who was once forced to use MultiMate on an IBM PC XT. The Mac seems to be healing those deep scars; she's now sitting down at the computer *voluntarily*.

I'm using a new Macintosh SE with Apple's stock hard disk drive and an external Jasmine 160 drive. Less than a month after I purchased the computer, I ripped out the factory-installed memory and dropped in 4 megabytes of 120-ns Lightning single in-line memory modules. I also bought myself a Radius Accelerator 16 card, and it's wonderful.

I chose the Radius for two major reasons: price and convenience. At $995, it's half the price of many other boards. And since I test software, it's often necessary for me to shut off the accelerator and deal with a stock SE. By holding

continued

The QMS has sold me on laser printers as the greatest thing since sliced bread.

down the mouse button on start-up, the Radius gives me the option of shutting off either the code cache, the data cache, or the whole thing.

Since the Mac itself is becoming a memory hog with MultiFinder and HyperCard, I also appreciate the fact that the card uses motherboard RAM. While it might not be as blazingly fast as accelerators with on-board memory, I didn't have to buy 4 megabytes of chips for both the 68000 *and* the 68020. I'll concede that other accelerators might be a hair faster, particularly for number crunching, but Radius gives me text scrolling so fast I can't make out the words as they fly by. In graphics programs, objects that used to jump slowly across the screen trying to keep up with the cursor now slide easily.

For printers, I have an Okidata Microline 192, an Apple Imagewriter II, and a QMS-PS 800 laser printer. The Okidata is hooked to the Tandon, the Imagewriter II plugs into the Mac, and the QMS is on the TOPS network so both computers can have access. The Okidata has performed well for 2½ years. The Imagewriter II is a recent addition, but a glance at the guts has convinced me it's the most solidly built printer I've ever owned. The QMS handles the bulk of the printing around here, and it's sold me on laser printers as the greatest thing since sliced bread.

The whole system is cabled together using TOPS networking software, the TOPS FlashCard in the Tandon, and PhoneNet connectors and wiring from Farallon.

Apology to Microsoft

In January, I attacked Microsoft for the inability of both Word 3.01 and Works 1.1 on the Macintosh to eliminate blank lines during a mail merge. I was half right. Word has problems, but Works does kill a blank line if it contains nothing but a null field. However, this feature is undocumented in both the original Works 1.0 manual and the pamphlet that accompanies the 1.1 update. According to Tim Lundeen, one of the authors of Works, the documentation was frozen before the software was finished. Silly me to trust the manual! Sorry, Microsoft.

On the Right Track

My December column, in which I mentioned a digital control system for Märklin model trains, prompted a brief note from Richard F. Dermody, coordinator of the Computers in Model Railroading special interest group of the National Model Railroad Association. He writes, "I thought you might be interested in knowing that there are more than a few people with 'a passion for model railroading and computers' out there, as the hundreds of members in this special-interest group would indicate. 1988 will mark our seventh year of publishing a bimonthly newsletter devoted to these two subjects. . . . There are also alternatives to the Märklin system, which unfortunately controls only Märklin trains of mostly European prototype, rather than the North American prototypes more commonly modeled in the U.S. and Canada."

If you send a stamped, self-addressed envelope, you can get further information about the group. Its address is NMRA CMR-SIG, 8431 Timber Glen, San Antonio, TX 78250-4416. ■

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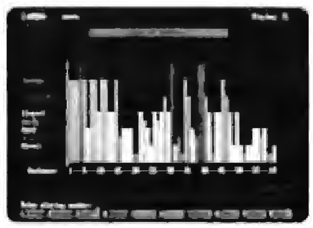

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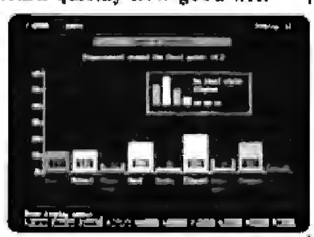

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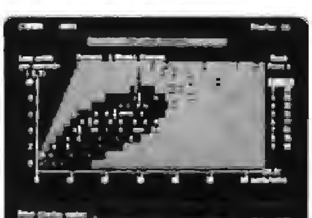

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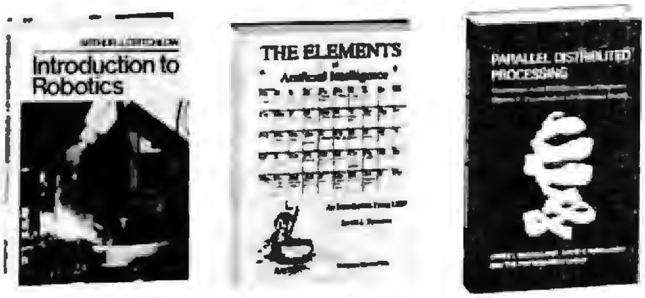

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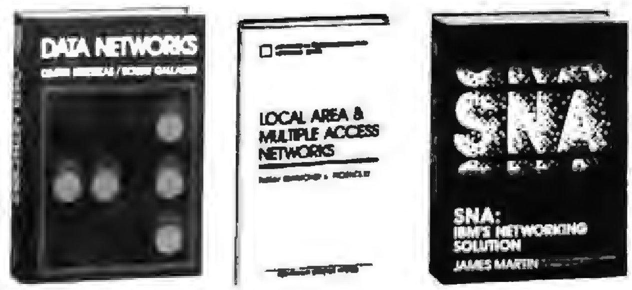

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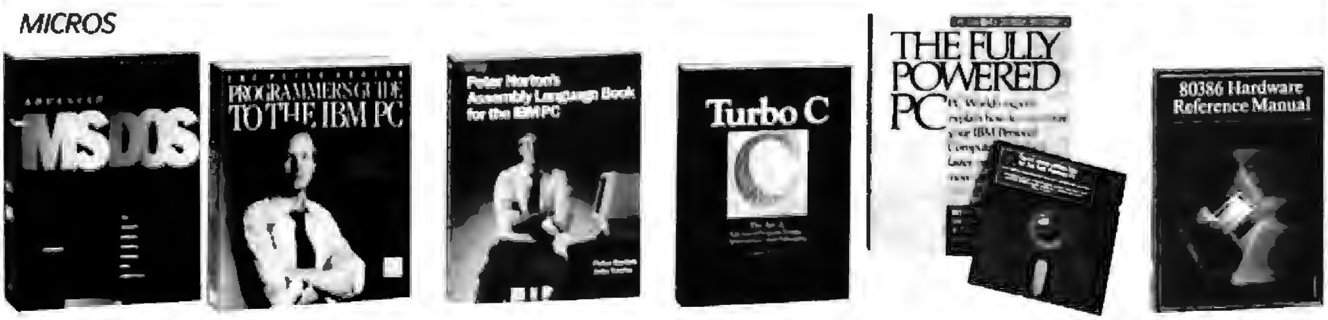

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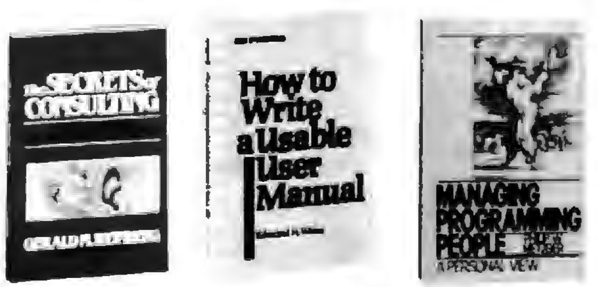

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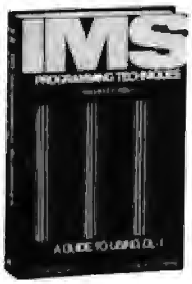

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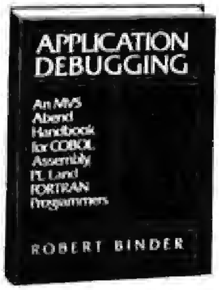

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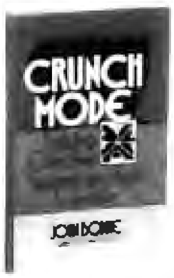

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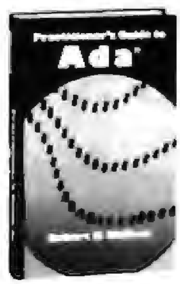

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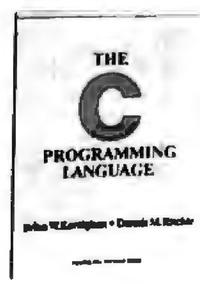

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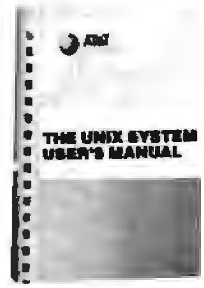

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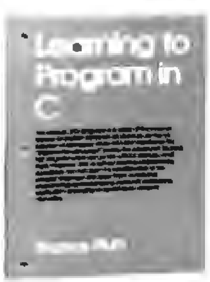

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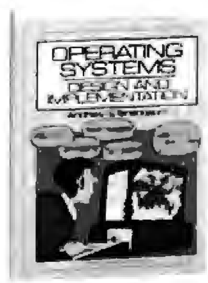

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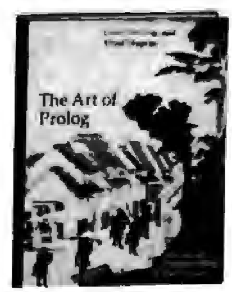

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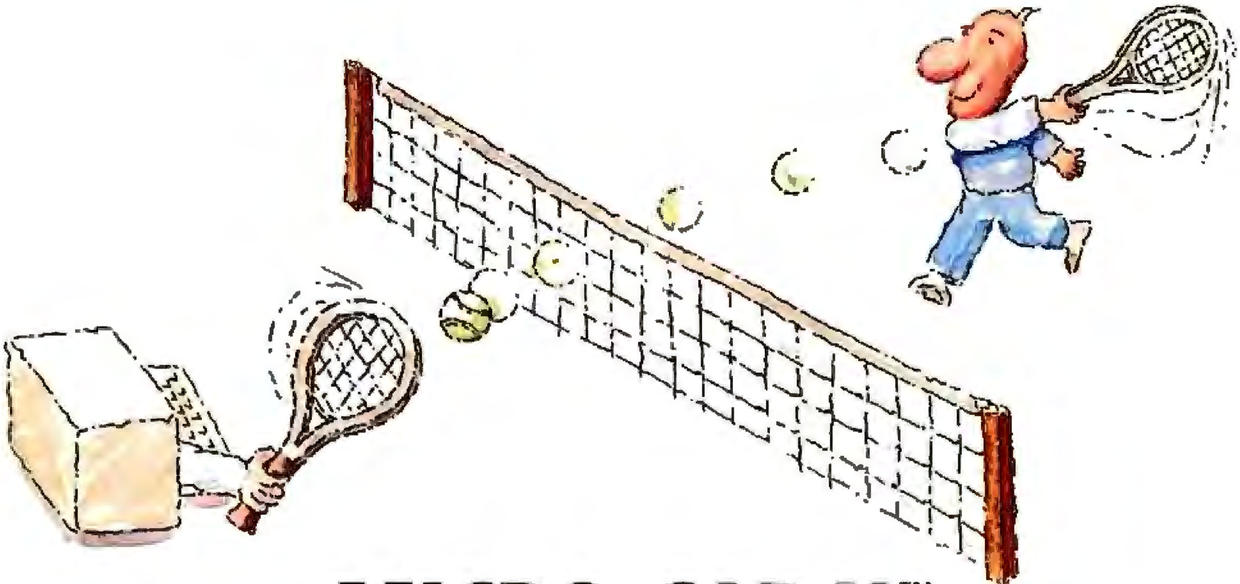

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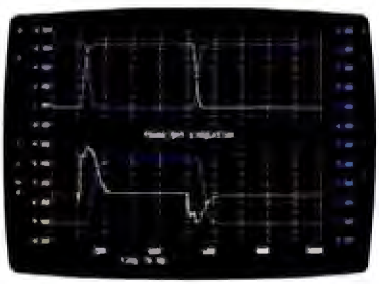

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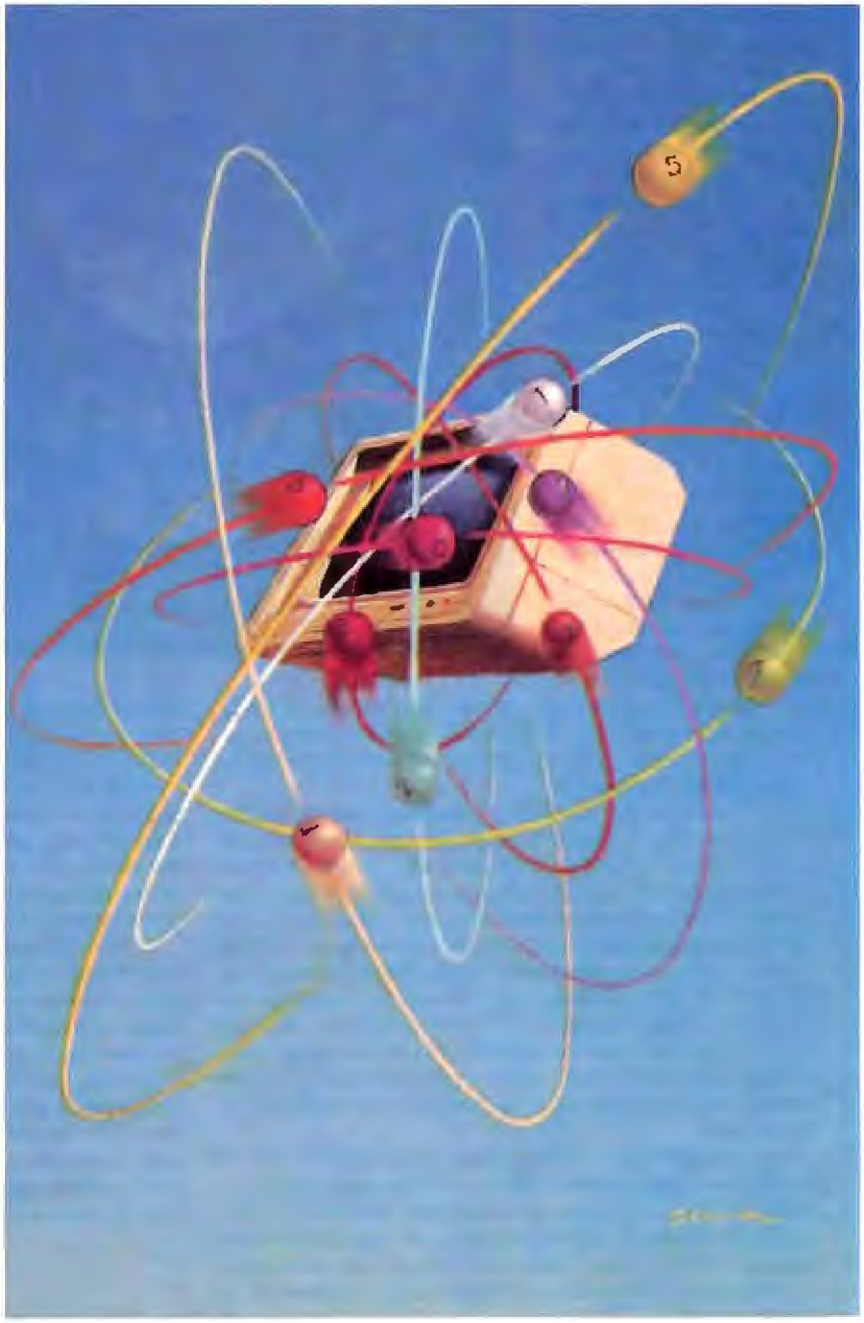
Floating-Point Processing



Introduction

Floating-Point Processing

Numbers don't float, of course (although the wrong number can certainly *sink* a calculation), but our microcomputers perform arithmetic on numbers stored with a floating-point representation all the time. Efficient computing requires floating-point processing. Fixed-point arithmetic limits the range of the numbers being manipulated. It also adds to the complexity of the operation by demanding a great deal of scaling among numbers with different "implicit" radix points. So, floating-point arithmetic has become a modern-computing necessity.

Given that necessity, finding better ways to perform such math gains significance, particularly as microcomputers take on more demanding applications in real-time processing, CAD, and scientific computing. In the era of graphics-intensive applications, high-quality hardware and software assistance for floating point is paramount.

For example, the number of floating-point operations (FLOPs) needed to display a single graphics image can add up as follows: Compute 12,000 image points, 120,000 FLOPs; rotate and scale the image to complete its nonviewable side, 28 4-by-4 matrix transformations, 300,000 FLOPs; clip the image (to display only the viewable surfaces), 72,000 FLOPs; convert coordinates to integers for pixel mapping, 130,000 FLOPs; shading and light source calculations, 360,000 FLOPs; interpolation of unplotted points, 300,000 FLOPs. The final tally—1.5 million FLOPs to display a single high-resolution image. The reason behind the primitive graphics of early-generation microcomputers suddenly becomes clear.

The examination of floating-point processing we offer in the following pages assesses where we stand today and speculates on where we might go tomorrow. By looking at the dynamics of floating-point processing, and some of the hardware and software issues involved in doing it, we can begin to understand how important this technology has become in personal computing.

We did not look at array processors—specialized engines for doing image-processing applications—but this class of hardware will undoubtedly become more prevalent in the future and will warrant our attention in a future issue.

Our coverage starts with "Avoiding Coprocessor Bottlenecks," in which Mauro Bonomi explains the Weitek 1167 architecture and shows where that floating-point unit (FPU) gets its performance. He explores the limitations imposed on performance by the bandwidth of the bus connecting the CPU and FPU. And in a text box to this article, BYTE's Tom Thompson assesses the performance of two Intel 80386-class floating-point accelerators—the Intel 80387 and the Weitek 1167. He put both accelerators through their paces with a series of common test programs to show how they perform.

Next, Prakash Chandra, in "Programming the 80387 Coprocessor," explains the additional functions that the newest Intel FPU provides. Not only is it a faster-clock-rate FPU, the 80387 adds new transcendental functions. Chandra explains the important differences between the 80387 and the earlier-generation Intel floating-point processors.

In his "Floating-Point Survival Kit," computer engineer Pete Wilson reviews the floating-point fundamentals, gives some insights into techniques for measuring floating-point speed, and evaluates some of the newest computer designs for speeding floating-point operations.

Finally, Carl Byington talks about doing IEEE 754-compatible math in software without major performance sacrifices. His article, "How to Get Better Floating-Point Results," also gives some tips on designing programs that give good answers regardless of whether the floating-point operations are executed in hardware or via software emulation.

—G. Michael Vose, Senior Technical Editor
George A. Stewart, Technical Editor

Illustration by Robert Tinney

Avoiding Coprocessor Bottlenecks

Overcoming bandwidth problems between the CPU and the floating-point math coprocessor

Mauro Bonomi

NUMERICS PERFORMANCE IN the millions of floating-point operations per second (MFLOPS) is vital to workstation tasks such as high-quality graphics, stress analysis, CAD, and electrical or mechanical simulations. With the increasing sophistication of business software, MFLOPS are fast becoming a necessity in many office applications as well. Linear programming, used to solve complex optimization problems in business and industrial planning, relies largely on floating-point computation. So does statistical analysis, employed in market research, product quality analysis, capacity planning, and stock portfolio analysis. The high-resolution graphics found in computer-aided drafting and desktop publishing make copious use of floating-point arithmetic (see the text box "Graphic's Prodigious Need for FLOPS" on page 198).

While high-end microprocessors such as the Intel 80386 provide general-purpose horsepower in the 3- to 4-MIPS range, their arithmetic performance lags far behind, delivering only thousands of floating-point operations per second—far too slow for compute-intensive personal workstation applications.

For higher numerics performance, system designers must turn to coprocessors and numerics accelerators. By relieving the CPU of floating-point math, these arithmetic engines can increase system performance markedly. A range of numerics accelerators are available, from conventional coprocessor chips, like Intel's 80387 and Motorola's 68882, to very fast bit-slice array processors.

Conventional coprocessors are relatively inexpensive and run standard software but offer performance levels suitable only for low-intensity numerics applications, such as spreadsheet recomputation and two-dimensional graphics. Array processors, on the other hand, are often expensive and difficult to program. They execute special operations, such as matrix multiplications and vector calculations, very rapidly. But because of their complex architectures, often featuring multiple memory banks, pipelined stages, and multiple address generators, they are not supported by standard compilers. Simple recompilation of existing software is not possible.

A variation on the conventional coprocessor is the memory-mapped coprocessor. These coprocessors reach a middle ground between conventional coprocessors and array processors; they provide standard software support like the conventional coprocessors but move up the performance curve toward array processors. Memory-mapped coprocessors vary from conventional coprocessors in one vital respect: Memory mapping attempts to deal with the bus bandwidth bottleneck.

Sun, Apollo, and Masscomp all make proprietary memory-mapped floating-point accelerators for workstations; in the personal computer world, the Weitek 1167 is the only example of a memory-mapped coprocessor.

Bottlenecks Limit Performance

The vast majority of arithmetic calculations performed by any computer employ real numbers and so require floating-point processing. Such processing is, however, a good deal more complex than integer math. The computer must keep track of a mantissa and an exponent for every operand and perform scaling after each arithmetic operation to reduce the result to a normalized format.

Owing to silicon space limitations, microprocessors, such as the 80386 and the 68020, feature integer-only ALUs. Floating-point operations are accomplished through software subroutines. Each such operation is carried out by the integer hardware as a lengthy series of ALU steps (adds, subtracts, and shifts).

This type of software implementation places a significant drag on performance in numerics-intensive tasks. Numerics coprocessors provide dramatic gains in speed by implementing floating-point functions in specialized hardware. Coprocessors work in close conjunction with the microprocessor.

Assuming, for example, that two single-precision numbers, A and B, stored in two 80386 registers must be added and the result C stored back in the 80386, the following actions must be carried out: The microprocessor must instruct the coprocessor to execute an addition, pass the two operands, and then store the result after the completed operation. Clearly, the resulting system performance depends on two main factors: the raw speed

continued

Mauro Bonomi is a product manager at Weitek. He can be reached at 1060 East Arques, Sunnyvale, CA 94086.

Graphic's Prodigious Need for FLOPS

One of the most math-hungry applications is three-dimensional graphics, used extensively in CAD, computer animation, and a variety of scientific problems. Generating even the simplest image of a three-dimensional solid, for example, can consume prodigious numbers of floating-point operations. Beginning from a simple geometrical description of an object, the computer must derive a model of the object's entire surface and its relationship to the viewing screen, reflected light, and perspectival attributes.

Consider the goblet in photo A. The first step in rendering a realistic image is to create a mathematical model of the object. The goblet is defined in terms of quadratic functions representing simple geometric shapes: a sphere, cylinder, and two hyperbolic surfaces, each truncated by one or more planes. For example, the quadratic function for the sphere is $X + Y^2 + Z^2 = K^2$.

Photo A: *The goblet.*

The equations are next solved for various values of X and Y. The result is a set of coordinate points, representing points on the surface of the goblet. In a process known as tessellation, each point is treated as the vertex of a triangle. The surface as a whole is represented by a large number of adjacent triangles, much like a faceted gem, that approximate the smoothly curving surface of an actual goblet (see figure A). The greater the number of surface points computed, the higher the quality of the final picture. For this image, 12,000 points were computed with a total of about 120,000 floating-point calculations.

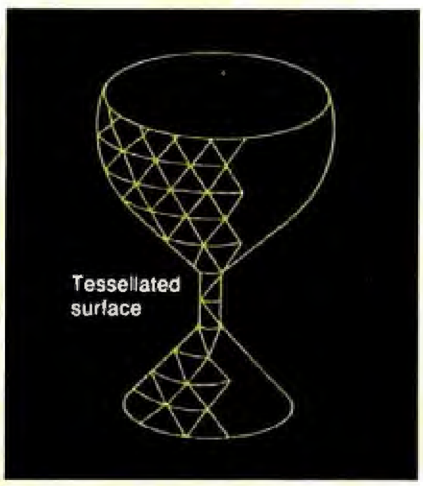


Figure A: *The tessellated goblet.*

The generalized surface image must next be rotated, translated, and scaled. That is, it must be assigned an exact orientation, position, and size. The coordinates of each triangle vertex are multiplied by a 4-by-4 transformation matrix.

Twenty-eight floating-point operations are needed to transform each point; transforming the entire picture takes 330,000 calculations.

Once the image has been transformed, it must be determined which points fall within the viewing space (i.e., which points lie inside the picture frame). Clipping, as this process is called, involves six calculations per point for a total of 72,000 calculations. Perspective transformation comes next. The internal, three-dimensional model of the goblet is projected onto the two-dimensional coordinates of the computer screen. Screen coordinates must be converted into integer values representing pixel locations. Roughly 130,000 operations are required.

A shading model must then be used to compute the colors and intensities associated with each point on the screen. Such models take into account the properties of both the surface of the object and the light source. Light source calculations entail more than 360,000 operations for the vertex points projected onto the screen. Shading for pixels not corresponding to vertices of the tessellated image is derived via interpolation. Assuming the goblet takes up 30 percent of the screen, interpolation requires close to 300,000 calculations.

At this point, the information is complete and is ready to be displayed. All told, the image has required approximately 1.5 million floating-point operations. Many more operations are required every time the image is rotated, translated, or rescaled.

---

of the floating-point hardware and the efficiency of the interface between the microprocessor and the numerics coprocessor. Even if the floating-point unit (FPU) latency—the time required to generate a result from two input operands—could be reduced to 0, an inefficient interface protocol could limit system performance.

Low-Latency Data Paths

The 80386/80387 combination illustrates conventional coprocessor function. The 80387, connected to the system data bus, monitors the same program instruction stream as the microprocessor does. The microprocessor is responsible for generating all addresses for both code and data. Operands and op codes are transmitted to the coprocessor from memory via the data bus. Whenever the microprocessor detects a coprocessor instruction, it waits until the coprocessor becomes idle, lets the coprocessor begin the instruction, and then moves on to the next instruction. If the 80387 is still busy by the time the 80386 encounters another coprocessor instruction, the microprocessor waits until the coprocessor is done. This process is invisible to the programmer; it appears as though there is only a single processor.

Despite this tight coupling and ease of programming, the performance of conventional numerics coprocessors suffers both from some inherent processing limitations and from interface bottlenecks. To begin with, simple operations such as adds and multiplies may require multiple passes through the hardware. This is due to limited silicon space for ALUs. Similarly, the number of on-chip registers is often relatively small. But a bigger problem is that both data and instructions are sent to conventional coprocessors via a data bus of limited bandwidth.

Memory-mapped coprocessors accelerate floating-point operations in two ways: They use dedicated 64-bit floating-point multiplier and ALU data paths, and they provide an interface that lets the coprocessor acquire data *and* instructions by using both the address and the data bus simultaneously.

For example, consider the simplified block diagram of the Weitek 1167 memory-mapped coprocessor and its interface to the Intel 80386 (figure 1). The multiplier and ALU data paths execute such operations as single-precision adds, subtracts, and multiplies in a single pass through the silicon. The 1167 multiplier and ALU flow-through time is under 200 nanoseconds for a single-precision operation. In contrast, conventional coprocessors usually require over 1.5 microseconds (7 to 8 times slower) to carry out the same operation.

The coprocessor is connected to the 80386 via the control, data, and address buses. *Instructions* (op codes) are sent to the coprocessor using the system address bus, while *data* (operands) are sent over the data bus. As the address bus specifies the instruction to be performed, the data bus can pass a 32-bit operand simultaneously. This parallelism reduces bus bottlenecks that otherwise significantly limit system performance.

View of the System Address Bus

The microprocessor treats a memory-mapped coprocessor as a distinct region of physical memory. Data-moves to and from this memory region select the coprocessor and specify both the floating-point op code, the location of the two operands, and the destination of the computational result. At the same time, the data on the data bus can provide any operand not already present in the coprocessor's registers.

Figure 2 shows the Weitek coprocessor view of the 80386 address bus. The coprocessor is mapped into the physical memory area ranging from C0000000h to C000FFFFh. A given address in this area selects the coprocessor, indicates the instruction for the coprocessor to perform, and specifies the operand locations (Source1 and Source2/Destination). The most significant 16 bits of the physical address identify a coprocessor instruction. If the upper bits of the address are not equal to C000h, the address does not specify a Weitek command and is ignored by the coprocessor. The next 6 bits of the address specify the coprocessor instruction to be executed. The least significant 10 address bits specify the registers that will provide sources and destination for the instruction.

Source2 and Destination always coincide. When Source1 is set to 0, the Source1 data is provided by the system data bus. Source2 and Destination, on the other hand, always specify one of the remaining 31 32-bit registers (1 to 31) of the coprocessor register file. This means that one of the two operands always resides in the coprocessor register file.

Generating Instructions

Coprocessor instructions for the Weitek 1167 are specified via simple 80386 memory moves. Assuming that the two single-precision operands in the 80386 registers EAX and EBX need to be added and the result is to be stored back in register EAX, the following three memory move instructions will execute the operation:

```
1) mov ADDR1, eax   ; load content of EAX (A) into the Weitek 1167 register file.
2) mov ADDR2, ebx   ; load content of EBX (B) into Weitek register file and add it to A.
3) mov EAX, ADDR3   ; store result C back into 80386 register EAX.
```

Addresses ADDR1, ADDR2, and ADDR3 are derived by filling the address fields, shown in figure 2, with the proper values. The most significant 16 bits of all the addresses are set to C000h in order to select the coprocessor. The next 6 bits are filled with the op code for LOAD, ADD, and STORE, respectively. Finally, the least significant 10 bits will be filled with the operand addresses.

As all the above operations involve one operand coming from the bus, Source1 will always be set to 0. Source2 can instead specify any of the remaining 31 registers (1 to 31) in the Weitek 1167 register file. With the move to ADDR2, the 80386 passes a 32-bit operand (B) to the coprocessor on the data bus and specifies the floating-point instruction that needs to be executed (ADD). This is an example of the parallelism provided by the memory-mapped interface.

To hide the details of the memory-mapped interface from the programmer, memory-mapped coprocessors feature macros, one for each coprocessor instruction. Using Weitek 1167 macro notation, for example, the addition sequence above becomes

```
1) wfld ws1, EAX    ; load EAX (A) into Weitek register 1.
2) wfadd ws1, EBX   ; add Weitek register 1 (A) to EBX (B).
3) wfst EAX, ws1    ; store result from Weitek register 1 to EAX.
```

The instruction stream assumes that reg-

continued

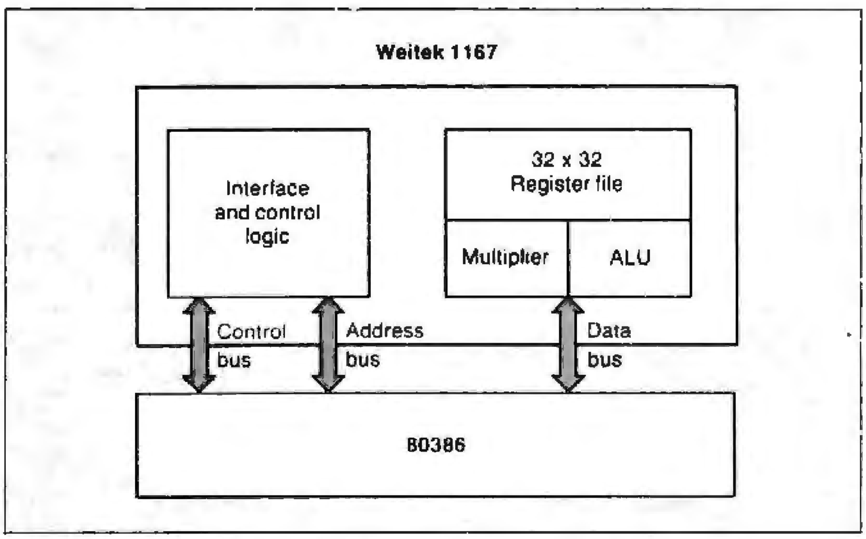


Figure 1: *A block diagram of the 80386/Weitek 1167 interface.*

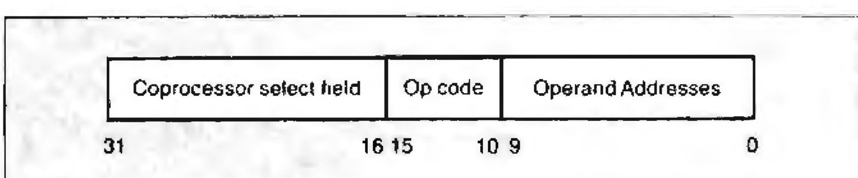


Figure 2: *The Weitek 1167 view of the 80386 address bus.*

Photo 1: *The beach ball.*

ister 1 has been used to accumulate the result inside the coprocessor.

Large Register Sets

Memory-mapped coprocessors commonly offer large internal register sets that can be used to store constants and to accumulate partial results. The accumulation of partial results in internal registers lets the coprocessor minimize the number of loads and stores between the microprocessor and the FPU.

When performing a three-dimensional graphics transformation, for example, requiring the multiplication of a large number of vectors of four elements each by a 4-by-4 transformation matrix, the programmer can store all 16 matrix coefficients in the coprocessor register file and then use them to transform all the vectors.

C programmers can define all variables processed by the coprocessor as temporary variables. The compiler will then allocate such variables to coprocessor internal registers, thus holding the number of store and load operations between microprocessor and coprocessor to a minimum.

To appreciate the performance differences between conventional and memory-mapped coprocessors, see "The Intel 80387 vs. the Weitek 1167" by Tom Thompson, on page 205.

Listing 1: *The C code to generate the beach ball. (Code written by Bruce Holloway of Weitek.)*

```
#include <math.h>
#include <stdio.h>
#include <time.h>

clock_t start,stop;
float pi;
int colors[]={3,6,10,13,6,3,10,13,6,3,13,1
       0},d[]={640,350,1},i,k,
  palette[]={000,010,001,011,020,002,022
       ,077,040,004,044,060,006,066,007,077},
  x,y,x_min,x_max,y_min,y_max;
unsigned short random;

main()
```

continued

Compiling: An Example

The beach ball picture shown in photo 1 was generated on a 20-MHz Compaq Deskpro 386/20 with an EGA graphics card. The C code for this simple graphics example is presented in listing 1. The program uses the Phong shading technique to compute the intensities and colors of the surface of the ball. The idea behind this technique is to compute normal (perpendicular) vectors to each point on the surface using an interpolation scheme and then apply the shading model at each pixel displayed.

The program involves a large number of floating-point computations on single-precision numbers, including the four basic instructions (add, subtract, multiply, and divide), as well as special functions (sine, cosine, and square root). The C program was compiled with a MetaWare High C compiler that supports both the Weitek 1167 and the 80387 coprocessor. The compiler generates either 80387 or Weitek 1167 object code. Users choose the desired coprocessor by setting a special switch on the command line when giving the compile command.

Running without a floating-point coprocessor, with the 80386 emulating

continued

```
{
  float a,b,c,l0,l1,l2,ln,ln1,n0,n1,n2,p,q,r=128,s,t,v[12][3];
  int n;

  /* Put EGA in hi-res graphics mode & initialize pallette. */
  video_int(0x10);
  for (n=0;n<16;n++)
    video_int(0x1000,n+(palette[n]<<8));

  /* Print title & start timing. */
#ifdef Intel
  printf("\n\n\t\t       80387 Phong Shading Demonstration\n");
#else
  printf("\n\n\t\t    Weitek 1167 Phong Shading
      Demonstration\n");
#endif
  printf("\n\n\n\n\n\n\n\n\n\n\n\n\n\n \n\n\n\n\n\n\n");
  start=clock();

  /* Pixel aspect ratio. */
  a=1.3;
  /* Screen center coordinates. */
  b=.5*(d[0]-1);
  c=.5*(d[1]-1);
  /* Unit length light source vector. */
  l0=-1/sqrt(3.);
  l1=l0;
  l2=-l0;
  /* Ratio of circumference to diameter of  a circle. */
  pi=4*atan(1.);
  /* A dozen vertices evenly spread over a  unit sphere. */
  v[0][0]=0;
  v[0][1]=0;
  v[0][2]=1;
  s=sqrt(5.);
  for (i=1;i<11;i++) {
    p=pi*i/5;
    v[i][0]=2*cos(p)/s;
    v[i][1]=2*sin(p)/s;
    v[i][2]=(1.-i%2*2)/s;
  }
  v[11][0]=0;
  v[11][1]=0;
  v[11][2]=-1;

  /* Loop to Phong shade each pixel. */
  y_max=c+r;
  y_min=2*c-y_max;
  for (y=y_min;y<=y_max;y++) {
    s=y-c;
    n1=s/r;
    ln1=l1*n1;
    s=r*r-s*s;
    x_max=b+a*sqrt(s);
    x_min=2*b-x_max;
    for (x=x_min;x<=x_max;x++) {
      t=(x-b)/a;
      n0=t/r;
      t=sqrt(s-t*t);
      n2=t/r;
      /* Compute dot product and clamp to positive value. */
      ln=l0*n0+ln1+l2*n2;
      if (ln<0) ln=0;
      /* cos(e.r)**27 */
      t=ln*n2;
      t+=t-l2;
      t*=t*t;
      t*=t*t;
      t*=t*t;
      /* Nearest vertex to normal yields max dot product.  Get
      its color. */
```

continued

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```
      for (i=0,p=0;i<11;i++)
        if (p<(q=n0*v[i][0]+n1*v[i][1]+n2*v[i][2])) {
          p=q;
          k=colors[i];
        }
      /* Aggregate ambient, diffuse, & specular intensities &
      do dither. */
      i=k-2.5+2.5*ln+t+(random=37*random+1)/65536.;
      /* Clamp values outside range of three color levels to
      black or white. */
      if (i<k-2) i=0; else if (i>k) i=15;
      draw_dot();
    }
  }
  stop=clock();
  reg_reset();
  printf("\t\t\t\tTime = %3.2f seconds",((double)(stop-
      start))/CLK_TCK);
  while (clock()-stop<5*CLK_TCK);
  /* Put EGA in 80-column mode. */
  video_int(0x03);
}
```

Listing 2: *Sample of compiler output for the 80387.*

```
                                ;    s=r*r-s*s;
0214  d9 46 c8                  fld     dword ptr -56[bp]
0217  d8 c8                     fsqr
0219  d9 46 c4                  fld     dword ptr -60[bp]
021c  d8 c8                     fsqr
021e  de e9                     fsub
0220  d9 5e c4                  fstp    dword ptr -60[bp]
                                ;    x_max=b+a*sqrt(s);
0223  d9 46 c4                  fld     dword ptr -60[bp]
0226  d9 fa                     fsqrt
0228  d8 4e fc                  fmul    dword ptr -4[bp]
022b  d8 46 f8                  fadd    dword ptr -8[bp]
022e  e8 ----e                  call    _mwtrunc
0231  a3 0054r                  mov     @FONGBALL+84,ax
```

Listing 3: *Sample of compiler output for the Weitek 1167.*

```
              ;    s=r*r-s*s;
0388  64:a2 0719     wload  .S fr2,fr25   ; mov al,fs:[]
038c  64:a2 081a     wmul   .S fr2,fr2    ; mov al,fs:[]
0390  64:a2 0b7a     wmul   .S fr26,fr26  ; mov al,fs:[]
0394  64:a2 107a     wsub   .S fr26,fr2   ; mov al,fs:[]
             ;    x_max=b+a*sqrt(s);
0398  64:a2 471a     wcvtsd .S fr2,fr26   ; mov al,fs:[]
039c  66:64:ff 36 0c18  push   .S fr2     ; push fs:[]
03a2  66:64:ff 36 0c1c  push   .S fr3     ; push fs:[]
03a8  e8 ----e       call   sqrt
03ab  64:a2 45a1     wcvtsd .S fr4,fr13   ; mov al,fs:[]
03af  64:a2 45a8     wcvtsd .S fr6,fr12   ; mov al,fs:[]
03b3  64:a2 889a     wmul   .D fr2,fr6    ; mov al,fs:[]
03b7  64:a2 8098     wadd   .D fr2,fr4    ; mov al,fs:[]
03bb  64:a2 bc1a     wfix   .D fr2,fr2    ; mov al,fs:[]
03bf  66:64:a1 0c18 wstor   .D fr2,eax    ; mov eax,fs:[]
03c4  66:0f a4 c2 10            shld   edx,eax,16
03c9  a3 0054r                  mov    @FONG1167+72,ax
```

80387 instructions, the program takes 8 minutes to complete. Adding a 20-MHz 80387 reduces the execution time to a little more than 28 seconds. Finally, the Weitek memory-mapped coprocessor cuts execution time by about 3 times, down to only 10 seconds. The 200 percent performance improvement was achieved by simply recompiling the source code with no hand-coded optimizations.

Samples of the compiler output for both the 80387 and the Weitek 1167 are provided in listings 2 and 3. When compiled for the 80387, the code line `s=r*r-s*s` is translated into the code stream in listing 2.

The same equation is translated into 1167 memory moves by the compiler when the Weitek coprocessor is selected. The Weitek object code shown in listing 3 makes efficient use of coprocessor registers. The equation result `s` (`s=r*r-s*s`), for example, is not stored back into the 80386 but is left in the coprocessor register file and is then used by the instruction (`x_max=b+a*sqrt(s)`), thus minimizing the data transfers between the microprocessor and the coprocessor and freeing up the system bus.

Programming for Performance

When writing high-level language code for a memory-mapped coprocessor, some simple techniques can lead to significant performance improvements in the compiled code. First, variables used only in specific subroutines can be defined as local variables. The compiler then allocates such variables to coprocessor registers and will not store them back to main memory at the end of each instruction.

In the case of the 1167, the assembly language programmer has access to special instructions not otherwise available to compiler users. The multiply-accumulate (`wfmac`) instruction is an example. This instruction, useful in implementing matrix multiplications, specifies the multiplication of the two input operands, followed by the addition to a previously calculated partial result. A single memory move can then specify two floating-point instructions (multiply and add), further decreasing the burden on the system bus.

Additional assembly-level instructions that can improve the system performance are block moves—that is, moves of blocks of data to or from adjacent memory locations. A block move effectively encodes a stream of floating-point instructions. It is useful in loading and unloading the entire contents of the coprocessor register file, as well as in implementing vector adds and multiplies.

Boiling Down

Accelerating floating-point performance boils down to more than just clock rates and the size of machine words. We need the hardware assistance of dedicated ALUs and multipliers. But equally important is the need for efficient ways to move data and instructions between the main processor and the math coprocessor.

Removing the coprocessor instruction stream from the data bus—using the address bus to transmit op codes—leaves more room for passing operands. This strategy is one way to increase data bus bandwidth and improve processor/coprocessor interaction. ■

The Intel 80387 vs. The Weitek 1167

Tom Thompson

AS THE OTHER articles in this section explain, the new generation 80386 floating-point hardware improves upon the math coprocessors previously available. To find out if they really deliver on their collective promise to enhance floating-point performance, I ran several tests to determine how the 80387 and Weitek WTL 1167 stacked up.

The Compaq 386/20 lets you use this new generation of math coprocessor. While the 80387 is a single chip, the Weitek 1167 is a set of three chips designed to work in parallel with the Intel 80386 and provide floating-point performance superior to the 80387. Compaq supplies this coprocessor on a cleverly designed Weitek Coprocessor Board that also has an 80387 socket. This unique ability to use both coprocessors within the same computer gave BYTE the opportunity to compare the floating-point performances of both.

Compaq's Weitek Coprocessor Board comes in a kit costing $1999 that contains the coprocessor board, a special interconnection board, a 38-page installation guide, and a tool for removing the 80387 from its socket. The board has a PC-form factor with a standard PC-card edge connector for mounting it in the computer. The interconnection board plugs into the 80387 socket on the Deskpro's motherboard and attaches to two male connectors on the coprocessor board, opposite the PC edge connector. This second pair of connectors lets the computer communicate with the 80387 when it's placed on the coprocessor board. Because of the location of the motherboard's 80387 socket, you must install the Coprocessor Board in slot 2.

The installation guide uses photos and detailed text to guide you step by step through the board installation. However, the disassembly procedure used is complex: You are required to remove the Deskpro's entire motherboard just to remove the 80387 and install the interconnection board on its socket. I used a shortcut by removing the reinforcement bracket, the RF shield, and the 32-bit memory board in slot 1. This saved me a lot of disassembly work and having to run SETUP to reconfigure the system. (My guess is that Compaq wants you to go through the elaborate disassembly process to avoid stressing the motherboard when the interconnection board is attached.)

When you have removed the 80387 from the computer, you then place it in the 80387 socket on the coprocessor board. Once the 80387 is in place, you mount the coprocessor board by very carefully sliding it (since you have three connectors to mate instead of one) into slot 2.

The Tests

I ran a number of benchmarks (compiled with MetaWare's High C version 1.4) to test both the Weitek coprocessor and 80387's handling of floating-point operations, transcendental functions, and a mix of the two. A compiler switch directed High C to generate either Weitek coprocessor- or 80387-specific instructions. The transcendental run-time libraries are from Weitek and licensed to MetaWare for use with its compiler. I used Phar Lap's version 1.1t Linker and DOS Extender to run the benchmarks in the 80386 protected mode.

The Float and Calcpi benchmarks are floating-point intensive. Calcpi computes the value of π from a Taylor series expansion. Although the arctangent is used in Calcpi, it is used only once, so that benchmark can safely be said to be floating-point intensive. The Whetstone and John Walker's Fbench benchmarks are representative of a mix of floating-point and transcendental functions. The Whetstone has few transcendental function calls, while the ray-tracing algorithms in Fbench make heavy use of them. Finally, *Dr. Dobbs'* Savage benchmark uses only transcendental functions.

The results are shown in table 1. As you can see, the Weitek coprocessor easily outperforms the 80387 in floating-point operations. However, only a modest gain in performance is seen with the transcendental functions, notably with the Savage benchmark. This is because the WTL 1167 supports these functions as run-time libraries, not in silicon. The mixed-instruction benchmarks (Fbench and Whetstone) are probably more representative of real-world applications.

Since the benchmark programs are coded in C, all floating-point values are processed as double-precision. You can obtain better performance using single-precision values. ■

Tom Thompson is a BYTE technical editor with a BSEE degree from Memphis State University. He can be contacted at BYTE, One Phoenix Mill Lane, Peterborough, NH 03458, or on BIX as "tom_thompson."

Table 1: *The Weitek Coprocessor Board ran 7 percent to 68 percent faster than the 80387 processing double-precision numbers in our benchmarks.*

	Weitek 1167	Intel 80387	% Improvement
Fbench	3.35	4.01	16
Float	0.35	1.03	66
Savage	2.63	2.84	7
Calcpi			
Looptime	0.14	1.37	
Benchtime	0.99	3.11	68
KiloFLOPs per sec.	590.99	287.40	
Whetstone			
Execution time	0.35	0.57	38
Whets per sec.	2906469	1759199	

A Compaq 386/20 with 20-MHz 80386/80387 was used with Compaq's Weitek Coprocessor Board. One thousand iterations were run for the Fbench test, and 125,000 iterations were executed for Calcpi. All times are in seconds. "Improvement" indicates the improvement in execution speed compared to the 80387.

Programming the 80387 Coprocessor

A look at the differences between this FPU and its older cousins

Prakash Chandra

THE 80387 CHIP is a math coprocessor for the 32-bit 80386 microprocessor. The 80387—actually called a Numerics Processor Extension (NPX) by its maker, Intel Corp.—implements the IEEE 754-1985 Standard for Binary Floating-Point Arithmetic and provides numerics capabilities that include support for floating-point, extended-integer, and binary-coded-decimal (BCD) data types. The 68-pin 80387 operates independently of the real, protected, and virtual-8086 modes of the 80386.

While maintaining upward object-code compatibility with the 8087 and the 80287, the 80387 contains a variety of new instructions, including instructions to compute sine and cosine functions, and it extends the capabilities of many existing instructions. Object-code compatibility ensures that any program running on the 8087 or the 80287 will run on the 80387 without recompilation.

Let's look at the key differences between the 80387 and the earlier 8087/80287 floating-point units (FPUs). For a description of the performance characteristics of the 80387, see the text box "80387 Performance" on page 212.

Architectural Overview

The 80287 was designed before the final IEEE-754 standard was approved. The 80387, on the other hand, fully conforms to the standard, including automatic normalization of denormal operands, support of only the affine interpretation of infinity (the 80287 supports both affine and projective interpretations), and IEEE 754-compatible unordered and partial remainder instructions.

The programmer of an 80386/80387 computer system can view the 80387 as a means to add extra registers, new data types, and trigonometric, exponential, and arithmetic instructions to those of the 80386.

• *Register set*: As figure 1 shows, an 80387 contains a set of eight 80-bit general-purpose registers that are individually addressable, plus three 16-bit registers and two 48-bit registers. The general-purpose registers are organized in the form of a stack. The top of the stack is designated by the TOP field of the 80387 status-word register (described later). Numeric instructions address the eight general-purpose registers relative to the top of the stack. In the rest of this article, I'll use ST to indicate the top of the stack and ST(i) (with $i = 0, \ldots, 7$) to represent the ith register from the top of the stack.

The three 16-bit registers in the 80387 are known as status-word, control-word, and tag-word registers. The overall state of the 80387 is stored in the status word. The control-word register is used to control processing options in the 80387. The tag word indicates the contents of each register in the general-purpose register stack.

The function of the tag word is to optimize the 80387's performance and stack handling by making it possible to distinguish between empty and nonempty register locations. It also allows programmers of exception handlers to check the contents of a stack location without the need to perform complex decoding of actual data.

The 48-bit instruction and data-pointer registers provide for user-written exception handlers. These registers, which are actually located in the 80386, can be referenced only by a subset of 80387 instructions and are used by the 80386 to save the instruction address, the operand address (if any), and the instruction op code whenever the 80386 decodes an 80387 instruction.

• *Data types*: As figure 2 shows, the 80387 supports seven data types in three different formats—binary integer, BCD integer, and binary real. Internally, all numbers are stored in the extended-precision real format.

• *Special numeric values*: A real number in the 80387 has three parts—sign, significand, and exponent. The 1-bit sign indicates whether the number is positive or negative. The number's significant digits are held in the significand field. The exponent field determines the location of the "decimal" point within the significant digits.

The data format of the 80387 also permits representation of special numeric values. A significand of 00...00B (B=binary) and a biased exponent of 00...00B represent the value 0. A 0 can be positive or negative. Infinity is another special numeric value, represented by a significand of 1.00...00B and a biased exponent of 11...11B. The

continued

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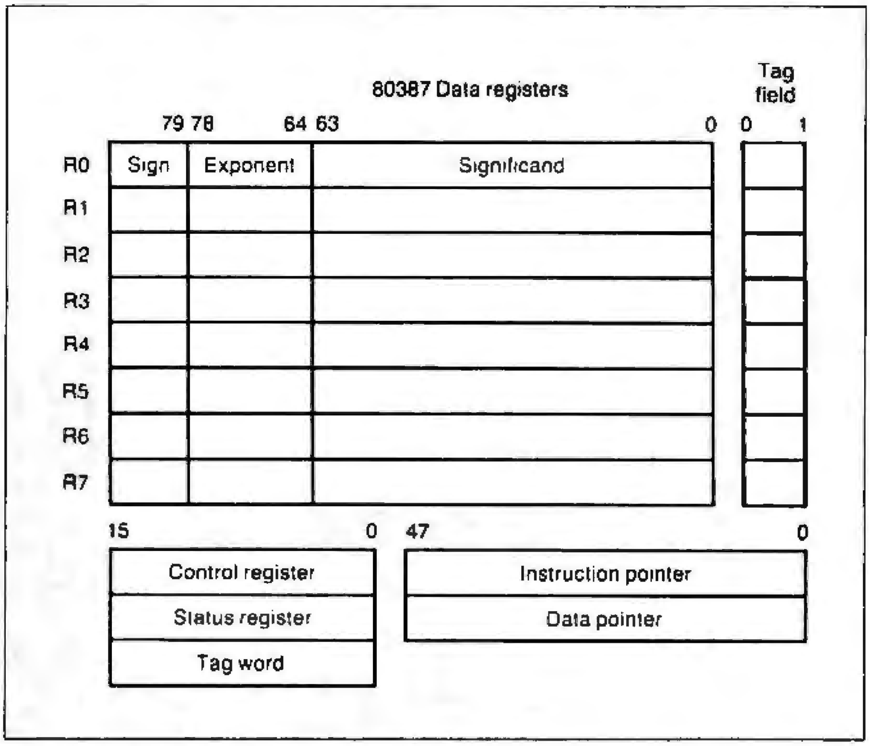

Figure 1: *The register model of the 80387.*

80387 allows both positive and negative infinities. A third special case represents denormal numeric values that occur in computations involving extremely small numbers. Use of denormal values allows the gradual loss of precision in computations on small numbers.

The class of real numbers represented by an exponent of 11...11B and a significand of anything except 1.00...00B is termed a NaN (not a number). The 80387 uses two classes of NaNs—signaling NaNs (SNaNs) and quiet NaNs (QNaNs). The 80287, on the other hand, employs only one type of NaN—the equivalent of QNaN in the 80387.

A signaling NaN has a 0 in the most significant bit of its significand. Although the 80387 never generates a signaling NaN itself, it recognizes signaling NaN operands and causes an invalid-operation exception whenever an arithmetic operation is performed on a signaling NaN operand.

For example, a compiler could use the signaling NaN to detect the use of a variable in a program before the variable has been initialized. This can be done by initializing all variables declared in a program to be a signaling NaN. If a variable

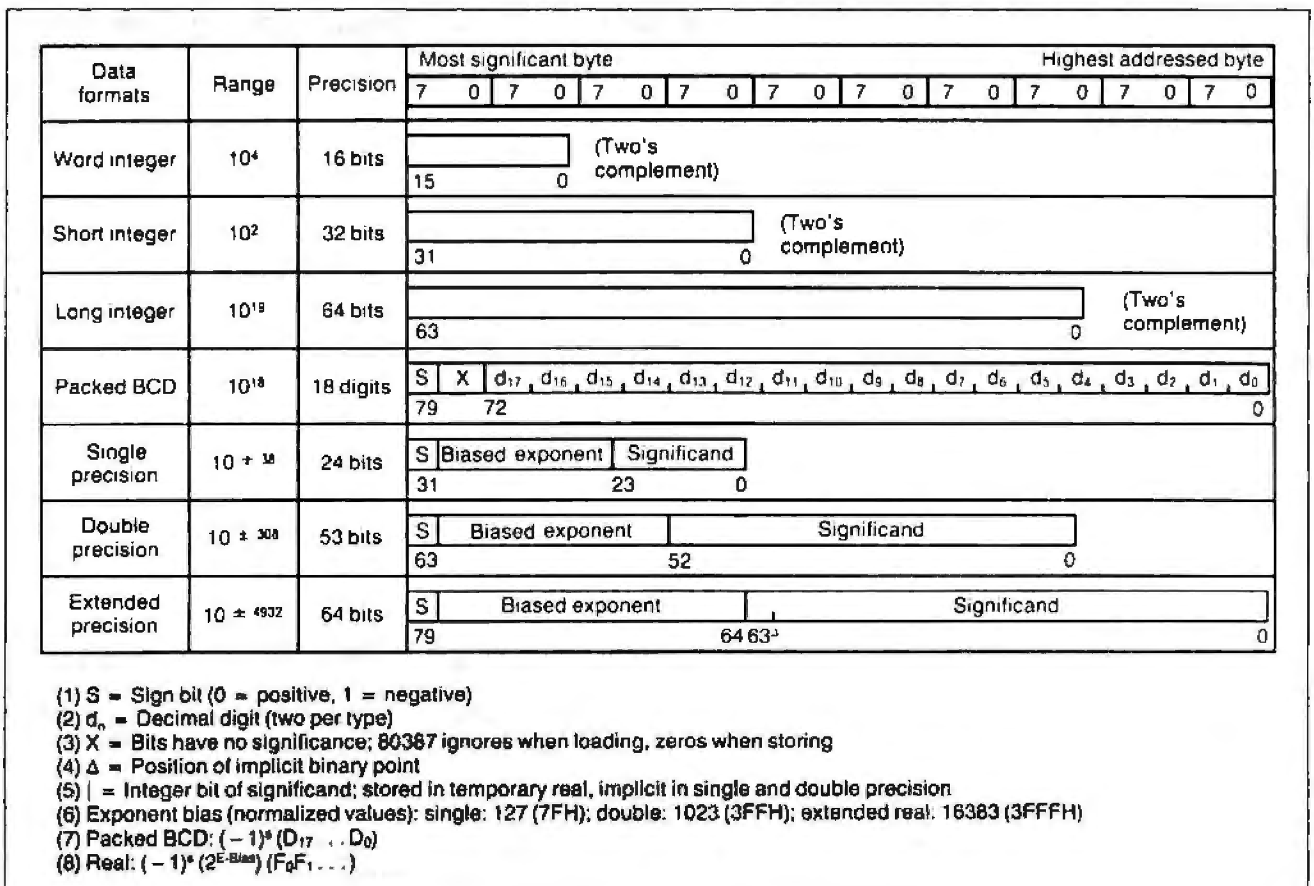

Figure 2: *The data types supported by the 80387.*

is used in an arithmetic operation before it has been initialized, it will cause the operation to be performed on a signaling NaN. If the invalid operation exception were unmasked, an exception would occur to identify the offending variable.

A quiet NaN in the 80387, which contains a 1 in the most significant bit of its significand, behaves the same way as a NaN in the 80287.

New Instructions in the 80387

The 80387 contains seven new instructions not in the 80287. Of these, three are transcendental instructions, three are unordered compare instructions, and one is an IEEE-754 partial-remainder instruction. Table 1 summarizes these new instructions. The text box "Processor Initialization and Control" on page 210 explains another key difference between the 80387 and 80287.

• *Trigonometric instructions*: The trigonometric functions accept a practically unrestricted range of operands. The instruction FCOS computes the cosine of the contents of ST and replaces it with COS(ST). The value contained in ST must be in radians, and its absolute value must be less than 2^{63}. If the operand is within this range, the C2 bit (the eleventh bit) of the status word is cleared. The C2 bit is set to 1 if the operand of FCOS is outside the range and ST remains unchanged. The instructions FPREM and FPREM1 can be used to reduce the operand to a specified range.

The FSIN instruction works the same way as the FCOS instruction. It replaces the contents of ST, which must be expressed in radians, with SIN(ST). The operand range restriction for FCOS also applies for FSIN. The FSINCOS instruction computes both the sine and the cosine of the contents of ST. First, the contents of ST are replaced by SIN(ST), and then COS(ST) is pushed onto the stack. The operand range requirements for FCOS apply to FSINCOS, too.

• *Unordered compare instructions*: In addition to all the compare, test, and examine operations of the 80287, the 80387 offers three new instructions—FUCOM, FUCOMP, and FUCOMPP—to perform unordered comparisons. The FUCOM instruction operates like the FCOM (compare real) instruction in that it compares the value on the top of the stack to the source operand, where the source operand can be in a register or on the stack, or a single- or double-real memory operand. This instruction will not, however, generate an invalid-operation exception if one of the operands is a NaN. Table 2 shows the values of the condition code bits in the status word (bits 9, 10, 11, and 15) for various situations. If either operand is a NaN, the condition bits of the status word are set to unordered.

FUCOMP and FUCOMPP behave like FUCOM and also pop the stack once and twice, respectively.

• *IEEE 754-compatible remainder instruction*: The IEEE 754-compatible partial-remainder instruction in the 80387, FPREM1, computes the remainder of the division of ST by ST(1). The result is stored in ST. The instruction finds a remainder *r* and a quotient *q* such that

$$r = ST - ST(1) \times q,$$

where *q* is the integer nearest to the exact value of ST/ST(1). FPREM1 always produces exact results, and therefore the 80387's rounding control mode has no effect on the result.

If the FPREM1 instruction is used on operands that differ greatly in magnitude, it can consume large amounts of time and will also increase the computer's interrupt latency, since the 80387 can be interrupted only between instructions. The instruction, therefore, may terminate before the calculation has been completed. If this happens, the C2 bit of the status word is set, indicating incomplete calculation. The contents of ST in this case contain only the partial remainder. FPREM1 can reduce the exponent of ST by up to (but not including) 64 in one execution. If the reduction is complete, the C2 bit of the status bit is set to 0, and C3, C1, and C0 contain the least-three significant bits of the quotient generated. The FPREM1 instruction differs from the 8087/287 instruction FPREM in two ways:

1. Remainder *r* produced by the instruction FPREM is in the range $0 \leq r <$

continued

The 80387 provides the system designer with significant enhancements in features and speed over the 80287.

Table 1: *The new instructions added to the 80387 instruction set.*

Instruction	Function
FCOS	Cosine
FSIN	Sine
FSINCOS	Sine and cosine
FUCOM	Unordered compare real
FUCOMP	Unordered compare real and pop
FUCOMPP	Unordered compare real and pop (twice)
FPREM1	IEEE Standard partial remainder

Table 2: *The values of the condition code bits in the 80387 status word for various conditions.*

Order	C3 (ZF) (Bit 15)	C2 (PF) (Bit 11)	C0 (CF) (Bit 9)	80386 Conditional branch
ST > operand	0	0	1	JA
ST < operand	0	0	1	JB
ST = operand	1	0	0	JE
Unordered	1	1	1	JP

Table 3: *The operand ranges for the 80387 compared to the 80287.*

Instruction	Function	80387 Operand range	80287 Operand range
FPTAN	Partial tangent	$\lvert ST(0)\rvert < 2^{63}$	$\lvert ST(0)\rvert < \pi/4$
FPATAN	Arctangent	Unrestricted	$\lvert ST(0)\rvert < \lvert ST(1)\rvert$
F2XM1	$2^x - 1$	$-1 \leq ST(0) \leq 1$	$0 \leq ST(0) \leq 0.5$
FSCALE	Scale	Unrestricted	Undefined in $0 < \lvert ST(1)\rvert < 1$

$|ST(1)|$, or $-|ST(1)| < r \leq 0$, depending on the sign of the dividend. FPREM1, on the other hand, produces a remainder r such that $-|ST(1)|/2 < r < |ST(1)|/2$.
2. The low-order three bits of the quotient as reported in the status word bits C3, C1, and C0 may differ by 1 in some cases because FPREM1 and FPREM choose the value of quotients differently.

Extended Operand Range

The 80387 has extended the operand ranges of four instructions: FPTAN, FPATAN, F2XM1, and FSCALE. Table 3 compares the operand ranges for the 80387 with those for the 80287.

The allowed operand range for the FPTAN (partial tangent) instruction in the 80387, which computes the function y = TAN(ST) (ST is in radians), is $|ST(0)| < 2^{63}$. The corresponding range for the 80287 is $|ST(0)| < \pi/4$. The FPTAN instruction reduces the operand internally using an internal $\pi/4$ constant, which is more accurate than the value obtained using a constant instruction like FLDPI.

The F2XM1 instruction in the 80387 computes the function $y = 2^x - 1$, $-1 \leq x \leq 1$. This represents an increase in the range from $0 \leq x \leq 0.5$ in the 80287.

Instructions FPATAN (arctangent) and FSCALE in the 80387 have unrestricted operand ranges. The arctangent instruction FPATAN computes the function θ = ARCTAN(y/x), where x and y indicate the contents of ST(0) and ST(1), respectively. Although the range of the operands is unrestricted, the range of the result depends on the relationships between the operands, as shown in table 4.

FSCALE, which scales the top of the stack by the power of 2 given in ST(1), has no restriction on the range of value in ST(1) as the 80287 did. If $0 < |ST(1)| < 1$, the scaling factor is taken to be 0 in the 80387. This contrasts with the 80287, which produces an undefined result.

Rounding Control

Constants 0, 1, π, $\log_2 10$, $\log_2 e$, $\log_{10} 2$, and ln 2 can be loaded onto the 80387 stack using FLDZ, FLD1, FLDPI, FLDL2T, FLDL2E, FLDLG2, and FLDLN2 instructions, respectively. These constants have full extended-real precision (64 bits) and are accurate to approximately 19 decimal digits. The 80387 allows rounding of these internal constants according to the rounding control (RC) bits (bits 11 and 12) of the control word. If the RC bit is set to the Nearest rounding mode, the 80387 produces the same constant as produced by the 80287.

Denormal Operations

The 80387 allows the use of denormal operands with FBSTP (packed decimal BCD store and pop), FDIV (divide real), FIST (integer store), FISTP (integer store and pop), FPREM (partial remainder), and FSQRT (square root) instructions. This differs from the 80287, which raises an invalid-operation exception when denormal operands are passed to these instructions.

Exceptions occur whenever the 80387 receives an invalid operand or produces a

Processor Initialization and Control

During initialization of an 80386 system, system software must recognize the presence or absence of an FPU and set flags in the 80386 machine status word to reflect the state of the numeric environment. If an 80387 is present, it must also be initialized.

Recognizing the 80387

Listing A shows a routine to determine the presence of a coprocessor (8087, 80287, or 80387). The algorithm first tries to determine if a coprocessor is present by examining the status and control words. An affirmative test confirms the presence of a coprocessor. To test for the presence of an 80387, both positive and negative infinities are generated and their values compared. Since the 80387 differentiates between positive and negative infinities, this comparison indicates that the two infinities are different. The 80287, however, does not differentiate between the two infinities.

This program sets the word at SS:FFFEH to 0 if no FPU is present, to 1 if an 8087 or 80287 is present, and to 2 if an 80387 is present. Once this test has been performed and the word at SS:FFFEH appropriately set, a program

Listing A: *A routine to check for the presence of a math coprocessor.*

```
dgroup      group     data
cgroup      group     code

code  segment  public 'code'
  assume    cs:cgroup,ds:dgroup
;
; Look for an 8087, 80287, or 80387 NPX.
; Note that we cannot execute WAIT on 8086/88 if no 8087 is
                                      present.
; Set word at SS:FFFEH to 0 for no NPX, 1 for 8087 or 80287, 2
                                      for 80387
;
test_npx:
  fninit                    ; Init NPX, must use non-wait form!
  mov  si,0fffeh            ; Set offset of status variable
                        ; SS:FFFEH can be accessed at any time
  sub  si,bp                ; [BP+SI] points at SS:FFFEH
  xor  dx,dx                ; Clear NPX status flag
  mov  word ptr [bp+si],5A5AH ; Initialize temp to non-zero
                                      value
  fnstsw    [bp+si]           ; Must use non-wait form of fstsw
                        ; It is not necessary to use a WAIT
                                      instruction
                        ;  after fnstsw or fnstcw.  Do not use one
                                      here.
  cmp  [bp+si],dl           ; See if correct status with zeroes was
                                      read
  jne  set_flags            ; Jump if not a valid status word,
                                      meaning no NPX
;
; Now see if ones can be correctly written from the control
                                      word.
;
  fnstcw    [bp+si]           ; Look at the control word do not use
                                      WAIT form
                        ; Do not use a WAIT instruction here!
```

needs to just examine the value at SS:FFFEH to determine which FPU is present. This can also be used to execute different code, depending on whether an 80287 or an 80387 is present.

80387 Initialization

There is a difference in FPU initialization between the 80287 and the 80387. Either the FINIT or FNINIT instruction initializes the 80387 to a state compatible with the state of the 80287 after FINIT or a hardware RESET. A hardware RESET of the 80387, however, leaves it in a state that is *not* the same as its state after a FINIT or FNINIT instruction. The two states have these differences:

1. The mask bit for the invalid-operation exception is reset.
2. The invalid-operation exception flag of the status word is reset.
3. The exception-summary bit of the status word is set.

These settings cause the FPU to assert the ERROR# output to indicate that an 80387 is present. It is, therefore, necessary to execute an FNINIT instruction after a hardware reset of the 80387.

```
 mov  ax,[bp+si]          ; See if ones can be written by NPX
 and  ax,103fh          ; See if selected parts of control word
                                  look OK
 cmp  ax,3fh              ; Check that ones and zeroes were
                                  correctly read
 jne  set_flags           ; Jump if no npx is installed
;
; Some numerics chip is installed.  NPX instructions and WAIT
                                  are now safe.
; See if the NPX is an 8087/287 or 80387.
; This code is necessary if a denormal exception handler is
                                  used or the
; new 80387 instructions will be used.
;
 inc  dx                ; Indicate 87/287 by default status=1
 fld1                   ; Must use default control word from FNINIT
 fldz                   ; Form infinity
 fdiv                   ; 8087/287 says +inf = -inf
 fld  st                ; Form negative infinity
 fchs                   ; 80387 says +inf <> -inf
 fcompp                   ; See if they are the same and remove
                                  them
 fstsw    [bp+si]          ; Look at status from FCOMPP
 mov  ax,[bp+si]
 sahf                   ; See if the infinities matched
 je   set_flags           ; Jump if 8087/287 is present
;
; An 80387 is present.  If denormal exceptions are used for an
                                  8087/287,
; they must be masked.  The 80387 will automatically normalize
                                  denormal
; operands faster than an exception handler can.
;
 inc  dx                ; Set status variable to 2
set_flags:
 mov  [bp+si],dx
```

result that cannot be represented. When an exception occurs, the 80387 does one of the following:

1. Handles the exception itself by invoking the default exception handler. This happens when the exception is masked (i.e., the corresponding mask bit in the control word is set to 1).
2. Signals the host (80386) that an exception has occurred and invokes a user-supplied exception handler. This is the case when the exception is unmasked—that is, the mask bit in the control word is set to 0.

Types of Exceptions

The 80387 recognizes six types of exceptions: (1) invalid operation; (2) divide-by-zero; (3) denormal operand; (4) numeric overflow; (5) numeric underflow; and (6) inexact result. These six types are described in detail below.

• *Invalid operation*: An invalid-operation exception occurs in two situations: An arithmetic instruction encounters an invalid operand, or a stack operation results in a stack overflow or underflow. As described earlier, the 80387 recognizes two kinds of NaNs—signaling and quiet. An invalid-operation exception is usually raised only upon encountering a signaling NaN. The instructions FCOM, FIST, and FBSTP, however, flag an invalid-operation exception on quiet NaNs. The 80287, on the other hand, signals an invalid-operation exception upon encountering any kind of NaN, since it does not differentiate between two NaNs.

While the 80287 defines and supports special handling for pseudozero, pseudo-NaN, pseudoinfinity, and unnormal formats, the 80387 neither generates nor supports these formats and raises an invalid-operation exception whenever it encounters them in an arithmetic operation.

• *Divide-by-zero*: A zero-divide exception is reported whenever an attempt is made to divide a finite number by 0. This can happen in instructions like FDIV, FDIVP, FIDIV, FDIVR, FDIVRP, and FIDIVR that do explicit divides or in instructions that do divides internally, such as FYL2X ($y \times \log_2 x$) or FXTRACT (extract exponent and significand). If the zero-divide exception is masked, the 80387 responds by returning infinity signed with the exclusive-OR of the signs of the operands in the case of divide (FDIV, etc.) and FYL2X instructions. For FXTRACT, ST(1) is set to negative infinity and ST is set to 0 with the same sign as the original operand. In the event of an unmasked divide-by-zero exception, the operands remain unchanged.

• *Denormal operand*: The 80387 reports a denormal-operand exception whenever an attempt is made to operate an arithmetic instruction on a denormal operand. The masked response for the instruction is to set the DE-bit (bit 2) of the status word and to then proceed with the instruction.

The 80387 does not raise an invalid-operation exception when it encounters a

continued

80387 Performance

The 80387 provides a considerable speed improvement over its predecessor, the 80287. This has been accomplished by using a higher clock speed, an optimized core that takes fewer clocks per instruction than the 80287, and new transcendental instructions. Benchmark results on a system using a 20-MHz 80386 and 80387 show that the Double-Precision Whetstone Performance Index for the 80387 is 1.8 mega-Whetstones. Whetstone is a measure of the number of floating-point computations that can be computed by the processor per unit time.

Using an 80387 in a Compaq Deskpro 386/20 Model 30 reduces the time to remove hidden lines from a sample drawing of the space shuttle using the AutoCAD version 2.62 HIDE command by a factor of 2.6 over the 80287 used in a Compaq Deskpro 286 Model 40. (Source: Compaq Deskpro 386/20 Personal Computer Features/Specifications).

For results of performance tests performed at BYTE on the 80387, see table 1 in "The Intel 80387 vs. the Weitek 1167" by Tom Thompson on page 205.

Compilers available for the 80386 from Green Hills, MetaWare, Silicon Valley Software, Language Processors, and Austec provide a switch for the 80387 that allows the compiler to generate in-line 80387 instructions.

Table 4: *The result range of operands depends on the relationship between the operands.*

Sign(y)	Sign(x)	|y| < |x|?	Final result
+	+	Yes	$0 < \text{atan}(y/x) < \pi/4$
+	+	No	$\pi/4 < \text{atan}(y/x) < \pi/2$
+	−	No	$\pi/2 < \text{atan}(y/x) < 3 \times \pi/4$
+	−	Yes	$3 \times \pi/4 < \text{atan}(y/x) < \pi$
−	+	Yes	$-\pi/4 < \text{atan}(y/x) < 0$
−	+	No	$-\pi/2 < \text{atan}(y/x) < -\pi/4$
−	−	No	$-3 \times \pi/4 < \text{atan}(y/x) < -\pi/2$
−	−	Yes	$-\pi < \text{atan}(y/x) < -3 \times \pi/4$

Table 5: *The rounding modes of the 80387.*

Rounding mode	Sign of true result	Result
To nearest	+	+∞
	−	−∞
Toward −∞	+	Largest finite positive number
	−	−∞
Toward +∞	+	+∞
	−	Largest finite negative number
Toward 0	+	Largest finite positive number
	−	Largest finite negative number

denormal operand in FSQRT, FDIV, or FPREM, or upon conversion to BCD or to integer. The operation proceeds by first normalizing the value. The 80287 will raise an invalid operation in such cases. Furthermore, the 80387, in contrast with the 80287, reports a denormal exception if a denormal operand is found in transcendental instructions and in FXTRACT.

- *Numeric overflow and underflow:* Numeric overflow and underflow exceptions occur when the exponent of a numeric result is too large or too small, respectively, to be represented in the destination format.

The masked response to the numeric overflow exception depends on the

continued

rounding mode. Table 5 shows the results of the computation for various rounding modes. The masked response in the case of rounding mode set to chop (i.e., toward 0) is to produce the most positive or the most negative number. The 80287 will not report an overflow exception in a similar situation. It will, in fact, signal overflow only when the rounding control mode is *not* set to round to 0.

If the overflow exception is not masked in the 80387, it raises the precision exception (inexact result). When the result is stored on the stack, the significand is rounded according to the precision control (PC) bits (bits 9 and 10) of the control word, or according to the op code. In the 80287, on the other hand, the precision exception is not reported, nor is the significand rounded.

The underflow exception is flagged by the 80387 if the true result is so small that it cannot be represented in the destination format. When the underflow exception is masked, it is signaled when there is a loss of accuracy in the result. The 80287 will report the underflow exception on underflow if rounding is toward 0, regardless of loss of accuracy.

If the underflow exception is unmasked and the result is to be stored on the stack, the significand is rounded according to the precision control bit of the control word in the 80387. The 80287 does not round the significand on the stack.

• *Inexact result:* If an operation produces a result that cannot be represented exactly in the destination format, the inexact-result exception is reported. The inexact exception is also raised in the event of an underflow exception with a loss of accuracy.

The 80387 does not give precedence to the denormalized exception, whether it is masked or not. In the 80287, the unmasked denormal exception takes precedence over all other exceptions.

Programming Examples

Listing 1 shows an example of 80387 code to compute $y=e^z$. Note that $e^z = 2^{z \times \log_2 e}$. The program first checks to find out whether an 80387 or an 80287 is present. This is done by examining the value stored at SS:FFFEH. If an 80387 is present, the code takes advantage of the fact that the instruction F2XM1 accepts operands in the range $-1 <= z <= 1$. First, the largest integer X that satisfies the condition $z \times \log_2 e = x + y$ is found. Note that all values of y satisfying the above condition must lie in the range $-1 <= y <= 1$. The expression $2^{z \times \log_2 e}$ is computed by computing the expression $2^x \times [(2^y - 1) + 1]$. Slightly different code is used to compute e^z if an 80287 is pre-

Listing 1: *A code sample illustrating the use of 80387 instructions.*

```
; compute ez, assume Z is in ST
FLD1
CMP SS:BYTE PTR 0FFFEH,1 ; 80287 or 80387?
JE USE_287
 ; 80387 found
FLDL2E ; load log2e
FMUL ST, ST(2) ; ST = Z * log2e
FST ST(2)
FPREM ; reduce ST between -1 and 1 F2XM1
FADD
FSCALE
FSTP ST(1)
RET
USE_287:  ; 80287 found
FCHS
FLDL2E
FMUL ST, ST(2)
FST ST(2)
FTST
JB NEG_VAL
FPREM
FSCALE ; postitive value
F2XM1
FSUBR
FMUL ST, ST(0)
FSCALE
FSTP ST(1)
RET
NEG_VAL:  ; negative value
FPREM
FCHS
FSCALE
F2XM1
FSUB ST,ST(1)
FMUL ST,ST(0)
FDIV
FCHS
FSCALE
FSTP ST(1)
RET
```

Listing 2: *Sample code illustrating the use of built-in transcendental functions.*

```
; compute ARCSIN(Z), assume Z in ST
FST ST(1) ; ST(1) = ST = Z
FMUL ST, ST(0) ; ST = Z2
FLD1
FSUBR ; ST = 1-Z2
FSQRT ; ST = SQRT(1-Z2)
FPATAN ; ST = ARCTAN(Z/SQRT(1-Z2))
RET
```

sent, since the F2XM1 instruction in the 80287 supports only operands in the range $0 <= z <= 0.5$.

An example of how to compute the function ARCSIN(z) is illustrated in listing 2. It makes use of the relationship ARCSIN(z) = ARCTAN(z/SQRT($1-z^2$)).

New Look

The 80387 provides the system designer with significant enhancement in features and speed over the 80287. It fully conforms to the IEEE 754-1985 Standard for Binary Floating-Point Arithmetic. While maintaining object-level compatibility with the 8087 and the 80287, it provides the 80287 set of floating-point instructions with additional trigonometric, unordered comparison, and partial-remainder instructions. The operand ranges for some 80287 instructions have been expanded in the 80387. ■

Floating-Point Survival Kit

An insider's look at number-crunching fundamentals, standards, benchmarks, and high-performance designs

Pete Wilson

MICROCOMPUTERS HAVE NEVER been better at number crunching. In computation-bound applications, high-end microprocessors actually can outstrip some minicomputers. And they're getting better.

The performance of the new 32-bit machines is an order of magnitude greater than the old 80286-family devices. Now every vendor (of microprocessors, personal computers, and workstations) is increasingly claiming magnificent performance levels on sundry benchmarks.

While this is fun for the vendors, it can be confusing to purchasers. How can you judge how good a design might be for number crunching? What, if anything, do the various benchmarks mean? To help provide some answers, I'll review the fundamentals of floating-point arithmetic, examine some issues in building floating-point systems, skim over some benchmarks, look at how machine designers get high-performance floating point, and then wrap it all up with some words of advice.

What Is Floating Point?

Integer arithmetic is useful for many applications. However, when an application needs to deal with a very wide dynamic range of values, integers fall short. A 32-bit processor, doing integer arithmetic, can deal simply with a range of values where the largest value is no more than 2^{32} (about 4000 million) larger than the smallest, while a 16-bit machine can handle—with the same ease—a range of just 65,536 to 1.

The need for wider ranges arises in situations as disparate as quantum cosmology (mixing subatomic dimensions with astronomical distances in the same program) and CAD (where the smallest components have tolerances in microns but the complete project covers some city blocks).

We could deal with these situations by doing multiword (e.g., 96-bit) integer arithmetic with our processors, but it is usually more convenient to use floating-point arithmetic. Floating point buys—for a given bit budget—a vastly wider dynamic range in values. The price paid is that the answers have less resolution and the execution time or hardware cost is greater than if we had been able to stick with word-length integer arithmetic.

A 32-bit processor doing integer work represents each integer as a word; all 32 bits of the word are used to represent the size of the variable. A 32-bit processor doing floating-point work breaks each 32-bit word up into two separate fields: one field is a number, while the other is a scaling factor for that number. Many choices are possible for the meanings of these two fields: For example, the value field could represent an amount in the range 0.25 to 0.5, while the scaling factor represents the number of places to shift the value field left (positive factor) or right (negative factor) to compute the value of the number.

Doing arithmetic in floating point has a number of pitfalls; things don't always work the way you might expect. To illustrate some of these issues, I'll work through some simple examples. First, let's adopt a floating-point format which packs an unsigned 24-bit value field (the mantissa, also known as the significand) and a signed 8-bit scale field (the exponent) into a 32-bit value. The mantissa represents numbers in the range 0.25 to (nearly) 0.5 (so the most significant bit of the mantissa means 0.25, and the least significant bit means 2^{-26}) and is unsigned to keep the examples simple. This format can deal with numbers in the range of about 0.25×2^{-128} to 0.5×2^{127}, or about 10^{-40} to 10^{40}.

Using this representation, let's look at converting the values from fixed-point binary to floating point. Fixed-point binary represents numbers as *Integer.Fraction*, where *Integer* is a (possibly multiword) bit pattern representing the integer portion of a number, and *Fraction* is a (possibly multiword) bit pattern representing the fractional part; the most significant bit of the fractional part has value 0.5, and the least significant bit of *Integer* has value 1. We shift the binary point in *Integer.Fraction* until its value lies in the range 0.25 to 0.5; that value becomes the mantissa. The number of shifts required becomes the exponent of the floating-point number. If the original number was larger than 0.5, we shifted it down, so the exponent is a negative number; if the value was smaller than 0.25, we shifted the binary fixed point up, and

continued

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Implementing Floating Point

Implementing IEEE floating point in hardware or software is not easy. First, the standard itself calls for some complex operations. Second, it matters to some customers that the results are correct. (You wouldn't want an air traffic control system to have errors in the floating-point hardware used in the radar systems to track the planes.) The combination is a nuisance because it is too complex to test—there are too many possible combinations to look at (suppose you wanted to test the double-length operations; then there are four operations (+, −, *, /) to be done on pairs of 64-bit numbers; this corresponds to $2^{(2+64+64)}$ or about 10^{39}. At a nanosecond per operation, this takes about 10^{30} seconds, which is too long to wait to bring something to market, even if we had some means of getting the correct answers fast enough to do the comparisons.)

Because of this, when INMOS decided to build the T800—a microprocessor combining a 32-bit integer CPU, an IEEE floating-point unit (FPU), 4 kilobytes of memory, an eight-channel direct memory access (DMA) driving interprocessor communications channels plus other facilities—it was necessary to take a different approach.

The approach was simple; if it's impossible to show by testing that the design is correct, then it is necessary to create a design which is provably correct. The situation is much the same—but noticeably more complex—as the exercises we did at school in geometry to prove relationships (e.g., the Pythagorean theorem). The basis is to have a language of some form (Pythagoras used the language of geometry) in which you can describe the situation and which has appropriate rules that allow you to demonstrate that two statements in the language either do or don't mean the same thing. Then you write a description of IEEE arithmetic and a description of your design and show that they are equivalent. Then your design is correct.

In practice, more than one language was needed. It was done like this: First, a description of IEEE arithmetic was written in a language called Z, which was created by Jean-Raymond Abrial and has been developed and used extensively by members of the Oxford University Programming Research Group (PRG), with whom INMOS worked very closely in this project. Z was designed to tackle the problems of specifying real systems. You specify things in Z quite straightforwardly; the example in figure A shows a Z specification of the range checking that needs to be done inside IEEE arithmetic.

The specification is labeled with its name and consists of a box with an upper and a lower portion. The upper portion is equivalent to the declaration section of a programming language; here it says that there is something called `Areg` that is a `Floating_Point_Register`, and something called `Error_Flag` that is a `Boolean`. Both have values associated with them; the names are the values prior to the operation, and the primed names are the values after the operation.

The lower portion of the box contains constraints on the values that the things

a) Floating check integer range module

```
Areg, Areg' : Floating_Point_Register

Error_Flag, Error_Flag' : bool
-----------------------------------------------
fv ∈ Z
Areg' = Areg
fv Areg ∈ [MinInt, MaxInt] → Error_Flag' = Error_Flag
fv Areg ∉ [MinInt, MaxInt] → Error_Flag' = true
```

b) High-level Occam representation

```
IF
   Areg.Exp < LargestINTExp
      SKIP
   (Areg.Sign = NEGATIVE) AND (Areg.Exp =
                          LargestINTExp) AND
                          (Areg.Frac = MSBit)
      SKIP
   TRUE
      SetError(ErrorFlag)
```

c) Low-level Occam representation

```
SEQ
   AregsignNEGATIVE := (Areg.Sign = NEGATIVE)
   ExpZbus := (Areg.Exp - LargestINTExp)
   ExpZbus := ExpZbus < 0
   IF
      ARegSignNEGATIVE
         /*... do the negative case */
      NOT AregSignNEGATIVE
         IF
      ExpZBusNeg
         SKIP
      NOT ExpZbusNeg
         SetError(ErrorFlag)
```

Figure A: *Example of the specification language Z and its equivalents in Occam and microcode.*

in the upper portion can have. Here fv is a function that returns the value of a floating-point register (Z is the set of floating-point values). We see that the values of Areg before and after the operation are the same; and we see that whenever the value in Areg (looked upon as a floating-point number) is in the range [MinInt to MaxInt], the value of the Error_Flag after the operation is whatever it was before, and that if the value in Areg isn't in that range, then Error_ Flag contains the value true after the operation.

The first step in the exercise was to create specifications for all the operations needed for IEEE arithmetic in this form to provide a formal specification of just what IEEE arithmetic is. The next step is to create an equivalent description in another language—one that will be more useful in describing an implementation with its microcode, registers, and other detailed nasties—and to prove that the Z description and the new description are the same.

The language Occam was chosen for this; Occam has a formal semantics (i.e., every legal Occam statement has an unambiguous meaning) and so it is possible to demonstrate the equivalence of an Occam program to a Z specification. The Occam specification of the range-checking operation is shown; it is as close as practical to the Z specification. Proving that this is correct means proving two assertions—first, that there is an exponent (LargestINTExp) such that every register with a smaller exponent has a value in the range [MinInt..MaxInt]; second, that a register with a negative exponent sign bit, an exponent of LargestINTExp, and a mantissa with only the implied most significant bit set has a value of MinInt.

The Occam description is then moved a step closer to a real implementation by involving facilities and operations that are available from the microcode. This description is then itself taken and transformed yet again to use a microcode instruction pointer. Finally, this last Occam representation is taken and converted into real microcode.

To ensure that these successive transformations are all correct, two methods are used. One is to use the formal semantics of Occam; you can demonstrate that two programs in Occam do or do not have the same effect (if they have the same effect, if one is correct then the other one must be). The other is to use automatic translators—for example, getting microcode from Occam text can be done by a program which is analogous to a C compiler's preprocessor: It is a pattern-matching and textual-substitution program.

Being able to do something "in principle" isn't quite good enough in practice, and the design work wasn't done in the sequence outlined here. Rather, what happened was that the Z specification of the arithmetic was done first, and then an Occam implementation of the IEEE package that already existed (it implemented the floating point for the INMOS T414) was shown to be equivalent; this involved two transformations.

continued

d) Microcode-like Occam

```
INT NextInst:
SEQ
   NextInst := FloatingPointCheckIntegerRange
   WHILE NextInst <> NOWHERE
      IF
         NextInst = FloatingPointCheckIntegerRange
         SEQ
      AregsignNEGATIVE := (Areg.Sign = NEGATIVE)
      ExpZbus := (Areg.Exp - LargestINTExp)
      ExpZbus := ExpZbus < 0
      IF
         ARegSignNEGATIVE
            /*... do the negative case */
         NOT AregSignNEGATIVE
      IF
         ExpZBusNeg
      NextInst := NOWHERE
         NOT ExpZbusNeg
      NextInst := OutofRange
         NextInst=OutOfRange /* now setting error has
                              its own microinstruction /
      SEQ
         SetError(Errorflag)
         NextInst := NOWHERE
            /*...    other microinstructions */
```

e) Microcode version

```
FloatingPointCheckIntegerRange:
ConstantLargestINTExp
ExpXbusFromAreg        ExpYbusFromConstant
ExpZbusFromXbusMinusYbus

GOTO Cond1FromAregSign   -> (Cond0FromExpZbusNeg ->
                             (...,  ...),
                             Cond0FromExpZbusNeg ->
                             (NOWHERE, OutOfRange)
```

To do this, an Occam source transformation system (written in the ML programming language and implemented by the PRG) was used. The transformation of the (now demonstrably correct) Occam into microcode was then done semiautomatically using the textual-translation programs mentioned above.

Because the translation programs weren't themselves proven correct, it is possible that the transformations they did were not correct, and so the aim of having a formally proven correct implementation was itself not met. Nonetheless, using the formal methods paid off very well. The first T800 appeared last February, and by that time it had already been decided to improve the performance of the production machine by speeding up the floating-point multiply; other than that, though, there were never any floating-point errors discovered in the Rev A design.

The first silicon of the faster design appeared in May, and it turned out a few idiosyncracies had slipped through the net. These errors were fixed in the current Rev C, which is now shipping in volume; one flaw still exists in the Rev C—if you divide infinity by infinity you get infinity rather than NaN, but this is taken care of by compilers and won't be visible to customers. From start of design to volume production took INMOS just 18 months; this is much quicker than most design cycles for just coprocessors, and so seems to justify the approach taken.

The other half of correctness is performance; doing the design in this style didn't damage the T800's performance at all. To indicate how well it has succeeded, here's the set of benchmark results obtained using a Logical Systems C compiler on a CSA PART.1 board. (Logical Systems offers a transputer C compiler/assembler/linker package; it is written in C, and the price includes the source to the complete compiler: CSA is one of a number of companies making add-in cards; the PART.1 provides four T800s each with a megabyte to plug into an IBM PC or compatible.)

Since the compiler is a beta release and the people doing the measurements are the people who built the boards, this doesn't count as an official BYTE benchmark; nonetheless, the source code of the programs as used and the generated transputer assembler are available on BIX, in print, and on disk.

Benchmark Results

The benchmarks were run on CSA's PART.1 with 20-MHz T800C, using the Logical Systems C compiler 87.8D (LS C) and the Lattice Logic Ltd. C compiler 1.3 (3L C). The timings in tables A, B, and C were obtained using the transputer's low-priority timer.

The figures in table A are in seconds except for the Dhrystone and Whetstone, which are in units of Dhrystones per second and Whetstones per second.

Table B shows the results of the complex fast Fourier transform (FFT) benchmark using IEEE single-precision arithmetic. Times are in milliseconds. Tests were run on the PART.1 system (LS C). The Lattice Logic C (3L C) compiler would not compile the FFT benchmark.

Table C presents results of a FLOPS benchmark. The following code sequences were executed iteratively with the loop overhead subtracted to show the T800's sustained FLOPS capability:

```
(a)  c = a+b; c = a-b; c = a*b; c =
          a/b;
(b)  f = ((((((((a+b)-c)*d)/e)+
          b)-c)*d)/e);
```

Both C compilers show a dramatic increase in FLOPS when executing (b) as compared to (a). Given the long expression, the compiler makes use of the transputer's ability to overlap FPU and CPU processing time.

Table A: *Standard BYTE benchmark results, showing different compilers produce significant differences on the same T800-based PART.1 machine (the PC AT results are included for comparison purposes only).*

	PART.1 LS C	PART.1 3L C	IBM PC AT 8-MHz 8027
Whetstone (single)	4,002,400	N/A*	N/A
Whetstone (double)	N/A*	2,016,510	N/A
Dhrystone	8634.13	5667.34	1590.00
Fibonacci (sec.)	15.07	22.54	126.22
Float (sec.)	0.16*	0.27	10.98
Savage (sec.)	02.67*	5.88	37.30
Sieve (sec.)	6.39	6.14	24.60
Sort (sec.)	4.55	4.64	43.17

*IEEE single-precision. The version of the Logical Systems C compiler tested supports single-precision arithmetic only.

Table B: *Complex FFT benchmark results (not available for PC AT).*

Points	Forward (ms)	Inverse (ms)
64	3.072	3.392
128	6.592	7.168
256	14.336	15.552
512	31.104	33.600
1024	67.520	72.512

Table C: *Results of the FLOPS test. Long-expression times are faster because FPU/CPU overlapping is possible.*

	(LS C) single-precision	(3L C) double-precision
Short expression	1,095,415	733,602
Long expression	1,552,872	1,038,551

so the exponent is positive.

Shifting occurs a great deal in floating-point work; any processor that wants to get reasonable performance without a coprocessor will normally provide a specialized instruction set for the operation. The instruction—*normalize*—examines the number to be converted, starting at the most significant bit. It moves down the word until it finds two adjacent bits of different value; suppose bit n and $n-1$ are found to be 0 and 1. The mantissa is then simply obtained by shifting the whole word left by (word length $-n$) bits and setting the exponent to n.

Grainy Numbers

Given this picture, a number of facets of doing arithmetic in floating point can now be illuminated. First, note that it is not possible to represent exactly all numbers using floating-point format. For our 32-bit format, for example, it is possible to represent every integer between 0 and 2^{24} (8,388,608). But we cannot exactly represent all the fractions, nor can we represent all the integers larger than 2^{24}; 2^{24} is represented as 0.5×2^{26}; the smallest value we can add to that is $2^{26} \times$ the least significant bit of the mantissa, which is 0.5×2^{-24}, with a value of 0.5×2^2. This is 2. So the "next" number after 8,388,608 is 8,388,610. This example shows that there are gaps in the numbers that can be exactly represented.

This phenomenon is often referred to as the "graininess" of floating-point numbers; just as high-speed photographic film can obscure fine detail by its large grain size, so can each floating-point number represent a range of numbers in the real world up to a certain limit on detail.

This graininess has two important side effects; first, if you try to add a very small number to a very large number, the result can be that the large number is unchanged. So don't try to write program loops that say `FOR i=0 TO 100000000 STEP 1` unless you're sure that adding the step size actually changes the number. And if you subtract two large values, the result can be inexact, so be careful when using the results of such subtractions. A related problem is that since the numbers aren't exact, it is not unusual to find that the program that says `IF a=b THEN ...` doesn't work reliably.

How is the number 0 to be represented? Looking at the situation simply, any floating-point number with a 0 mantissa has a value of 0. But the rules say that mantissae have to be in the range 0.5. .0.25, so properly speaking we cannot have a floating-point 0 in the number scheme. Instead, most schemes have a special representation for 0. This might be mantissa=0, exponent= -127, for example. Such "special case" representation is useful because it gives us access to lots of bit patterns that are not legal floating-point numbers that we can use to indicate special circumstances. Now, for example, we can choose another of the bit patterns to mean infinity, so rather than just complaining "overflow" when we divide the largest possible number by the smallest, we can set the result to infinity.

Sometimes it is useful to relax the rule that says the mantissa must be in the normalized range. For example, try dividing 0.25 by the largest possible number. The result is a quarter of the smallest possible number, which we could represent simply enough if we allow the mantissa to have a value outside the 0.25. .0.5 range.

Numbers like this, whose mantissae are too small, are called "denormalized." Their only real problem is that they are even less accurate than the normalized numbers. Nevertheless, they are still useful—provided the programmer has been careful with the organization of the arithmetic—in that they provide some indication of the answer even when the exact value is unrepresentable.

The Need for Standards

Suppose we change our floating-point format from 24-bit mantissa and 8-bit exponent to have a wider dynamic range—say 22 bits of mantissa and 10 bits of exponent. Then we'll find that running exactly the same program with this scheme will, in general, give us quite different answers from our initial scheme.

This is what used to happen when people moved programs from one computer to another. The various computers all had slightly different floating-point schemes, and programmers had to be highly competent numerical analysts to design programs that were robust enough to provide useful answers when they were moved between floating-point schemes. This was a real nuisance; it was a situation crying out for a standard.

Such a standard now exists: the IEEE standard 754-1985. The document specifies a standard for the representation of binary floating-point numbers and for the rules governing rounding, truncating, and accuracy. All the major manufacturers of microprocessors support the standard (e.g., Intel's 8087, 80287, and 80387; Motorola's 68881 and 68882; INMOS' T800 and T414).

The standard specifies three formats—for single length, double length, and extended-format floating-point values. Single length fits in 32 bits and comprises 24 bits of mantissa and 8 bits of exponent; double length puts 53 bits of mantissa and 11 bits of exponent into 64 bits, and extended uses 80 bits for a 64-bit mantissa and 16-bit exponent.

Accuracy and Loops

Why use the double format instead of the single? Often, single-length operations go faster (especially multiply and divide) and need less memory. The problem is that, loosely speaking, every time you combine a pair of numbers you lose up to a bit of accuracy. Suppose you multiply two single-length floating-point numbers. The result should have 48 bits of mantissa, but it only has 24 bits; if renormalization was necessary, some bits that mattered will have been lost. The same things happen—even worse—with division.

So if you write a program that does lots of operations repeatedly on a set of numbers, they slowly lose accuracy as low-order bits slip off the bottom. The simple cure is to use as many bits of mantissa as possible—thus the attraction of double-length and extended formats.

The effects of this accumulating round-off error are worst in programs that keep crunching on numbers; big loops that compute stuff on one iteration and use the results in the next, which produces results for the next iteration (and so on), are obvious dangers.

Measuring Performance

Now suppose that you have a numerically demanding application and you need to choose a system on which to run it. With the more or less universal adoption of the IEEE standard, you can be reasonably sure (barring implementation errors—see the text box "Implementing Floating Point" on page 218) that all the alternatives will give you the same (hopefully correct) answer. But they'll take varying amounts of time to do it. If you need very high performance, then it can matter which machine you buy.

There are two classical answers to the problem. One is the not very helpful suggestion that you try your application out on every machine and then buy the fastest: the problem with this is that the cost can be very high (even if you can find a machine nearby) and that, in any case, your application is likely to change. So then you'd have to do the whole exercise over again. What's needed is some program whose performance on a range of machines is a good predictor of how well other programs will run on those machines. All you need to do is to find a good predictor program, run it on the candidate machines, and choose the fastest.

This is the second classical answer: the predictor programs are called benchmark

continued

programs, and the whole process of benchmarking is fraught with pitfalls. While in practice the only realistic way to get some hint of comparative performance is to use benchmark programs, it is important to understand both the needs of your own application and the strengths and weaknesses of the benchmarks themselves.

As an example, consider the benchmarks that have become accepted as indicators of integer performance: The Sieve of Eratosthenes and the Dhrystone are both widely used. Trouble is, neither of these is any good at predicting the performance of a real program on the machines. The Sieve is a very small program, so it fits completely inside the instruction cache of many modern microprocessors when real applications generally won't; the result is that the Sieve is an optimistic predictor of performance for machines with an instruction cache. (Examples of microprocessors with instruction caches are Fairchild's Clipper chip set, Intel's 80386-equipped Above-Board, INMOS' T800, and Motorola's 68020.)

And the Dhrystone spends far too much time doing string manipulations. Not only do real applications spend less time manipulating strings than the Dhrystone does, but strings are dealt with quite differently between languages. As a result, Pascal Dhrystones for a computer can be quite different from C Dhrystones.

This difference arises because in Pascal (and Ada, the original Dhrystone implementation language) the length of a string is always known—it's attached as a byte count to the front of the string. In C, the length isn't known, but the last character is followed by a zero. So to copy a string from one place to another in Pascal, you can use a block move (on a machine that has the instruction), while in C you have to generate code that first finds the end of the string.

So it is important to understand just what a benchmark is trying to measure as well as knowing how well it does it, and it is unlikely that comparing even nominally equivalent programs in different languages can be relied upon.

Floating-Point Benchmarks

The usual floating-point benchmarks are the Whetstone, Linpack, Savage, and the Livermore Loops. Each takes a different view of what is interesting.

The *Whetstone* originated in England at the National Physical Laboratories (NPL) in the 1960s. Originally written in Algol 60, it was intended to represent a typical medium-size scientific computation mix. The idea was that if you were a scientist or an engineer, the performance of a computer with the Whetstone benchmark would be a reasonable indicator of how well the machine would do with a wide range of programs of interest to you. Such programs do a lot of floating-point, array, and trigonometric work. The benchmark consists of a set of little tasks; the time for each task is noted, and the machine's performance is measured as a weighted sum of the individual times.

As an aside, today's compilers can totally destroy the usefulness of a benchmark program if it isn't written properly (by noticing, for example, that a result computed inside a loop is never used, a compiler can decide not to generate code for that piece of program; then it will notice that the loop isn't controlling any code, and remove that. Pretty soon you have a null program). The Whetstone was carefully written, and seems to be proof against optimizing compilers. The Dhrystone, whose whimsical name is a pun on Whetstone, regrettably is not proof against optimizing compilers.

Linpack is a different kettle of fish. Owners of supercomputers tend to have them spend much of their time solving partial differential equations numerically, and the Linpack benchmark is simply a standard program with a standard set of data that does just that. Unlike the Whetstone—which is a contrived program intended to exhibit balanced behavior—Linpack is a real program used for real work. However, it does have the major weakness (as a benchmark) of being a very poor predictor of general performance for the very reason that it does just one job.

Further, a computer's performance on the Linpack benchmark is mostly an indicator of how quickly the machine can run a single inner loop of the program. This loop can be vectorized quite nicely, so machines like the Cray run it very quickly.

The *Savage* benchmark isn't about speed at all. It was designed to indicate how reliable—in the sense of accurate—the trigonometric routines in a floating-point implementation are.

At first glance, this seems strange; surely all IEEE-standard packages will produce exactly the same accuracy? Not so; even standards have "gotchas." The IEEE standard specifies three ways of doing sums—the single length (32 bits; 24 mantissa, 8 exponent), double length (64 bits; 48 mantissa, 16 exponent), and extended (80 bits; 64 mantissa, 16 exponent). Implementations have some freedom about just how they use these.

For example, assume that you're a floating-point coprocessor and have been given three single-length numbers and asked to do some sums with them. Because you're feeling kind toward the world, you convert the numbers to extended format, work on them in that format, and convert back to single length. This use of extended format provides extra precision to the answer, surely something that the world will be grateful for.

This approach is used by the Intel family of floating-point processors, and on the surface it sounds like a good idea; since the FPUs always work in 80-bit for-

continued

mat, you get the best possible answers (without any speed penalty, since the processors are built around an 80-bit ALU), and the approach is allowed by the standard.

But the approach can lead to some bizarre side effects. Suppose you've written a program that needs to compute the value of (a/b)*c. Being a little unsure of yourself, you do it step by step as a sequence of operations: First you calculate a/b (and store the result somewhere, say x), and then you multiply the result by c. So your program might say

```
float sum(a,b,c)
float a, b,c;
        {
        float x;
        x = a/b;
        return x * c;
        }
```

Testing it, you find that the steady approach has paid off and that it works, so now—flush with success—you get rid of the temporary variable x:

```
float sum(a,b,c)
float a, b,c;
        {
        return (a/b)*c;
        }
```

Running it again, you get a different answer. Of course, what happened was that in the first example, the program computed a/b in extended precision, shrank the result down to single length, and used that for the division. In the second case, the sum was done in extended precision all the way through, and so the answer could be different since the rounding done could be different.

The same sort of thing can happen if your compiler-writer wasn't too careful about the code generated. If you wrote x = c*(a/b)−d*(a/b), the compiler should notice that a/b is used twice, work it out just once, and reuse the result. Optimizing compilers will also note reuse of an expression across several lines of program and try to do the same thing (this is called common subexpression elimination) to speed up execution.

If the compiler generates code that causes the FPU to save the result of evaluating a subexpression in memory, then it is important that the result be saved as an extended-precision number; this takes up 10 bytes of memory and lots of store cycles. Sloppy coding might save it as a single-length result, so that if you compiled with optimization off you'd get no subexpression elimination and one answer, while compiling with optimization on would give the elimination and yield a different answer.

To return to the Savage benchmark: As indicated, it is intended to provide you with an indication of the accuracy of the trigonometric routines in your implementation, and it does that by computing the value of an expression whose value is known exactly (from trig identities, rather than by doing the calculation to exact accuracy).

Finally, the *Livermore Loops* are, in a sense, an up-to-date version of the Whetstone. Like the Whetstone, they attempt to indicate how well a machine will work on a range of scientific applications by providing a sequence of subtests. Unlike the Whetstone, though, the performance figure isn't a single figure formed as a weighted average of the individual times. Rather, the "official" benchmark results indicate performance in MFLOPS (million floating-point operations per second) in terms like the average, the fastest, the slowest, and the standard deviation. So you get an idea of the spread of capability of your machine rather than just a single-point figure; immediately, this makes the Loops a better predictor than the other benchmarks for scientifically oriented work.

The Loops themselves (so-called because they consist of a number of program loops representing the vital portions of many interesting problems in physics and math) only have one drawback (for our purposes); they're written in FORTRAN while most personal computer system analysts and testers use C.

High-Performance Floating Point

Next we look at how to design a computer to get it to give a high floating-point performance. As with everything, we need first to identify what the problem is before trying to fix it; from the earlier discussions, it seems that the Livermore Loops give a useful indicator of what needs to be done in number crunching, so we'll use that as a guide. Looking at the Loops, we quickly come to these conclusions: Most floating-point sums involve complex expressions and array access.

As an example, here is the code for Livermore Loop 7:

```
DO 7 k = 1,n
   X(k) = U(k) + R*( Z(k) + R *
   Y(k)) + T*(U(k+3) + R*(U(k+2)
   + R * U(k+1)) + T*(U(k+6) +
   R*(U(k+5) + R * U(k+4)))
7 CONTINUE
```

This is FORTRAN for "execute that loop n times with k varying from 1 to n." Look at what the code is doing; for example, look at what needs to be done to do some of the work, like computing R * U(k+4).

First, we need to compute the address of the array element. This involves getting the address of the base of the array (this is FORTRAN, and COMMON at that, so it's in a fixed location in memory), adding (k+4) times the word-length of a floating-point number to that address, reading that location from memory, then getting the value of R (in a register, say, since it's going to be used a lot) and multiplying them together. And that's if our compiler-writer had been naughty: really, we should check that the element we're accessing actually is inside the array.

The first thing that's obvious is that having a processor with an infinitely fast floating-point multiply isn't a complete cure: all that accessing takes time, instructions, and memory accesses. In fact, it looks like the biggest problem is getting data to an FPU. So two routes are taken to minimize the loading times.

First, clever compilers can look at the code and save some time. In this example, we look at quite closely bunched elements in an array; the elements we look at next time around are close to the previous time's elements. So a compiler would take advantage of this by using a pointer (and store the pointer in a register, if the machine has registers); accessing U(k + 4) comes down to reading the contents of memory at location 4 × 8 + (register 4)—that is, 32 bytes beyond where register 4 is pointing (assuming 64-bit values). Then the register is incremented at the bottom of the loop by 4 bytes, and around we go again. This also lets the bound-checking be done once per loop iteration, rather than on every access.

The result of this transformation is that each array access is now just an indexed load, which is a lot quicker. But it will still take the machine at least 10 (one for each read plus a write) memory cycles to compute the value for X(k), plus the time for an add (to increment the pointer), plus whatever code is needed to check the loop end conditions; typically, this will total at least 25 integer instructions. The program runs faster, but even with infinitely fast floating-point work, it still takes 25 integer-instruction times per loop iteration. And it's pretty difficult to get infinitely fast FPUs.

Or is it? Look at the code again. It is a sequence of fetching things from memory, operating on them, fetching other things from memory, operating on those, and then combining the results. To do R*(U(k+2)) + R*(U(k+1)), we need to get U(k+1), multiply it by R, then get U(k+2) and add that in, and then multiply by R. If we design the FPU/processor interface properly, we can get U(k+1) from memory, give it to the FPU, give R

continued

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to the FPU, and tell it to multiply them together. While it's doing that, we go and read U(k+2) from memory, hand it to the FPU, and tell it to add it in. By the time we tell the FPU to do the addition, we'll have had several instruction times for the FPU to have finished the multiply.

This approach of letting the FPU and the CPU run in parallel is the other half of getting floating-point performance out of normal machines, and has been adopted by all the microprocessor vendors. The effect, given a sufficiently fast FPU (one that can do a floating-point add in about the time the CPU can do a memory read and an instruction or so), is to get the computational power of an infinitely fast FPU for a wide range of real programs.

The Supercomputer Advantage

That sort of approach, with computers typical of today's workstations and high-end personal computers, can result in systems which can do a sustained 1 or 2 MFLOPS; you can get this from a T800, or from an Intel/Weitek 80386/1167 combination, for example. The limit is the variable accessing and control, rather than the FPU times. How does a Cray go so much faster?

Well, there are some obvious differences. First, the memory is quicker (and so is the machine that fetches operands). But, perhaps surprisingly, for many computations, the Cray isn't so very much faster. For example, a T800-20 can hit 2.5 million (64-bit) Whetstones per second, while a Cray X-MP-1 hits 26.6 million. Then supercomputers are only 10 times as fast as a microprocessor. But on Linpack, where the T800 will offer perhaps a little below 1 MFLOP, the X-MP-1 will be a hundred times faster. Why the difference?

Consider doing a vector multiplication. To do this, you take each element in a row of a matrix, each element in a column, multiply the corresponding elements pairwise, and add up the answers. Then you repeat the operation lots of times.

Now assume you have an FPU with two inputs, and that you have a clever block-move instruction in your CPU. You could move the row elements one by one into one input, and the column elements one by one into the other. Then you tell the FPU to multiply together its inputs, and you'll get a sequence of outputs. If you then attach another FPU to the output of the first FPU, and tell it to add what it sees on its input to what it's already got, you can get the complete (row × column) computation done in no more time than it takes to blast the values from memory.

The block moves have to be clever (the elements are not side by side), so successive values are some distance apart. This sort of extra hardware resources lets Crays go faster than normal processors, but only on the right sort of problem.

Suppose that 100 MFLOPS or so isn't enough. How do we go much faster? Brute strength helps; faster technologies squeeze down the cycle times of machines so that they go ever faster. Today's limit for traditional supercomputers seems to be around 1000 MFLOPS; if we want to go faster, another approach is needed.

The only approach that seems to have the right sort of promise is the obvious one—do more things at once. There are a couple of different approaches to this: one connects up fairly small numbers of horribly quick computers, and the other—more relevant here—connects up large numbers of microprocessors.

Typical examples of the latter are Intel's iPSC Hypercubes (which use bucketloads of 80386s), Floating Point Systems T-Series and Meiko's Computing Surface (which both use INMOS transputers), systems from Ametek and BBN (which use 68000-family machines), plus NCube (which uses a custom microprocessor). These machines all offer the promise of going faster as you add processors to them; being microprocessor-based gives them excellent price/performance.

But unlike Crays, which have compilers that can take care of the clever hardware efficiently, these machines don't have compilers which can take a "normal" program and massage it automatically so that the awesome power of a collection of 1024 T800s can be brought to bear. But with the price/performance offered by the approach (Floating Point Systems' top machine is quoted at 18 giga-FLOPS, for example), it is becoming increasingly attractive to rewrite code especially for these machines. This has relevance, since you can buy multiprocessor add-in cards for personal computers, so this extra performance is there for many personal computer owners (for instance, the CSA PC add-in card described on page 220).

Not Written in Stone

We've seen some of floating point's quirks and pitfalls, had a look at benchmarks, seen how supercomputers do even better, and finished by seeing how the ordinary microprocessor is turning the tables on the supercomputers.

In the course of the discussion, I hit on the Livermore Loops as the best all-around benchmark, spoiled only by the fact that they're in FORTRAN; this leaves the Whetstone benchmark as the most widely useful microprocessor benchmark for the moment. Do bear in mind, though, that benchmark results should not be written in stone: A better compiler, a faster clock speed, a bigger cache, and faster memory can all overturn the league tables. Remember that the final choice of a machine should be made by using knowledge of the complete needs, not by simply referring to some published tables. ■

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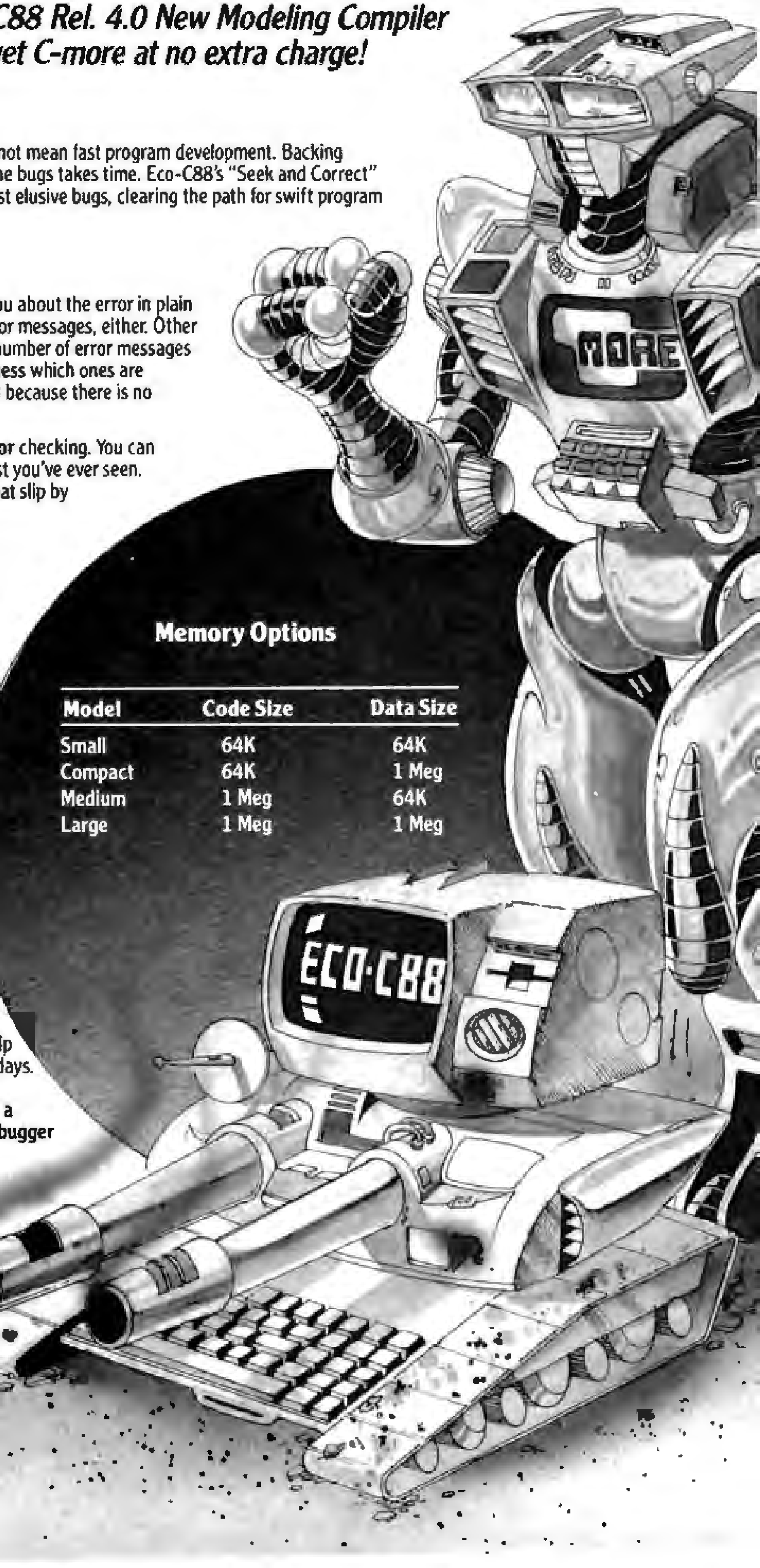

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BYTE

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How to Get Better Floating-Point Results

With or without an FPU, careful program design is the only sure way to guarantee the validity of floating-point computations

Carl Byington

FLOATING-POINT COPROCESSOR units (FPUs) are the key to getting good number-crunching performance out of personal computers, and yet they are usually extra-cost options. To be fair to users who haven't added one to their computers, a software designer has to write software that will use an FPU if one is present or perform the necessary operations using the main processor otherwise. In a compiler system, the component that takes care of this is called a floating-point emulator.

Unfortunately, all emulators are not alike. They do not behave identically nor always emulate the hardware exactly. This means that a given program may produce different results, depending on whether an FPU is present, and, if not, depending on which emulator is used.

But you can solve or at least control the problem by designing the high-level algorithm carefully, based on a few principles that derive from an elementary understanding of the emulation process and floating-point representation systems.

This article discusses some of the trade-offs involved in emulating floating-point hardware and explains the implications for programmers. All the specific examples in this article apply to the Ryan-McFarland RM/FORTRAN version 2.4 8087 emulator, which I helped design and implement. Previous versions of the compiler had used the emulator provided by Intel. We (the compiler design team) knew we could significantly speed up the emulation by writing a new emulator with a different set of design goals. The Intel emulator was designed to produce an exact emulation of the 8087 chip. It calculates results more precisely (and therefore more slowly) than is required by the RM/FORTRAN compiler. The Intel emulator also fails to take full advantage of the 8086 instruction set. For instance, many internal variables are maintained in memory, rather than in registers.

The 8087 chip can work with numbers in three basic formats: the 32-bit (24-bit significand) single precision; 64-bit (53-bit significand) double precision; and 80-bit (64-bit significand) temporary. I will refer to these various formats by the number of significand bits (24, 53, and 64).

The version 2.4 emulator was designed to produce results accurate to 60 bits. The primary design goal was to increase the speed of floating-point computations subject to the 60-bit precision requirement. A secondary goal was to increase the precision beyond 60 bits whenever possible so long as the speed was not reduced. A third goal was to make the emulator as small as possible, but this was not allowed to interfere with the first two goals. The speed objective is easily understandable, but why choose 60-bit precision when both the 8087 hardware and the Intel emulator calculate results to 64-bit precision? We did this because it doesn't affect the precision of the results produced by a FORTRAN program.

Precision and How to Keep It

Three factors control the precision of the results produced by a FORTRAN program: the algorithm (sequence of operations) and input data the program uses, the order of those operations after the compiler has optimized and rearranged the code, and the precision of individual operations within the FPU or emulator.

The entire FORTRAN system (compiler and emulator) has no control over the first factor; that is left up to the programmer. The second and third factors are related in that the choice of precision in the emulator needs only to match the precision requirements of the compiler.

RM/FORTRAN assumes that intermediate results need to be calculated to only 24 (`REAL`) or 53 (`DOUBLE PRECISION`) bits. Intermediate results will be calculated to a greater precision if there is no performance penalty. The emulator calculates the standard add, subtract, multiply, and divide functions to 64-bit precision; and it calculates the square root, tangent, arctangent, exponential, and logarithm functions to 60-bit precision.

Only two things can be done with the result of an arithmetic operation: It can be stored in a FORTRAN variable or used as an operand of another arithmetic operation. In the former case, the result's precision will be reduced to 53 bits. In the latter case, two further possibilities apply. The result may be used directly with its full precision, or the compiler optimizer may choose to store it in a compiler-generated temporary variable for later reuse, in which case the temporary

continued

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variable will have a maximum precision of 53 bits.

Consider the FORTRAN statements

```
DOUBLE PRECISION A,X,Y,Z
A = X+(Y+Z)
```

One possible 80x87 FPU code sequence to calculate A is

```
FLD  X ;floating point load X
FADD Y ;floating point add Y
FADD Z ;floating point add Z
FSTP A ;floating point store A
```

The register operand for the second FADD can have up to 64 significant bits, since it was calculated by the first FADD.

Now consider a second code sequence that might be generated if the subexpression Y+Z appeared in more than one expression in the FORTRAN program:

```
FLD  Y ;floating point load Y
FADD Z ;floating point add Z
FST  T ;save subexpression in temp T
...
FLD  T ;floating point load T
FADD X ;floating point add X
FSTP A ;floating point store A
```

Here the precision of T is only 53 bits (a double-precision temporary generated by the compiler), and the results may not be identical to those produced by the first code sequence.

The compiler and emulator guarantee that each elementary arithmetic operation is accurate to at least 53 bits. You can still write FORTRAN code that is exact in the mathematical sense and yet produces very imprecise results. Two common causes for this loss of precision are subtraction of two numbers that are almost identical and addition of two numbers of widely different magnitudes. As an example of the first situation, consider the problem of finding the roots of the quadratic equation $x^2 + 2bx + c = 0$.

The standard formula gives us

$$x_1 = -b + \sqrt{(b^2 - c)},$$
$$x_2 = -b - \sqrt{(b^2 - c)}.$$

If these were implemented with infinitely precise arithmetic and the coefficients b and c were known exactly, they would produce the exact roots of the quadratic equation. But when they are used in a FORTRAN program, several things happen. Here are the FORTRAN statements:

```
x1 = -b + Sqrt(b**2 - c)
x2 = -b - Sqrt(b**2 - c).
```

First, the coefficients can be known exactly but represented only imprecisely in FORTRAN variables with 53-bit precision. Second, the individual arithmetic operations are implemented with only 53-bit precision. Let us see what effect this has on the precision of the result when b is approximately -2^{26} and c is approximately 1. The result x1 will have 53 bits of precision; x2 will have only a few bits of precision (note that we're now using FORTRAN rather than algebraic variables). Why did this happen?

Consider the computation of x2. The expression b**2 will be calculated to 53 bits and is approximately 2^{52}. The value of b**2-c is calculated to 53 bits, but only a few high-order bits of c take part in this calculation. The expression Sqrt(b**2-c) is calculated to 53 bits and is almost exactly the same as -b. The final step in the calculation of x2 is a subtraction involving operands that are almost identical; the result of this subtraction has only a few bits of precision.

Look at the FORTRAN numbers A, B, C, and D in table 1a. A and B share 50 high-order bits. A-B is C, which has 50 high-order 0s. D is the result of normalizing C, so the high-order bit of D is 1. But the low-order 0s in D are an artifact of the floating-point arithmetic, and they have no significance. D is really known to only three bits of precision, even though its representation in a FORTRAN variable will have 53 significand bits.

This is essentially what has happened in the final subtraction in the calculation of x2 above. An alternate formula is x2=c/x1, which can be calculated to 53 bits of true precision. The quad program in listing 1 demonstrates the different results obtained using these two approaches. Note that the computation of the error in x1 is itself an ill-posed computation with no significant bits. The compiler has calculated that error (variable x3) twice with two different results.

Now we'll look at an example where you lose precision by adding numbers that are very far apart. Consider the numbers in table 1b. The magnitude of A is very different from the magnitude of B. C is B modified so that the exponent will match the exponent of A. Note that in order to make the exponents match, all the bits of B have been lost. D is A+C, which is the same as A. In this case, you have not lost any precision, since the sum is still correct to 53 bits.

Now consider the problem of calculating the sum of the power series $1 + r + r^2 + r^3 + r^4 + \ldots$, where r is in the interval (0,1). If r is .99, then the sum of the infinite series is 100. If the first 2000 elements are added in the order indicated, starting with the first and largest element, the partial sum will eventually become much larger than subsequent series elements, producing a problem similar to that illustrated in table 1b.

This problem can be partially solved by summing the series starting with the smallest elements first. The loss of precision is then not so severe, although it still occurs. The only way to eliminate this problem is to use an array of accumulators and add the next series element into the appropriate accumulator. A far better algorithm in this case is to throw away the series expansion and calculate the mathematically equivalent expression $1/(1-r)$.

The series program in listing 2 demonstrates these techniques. The do 15 loop initializes the sumx array. The index statement function calculates a subscript for the sumx array. The array element at that position should either be 0 or have a value close to the value of the series element r**i. The do 16 loop checks for array elements that have become too large and effectively propagates the carry. The do 25 loop finally adds the

continued

Table 1: *Results of computations involving* **(a)** *subtraction of nearly equal numbers and* **(b)** *addition of numbers of widely different magnitudes.*

a) C=A−B and D=C (normalized).

```
A = 0 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxyyy × 2^26
B = 0 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxwww × 2^26
C = 0 00000000000000000000000000000000000000000000000000zzz × 2^26
D = 0 zzz00000000000000000000000000000000000000000000000000 × 2^-24
```

b) A and B are to be added, C=B (normalized), D=A+C

```
A = 0 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx × 2^3
B = 0 yyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyyy × 2^-50
C = 0 00000000000000000000000000000000000000000000000000000 × 2^3
D = 0 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx × 2^3
```


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Listing 1: (a) *A FORTRAN program illustrating ill-formed and well-formed calculations of the quadratic formula, followed by* **(b)** *a sample run of the program.*

(a)

```
      program quad
      double precision b, c, x1, x2, x3, x4
10    write (6, 1)
      write (6, *) 'Enter coefficients b and c separated by
                                                 spaces: '
      read (5, *) b,c
      if (c .eq. 0.0) stop
      write (6, 1)
      write (6, 3) b, c
c
      write (6, *) 'Method one.'
      x1 = -b + sqrt(b**2-c)
      x2 = -b - sqrt(b**2-c)
      x3 = x1**2 + 2*b*x1 + c
      x4 = x2**2 + 2*b*x2 + c
      write (6, 2) x1, x2, x3, x4
c
      write (6, *) 'Method two.'
      x1 = -b + sqrt(b**2-c)
      x2 = c/x1
      x3 = x1**2 + 2*b*x1 + c
      x4 = x2**2 + 2*b*x2 + c
      write (6, 2) x1, x2, x3, x4
c
      goto 10
c
1     format (1x)
2     format (' x1 solution   ', D25.18 /
     $        ' x2 solution   ', D25.18 /
     $        ' error in x1   ', D25.18 /
     $        ' error in x2   ', D25.18)
3     format (' b             ', D25.18 /
     $        ' c             ', D25.18)
      end
```

(b)

```
Enter coefficients b and c separated by spaces: -3e7 1

b              -0.300000000000000000D+08
c               0.100000000000000000D+01
Method one.
x1 solution     0.599999999999998510D+08
x2 solution     0.149011611938476563D-06
error in x1    -0.800024414062500000D+01
error in x2    -0.794069671630857155D+01
Method two.
x1 solution     0.599999999999998510D+08
x2 solution     0.166666666666667067D-07
error in x1    -0.794067382812500000D+01
error in x2    -0.220580931992175877D-14

Enter coefficients b and c separated by spaces: -3e8 1

b              -0.300000000000000000D+09
c               0.100000000000000000D+01
Method one.
x1 solution     0.600000000000000000D+09
x2 solution     0.000000000000000000D+00
error in x1     0.000000000000000000D+00
error in x2     0.100000000000000000D+01
```

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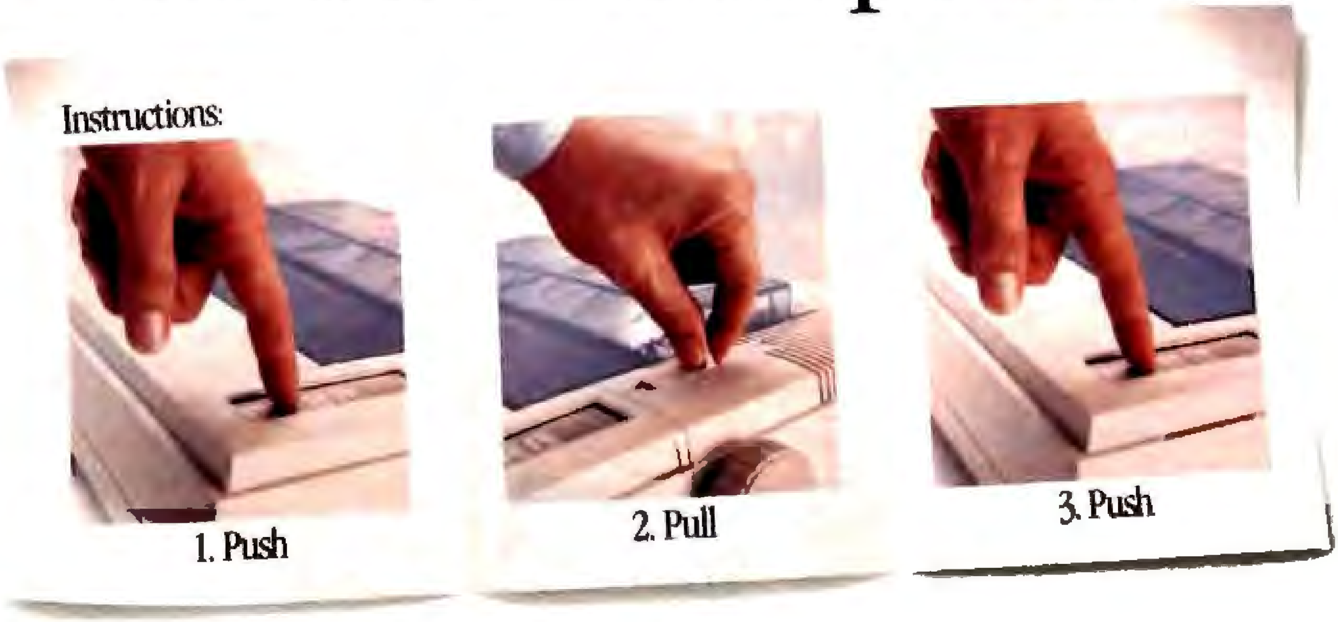

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```
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x1 solution     0.60000000000000000000D+09
x2 solution     0.16666666666666667D-08
error in x1     0.10000000000000000000D+01
error in x2     0.2818925648462311530D-17

Enter coefficients b and c separated by spaces: -3e9 1

b              -0.30000000000000000000D+10
c               0.10000000000000000000D+01
Method one.
x1 solution     0.60000000000000000000D+10
x2 solution     0.00000000000000000000D+00
error in x1     0.10000000000000000000D+01
error in x2     0.10000000000000000000D+01
Method two.
x1 solution     0.60000000000000000000D+10
x2 solution     0.16666666666666666D-09
error in x1     0.10000000000000000000D+01
error in x2     0.00000000000000000000D+00

Enter coefficients b and c separated by spaces: 1 0
```

Listing 2: (a) *A FORTRAN program illustrating various approaches to the calculation of a power series, followed by* **(b)** *a sample run of the program.*

(a)

```
      program series
      double precision r, sum, sumup, sumdown, x
      double precision sumx(30), sumw
      index(x) = 4 + int(-log10(x))
c     sumx(i) < 10**(4-i)
c
      km = 30
c
10    write (6, 1)
      write (6, *) 'Enter r and n separated by spaces: '
      read (5, *) r, n
      if (r .eq. 0) stop
c
      sum     = (1-r**n) / (1-r)
      sumup   = 0
      sumdown = 0
      do 15 j = 1,km
        sumx(j) = 0
15    continue
c
      do 20 i = 0, n-1
        sumup   = sumup + r**i
        sumdown = sumdown + r**(n-1-i)
        j = index(r**i)
        sumx(j) = sumx(j) + r**i
        do 16 k = j, 2, -1
          if (sumx(k) < 10**(4-k)) goto 20
          sumx(k-1) = sumx(k-1) + sumx(k)
          sumx(k)   = 0
16      continue
20    continue
c
      sumw = 0
      do 25 j = km, 1, -1
        sumw = sumw + sumx(j)
25    continue
```

continued

```
c
      write (6, 2) r, sum, sumw, sumup, sumdown
      goto 10
c
1     format (1x)
2     format (' r                         ', d25.18 /
     $        ' correct partial sum     ', d25.18 /
     $        ' calculated with array ', d25.18 /
     $        ' added from largest      ', d25.18 /
     $        ' added from smallest     ', d25.18)
      end
```

(b)

```
Enter r and n separated by spaces: .99 40
r                       0.989999999999999991D+00
correct partial sum     0.331028241430319454D+02
calculated with array   0.331028241430319454D+02
added from largest      0.331028241430319312D+02
added from smallest     0.331028241430319454D+02

Enter r and n separated by spaces: .99 2000
r                       0.989999999999999991D+00
correct partial sum     0.999999998136242567D+02
calculated with array   0.999999998136242567D+02
added from largest      0.999999998136241804D+02
added from smallest     0.999999998136241857D+02

Enter r and n separated by spaces: 0 1
```

sumx array elements to arrive at sumw. Note that this algorithm works only when all the series elements have the same sign. For an alternating series, you need separate arrays for the positive and negative elements; merging the two arrays produces the final answer.

Note that the calculation using the array of accumulators matches the accuracy of the exact solution. If an exact solution is not known, then this method can be used to avoid loss of precision, although it is very slow.

The design goals for an emulator are influenced by the data types available in the language, the code sequences generated by the compiler, and the compiler and run-time system's assumptions regarding precision. The 80x87 emulator we designed for RM/FORTRAN achieved our design goals of dramatic speed improvement (approximately a factor of 5) with no loss of precision at the FORTRAN level. Although the emulator produces results different from those produced by the 8087 hardware, they are no less precise.

To analyze a FORTRAN program to determine the precision of its output, you need to know the size of the input numbers. As the quadratic-roots problem demonstrated, the standard formula works fine for some argument ranges but is terrible for others. You must then analyze each subtraction operation (or addition of numbers with opposite signs) to determine if the operands of that subtraction might ever be almost identical; if so, you should find another way to solve the problem, or at least be aware of the resulting loss of precision. In general, the addition of two numbers that are far apart doesn't result in precision loss, unless you calculate a series of such additions.

If your FORTRAN program produces significantly different results on the 8087 hardware versus the emulator, then you are using an algorithm that depends on 64-bit precision arithmetic. Any small change to that program may cause the compiler optimizer to reorder the object code such that the precision will drop to 53 bits, even on the 8087 hardware. This is a simple though incomplete test for imprecise results.

As the quadratic-root and series-sum problems showed, changing the numerical algorithm at the FORTRAN level can have a larger effect on the precision than any compiler or emulator change. There is no substitute for analyzing the numerical accuracy of the FORTRAN code. ■

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Part 3: Memory Management and Windowing

Steve Ciarcia

The BCC180 Multitasking Controller

The BCC180's multitasking BASIC compiler can operate on a variety of hardware—even on an IBM PC

For the past two months, I've been discussing a 64180-based multitasking computer, the BCC180 (see photo 1). In common with most of my projects, it is hardware, but because of its unique multitasking capabilities, I have made much of the presentation a tutorial on multitasking. This month, I'll conclude with a discussion of the memory management and windowing capabilities of BASIC-180.

Memory and the 64180

The 64180 processor has two great advantages over the Z80. First, it contains a wide variety of on-board peripherals, including timers and universal asynchronous receiver/transmitters (UARTs). Second—and more important—it has an onboard memory management unit (MMU).

The MMU lets the 64180 directly address up to 1 megabyte of memory. The memory connected to the 64180 is called physical memory; it is the entire "universe" of memory available to the processor. The memory that can be addressed with any one map, or configuration, of the MMU is called the logical address space. Every address generated by a user's program is a logical address.

The MMU's role is to translate logical addresses into physical addresses. If, for example, a program tries to reference location 0, this is a reference to logical address 0. The actual physical address will be a function of the mapping of the MMU. It may indeed use physical address 0 (on power-up, the MMU translates every logical address to exactly the same physical address). Or, if the program had set the MMU, it could use physical address 10000 hexadecimal. (For the remainder of the article, all addresses will be in hexadecimal unless otherwise specified.)

The 64180's MMU lets programs segment the memory on any one map into three different areas. For instance, references to logical addresses 0 to 3FFF could access physical addresses 0 to 3FFF, references to logical addresses 4000 to 7FFF could access physical addresses 10000 to 13FFF, and the last half of the logical space could access physical addresses 40000 to 47FFF. Virtually any combination is possible.

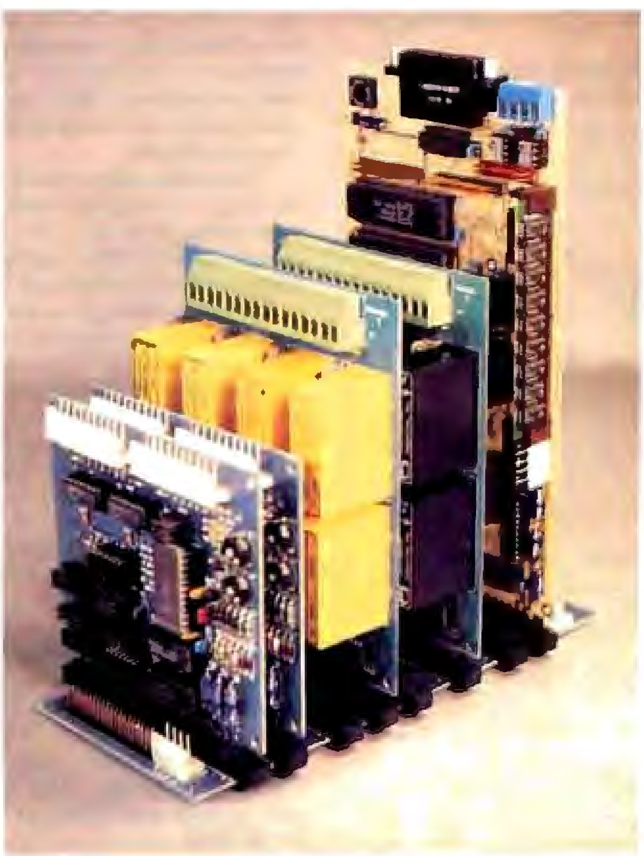

Photo 1: *The BCC180 (tall board in the rear) shown here in a typical process-control configuration. In addition to the BCC180's own functions, this system has 32 channels of 12-bit A/D and 16 channels of optoisolated AC I/O.*

Using All Available Memory

Although the MMU provides a fairly convenient way to handle large amounts of memory while still maintaining Z80 compatibility, it is not magic. The MMU is useless unless applications programs are specifically written to use it. None of the thousands of existing CP/M programs can take advantage of the power of the MMU; even running on a 64180, they are still limited to 64K bytes of memory. Handling the MMU is not trivial. Only a handful of programs have been written to take advantage of this powerful feature. Fortunately, BASIC-180 is one of these.

Writing a compiler that generates code to automatically remap the MMU is a

continued

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pretty tough task. How would you do it? One approach is to start compiling code from address 0 until FFFF is encountered, then (or shortly before) drop in code to remap the MMU so the next 64K-byte region is available, and so on. This approach can be made to work, but you pay a high price in terms of performance. Every FOR...NEXT, GOTO, and GOSUB may require MMU remapping. Worse, every time a program calls built-in run-time routines (of which there are always many), software may have to remap the MMU.

Interestingly enough, the IBM PC's famous lack of performance is partially due to this. Although the PC does not use a conventional MMU, addresses are pretty much limited to 16 bits. Address references outside a 64K-byte region must involve manipulation of the 8088's segment registers, hampering the machine's performance.

BASIC-180 takes a unique approach. In all operational modes except MAPCOMPILE (which I'll describe later), when a BASIC-180 program is running, it ignores the MMU. (Of course, BASIC-180 does initially configure the MMU, but this occurs only at the program's start.) This ensures that BASIC-180 is compatible with all Z80 systems. You can compile programs of any size to disk, even though the compiler uses only around 48K bytes. If you compile a program using the MAPCOMPILE command, BASIC-180 uses the memory map shown in figure 1.

BASIC-180 compiles the "run-time package"—or library of support code required by a program—at logical address 0 to 3FFF. The compiler maps these logical addresses to the same physical addresses (0 to 3FFF).

The variable area consists of both variables defined in the program and temporaries required by the run-time routines. This area must reside in RAM, whereas all the compiled code typically is in EPROM. The temporary area is compiled from the top of logical memory (64K) down for as far as is required. If 16K bytes of RAM is needed, it is compiled to logical address C000 to FFFF. This area is mapped to physical addresses starting at 7FFFF and down.

Finally, BASIC-180 compiles the user's program into logical addresses between the run-time and RAM areas. Every task is compiled to the same range of logical addresses. Thus, the lead task starts at address 4000, as does task 1, task 2, and so on. Although these tasks have the same logical address, they reside in memory at different physical addresses. The upshot is that, since a given task "sees" only its own logical space, multiple tasks executing on the same system are largely unaware of one another.

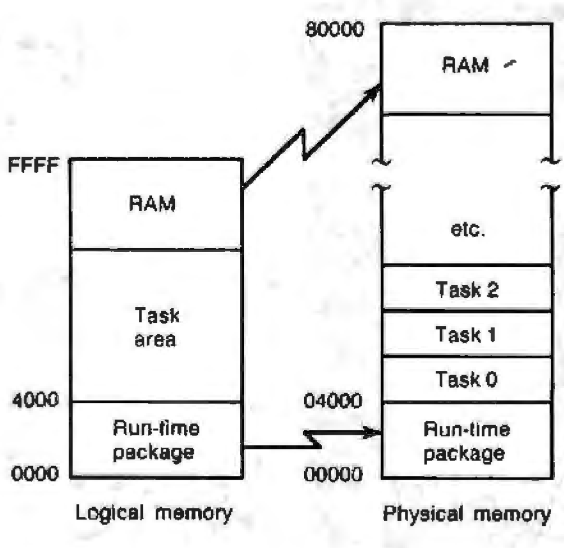

Figure 1: *Memory map for programs compiled using the* MAPCOMPILE *command, showing the relationship between logical memory and physical memory.*

Context Switching

The trick to the success of this approach is context switching. In a multitasking environment, only one task can be executing at any specific moment. BASIC-180 takes advantage of this fact by having the context switcher remap the MMU whenever a tick interrupt is received. The currently executing task's context is saved, and this task is mapped out ("into the ozone," as the experts say) and the next task mapped in. Now, the new task is at the same logical address space as the last one was and can start running.

On the BCC180, a hardware interrupt drives the software context switcher to sequence multitasking. The interrupt is provided by the 64180's internal timer number 0, which BASIC-180 configures to generate 60 interrupts per second. The interrupts from the timer invoke BASIC-180's context switcher, which must then suspend execution of the current task and decide which task to execute next.

The context switcher is structured around a table called the task control block (TCB). Each TCB entry includes the task's current state (e.g., active and suspended), its reschedule interval (specified on the task's RUN statement), how many ticks are left until the interval elapses, the task's priority, the task's memory management map (so the context switcher knows where the task exists in physical memory), and the task's current stack pointer.

Each time the context switcher is invoked, it examines every entry in the table to determine which task must run next, searching in order of priority. The switcher checks tasks' states to find those that are either *suspended* (whose execution was stopped in midstream by an interrupt) or *ready* (they've never been executed but are now ready for execution). It examines tasks of equal priority in a round-robin fashion, giving them all an equal chance to execute.

The switcher starts a ready task at that task's first executable location, and a suspended task at the location it left off when last interrupted. If no task currently requires processor time, the context switcher idles, waiting for the next interrupt. (See table 1 for a further breakdown of task states.)

Context switching is a complex procedure, requiring a substantial number of instructions. The TCB is arranged in a doubly sorted order (by round-robin and by task priority) to speed TCB searches. At 60 ticks per second, less than 5 percent of the processor's time is consumed by context switching.

The process of remapping the MMU occupies a tiny percentage of the context-switching time, so little processing overhead is added. The system can therefore manage large multitasking programs with numerous tasks that sprawl across a megabyte of memory at little expense of processor time.

The 64180's MMU has a minimum mapping resolution of 4K bytes. Therefore, each task compiled by BASIC-180 will take at least 4K bytes, since each task must reside in a separate map.

The revision 1 mask of the 64180 in a plastic leadless chip carrier (PLCC) package supports 20-bit address spaces or 1 megabyte of RAM. BASIC-180 has a somewhat arbitrary limit of 32 tasks per program. In a 1-megabyte address space, each task can therefore take up to 32K bytes (since 32K bytes × 32 tasks = 1 megabyte). This is quite reasonable, since the run-time package uses 16K bytes. If 16K bytes of RAM is required for variables and temporaries, 32K bytes is left for tasks in the logical address space (16K run time + 16K variables/temporaries + 32K program = 64K, the *logical* address space of the 64180).

As you can see, in BASIC-180 large programs are intrinsically tied to multitasking. Nonmultitasking programs are restricted to 64K bytes of total memory use. This encourages programmers to think in terms of segmenting a program into separate, asynchronous activities. A future Circuit Cellar will cover a multiprocessor system, in which this programming style becomes very important.

Table 1: *Task states.*

Active: The task is actually executing. Only one task can be active at any time.

Ready: The task has as yet not been executed but is ready for execution as soon as CPU time becomes available

Suspended: The task was executed but was preempted by a clock tick. It is ready to resume execution from where it left off as soon as CPU time becomes available

Waiting: The task was executing but put itself in an idle mode The CPU will restart the task after a specified amount of time measured in clock ticks

Dormant: The task has not been made available for execution. It requires no CPU time.

Interactive Compilation

I don't have the patience to use most high-level languages. The scenario usually goes like this: You invoke an editor, enter the program, call up the compiler, which inevitably points out a few misplaced semicolons (I thought the computer was supposed to relieve me of trivia. . .), so you have to go back to the editor, fix the code, and recompile, by now hoping desperately that some other silly syntactical mistake isn't still lurking.

After the compiler is finally happy, you repeat the same process with the linker. (Oh, no! The linker looks at only seven characters of a symbol, but my language recognizes eight! Back to the editor, boys.) Finally, you're ready to test the program. If it doesn't work, you'll often edit lots of print statements into the code to try and localize the problem. No wonder programmers get only 10 lines of good code a day.

BASIC-180 supports two very different development environments. You can write and test code on the BCC180 itself, or you can write and at least partially test code on a host computer like the SB180. This kind of cross-development environment is nice because you can use all the resources of the operating system.

The most important of these is the disk system. (I'm seriously considering adding a floppy disk drive and small computer system interface [SCSI] hard disk interface board to the BCC bus very soon. Circuit Cellar Ink will contain news of that construction project.) You can save various versions of the source and compiled code, adapt portions of old programs for use in a new one, and take advantage of operating-system utilities to ease the development process.

The downside of developing code on a host system is the lack of compatible I/O. In any process-control system, the BCC180 will no doubt be connected to unusual I/O devices not available to the host development system (e.g., parallel I/O lines connected to contact closures, relays, and so forth). For the present, this involves a trade-off.

Most systems use limited access to I/O. If speed is not the overriding consideration, you should use well-designed modular code to segment the I/O drivers into driver routines. When operating in a cross-development mode, you can replace these drivers with code that simulates the behavior of the physical devices. Perhaps only limited simulation is practical, but you can still test much of the code.

BASIC-180 will run on the SB180 just as it does on the BCC180. The BASIC source code is 100 percent compatible. BASIC-180 will even run on an IBM PC under a CP/M simulator like ZSIM from Z-World.

On a cross-development system, you can compile and test BASIC code in one of three ways: interactively, using the `DISKCOMPILE` command, or using the `MAPCOMPILE` command.

When compiling interactively, BASIC-180 appears to operate just like an interpreter. You sign on to the BASIC and edit, run, test, and modify programs, all under the control of BASIC-180. BASIC-180 includes a line editor for easy entry and alteration of programs. Using the `SAVE` and `LOAD` commands, you can save code to and load it from disk.

The `RUN` command starts a BASIC program executing, as in an interpreter. However, when you issue `RUN`, BASIC-180 compiles the program into true native machine code, then executes it. The program—being compiled instead of interpreted—runs faster. Furthermore, the `RUN` command causes BASIC-180 to compile the program to RAM—not disk—so compilation is also speedy. (On the SB180, compilation is over 150 BASIC statements per second.) Best of all, you can test, modify, and retest the program in seconds, just as in an interpreter. As far as I'm concerned, this is the only way to develop code. Only a few other languages now use this approach.

Once you have your program working the way you want it to, you can compile it to an efficient disk file using the `DISKCOMPILE` command. BASIC-180 reads the BASIC source code from a disk file, converts it to native 64180 object code, and saves it to a stand-alone executable file, just like any other CP/M program.

You can use `DISKCOMPILE` to create program files that you ultimately convert to Intel hexadecimal format and burn into EPROMs for stand-alone execution on the BCC180. BASIC-180 always generates ROMable code. This means that programs created with BASIC-180 require only limited operating-system support, if any, and the code and data areas of a BASIC-180 program are kept separate. BASIC-180 lets you define where RAM should be, so you can support the segmented memory typical of ROM-based systems.

To create large multitasking programs, you use BASIC-180's `MAPCOMPILE` command. `MAPCOMPILE` produces a root .COM file that contains a loader and the run-time routines. It then generates a file for each task. These files have the extension .Txx, where xx is the task number. When you invoke the root program (by typing its name, just as you would for any other .COM file), the built-in loader reads each of the task files from disk into the proper area of physical memory, remapping the MMU as required.

Plug and Go

A truly unique feature of the BCC180 version of BASIC-180 is that the compiler itself, and not just the compiled code, can operate from ROM on the BCC180. Most languages need a great deal of operating-system support. A few interpreted BASICs operate from ROM (like the ROM BASIC for the IBM PC), but you'll find few ROM-resident BASIC compilers.

BASIC-180 supports its interactive development environment even in ROM. You'll find nearly all the features available on disk-based systems in the ROM version, including a line editor.

continued

The ROM version of BASIC-180 requires just the BCC180 board, a terminal, and a power supply (you'll need the optional BCC180 EPROM programmer board to generate ROM-based programs). When powered up, the BASIC or a system monitor is available immediately. You can enter, edit, and test programs, just as if you were using an interpreter.

The great advantage of developing code on the BCC180 is that you have all the BCC180's resources available. There is no need to write I/O simulation routines; you can develop critical I/O handlers interactively. Without disks, however, there would seem to be no way to save BASIC source or compiled code. Fortunately, past experience suggested a solution to this problem.

One of the better features of my 8052-based BCC52 is its onboard EPROM programmer that functions like write-once mass storage. I can't stand to rekey programs, so when Softaid's people designed this BASIC-180, I had them add the ability to save programs directly to EPROM in the same manner as the BCC52. When you connect the BCC180's auxiliary EPROM burner, you can use `ROMSAVE` and `ROMLOAD` to save and retrieve programs to and from an EPROM (27256). BASIC-180 burns a tokenized (compressed) form of the BASIC source program into the EPROM.

Of course, BASIC-180 doesn't create any sort of file structure on the EPROM. `ROMSAVE` simply burns each program into the next unused spot in the EPROM, assigning that program a sequential number that ranges from 1 to the number of programs in the EPROM. You load a program from an EPROM using `ROMLOAD`, which requires as an input argument the `ROMSAVE`-generated number of the program.

You can also use `MAPCOMPILE` to compile programs into the EPROM. In this case, `MAPCOMPILE` burns the programs into the EPROM at the compiled physical addresses, so that you can create a program that executes on power-up by placing the EPROM in the appropriate BCC180 ROM socket(s).

(a)

(b)

Photos 2a and 2b: *BASIC-180's multitasking windows are sophisticated enough to simulate a Macintosh environment on a serial terminal, as shown in* (a) *and* (b) *above.*

Windowing

When I first ran into multitasking, I was confused as to how different tasks would handle terminal display I/O. What happens when I program three tasks to simultaneously display results? Do I end up with a jumbled mess of asynchronous `PRINT` statements going to a common display? Of course not.

BASIC-180 gives you a complete set of window control statements. A window is a subsection of the CRT display terminal with a definable size and position. A window can be any size (up to 24 lines by 80 characters), and you can have up to 10 windows in use at once. When your program selects a window, all output will go to that window until the program selects another. The window's borders act as barriers to `PRINT` statements (see photos 2a and 2b).

BASIC-180 lets you assign windows to tasks, so that you might assign window 1 to task 4 and window 2 to task 12. All output from task 4 will then go to window 1, and all output from task 12 will go to window 2.

The following BASIC-180 statements control windowing:

`WINDOW` defines a window's size and location.
`WSELECT` selects a window for output.
`WFRAME` draws an outline around a window.
`WCLEAR` erases a window.
`WSAVE` saves the contents of a window to an array.
`WUPDATE` restores to the screen a window that has been saved with `WSAVE`.

The following program defines a square window 10 characters wide and high, whose upper left corner is at column 10, row 10, on the CRT. It is defined as window number 1. A box is drawn around it using the "_" and "|" characters:

```
10 WSELECT 1
20 WINDOW 10,10,20,20
30 WFRAME "_","|"
```

All subsequent `PRINT` statements will send their output to this window.

The `WSAVE` and `WUPDATE` statements let you write programs with pop-up or pop-down windows, so you can create programs with a Macintosh-like user interface. `WSAVE` saves on-screen data located behind the pop-up/pop-down window, and `WUPDATE` restores the screen after the window has been removed.

The following program draws three windows side by side on the screen and assigns a task to each one. All three tasks then run concurrently, each one writing to the window assigned to it:

```
5 INTEGER T1,T2,T3,A,B,C,D,I
10 ERASE
100 DATA 1,1,10,10
105 DATA 1,12,10,22
110 DATA 1,26,10,35
200 FOR I=0 TO 15 STEP 4
210 WSELECT I / 4
220 READ A,B,C,D
```

continued

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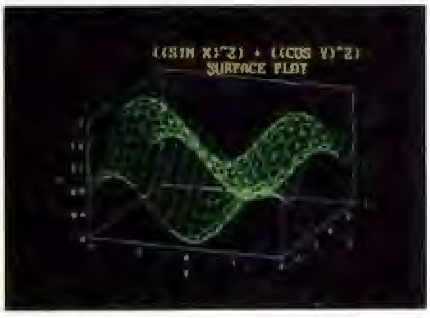

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```
230 WINDOW A,B,C,D
240 WFRAME "_","|"
250 WINDOW A+1,B+1,C-1,D-1
260 NEXT I
300 RUN 1,30
301 RUN 2,50
302 RUN 3,70
310 GOTO 310
1000 TASK 1
1010 WSELECT 0
1020 WCLEAR
1030 FOR T1=1 TO 9:
     PRINT "TASK 1": WAIT 5:
     NEXT T1
1040 EXIT
1100 TASK 2
1110 WSELECT 1
1120 WCLEAR
1130 FOR T2=1 TO 9:
     PRINT "TASK 2": WAIT 5:
     NEXT T2
1140 EXIT
1200 TASK 3
1210 WSELECT 2
1220 WCLEAR
1230 FOR T3=1 TO 9:
     PRINT "TASK 3": WAIT 5:
     NEXT T3
1240 EXIT
```

Windowing makes extensive use of the cursor-positioning commands of the terminal you're using but, since no standard exists for terminal cursor positioning, the disk-based version of BASIC-180 comes bundled with an installation program that lets you configure it for your terminal or terminal emulator (the ROM-based version has patch points). BASIC-180 can support virtually any terminal's format.

In Conclusion

Finally, I am the quintessential nonprogrammer. I even design hardware to get around programming. The BCC180 and BASIC-180 do serve my purpose, and I hope you find them useful as well. Indeed, they let you work in an easy language, and they support the multitasking that has become so essential as applications become more complex. But, foremost, they raise personal computing performance to a level you would expect only in more expensive microcomputer systems.

Next Month

The Circuit Cellar SmartSpooler. ■

I'd like to acknowledge and personally thank Ken Davidson and Jack Ganssle for their efforts on the BCC180 project. Ken Davidson's extensive knowledge of the HD64180 helped us avoid the omnipresent hardware design pitfalls, and Jack Ganssle's superb software talents helped explain multitasking in a way that can really be understood.

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

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume II* covers December 1978 through June 1980. *Volume III* covers July 1980 through December 1981. *Volume IV* covers January 1982 through June 1983. *Volume V* covers July 1983 through December 1984. *Volume VI* covers January 1985 through June 1986.

It's virtually impossible to provide all the pertinent details of a project or cover all the designs I'd like to in the pages of BYTE. For that reason, I have started a bimonthly supplemental publication (with no advertising) called Circuit Cellar Ink, which presents additional information on projects published in BYTE, new projects, and supplemental applications-oriented materials. For a one-year subscription (6 issues), send $14.95 to Circuit Cellar Ink, P.O. Box 3378, Wallingford, CT 06494. Credit card orders can call (203) 875-2199.

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Jerry R. Van Aken and Carrell R. Killebrew Jr.

Better Bit-Mapped Lines

Bresenham's Line Algorithm provides a quick way to approximate lines on a bit-mapped display

Drawing a line is a fundamental operation in a computer graphics system, but representing a line on a bit-mapped display is not as simple as it seems. The problem is that computers cannot represent a straight line exactly. Since few pixels are likely to lie exactly on the line, a line algorithm must choose a connected set of pixels that follows the path of the line as closely as possible.

Early computer graphics systems used a digital differential analyzer (DDA) algorithm to choose the pixels for drawing a line. DDA line generation suffers because the algorithm uses floating-point arithmetic, which is slow in a typical computer system. A line algorithm using simple integer arithmetic would be much faster.

In 1965, Jack Bresenham of IBM published a fast line-drawing algorithm that uses only integer addition and subtraction. This article derives Bresenham's Line Algorithm from basic principles and provides source program listings in Pascal. [Editor's note: *Source code listings for this article are available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement. See "Program Listings" in the table of contents.*]

Drawing a Line Faster

Figure 1 illustrates the basic principle of Bresenham's algorithm. A line segment extends from the origin to a point (a,b), and the equation that must be satisfied by all points on this line is

$$f(x,y) = b \times x - a \times y = 0.$$

Points that do not satisfy this equation lie to one side or the other of the line. As Bresenham's algorithm tracks the line from beginning to end, it measures the value of $f(x,y)$ at regular intervals in order to choose pixels along the way to represent the line. At a point (x,y) located below the line, $f(x,y)$ is positive (i.e., $b \times x - a \times y > 0$). Above the line, $f(x,y)$ is negative. By monitoring the sign of the function at or near the current pixel, the algorithm can tell whether it is moving too far above or below the line, and make a course correction when choosing the next pixel. This is a powerful technique that has been extended to computer drawing of more complex curves such as circles, ellipses, and other conic sections.

Figure 2 is a line drawn by the algorithm. The line segment starts at (0,0), ends at (10,4), and is defined by the equation

$$f(x,y) = 4 \times x - 10 \times y = 0.$$

The algorithm selects the pixels in figure 2 that lie as close as possible to the actual line. As the line is drawn from left to right, each new pixel is selected to be either the pixel directly to the right of the previous pixel (a horizontal move), or the pixel above and to the right of the previous pixel (a diagonal move).

The algorithm chooses between these two pixels by determin-

continued

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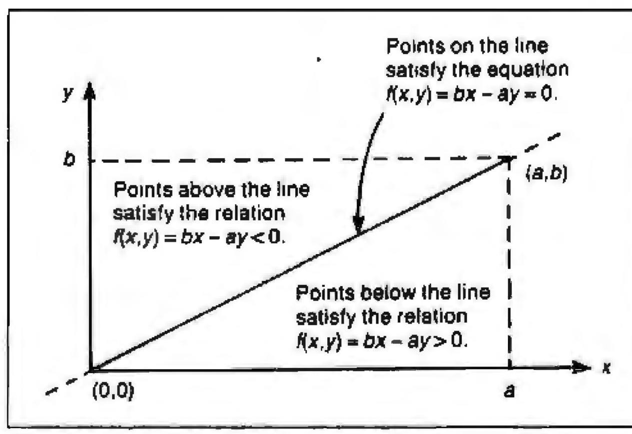

Figure 1: *Basic principles of the algorithm.*

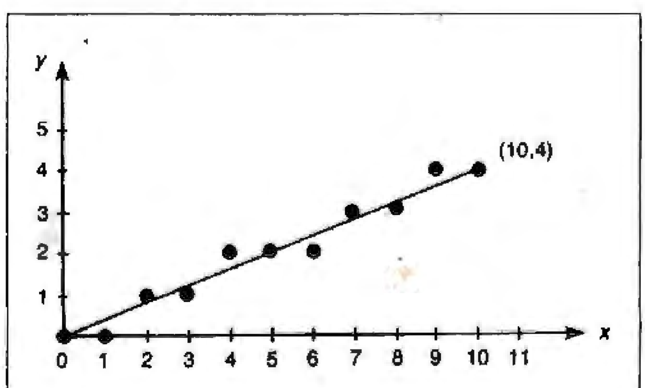

Figure 2: *Pixel approximations of line from origin to (10,4).*

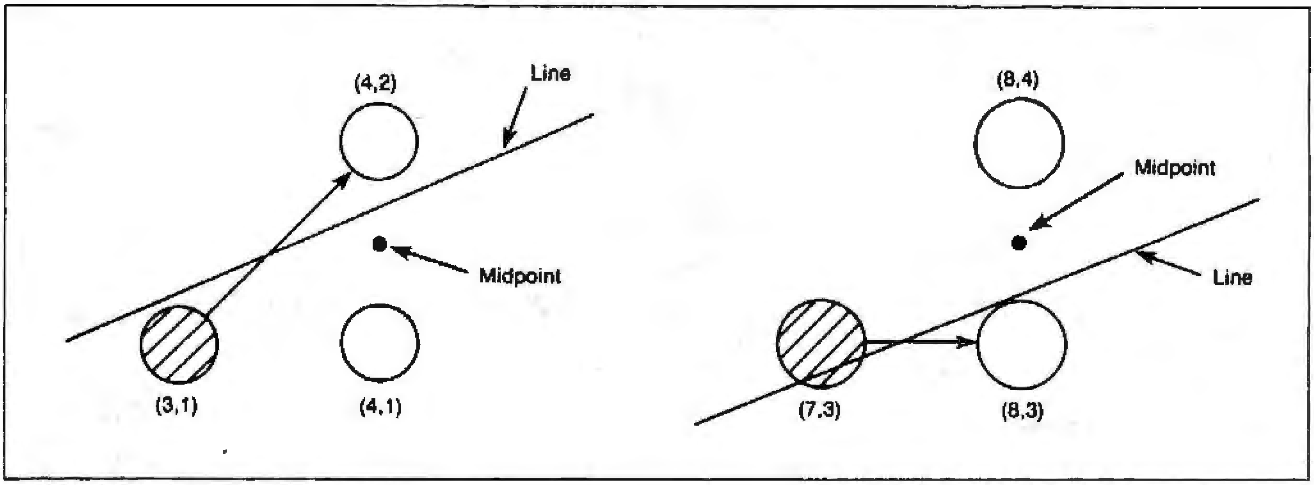

Figure 3: *Examples of the decision process.*

Listing 1: *A line algorithm restricted to the first octant.*

```
procedure draw_line (a, b: integer);
                    { a is the endpoint x
                          coordinate. }
                     { b is the  endpoint y
                           coordinate.}

var x,               { current x coordinate }
    y,               { current y coordinate }
    d,               { decision variable    }
    i:               { loop index          }
       integer;

begin { draw_line }
    x := 0;          { line starts at (0,0) }
    y := 0;
    for i := 0 to a do  { Draw the a+1 pixels
                          in the line. }
      begin
   draw_pixel(x,y);
   d :=  b * (x + x + 2) { Evaluate line
                           formula at
                           midpoint. }
         - a * (y + y + 1);
   if d < 0 then        { Is midpoint  above
                              the line? }
       x := x + 1;      { Yes, step
                             horizontally. }
   else
     begin             { Midpoint is below the
                                   line, }
       x := x + 1;    { so step diagonally. }
       y := y + 1
     end { else }
      end { for }
end; { draw_line }
```

ing which is closer to the actual line. It does so by checking whether the point exactly halfway between the two pixels lies above or below the line. If the line passes below the midpoint, it chooses the lower pixel; otherwise, it chooses the upper pixel.

Figure 3a shows where the algorithm chooses the upper pixel. It illustrates the decision process performed by Bresenham's algorithm in selecting the pixel at (4,2) in figure 2. The pixel at (3,1) is already turned on, having been selected in the previous step. The problem now is to choose between the pixels at (4,1) and (4,2). To make this decision, the algorithm evaluates the function $f(x,y) = 4 \times x - 10 \times y$ at a point lying at (4,1.5), halfway between the two pixels under consideration. At the midpoint, the function evaluates to $4 \times 4 - 10 \times 1.5 = 1$. Since this is a positive value, the midpoint must lie below the line. The pixel at (4,2) therefore lies closer to the line, and is selected.

Figure 3b is an example where the algorithm selects the lower of the two pixels it considered. This figure illustrates the selection of the pixel at (8,3) in figure 2. The algorithm chooses the pixel at (8,3) over the one at (8,4) by observing that the function $f(x,y)$ evaluated at the midpoint (8,3.5) is $4 \times 8 - 10 \times 3.5 = -3$. The negative value indicates that the midpoint is located above the line. The pixel at (8,3) therefore is closer to the line than the one at (8,4) and is selected.

The Basic Algorithm

Listing 1 is a rudimentary form of the algorithm capable of drawing the line shown in figure 2. It takes as its input arguments the endpoint coordinates a and b. For the sake of simplicity, assume that the starting point is always (0,0) and that the endpoint coordinates (a,b) satisfy the relation $0 \leq b \leq a$, where a and b are integers. (In other words, point (a,b) lies in the first octant of Cartesian coordinate space.) The algorithm is easily extended to overcome these restrictions, as we will show later.

A drawback to this form of the algorithm is that each iteration of the inner loop requires two multiplications, which are more time-consuming than simple operations such as addition. A later version of the algorithm will replace the multiplications with simpler operations in order to speed up line drawing. The line drawn by the algorithm in listing 1 is described by the equation $f(x,y) = b \times x - a \times y = 0$. At the start of iteration i of the `for` loop, a single pixel is drawn at the current location $(x[i], y[i])$ by the function `draw_pixel`. As illustrated in the examples of figure 2, the two candidate pixels for the next point to be drawn are located at $(x[i] + 1, y[i])$ and $(x[i] + 1, y[i] + 1)$, and the midpoint of these two pixels is at $(x[i] + 1, y[i] + ½)$. The algorithm chooses between the two candidate pixels based on the sign of $f()$ evaluated at the midpoint, which is $b \times (x[i] + 1) - a \times (y[i] + ½)$. The algorithm in listing 1, in fact, assigns twice this value to variable d, called the decision variable:

$$\begin{aligned} d[i] &= 2 \times f(x[i] + 1, y[i] + ½) \\ &= b \times (2 \times x[i] + 2) - a \times (2 \times y[i] + 1). \end{aligned}$$

Multiplying $f()$ by 2 ensures that d is an integer for all values of

a; the factor of 2 has no other effect, since the sign of d will always be the same as that of $f()$ evaluated at the midpoint.

Speeding Up the Algorithm

You can make the algorithm in listing 1 faster by reducing the calculations required to evaluate d during each iteration of the loop. In general, d increases by $2 \times b - 2 \times a$ for a diagonal step, and by $2 \times b$ for a horizontal step. A little algebra shows that this is always true. In stepping diagonally from a point

$$(x[i], y[i])$$

to

$$(x[i] + 1, y[i] + 1),$$

the value of d changes from

$$d[i] = 2 \times b \times x[i] + 2 \times b - 2 \times a \times y[i] - a$$

to

$$d[i+1] = 2 \times b \times x[i] + 4 \times b - 2 \times a \times y[i] - 3 \times a$$

(a change of $2 \times b - 2 \times a$). When a horizontal step is taken from a point

$$(x[i], y[i])$$

to

$$(x[i] + 1, y[i]),$$

the value of d changes from

$$d[i] = 2 \times b \times x[i] + 2 \times b - 2 \times y[i] - a$$

to

$$d[i+1] = 2 \times b \times x[i] + 4 \times b - 2 \times a \times y[i] - a$$

(a change of $2 \times b$). By calculating these two values prior to entering the drawing loop, you can improve line-drawing performance. This way, you reduce updating d during each iteration to simply incrementing d by the appropriate loop constant.

Listing 2 is an improved version of the algorithm in listing 1. It eliminates the two multiplies per loop, and updates decision variable `d` incrementally. It calculates the initial value of `d` in terms of the initial values of `x` and `y` as follows:

$$d[0] = b \times (2 \times x[0] + 2) - a \times (2 \times y[0] + 1) = 2 \times b - a$$

where $x[0] = y[0] = 0$. Two new variables, `nondiag_inc` (which equals $2 \times b$) and `diag_inc` (which equals $2 \times b - 2 \times a$) are created to increment `d` during each iteration.

A Fast Unrestricted Algorithm

The algorithm in listing 2 is still subject to the restrictions that the starting point must lie at (0,0) (the origin), and the endpoint coordinates must satisfy $0 \leq b \leq a$ (which restricts the ending point to the first octant of Cartesian coordinate space). In listing 3, both restrictions have been removed by using symmetry and translation. This is the final form of Bresenham's algorithm.

Figure 4 illustrates how you can use symmetry to draw lines in any of the eight octants. Although each of the eight lines is in a different octant, the lines all have the same shape because they follow identical sequences of diagonal and nondiagonal steps in moving from the starting point to the ending point. The symmetry of the eight lines in figure 4 results from the fact that the algo-

continued

Listing 2: *A faster line algorithm, but still restricted to the first octant.*

```
procedure draw_line (a, b: integer);
{ a is the endpoint x coordinate. }
{ b is the endpoint y coordinate. }
var x,           { current x coordinate }
    y,           { current y coordinate }
    d,           { decision variable    }
    diag_inc,               { d's increment
              for diagonal steps }
    nondiag_inc:            { d's incr. for
               non-diagonal steps }
      integer;
begin { draw_line }
    x := 0;          y :=0; { start at (0,0) }
    d := b + b - a; { initial value for d }
    nondiag_inc := b + b;
      { Evaluate the d increment values.  }
    diag_inc := b + b - a - a;
    for i := 0 to a do            { Draw the
                 a+1 pixels in the line. }
      begin
  draw_pixel(x,y);
  if d < 0 then            { Is midpoint
                     above the line? }
    begin       { Yes, step horizontally. }
      x := x + 1;
      d := d + nondiag_inc   { Update the
                        decision variable.  }
    end { if-then }
  else
    begin  { Midpoint is below the line,  }
      x := x + 1;   { so step diagonally.   }
      y := y + 1;
      d := d + diag_inc       { Update the
                       decision variable.  }
    end { else }
      end { for }
end; { draw_line }
```

Listing 3: *Final form of Bresenham's Line Algorithm.*

```
procedure draw_line (xstart, ystart, xend,
                            yend: integer);

var x, y,         {current x and y coordinates}
  d,          {decision variable}
  a, b,       {line displacements in x and y}
  dx_diag,    {diagonal x step for next pixel}
  dy_diag,    {diagonal y step for next pixel}
  dx_nondiag, {nondiagonal x step for next
                            pixel}
  dy_nondiag,  {nondiagonal y step for next
                            pixel}
  diag_inc,    {d's incr. for diagonal steps}
  nondiag_inc, {d's incr. for nondiagonal
                            steps}
  swap:       {temporary variable for swaps}
    integer;

begin{draw_line}
  x := xstart;      {line starting point}
  y := ystart;
{Determine drawing direction and step to the
                            next pixel.}
  a := xend - xstart;   {Calculate difference
                            in x}
  b := yend - ystart;   {Calculate difference
                            in y}
{Determine whether ending point lies to right
 or left of start point.}
  if a < 0 then     {Drawing towards smaller
                            x-values?}
   begin          {Yes, because a is negative.}
  a := -a;        {Make a positive    }
  dx_diag := -1 {and set x-movement
                            accordingly.}
   end
  else       {Draw is towards larger x-
                            values.}
  dx_diag := 1; {Set x-movement towards
                            larger x.}
{Determine whether ending point lies above or
 below starting point.}
  if b < 0 then {Drawing towards smaller y-
                            values?}
   begin      {Yes, because b is negative.}
  b := -b;     {Make b positive and}
  dy_diag := -1     {set y-movement
                            accordingly.}
   end
  else       {Draw is towards larger y-
                            values.}
  dy_diag := 1;     {Set y-movement towards
                            larger y.}
{Identify octant containing ending point. }
  if a < b then     {Is y-diff. larger than
                            x-diff.?}
   begin      {Yes, so swap a and b    }
  swap := a;
  a := b;
  b := swap;
  dx_nondiag := 0;    {Since y difference is
                            larger, x}
  dy_nondiag := dy_diag  {doesn't change on
                            nondiagonal}
   end(if-then}     {steps, but y changes
                            every step.}
  else      {When x-diff. is larger than  }
   begin      {y-diff., x changes every
                            step.}
  dx_nondiag := dx_diag;   {and y changes
                            only on the}
  dy_nondiag := 0    {diagonal steps.}
   end(else)
  d := b + b - a;    {Initial value for d is
                            2*b-a.}
  nondiag_inc := b + b;   {Set initial d
                        increment values}

  diag_inc := b + b - a - a;
  for i := 0 to a do  {Draw the a+1 pixels.}
   begin
  draw_pixel(x,y);
  if d < 0 then     {Is midpoint above the
                            line?}
   begin      {Yes, step nondiagonally.}
    x := x + dx_nondiag;
    y := y + dy_nondiag;
    d := d + nondiag_inc  {Update the
                   decision variable.}
   end(if-then)
  else      {Midpoint is below the line.}
   begin     {so step diagonally.}
    x := x + dx_diag;
    y := y + dy_diag;
    d := d + diag_inc    {Update the decision
                            variable.}

   end(else)
   end(for)
end;(draw_line)
```

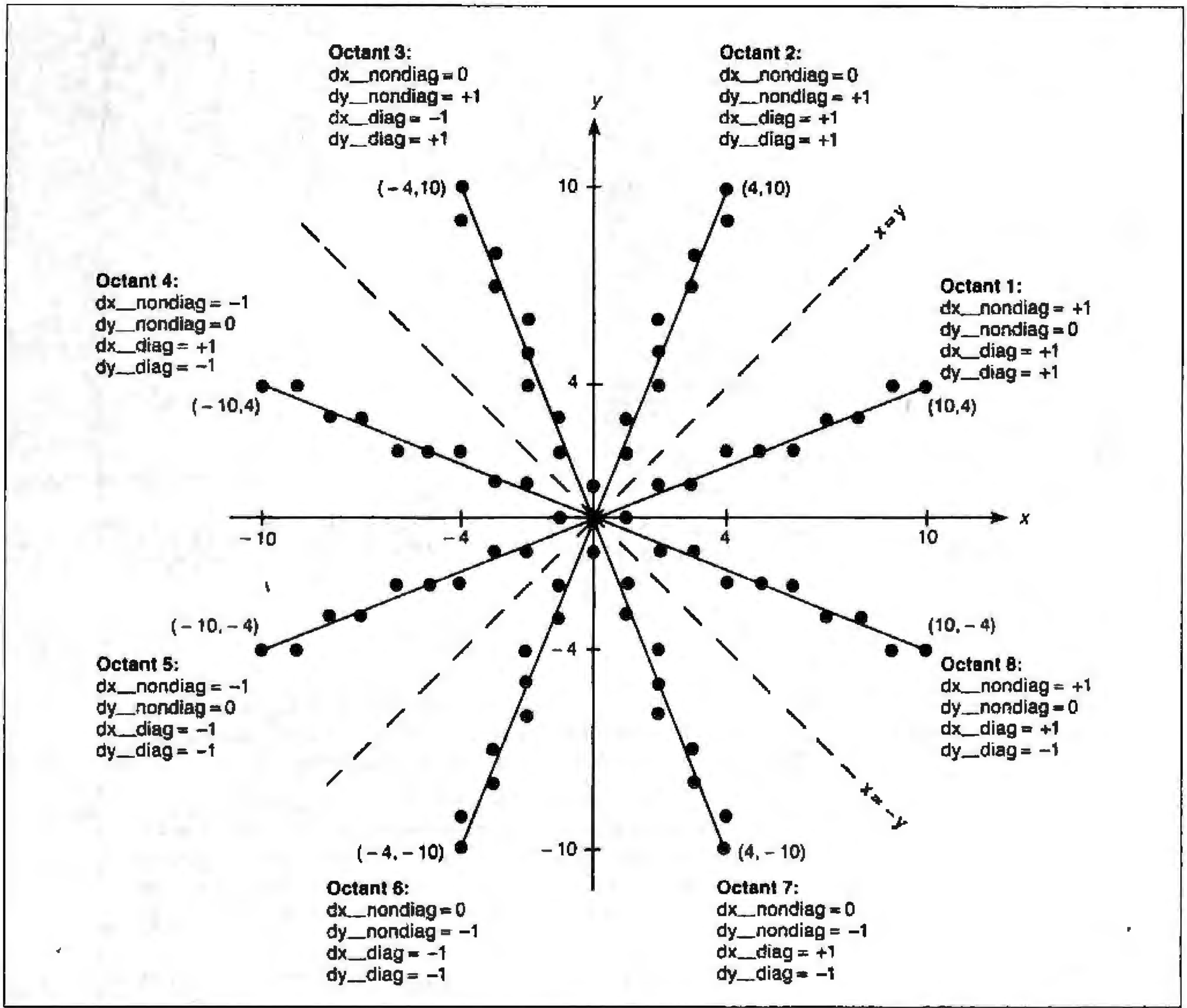

Figure 4: *Eight-way symmetry used for the general algorithm.*

rithm uses the same values of a and b (for this example, $a = 10$, $b = 4$) for each of the lines. The only difference between drawing in one octant and another is the direction of diagonal and nondiagonal steps. The algorithm in listing 3 tests the endpoints to determine in which octant the line lies. After the target octant is determined, the x and y increments for diagonal and nondiagonal steps are adjusted to draw the line in the proper direction.

In listing 3, nondiagonal steps cause x and y to increment by `dx_nondiag` and `dy_nondiag`; diagonal steps cause x and y to increment by `dx_diag` and `dy_diag`. Figure 4 shows the values of these increments in each of the eight octants.

The final step in achieving the general form of the algorithm in listing 3 is to allow the line to begin at points other than the origin. Whereas variables a and b represented the coordinates of the endpoint in listings 1 and 2, in listing 3 they represent the distances in x and y from the starting point to the ending point; a is set to the larger of these distances, and b to the smaller.

Described in geometric terms, when the algorithm initially assigns values to parameters a and b, it effectively translates the starting point of the line to the origin.

At this point in the algorithm, the ending point of the translated line is at (a,b), and variables a and b contain information regarding both the shape of the line and the octant of the translated ending point. In the three subsequent tests of the values of a and b (Is $a < 0$? Is $b < 0$? Is $a < b$?) the octant information is stripped away from a and b, leaving only the shape information. Meanwhile, all information regarding the octant of the ending point is transferred to the x and y increments `dx_diag`, `dy_diag`, `dx_nondiag` and `dy_nondiag`. All this takes place prior to entering the `for` loop in listing 3.

Practical Implementations

In a real graphics system, you should encode the algorithm in listing 3 in assembly language to make it run as fast as possible. For instance, a typical CAD diagram might contain hundreds of lines, and the user waits while the computer draws the diagram on the screen. The programmer should put the most effort into speeding up the `for` loop, since this is executed once for each pixel drawn, and one line may contain hundreds of pixels.

By comparison, the code that precedes the `for` loop executes only once per line. The call to the `draw_pixel` procedure should be replaced by in-line code for the `draw_ pixel` operation in order to remove the subroutine call overhead from the inner loop. ■

Dick Pountain

Multicolumn Paged Text

Use this program to lay out text in columns and to explore desktop-publishing software technology

Until recently, multiple-column text was something you found on newspaper and magazine pages, but not on the output from computers. The two main output devices used by computers—the CRT monitor and the line printer—were physically designed to produce single columns of text.

Then, graphic displays and desktop publishing arrived, and the market is now flooded with programs that organize text into pages, using multiple columns, typefaces, and type sizes. Increasingly, personal computer word-processing software is beginning to offer multiple columns for printed output (e.g., Microsoft Word), on the screen, or for both (e.g., WordPerfect).

The reason for wanting multiple columns is largely one of readability. The small point sizes used to cram more words into newspapers and magazines make for far too many words across a whole page width for comfortable reading. This would be particularly true in the case of broadside-size newspapers, where a line would hold more than 50 words; the human eye has a tendency to lose its horizontal tracking accuracy if asked to scan across too many words on a single line.

Breaking the text up into multiple columns ensures that each line contains a more readable number of words—typically, 6 to 12. Using multiple narrow columns also allows the layout designer greater flexibility in fitting several articles on the same page, particularly important in newspaper work. Books tend to employ larger point sizes and wide margins, yielding around 12 words across the page, and are rarely set in columns.

In the good old days of 9-pin dot-matrix printers with cobby typefaces, multiple-column output from a personal computer was neither necessary nor particularly desirable. A low-cost printer gets only about 13 words on an 80-column line anyway, and those are composed of fixed-width characters, possibly justified by crude insertion of full character spaces. Now that laser printers are common—and even dot-matrix printers can manage proportional spacing and near-letter-quality (NLQ) typefaces—columns start to make sense.

Apart from page layout and readability, another valuable use for multiple columns is the economical generation of lists. If you have to print 2000 short items, it is both wasteful and unsightly to print them in a single spindly column on 32 sheets when they will fit in four columns on 8 sheets. It was precisely this application that prompted me to write a utility for arranging text into multiple columns. I use a text editor that lacks this facility, but I have no intention of learning a new editor just to get it.

Before writing such a utility, it's important to decide exactly what you hope to achieve. Multiple-column-text programming covers a broad spectrum of difficulties. At the most difficult end of the spectrum is the provision of multiple columns on the screen, interactively, with automatic reformatting, word wrap, and line wrap. This means that new text can be inserted at any point on any line, excess words will wrap over onto the next line, and excess lines will wrap up to the top of the next column.

This is the sort of facility the next generation of word processors will offer as a matter of course. To achieve it requires storing the text in a dynamic data structure, something like an array of circular lists of circular lists. This can make screen updating a strenuous chore, especially if you're using a bit-mapped graphic display. It is not something you can retrofit to a text editor like

continued

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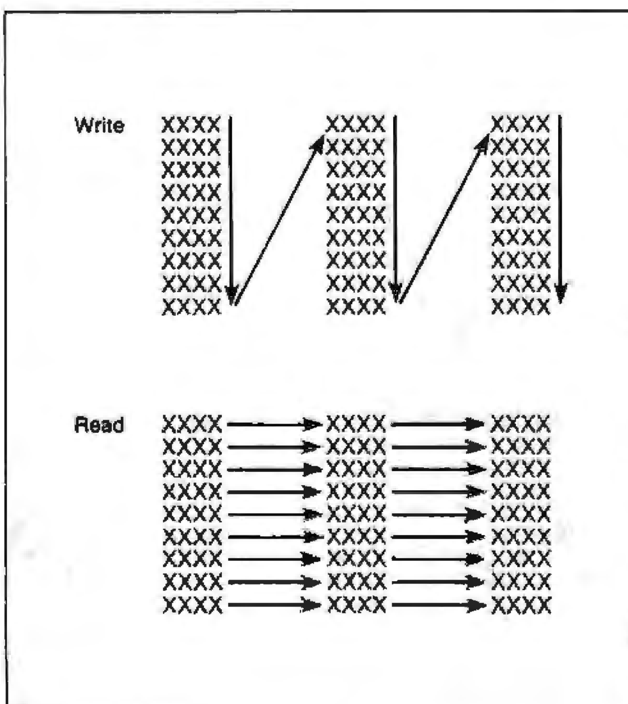
Figure 1: *The process of writing a two-dimensional array of characters up and down, then reading the same array across, yields the desired transformation to three-column text.*



mine, unless you have the source code and a lot of spare time on your hands.

At the opposite end of the difficulty spectrum we have a simple DOS utility that takes a plain ASCII text file and outputs another file with the text paged in a specified number of columns with a specified number of lines per page. This was my own coward's preference.

The root principle in implementing multiple-column output is delay. Both video display units and printers are physically capable of printing only single lines of text, ended by a carriage return. But if we are printing in, say, three columns, each *physical* output line will actually consist of three short *logical* lines from different places in the text.

The first two logical lines, therefore, need to be held back until the third one is reached before printing them all. If we regard output as a continuous data flow, we need a data structure that acts as a delay line, holding back logical text segments until the structure collects a full physical line.

However, in the case of my simple program, there is no need to regard output as a continuous data flow. Instead, you can think of output as a batch process, in which whole pages are collated and then output as units. In this case, we can build a data structure to act as a mold or template for the desired page; words "pour" into the mold until it is full, and then the "casting" is sent to the output file, complete with a page number.

Since this is a batch process whose dimensions are fixed from the start, a two-dimensional array of strings will be a perfectly good data structure to represent the page. This would not be a good choice if we were trying to implement interactive word wrap and line wrap, as we would have to move along many array

continued

Listing 1: *Pseudocode for the word-wrap algorithm.*

```
Program Pager
PageNumber <- 1
WHILE not at end of input text

  FOR Column FROM 1 TO ColumnsPerPage
             -- Fill the page template
    FOR Line FROM 1 TO PageLength
       IF not at end of input text
       THEN  read a line from input ->
                Page[Column, Line]
       ELSE  fill with blanks -> Page[Column,
                Line]
       ENDIF
    ENDFOR
  ENDFOR

  PhysicalLine <- empty string        --
                Write physical lines to output
                file
  FOR Line FROM 1 TO PageLength
    FOR Column FROM 1 TO ColumnsPerPage
        APPEND Page[Column,Line] TO
                PhysicalLine
    ENDFOR
    APPEND (enough blanks to pad out to
                column width) TO PhysicalLine
    WRITE PhysicalLine -> output file
    WRITE Carriage Return -> output file
  ENDFOR
  WRITE PageNumber -> output file
  PageNumber <- PageNumber + 1
ENDWHILE
```


Implementing this algorithm is quite straightforward in an interpreted language like BASICA because such languages allow the dimensioning of arrays at run time.

elements every time a new word was inserted.

A crude outline algorithm for the paging process is this: First, fill the template with words from the input by writing up and down the columns; second, write an output file by reading the template across all the columns at once.

For three columns, we could represent the process in a diagram like the one found in figure 1. We achieve the required transformation by looking at the same data structure from two different viewpoints.

We need to refine one aspect of the problem before we can proceed. I have talked lightly of words "pouring" into an array, but we actually have more to consider here. If we have prepared the input text with a text editor, it will already be formatted into lines of some length, according to the margin settings of the text editor.

When we page the text into multiple columns, they will be much narrower than the typical margins for a single-column document. Hence, the routine that fills the array needs to word-wrap the input text to this narrower column width. If we are talking about a sophisticated paging utility, it should also be able to justify the wrapped text and intelligently hyphenate it. But this means that the Fill routine needs to incorporate much of the capability of a good text editor.

It seemed silly to me to reinvent the wheel, when I already had a tool (my text editor) to hand that could handle these formatting chores superbly. The paging program I wrote therefore takes text files that have already been formatted to the correct column width using the text editor. At the same time as you reduce the margins, you can justify the text, if required, and arrange features like column headings to fit properly into the paged format, using all the facilities of the text editor.

The only inconvenience lies in having to write an extra intermediate file of this "galley" text, formatted to column width. But even on my slow computer, this takes only seconds. On the other hand, the construction of the paging utility itself is greatly simplified (it needs to know only how to wrap columns), and consequently the program goes very fast.

The algorithm can now be presented more formally in pseudocode (see listing 1). Implementing this algorithm is quite straightforward in an interpreted language like BASICA because such languages allow the dimensioning of arrays at run time. The program can decide on the dimensions of the Page array after it has asked the user for the number of columns and lines per page required.

Compiled languages like Pascal, C, or compiled BASIC impose a slight complication in that arrays can be dimensioned only at the time the program is compiled; obviously, it is unacceptable to have a different version of the program for every conceivable page layout. Fortunately, some calculation shows

continued

Adding Diagrams

It's easy to adapt the multicolumn-paged-text algorithm to run text around diagrams. You can define a "window" area—a space to be left blank for the later addition of a diagram—by the column and line numbers of its top left and bottom right corners. If we call these window coordinates $X1,Y1$ and $X2,Y2$, for $X1=1$, $Y1=4$ and $X2=2$, $Y2=7$, we have the window area shown in figure A.

To modify the program to produce window areas, we need to change the test on line 6 of procedure `ReadInPage` in listing 2 so that it checks whether the line currently under consideration falls outside the window. If so, the program reads input into that line; otherwise, the program should pad the line with blanks (in the same way that lines are padded on the last page, after the program reads end of file):

```
if not eof(InputFile)
 and not ((Column in [X1..X2]) and
    (Line in [Y1..Y2]))
```

The only other change to the program text required is some way of reading in `X1`, `Y1`, `X2`, and `Y2`. For the purpose of experiment, you can add them as four extra command-line parameters to be read in by `GetPageParms`.

This crude mechanism will of course make a window in the same place on every page, which is seldom what we want. However, it is no more difficult conceptually, and takes only a little more programming effort, to have a different window on every page. You need to store the window coordinates for each page in an array `Window[]`, which is indexed by `PageNumber` and the four coordinate types. For pages with no window, set all coordinates to 0. The extra declarations needed are

```
type WindowCoord = (Left,Right,Top,Bottom);
var Window: array [1..MaxPages, WindowCoord] of
   integer;
    X1,X2,Y1,Y2: integer;
```

The format for a document now consists of a sequence of records of the following form:

<pagenumber>,<X1>,<Y1>,<X2>,<Y2>

This information is kept in a separate ASCII file that gets read into the `Window` array when the program starts.

The next logical refinement is to include the contents of another file to fill the window so created. These files can contain

```
xxxxxxxx     xxxxxxxx     xxxxxxxxx
xxxxxxxx     xxxxxxxx     xxxxxxxxx
xxxxxxxx     xxxxxxxx     xxxxxxxxx
1,4                       xxxxxxxxx
                          xxxxxxxxx
                          xxxxxxxxx
             2,7          xxxxxxxxx
xxxxxxxx     xxxxxxxx     xxxxxxxxx
xxxxxxxx     xxxxxxxx     xxxxxxxxx
xxxxxxxx     xxxxxxxx     xxxxxxxxx
xxxxxxxx     xxxxxxxx     xxxxxxxxx
xxxxxxxx     xxxxxxxx     xxxxxxxxx
```

Figure A: *Defining a window area for multicolumn text.*

diagrams, bar charts, and tables drawn using block graphics characters. Bit-mapped graphics present enormous problems, but the truly dedicated (or crazy) could achieve even this on Epson-style printers using bit-image mode.

The principle is quite simple. Rather than filling the window area with blank lines, the program fills the area with slices from the diagram file. A function called `DiagramSlice` reads lines from the included diagram file and adjusts them to the proper length. The procedure `ReadInPage` now looks like this:

```
procedure ReadInPage;
var Column,Line: Integer;
begin
 X1 := Window[PageNumber,Left];
 Y1 := Window[PageNumber,Top];
 X2 := Window[PageNumber,Right];
 Y2 := Window[PageNumber,Bottom];
  for Column := 1 to ColsPerPage do
   for Line := 1 to LinesPerPage do
    if not Eof(InputFile)
     and not ((Column in [X1..X2])
      and (Line in [Y1..Y2]))
    then readln(InputFile,Page[Column,Line])
    else Page[Column,Line] := DiagramSlice;
end;
```

Now the format of a document has an extra element: the name of a diagram file. The record structure is <pagenumber>, <X1>,<Y1>,<X2>,<Y2>,<diagramfile name>. Alternatively, you might now prefer to put the X,Y coordinates into the diagram file itself.

I've shown a simple version of `DiagramSlice` in listing A. I've left the gruesome details of reading in the format from a file and opening the appropriate diagram files to you. All of a sudden, PageMaker and Ventura Publisher start to look quite cheap at the price, don't they?

Listing A: *A simple version of the function to read lines from the diagram file and adjust them to the proper length.*

```
function DiagramSlice: Stringtype;
var TempSlice: Stringtype;
 WindowWidth: integer;

begin
 if Eof(InputFile)
 then DiagramSlice := Blankline
 else
  begin
   WindowWidth := CharsPerline*(X2-X1+1);
   readln(DiagramFile,TempSlice);

   {Crop if long...pad if short}
   TempSlice := Copy(TempSlice,1,WindowWidth)
              + Space(WindowWidth-
length(TempSlice));
   if Column = X1
   then DiagramSlice := TempSlice
   else DiagramSlice := ' '
  end
end
```

Listing 2: *The column-wrap program in Turbo Pascal code.*

```
program Page;

const       MaxColsPerPage = 6;
            MaxPageLength = 60;
            MaxCharsPerLine = 40;
            PageWidth = 80;
            Blanks = ' ';

type        Linetype =
                string[MaxCharsPerLine];

var         Page:
                array[1..MaxColsPerPage,1..Max
                PageLength] of Linetype;
            BlankLine: Linetype;
            ColsPerPage, PageLength,
                PageNumber, CharsPerLine:
                integer;

            InputFile, OutputFile: text;
            InputFileName, OutputFileName:
                string[127];

  Procedure InitFiles;
  begin
    if paramCount = 0
    then begin write('Must specify an input
                     file');
                halt
         end;
    InputFileName :=  paramStr(1);
    if (pos('.PAG',paramStr(1)) <> 0) or
                (pos('.pag',paramStr(1)) <> 0)
    then begin
            writeln('Mustn''t PAGE a PAGEd
                file!!');
            halt
         end;
    if pos('.',paramStr(1)) = 0
    then OutputFileName := paramStr(1)+'.pag'
    else OutputFileName :=
                copy(paramStr(1),1,pos('.',par
                amStr(1)))+'pag';
    Assign(OutputFile, OutputFileName);
    Assign(InputFile, InputFileName);
    Reset(InputFile);
    if ioresult <> 0
    then begin
            writeln('File ',InputFileName,'
                not found');
            halt
         end;
    Rewrite(OutputFile);
    if ioresult <> 0
    then begin
            writeln('Error opening output
                file: is disk full?');
            halt
         end
  end ;

  procedure GetPageParms;
  var error: integer;
  begin
     val(paramStr(2),ColsPerPage,error);
     if (error <> 0) or (ColsPerPage >
                MaxColsPerPage)
     then begin
             write('Bad column parameter');
             halt
          end;
     val(paramStr(3),PageLength,error);
     if (error <> 0) or (PageLength >
                         MaxPageLength)
     then begin
             write('Bad line parameter');
             halt
          end;
  end;

  procedure ReadInPage;
  var Column, Line: Integer;
  begin
    for Column := 1 to ColsPerPage do
      for Line := 1 to PageLength do
        if not eof(InputFile)
        then
readln(InputFile,Page[Column,
Line])
        else Page[Column,Line] := BlankLine
  end;

  function Spaces(Num:integer):Linetype;
  begin
    Spaces := Copy(Blanks,1,Num)
  end;

  procedure WriteOutPage;
  var Column, Line: integer;
  begin
      for Line := 1 to PageLength do
        begin
          for Column := 1 to ColsPerPage do
               write(OutputFile,
          Page[Column,Line+
               Spaces(CharsPerLine-
               Length(Page[Column,
          Line])));
          writeln(OutputFile)
        end;
     writeln(Outputfile,
               Spaces(38)+'<',PageNumber,'>')
               ;
     writeln(Outputfile)
   end;

  begin
     Initfiles;
     GetPageParms;
     PageNumber := 1;
     CharsPerLine := PageWidth div
               ColsPerPage;
     BlankLine := Spaces(CharsPerLine);
     while not eof(InputFile) do
     begin
       ReadInPage;
       write('.');
       WriteOutPage;
       PageNumber := PageNumber + 1;
     end;
     Close(InputFile);
     Close(OutputFile)
  end.
```

Listing 3: *A version of the* `GetLine` *procedure; not very smart, this version wraps only whole words.*

```
const   CR = #13;
        LF = #10;

var LineBuffer: Linetype;

procedure GetLine(VAR Infile: text;
                  LineLength: integer;
                  VAR NextLine: Linetype);

  var NextWord: Linetype;
      Full: boolean;

    procedure GetNextWord;
    var Chr: char;
    begin
      NextWord := '';
      while (Chr <> ' ') and not
               eof(Inputfile) do
       begin
         read(InFile,Chr);
         if Chr <> LF
         then begin
                if Chr = CR then Chr := ' ';
                NextWord := NextWord + Chr
              end
       end
    end;

begin
  Full := false;
  while not Full and not eof(InFile) do
    begin
      GetNextWord;
      if NextWord <> ' '
      then if Length(NextWord)+Length(Line
        Buffer) > LineLength
           then   Full := true
           else begin
                  LineBuffer := LineBuffer
             + NextWord;
                  Full := false
                end
     end;
  NextLine := LineBuffer;          { Flush
           out result}
  LineBuffer := NextWord;          { Save
           leftover word for next time}
end;
```

that the size of the problem is such that a fudge is possible.

My printer (as is the case with most printers) uses A4 paper, which holds 60 lines of text with 80 characters per line. The largest number of columns I would ever want on such paper is six. The smallest number of columns I would ever want is two (otherwise, why use the program at all?), and two columns on my paper means at most a 40-character column width.

Six columns of 60 lines with 40 characters comes to around 15K bytes of storage. An array of this size will hold the most columns I will ever need, at the most characters per line I could ever need, and it's well within the memory limits of even modest computers. So to hell with elegance, let's waste bytes. We declare an array of this size and use as many columns and lines of it as are needed.

The program's source code in Turbo Pascal 3.0 is shown in listing 2. In this simple version, the name of the input file, the number of columns, and the number of lines per page must be given on the command line from which the program is invoked. For space reasons, I've kept the error checking quite rudimentary. A sample command line could be

```
C:>page byte40.doc 3 60
```

Before you can use this line, though, you'll need to format `byte40.doc` to a right margin of 26 (80/3), and justify it if desired, using your regular text editor. The program automatically renames the output file, in this case to `byte40.pag`.

In the version of the program I use in real life, I've added a system of template files, like a very poor man's Ventura Publisher. A template file specifies a page style, including the number of columns, page length, left- and right-page margins, header text, and rules. I keep a separate template file for each format I use regularly, and the template filename is given as the second parameter to `Page` in place of the numeric parameters used here.

To make `Page` into a stand-alone program (i.e., one that can accept an input file in any format and perform its own word wrapping), it's necessary only to write one new procedure—let's call it `GetLine`—and substitute a call to it for the statement

```
Readln(InputFile,Page[Column,Line])
```

at line 7 of `ReadInPage`.

The snag, as I've already suggested, is that `GetLine` will need to be quite a large procedure if you want it to be as smart as your average text editor; for example, doing intelligent hyphenation is in itself a suitable subject for several articles. To get you started, listing 3 contains a very slow, dumb version of `GetLine`, which can wrap only whole words. You could improve the speed by buffering more text in memory rather than reading single characters, as I have done here. The call in `ReadInPage` now takes the form

```
GetLine(InputFile,CharsPerLine,Page[Column,Line])
```

When you get as far as writing a `GetLine` procedure that word-wraps, hyphenates, and can perform justification with proportionally spaced fonts, you are well on your way to having a real desktop-publishing program. The next logical step is to deal with running columns around holes for pictures.

Batch methods of page layout like the one I have described here are far from ideal in applications where text runs around complex picture layouts. In such cases, it's more appropriate to use an interactive or WYSIWYG (what you see is what you get) design program that shows you the layout on the screen so that you can position the pictures. However, the program can be adapted, as described in the text box "Adding Diagrams" on page 260, to serve in the simple case of one diagram per page, where the diagrams are character-based (e.g., using IBM block graphics characters). ■

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Merrill Cornish

It's All in the Symbols

Numbers aren't everything; in fact, the "things" that they can represent might be in the minority.

We've always had symbols as names; now we're investigating symbols as numbers. We tend to relate what we hear to what we already know. Numbers are what we already know, so we tend to think of symbols as numbers, or as representing numbers; but symbols aren't numbers. And symbolic processing is *not* just another way of saying numeric processing.

Symbols are not truly symbols when they are used as variable names. Conventional programming languages use the term *symbol* to mean the name of a program variable. Lisp has variables named by symbols, but they aren't the same as the symbols we are discussing.

What makes symbolic processing symbolic is that the values a variable is allowed to assume now include other symbols as well as the traditional numbers. For example,

```
(setf a 1)      ; assignment of a number value
(setf b 'a)     ; assignment of a symbol value
a => 1          ; value of a is the number 1
b => a          ; value of b is the symbol a
```

One common misconception is that symbolic processing is artificial intelligence. While AI would probably be impossible without it, symbolic processing is also useful for things unrelated to AI. Another misconception is that you use symbolic processing so you don't have to explicitly declare the types of your numbers. If you need type checking for your numbers, you might want to use Lisp, but you don't necessarily need symbolic processing.

A third misconception is that symbolic processing means you do garbage collection. Not true; garbage collection can benefit any language—numeric or symbolic—that allows you to allocate run-time data. Its usefulness is not restricted to symbolic processing.

Now you know what symbolic processing is *not*, but what *is* it? In reality, symbolic processing means processing nonnumeric "things" that we can't reasonably represent as numbers. Thus, we represent these things as symbols. Symbolic processing is the natural complement of numeric processing. First, however, we must accept that there is something other than numbers.

With COBOL, FORTRAN, Pascal, C, and so on, we've been quietly indoctrinated to believe that data is numbers. While there's nothing wrong with that premise in context—that is, within the limits of procedural languages—the power of computing extends a lot further. This article describes how symbols differ from numbers, why we can't use numbers where we need symbols, and how the things we need symbols for are unique and valuable.

What Is Numeric Processing?

Venerable FORTRAN II supported only numeric data types. FORTRAN IV added logical data types. COBOL added more numeric types, such as packed decimal and an almost nonnumeric data type, characters. Characters were invented to record nonnumeric things, but we all *knew* that they were really small integers that always fit into 8 bits.

Since FORTRAN, most language designers have accepted the implied dictum: Data is numbers. And yet, the question "Are numbers enough?" always existed. As a partial response, Pascal's designers included sets, and C's developers recently added enumeration types.

But these two concessions to nonnumeric processing still have conveniently numeric internal representations. A set is really a one-dimensional array of 1-bit integers, while an enumeration resembles the assembly language practice of equating names to successive integers.

Numeric processing is a definite success story. The problem lies in our assumption that since it has been used for everything we've thought of so far, it should be used for everything we *can* think of.

It's All in the Data Types

If, as an experienced programmer, you are given a choice of any implementation language you wish to use for an application, your choice would probably be fairly predictable. For vector number-crunching applications, you would probably use FORTRAN; for business data processing, COBOL; for text pattern matching, SNOBOL; for systems programming, C; and so on. These choices have nothing to do with which language is best; they are purely pragmatic. Each particular language offers the data types and data structures needed to clearly and concisely describe a specific type of problem, plus the library functions to manipulate those structures.

For example, let's suppose you need to read a text file and produce a sorted list of words, the number of times each word occurs, their average length, and so on. How would you implement this program in FORTRAN 66, which has neither a character data type nor a string data structure?

Nothing's impossible. You could use FORTRAN's A1 format to read characters into an array. You could mimic string

continued

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storage by maintaining pairs of start/end indexes into that array, one pair per string. You could make the dimensions of the various fixed-size arrays larger than you'll ever need. You could write FORTRAN functions to access these pseudostrings, compare them for equality, order them, print them, and so on. You could make it work, but would you want to? You would have already written a significant amount of FORTRAN code before you even considered the original application.

However, there is a better solution. Consider the relative ease with which you could implement this application in C. C already understands that characters are characters and not stunted integers. C already knows how to store characters in strings. The standard C libraries already contain the necessary character-manipulation functions, such as `strlen`, `strcmp`, `strcpy`, and so on.

In short, C has the data types and data structures to support the application, and FORTRAN 66 doesn't. With C, you start programming the application immediately. With FORTRAN, you start by creating a virtual language within which you can then implement the application. When you do finally get to coding the application itself, the in-line FORTRAN housekeeping needed to make arrays of integers look like strings of characters constantly intrudes on the logic of the application. FORTRAN doesn't provide the *abstraction* we need for this problem; C does.

Symbol Data Types

In high-school English, many of us had to diagram sentences by breaking them into clauses, phrases, subjects, verbs, and so on. What if you had to implement such an analysis in a program? Remember, we aren't talking about understanding; we don't care what the sentences *mean*—we just want to classify the words in them.

While C has excellent string-handling capabilities, this is not a string problem; it's a symbol problem. C's string-handling facility is mainly interested in the physical aspects of string representation. Given the words *is*, *was*, and *were*, C's `strlen` function could tell you that they are 2, 3, and 4 characters long, respectively. But we need to know that they are all verbs, not nouns, adjectives, or adverbs; that *is* and *was* are singular while *were* is plural; and that *is* is present tense while *was* and *were* are past tense. Also, given the words *are* and *ARE*, C's `strcmp` function would tell you that they are different, although they are the same word.

C is doing what it is supposed to do. C is interested in the characters in a string, but we are interested in the *word* represented by the string and in its grammatical properties. C sees the word as a collection of individual characters and is unaware of any higher meaning to that collection. In other words, this time C doesn't provide the particular abstraction that we need.

Why Strings Won't Do

So far, we've seen how a true symbol data type would simplify our implementation. But, even if a string-based implementation isn't our first choice, shouldn't it still be an acceptable second choice?

The real question is: How acceptable is the extra code you have to write to get C to see the big picture and stop dealing with words as bags of characters?

For example, C programmers sometimes use strings as symbolic mnemonics, such as the string argument `r` telling `fopen` to open a file for reading. It's not always appropriate, however, to try to distinguish symbols by their printed representation. Consider the sentence: "BILL PAID HIS REPAIR BILL." Is the first BILL equal to the second BILL? C's `strcmp` function would think so.

Once your analysis determines that the subject is BILL and the object is BILL, then a C program would claim the sentence's subject and object are the same. But they aren't. The subject is a man, and the object is a piece of paper. The fact that this particular subject and object happen to have the same printed representation is merely coincidence.

The notion of symbolic data types introduces distinctions that never seemed important with numeric data types. For example, the Lisp predicate eq compares two symbols to see if they represent the same object, the same piece of memory. Therefore, `(eq` *`subject object`*`)` would return false since BILL, the subject string, is physically a different data structure from BILL, the object string. They are two different objects that just happen to be represented by the same characters.

The Lisp predicate `equal` compares the contents of two objects rather than the objects themselves. As a rule, if two objects print the same, `equal` will say they are the same. So in Lisp,

```
(eq subject object) => false
(eq subject subject) => true
(equal subject object) => true
```

The point is that when you deal with symbolic data types, you need more than the plain bit-pattern comparisons that number crunchers use.

The Power in Abstraction

Programmers have a vested interest in abstraction. Alan Turing showed us that even a very rudimentary machine can compute almost anything imaginable. But the process of programming a Turing Machine is tedious (see "The Turing Machine" by Isaac Malitz in the November 1987 BYTE). Abstraction is one of the things that makes programming bearable.

At the binary level, underneath the abstraction, the code breaks down to all ones and zeros. But the point of a programming language is to provide an abstraction that suppresses the things we don't care about while leaving the features we consider important out in the open and available. Furthermore, as we go from one application to another, our notion of what's important can shift radically.

FORTRAN provided us with at least three major abstractions that have appeared in virtually all languages since: DO loops, floating-point numbers, and I/O statements. While there are many ways of writing a loop, FORTRAN programmers are more interested in what's inside the DO loop than in the mechanics of indexing; so FORTRAN included a DO loop abstraction. Floating-point representations are a whole field of study, but FORTRAN programmers needed to *use* floating-point numbers, not study them; so FORTRAN included a floating-point abstraction.

And everyone needs to do I/O, but few want to write yet another ASCII-to-integer conversion. So FORTRAN included a FORMAT statement. (You might well argue that a FORTRAN FORMAT statement is *not* the best of all possible worlds, but that's not the point. Even FORMAT's arcane syntax still lets you think more in terms of what you want printed than how to output each character.)

Despite FORTRAN's successes, its array abstraction doesn't do too well on the word-counting application. The meaning of any number in a FORTRAN array is independent of any other number in that array. In contrast, a character in a C string has little meaning by itself. Instead, all the characters in the string taken together have a meaning. This distinction of individual meaning versus group meaning isn't just a pedantic nicety: It underlies why C does better than FORTRAN at itemizing words in a file.

However, when we try to parse a sentence, C's abstraction of strings as a collection of related characters doesn't help much. We don't want to spell the words; we don't even care what the words are; we just want to identify their respective parts of speech. C's abstraction isn't wrong; it just isn't the one we need.

Verbosity and Fragility

Working without the abstractions you need exacts a definite cost in verbosity and fragility. The verbosity is due to the additional source code you must add to do the things that a language with a more appropriate abstraction would have done for you. You can hide much of this source code inside function calls, but too much of it usually ends up in the form of manual programming conventions.

For example, a complex number is made up of a pair of ordinary numbers called its real and imaginary parts. Since FORTRAN was designed with abstractions for numerical analysis, it had complex numbers from the start. If you have declared A, B, and C as complex numbers, then the simple statement A = B × C is sufficient to cause the real and imaginary parts of B and C to be multiplied, recombined, and stored into the real and imaginary parts of A.

However, if FORTRAN didn't have complex numbers, we would have to handle the process ourselves. First, to represent a complex number, we could use a one-dimensional array of two elements for its real and imaginary parts. What would a simple

continued

multiplication of two complex numbers, A = B × C, look like?

```
A(1) = B(1)×C(1) - B(2)×C(2)
A(2) = B(1)×C(2) + B(2)×C(1)
```

The best abstraction that we could devise in FORTRAN would probably be a complex multiply function, such as CMULT (A,B,C), which is an improvement, but the fact that you don't have a true complex-number data type still shows.

Given the statement A = B × C in FORTRAN IV, where variable names beginning with A have been declared to be implicit complex numbers, the language's automatic memory-allocation abstraction would have allocated A for you. But before you used the CMULT(A,B,C) function above, you would have had to declare A yourself as DIMENSION A(2). Custom functions (and macros) can make do-it-yourself abstraction-building less painful, but the pretender still isn't as good as the real thing.

The actual load/add/store sequences executed by the hardware in these examples are identical. The difference is the level of abstraction available to the programmer. The lack of an appropriate abstraction is a definite programming liability.

In addition to being more verbose, your code also becomes more fragile, because the verbosity exposes more of the language's housekeeping as source code. The extra code provides more opportunity for errors, which can be introduced by anything from typographical errors to overlooking a special programming convention (i.e., when you did *this*, you forgot to do *that*). The code is also subject to errors due to its lack of intuitiveness. You could mistake it for a fragment of matrix multiplication; if you can't fathom its purpose, you can't be sure if it needs fixing.

The Next Step

This discussion of abstractions leads us to three real points:

- Each problem has its own preferred set of abstractions. If the programming language you are using doesn't provide the relevant abstractions, you will have to code them yourself.
- Conventional languages almost universally provide abstractions of numeric things and can perform numeric processing. Languages that provide abstractions of nonnumeric things can perform symbolic processing.
- The historical progress of computing is closely tied to the available abstractions—that is, the available programming languages. Symbolic processing is the next evolutionary step.

Of all the things that exist in the world and in our minds, we need to be able to abstract them before we can represent them in the ones and zeros of a computer. At present, abstractions have not wandered too far from the concept that data is numbers. Now, we are beginning to suspect that the things in this universe that numbers can represent may be in the minority.

Our progress beyond the bounds of numbers has come in stages. First, we found that symbolic operands couldn't always be represented in a 32-bit memory word, so we set up pointers as a general data representation. Next, we found that there were relationships too complicated to be described in a multidimensional array, so we devised trees. Then, we found that memory usage was too sophisticated for static allocation, so we created dynamic run-time allocation and de-allocation. Now, we are finding a need to process symbols that don't represent numbers. The idea of symbolic processing began when we first realized that data needn't be numbers; we have yet to see all the possibilities of that idea. ■

Circle 280 on Reader Service Card (DEALERS: 281)

continued from page 36
to stay late or work over lunch to learn something for their own sake—and the corollary is that management somehow can only rarely spare anyone long enough to send them to school or do training on company time.

There is a vicious cycle of ignorance and excuses for not learning and for not training at work in companies where management still perceives that the company is too small to support an active training program, in-house or out.

The company buys hardware and software because they are tools to use in processing data that is relevant to the company's business. That data is the property of the company, even when people move on or are replaced or promoted.

From personal experience, I know how hard it is to have the personnel department call the week after the director leaves, asking if anyone can help the new guy with this Visifile application that is running on a PC that had an oddball accelerator card, and what does "General Failure reading drive C" mean, anyway? And no, no one can find any backups or program disks or manuals, but we have to use it to get the time cards out, so since you're a programmer, why don't you fix it *right now*?

The now ex-director was a fairly knowledgeable PC user who had available the Lotus 1-2-3, dBASE, and WordStar that we could support, and he had gotten an IBM PC XT despite a request for an AT because he couldn't justify the more expensive machine. So, since he wanted to save himself the trouble of learning programs new to him, he brought from home (or bought without telling anyone) Visifile, PFS:Professional Write, Multiplan, ProKey, and several truly off-the-wall programs and some hardware to make himself feel that even though he didn't get an AT, he is still better equipped than the average guys who don't know how to work the angles and get what they want. Time cards, reports, and sensitive personnel records are now tied up in files and formats that are accessible only through programs no one else knows anything about. It appears that the hard disk drive is failing sporadically, with no backups in sight.

Your arguments boil down to encouraging personal creativity and initiative; mine boil down to being able to pick up and go on, even when that creative person has picked up and moved on, leaving someone else to clean up behind him. As in so many other things, there is a balance to be struck. In my mind, the critical factor in determining that balance is the degree to which disruption of company business will take place if a customized and personalized hardware/software setup is left for a new person to take over.

Standards serve the interests of the company mostly from a standpoint of continuity, and I have grown to appreciate continuity of service, and a predictable level of quality of service and product, as absolutely key ingredients in the success of any business.

At the very least, I will forever more make one demand: No matter what else goes on, no matter what hardware or software is used, I set a minimum standard and procedures for at least a weekly backup. This includes all users backing up all data files and turning those backups over to the DP department for off-site or fire-safe storage.

The DP mentality has more than tradition and bureaucratic mindset as its motive force. There are real concerns that can be addressed only by the implementation of standards at some level.

Charles Hahn
Orange, CA

Thank you. You do a good job of telling the MIS side of the story.—Jerry ■

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Richard Rankin

System Calls in Modula-2

Here's how to use Modula-2 to interact with your computer at the BIOS and DOS level

Niklaus Wirth created Pascal to help teach programming, but people discovered they had problems using it in real-world situations. For example, Pascal cannot access the computer's hardware at a low level. Wirth resolved this problem when he designed Modula-2, a successor to Pascal that was meant to be used in the real world.

It's easy to use Modula-2 to program an IBM PC or PS/2 at a lower level than you might normally use in another high-level language. The source code listing accompanying this article illustrates programming at the ROM BIOS level and the DOS level through Modula-2. I've tried to annotate it as much as possible for easy reading. [Editor's note: *The program* `MODDOS.MOD` *is available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement. See "Program Listings" in the table of contents. To "find" source code in the Listings areas on BIX and BYTEnet, search by article title, author, or issue date. Some archived files may contain numerous listings for a single article. A description of the file also accompanies each entry.*]

`MODDOS.MOD` gets, sorts, and prints directory entries matching a filename pattern; gets and prints the amount of available space on a specified disk; renames files; clears the screen; and locates the cursor in a specific place on the screen. I compiled and linked the source code with the Modula-2/86 package from Logitech. Because other Modula-2 implementations may provide a slightly different set of library modules from those of Logitech, you may need to change some of the identifiers in the source code listing.

You should watch out for several identifiers. `SWI` generates a software interrupt and is used for ROM BIOS calls. `DOSCALL` is used to call DOS routines and functions. `ADDRESS` is a data type for variables that can simultaneously be considered a pointer to a word or a record containing the segment and offset address of a variable. `ADR` is a function that returns the address of a variable.

`FROM ... IMPORT` *`<module names>`*: If the names of the modules to be imported are different from Logitech's, you will have to change the references to them here. The implementation and definition modules for both the `Yes` and `Vidserv` files are available at the tail end of `MODDOS.MOD`. You should extract these files, compile them separately, and import them as shown in the `IMPORT` section. Each `IMPORT` declaration names the module to be referenced and must also include the names of each variable, type, or procedure to be included in the final product. The ones used here, except as mentioned above, are supplied with the Modula-2/86 package as parts of the standard library.

In practice, `MODDOS.MOD` could have been written in distinct modules, compiled, and then merely called by a main driver program. To make the program more readable, however, I have combined the necessary parts into one module.

Getting the Directory

To use DOS to get the directory entries, I use the Modula-2 procedure `DOSCALL` to perform various DOS functions. If your Modula doesn't have a similar procedure, you can accomplish the same thing by issuing interrupt 21H with the DOS function number in the AH register (more on how to do that later).

The procedure `FindMatch` (see listing 1) locates the disk transfer area (DTA) and finds the first file that matches the wildcard pattern given in the global variable `filename`. The procedure gets the address of the current DTA by executing DOS call 2F hexadecimal (decimal 47); the DOS call returns the address in the variable `DiskTransferArea`, which was earlier declared as an `ADDRESS`. We will use the value of `DiskTransferArea` in this and other procedures to locate other useful information. When we call DOS with the value 4E hexadecimal (decimal 78) to start searching, we must provide it with the address of the pattern we want to match (`FileNamePattern`) and a `CARDINAL` number describing which files to look for (`attribute`, a global variable). The value of `attribute` is the sum of any or all of the following values:

1 read-only files
2 hidden files
4 regular files
16 subdirectories

For example, if you wanted to find all the regular and hidden files matching the pattern, you would set `attribute` to 6. There are also attribute values for getting the volume label (value of 8), and only files marked for archiving (value of 32), but these file types are of limited use.

When you execute DOS call 4E hexadecimal, DOS returns the first filename that matches the given wild-card pattern and attribute type. The name is an ASCIIZ string (an ASCII filename ended by a zero or null character), and it is located 30 bytes past the beginning of the DTA. Both `AsciizFileName` and `CharacterPointer` point to this location, and they are both incremented in the process of filling the character array `directory` with the filename to which both pointers point.

The beauty of Modula-2 over Pascal in this instance is that the use of pointers (`CharacterPointer` is defined as being of type

continued

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byteptr, which is a POINTER TO CHAR) allows us to circumvent Modula-2's type checking. This means that Character-Pointer or any other variable of type byteptr can be used to locate integers, characters, or any other basic type, although characters are the only byte-size information we would probably need to access. Variables declared as POINTER TO WORD are also useful for transferring 16-bit words into program variables. If you're familiar with Pascal, notice that there is no need to declare an ARRAY as PACKED. All characters are stored in a byte, instead of a word, so packing is effectively done all the time.

The next step is to determine the file's size, a 4-byte quantity that starts at DiskTransferArea+26. The variable cardinal points to this word, which is the low-word portion of the file size returned by DOS. (The high-word portion is located 28 bytes into the DTA.) If you were programming in 8086 assembly language, you would have to remember that the 8086 (and other members of its family) saves words as low byte/high byte. In Modula-2, however, since cardinal is a POINTER TO CARDINAL, assigning the dereferenced pointer to a variable of type CARDINAL (the statement CardinalSize:=cardinal^;) causes the language to convert the memory locations properly.

The final result for this value has to be in a variable of type REAL, since the file size may take on values larger than the 65,535-byte limit of a CARDINAL variable. I first convert it to a string, then to a real because both these procedures already exist (and no such cardinal-to-real procedure does); the end result is the REAL variable sizelow.

When a program calls DOS function 4E hexadecimal, DOS also saves the information needed to find the rest of the matching files that meet my criteria. The FindNext procedure (not listed here, but part of file MODDOS.MOD) will cycle through the directory until no more matches are found, using this information DOS has stored. You also have access to an error code and other file-related data; the attribute byte is at DiskTransferArea+21, a 2-byte time stamp is at DiskTransferArea+22, and a 2-byte date stamp is at DiskTransferArea+24.

The final procedure, GetDir, uses FindMatch, FindNext, and several other procedures to prompt the user for a wild-card pattern; then it gets, formats, and prints the files that match it.

Overall, this solution has the best of both worlds—the speed and simplicity of predefined DOS functions and the formatting and arithmetic conveniences of a high-level language. Note that the code to read in a filename and get its size involves duplication in the FindFirst and FindNext procedures. These blocks of code could have been modularized into shorter, more efficient procedures.

Free Space on a Disk

My next example uses DOS to help locate and print the available free space on a disk. A simple DOS call to function 36 hexadecimal (54 decimal) in procedure FreeSpace returns the number of available disk clusters, the total number of clusters, and the bytes per sector. If an error occurs, the DOS function returns FFFF hexadecimal or 65535 decimal in the variable error. If there is no error, it returns the number of sectors per cluster. As before, we convert certain cardinal numbers to strings, then to real variables so that the variable realfreebytes is big enough to hold any values given to it.

Renaming Files

The procedure for renaming a file, RenameFiles (see listing 2), is even simpler. The two input parameters to this procedure are the current filename (oldname) and the desired new filename (newname). This procedure uses the ADR function to get the filenames' addresses to pass to DOS, then calls on DOS function 56 hexadecimal (86 decimal) to do the work of renaming the file. Since this DOS function actually changes the file's directory entry, you can use it to move a file among subdirectories on the same disk, but you can't use it to rename a file from one drive to another.

Using ROM BIOS Calls

For examples of using the IBM PC or PS/2 ROM BIOS calls in Modula-2, I've added two functions to the library, Cls (clear the video screen) and GotoXY (go to a specified row and column); see listing 3. The ROM BIOS calls in this Logitech version are done through a Modula-2 procedure called SWI, which stands for software interrupt.

Logitech recommends that you push the 8086 base pointer before an SWI call and pop it immediately after. You can use the CODE procedure, which merely inserts its parameters directly into the final program, to create short assembly language sequences. CODE(55h) means to push the base pointer onto the stack, and CODE(5Dh) means to pop it. The SETREG procedure does exactly what it sounds like—it lets you set the value of a register directly.

Both ROM BIOS procedures use the interrupt value of 10 hexadecimal (16 decimal) to request video services. The call format is SWI(10h, parameter). By changing the parameter, this interrupt can activate such items as disk services, printer services, time and date services, and communications-port services. In general, anything that is available to an assembly language program is available to Modula-2 through the DOSCALL, SWI, and CODE procedures.

The DOSCALL and SWI procedures differ in that the former takes place at a much higher language level. The DOSCALL functions are similar to any Modula-2 procedure in that they use parameters specified in the heading of the procedure being called. The DOSCALL procedures then set the proper register values, generate the interrupt, and return the proper values.

When you use the SWI procedure, on the other hand, you must set the register values yourself. These values are passed "as is" when the software interrupt occurs. The values returned, if any, are placed in the proper return registers, and you use the GETREG procedure to return the value to your program variables.

If you don't like dealing with system interrupts, Modula-2 makes it simple to write your own library procedures to do the low-level work you want to hide. This means that you can write a series of library procedures to handle SWI calls, returning the values to your program in variables. From that point on, you can call your software-interrupt procedures with the same format as the DOSCALL procedures instead of recoding them each time and worrying about which parameter goes in what register. Modula-2's modularity is perfect for that sort of thing.

Clearing the Screen

You can clear the video display in several different ways. One quick way is to reset the screen mode to the mode it's already in; this effectively clears the screen on the IBM PC and many compatibles. A second way is to write blanks through the screen locations yourself. Since screen accesses wrap around if you write past the end of the screen (because you specify the screen page

continued

Listing 1: *The* `FindMatch` *procedure finds the first file that matches the wild-card string in the variable* `filename`. *This procedure is part of a larger file, MODDOS.MOD (see main text for details), and some of the variables listed here are declared elsewhere in MODDOS.MOD.*

```
PROCEDURE FindMatch (VAR error :CARDINAL;
                     VAR NumberFound
                              :CARDINAL);

(* This procedure uses DOS call 2Fhex to
locate the disk transfer area, and DOS call
4Ehex to find the first file that matches our
directory path and wild-card pattern.  When
this routine is called, DOS also provides the
information required to find additional files
matching the specifications *)

 VAR sizelow,sizehigh :REAL;
     CardinalSize :CARDINAL;
     cardinal   :cardinalptr;
     StringOfCardinal  :string;
     okay         :BOOLEAN;

  BEGIN

    FileNamePattern:=ADR(filename);
    DOSCALL(2fh,DiskTransferArea);
    DOSCALL(4eh,FileNamePattern,
            attribute,error);
   AsciizFileName:=
        DiskTransferArea+30;(* filename
                 starts 30 bytes into the
              DiskTransferArea *)
      CharacterPointer:=AsciizFileName;
    NumberFound:=1;(* increment the
                 counter for number of
                 matching files found *)
           counter:=1;
        WHILE CharacterPointer^<>nul DO
                (* ASCIIZ string, so it will
                 have a 0 byte at end *)
             directory(NumberFound,counter):=
                CharacterPointer^;
          AsciizFileName:=AsciizFileName+1;
          counter:=counter+1;
          CharacterPointer:=AsciizFileName;
        END;
        cardinal:=DiskTransferArea+26;
                (* set pointer to       low
                 order word of size *)
        CardinalSize:=cardinal^;
        CardToString(CardinalSize,
                 StringOfCardinal,12);
        StringToReal(StringOfCardinal,
                 sizelow,okay);
        cardinal:=DiskTransferArea+28;
                (* high order word of size
             located 28 bytes into
                 DiskTransferArea *)
        CardinalSize:=cardinal^;
         CardToString(CardinalSize,
                StringOfCardinal,12);
        StringToReal(StringOfCardinal,
                sizehigh,okay);

        sizelow:=sizelow+(sizehigh*65536.0);
        RealToString(sizelow,0,12,
                sizes[NumberFound],okay);

END FindMatch;
```

Listing 2: *The* `RenameFiles` *procedure changes the directory entry of a given file, or it returns an error message.*

```
PROCEDURE RenameFiles(VAR newname, oldname
      :filearray);

 VAR newfile, oldfile :ADDRESS;
     error             :CARDINAL;

 BEGIN
   oldfile:=ADR(oldname); (* the DOS calls
                               require the
                            ADDRESSes of *)
   newfile:=ADR(newname); (* the filenames *)
   error:=0;
   DOSCALL(56h,oldfile,newfile,error);
   CASE error OF
     3: WriteString('PATH NOT FOUND');
        WriteLn |
     5: WriteString('ACCESS DENIED');
        WriteLn |
     17: WriteString('PATH NOT FOUND');
         WriteLn
     ELSE ;
       END; (* CASE *)
END RenameFiles;
```

Listing 3: *The* `GoToXY` *and* `Cls` *procedures. This listing contains a complete module,* `Vidserv`, *which should be compiled separately and brought into another program through the* `IMPORT` *statement.* `GoToXY` *moves the cursor on the video display to a given row and column.* `Cls` *clears the screen by scrolling it up 24 lines.*

```
DEFINITION MODULE Vidserv;

FROM SYSTEM IMPORT AX, BX, CX, DX, CODE,
                   SETREG, SWI;
FROM InOut IMPORT Write;

  EXPORT QUALIFIED
    GotoXY, Cls, Tab;

 PROCEDURE GotoXY( col, row :CARDINAL);
 PROCEDURE Cls ();
 PROCEDURE Tab(spaces :CARDINAL);

END Vidserv.



IMPLEMENTATION MODULE Vidserv;

  FROM SYSTEM IMPORT AX, BX, CX, DX, CODE,
                     WORD, BYTE, DOSCALL,
                                SETREG, SWI;
  FROM InOut IMPORT Write;

  PROCEDURE GotoXY( col, row :CARDINAL);
       VAR rowl, coll :CARDINAL;
       dx :WORD;
  BEGIN
    rowl:=row-1;  (* adjust  row, col back to
                               0,0 *)
    coll:=col-1;
    dx:=WORD(coll+(rowl*256));
```

continued

```
    CODE(55H);         (* push BasePointer *)
    SETREG(AX,200H); (* position cursor
                              function *)
    SETREG(DX,dx); (* row in dh, col in dl *)
    SETREG(BX,0H); (* current page number *)
    SWI(10H);          (* ROM call for video
                              services *)
    CODE(5DH);       (* pop BasePointer *)

  END GotoXY;


  PROCEDURE Cls ();
    VAR  bottom :WORD;

  BEGIN
    bottom:=WORD(79+(24*256));
                             (* set bottom to
                             column 79 in
                             register DL *)
                       (* and row 24 in register
                             DH *)
    CODE(55H);       (* push BasePointer   *)
    SETREG(AX,600H); (* scroll up -  register
                              AH=6 *)
    SETREG(CX,000H): (* upper left row and
                              column - 0,0  *)
    SETREG(DX,bottom); (* lower right row in
                              dh, col in dl*)
    SETREG(BX,700H); (* blank line video
                              attribute *)
    SWI(10H);          (* ROM call for video
                              services *)
    CODE(5DH);         (* pop BasePointer *)

  END Cls;

 (* This procedure is not covered in the
       article: *)

 PROCEDURE Tab(spaces :CARDINAL);
    VAR counter :CARDINAL;
       BEGIN
         FOR counter:=1 TO spaces DO
          Write(' ');
         END; (* FOR .. DO *)
 END Tab;

 END Vidserv.
```

being affected, and the wrap occurs within that page), it doesn't really matter whether you start from the first screen location or not. If you don't start from the first screen location, though, your cursor will return to the position from which it started. If you want the cursor to end up in a certain position (upper left corner, for example) after the screen is cleared, you can use the `GotoXY` procedure to move it.

The procedure `Cls` clears the screen by scrolling up 24 lines. I chose to do it this way to provide a base procedure for you to change and make more useful. The call to `Cls`, which appears in listing 3, has no parameters. Notice, though, that the CX register contains the upper left coordinates of the window to be scrolled, and the DX register contains the lower right coordinates. This information makes it simple to change the procedure to a generic window-clearing procedure that clears a specified rectangle of text. All you need to do is add parameters to `Cls`, like this:

```
Cls(upperX,upperY,lowerX,lowerY)
```

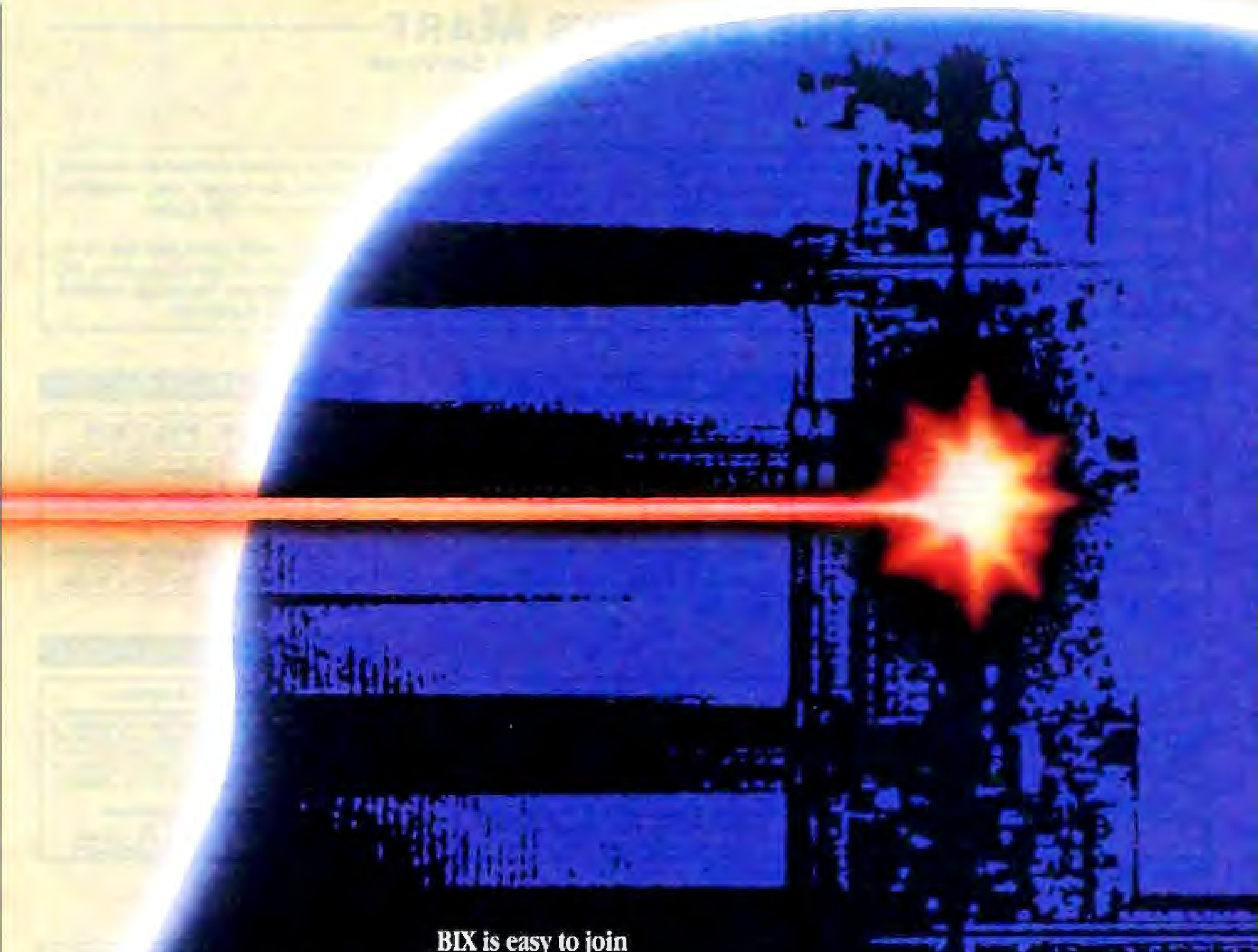
and correctly insert the parameters into the CX and DX registers. If you separately compile this as a module, you can use it in all your programs to clear either the whole screen or some portion of it.

Moving the Cursor

The `GotoXY` procedure (see listing 3) uses the requested row and column screen coordinates as its parameters. `GotoXY` subtracts 1 from each coordinate (allowing users to think of rows and columns that start numbering at 1, not 0), places the proper values into the correct registers, generates a software interrupt, and voilà!, your cursor is where you want it to be. This is another simple procedure that can be written once, compiled separately, and used by any program you write in the future.

Access and Control

Modula-2 is not a perfect programming language, but it offers the best features of Pascal (block structure and strong type checking) and C (low-level access to hardware). It also has several advantages over Pascal itself, most notably its separate compilation of modules, its cleaner syntax, additional programming constructs, and an improved I/O interface. Now that affordable Modula-2 implementations exist for most 16-bit microcomputers, you should consider getting to know it. ■



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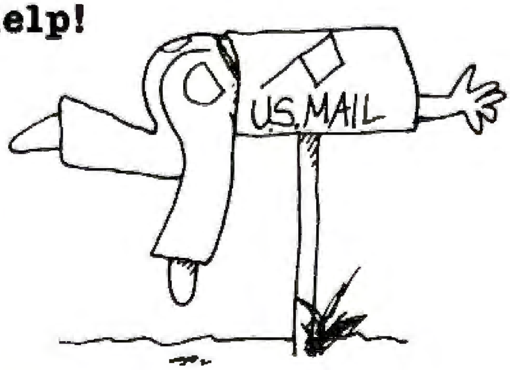

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4116-15	16,384 x 1	(150ns)	1.09
4128-20	131,072 x 1	(200ns) (Piggyback) ~~9.95~~	2.75
4164-120	65,536 x 1	(120ns)	2.75
4164-150	65,536 x 1	(150ns)	2.49
4164-200	65,536 x 1	(200ns)	1.49
TMS4416-12	16,384 x 4	(120ns)	3.49
8118	16,384 x 1	(120ns) ~~.49~~	.39
41256-100	262,144 x 1	(100ns)	5.95
41256-120	262,144 x 1	(120ns)	4.95
41256-150	262,144 x 1	(150ns)	4.75
50464-15	65,536 x 4	(150ns) (4464)	4.95
511000P-10	1,048,576 x 1	(100ns) 1 Meg ~~84.95~~	29.95
514256P-10	262,144 x 4	(100ns) 1 Meg	29.95

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Part No.			Price
2016-12	2048 x 8	(120ns)	1.89
2018-45	2048 x 8	(45ns) ~~6.95~~	5.49
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2114N	1024 x 4	(450ns)	.99
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	2.49
5101	256 x 4	(450ns) CMOS	1.95
6116P-3	2048 x 8	(150ns) CMOS	1.89
6116LP-3	2048 x 8	(150ns) LP CMOS	1.95
6264LP-12	8192 x 8	(120ns) LP CMOS ~~4.95~~	3.95
6264P-15	8192 x 8	(150ns) CMOS	3.49
6264LP-15	8192 x 8	(150ns) LP CMOS ~~6.75~~	3.49
6514	1024 x 4	(350ns) CMOS	3.49
43256-15L	32,768 x 8	(150ns) Low Power	11.95

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Part No.			Price
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TMS2532	4096 x 8	(450ns) 25V	6.95
TMS2532A	4096 x 8	(450ns) 21V	6.95
TMS2564	8192 x 8	(450ns) 25V	9.95
TMS2716	2048 x 8	(450ns) 3 Voltage ~~9.95~~	6.95
1702A	256 x 8	(1µs) ~~6.95~~	4.95
2708	1024 x 8	(450ns)	4.95
2716	2048 x 8	(450ns) 25V	3.75
2716-1	2048 x 8	(350ns) 25V	4.25
27C16	2048 x 8	(450ns) 25V (CMOS)	5.49
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	5.95
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	3.95
2764-45	8192 x 8	(450ns) 21V	2.95
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 21V	6.95
27128-25	16,384 x 8	(250ns) 21V	5.95
27128A-25	16,384 x 8	(250ns) 12.5V	5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	6.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.95
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)	7.95
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74HC10	~~.29~~ .19	74HC245	~~.99~~ .79
74HC14	~~.49~~ .29	74HC253	~~.59~~ .49
74HC30	~~.29~~ .19	74HC259	~~.69~~ .49
74HC32	~~.29~~ .25	74HC273	~~.99~~ .69
74HC74	~~.39~~ .29	74HC373	~~.99~~ .65
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74HCT08	~~.29~~ .17	74HCT175	~~.69~~ .39
74HCT10	~~.29~~ .17	74HCT240	~~.99~~ .89
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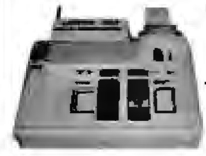

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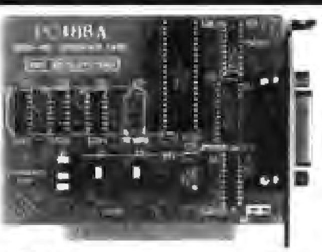

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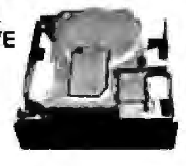
3½", 20 Mb, HALF HT. HARD DISK DRIVE



Fits standard 5¼" spacing. High speed, low power. Comes w/both full ht. and half ht. face plates. Mfr – Lapine #LT200/2000
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(IBM® PC/XT Compatible)
Removed from working equipment. Tested & formatted. Mfr – CMI model CM5619
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48 TPI (IBM® Compatible) DS/DD, 80 Track
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CDC #9409T
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IBM® AT Compatible 48/96 TPI, 1.2 Mb
Double side, high density, 160 tracks. Mfr – Panasonic #JU-475
Item #10005 **$109.95** New

96 TPI, DOS 3.2 Compat.
Double side, quad density. Mfr – Tandon TM55-4
Item #1904 **$79.00**
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Mindset® Color Graphics PERSONAL COMPUTER SYSTEM (Does not incl. monitor)

Runs all the same programs as an IBM® PC!

Fast graphics capabilities allow you to draw/animate & color objects instantly. 256K, w/360K floppy disk drive. Contains built-in RGB card/Monochrome card, & TV adapter. Also includes: Mouse & Joystick, & is supplied w/GW Basic & MS DOS 2.1
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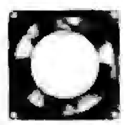
★ **RS-232 Module w/Power Option** Provides EIA standard RS 232 C serial interface.
Item #16080 **$39.95** New

★ **Modem Module**
Item #16081 **$39.95** New

27 CFM MINI FANS



50/60Hz., 12W.
Low noise level fans, can be mounted for blowing or exhaust.

1" Thin: contains 9 plastic blades. Dim.: 3⅛" sq. x 1" deep. Mfr – Tobishi #U92018
Item #10960 **$7.95** RFE

1½" Standard: contains 7 metal blades. Mfr – Rotron #SU2A1
Item #6970 **$7.95** New

SWITCHING POWER SUPPLY

DC Output: –5V @ .5A
+24V @ 1.0A
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Dim.: 7⅝"W x 1¾"H x 6⅛"D
Mfr – Xerox #105S80441
Item #15756 **$19.95** New

COMPUTER GRADE POWER SUPPLY

Other uses – runs CB & car radios. Comes ready to plug in!
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★ ★ ★ ★ ★ ★ ★ *Timex-Sinclair . . .* 2040 PRINTER

32 column ... compatible w/any of the Timex Sinclair computers, as well as our PC8300 Computer. Uses standard 4½" thermal paper.
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115 CFM MUFFIN® FANS

115VAC/60Hz.; 21W., 28A., 3100 RPM; 5-blade model; aluminum housing. Can be mounted for blowing or exhaust. Dimensions: 4"⅛" sq. x 1½" deep

NEW – Mfr: IMC
Item #1884 **$9.95**

USED – Mfr: Centaur/Howard
Item #6345 **$5.95**

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Precision steppers with increments from 1 to 7.5 degrees. Speeds up to 5,000 steps.

Fig. 1

Fig. 2 Shaft 1⅛" L x ⅜" dia.

Shaft 9⅟₁₆" L x ⅛" dia.

Item No.	Step Angle	Volts DC	Stall Torque oz/in	Type	Mfr. & Part No.	Fig	Price
5431	1	6	17	PM	N A Philips A82310-M2	1	$9.95 ea. 2/$14.95
5275	1 8	1 8	72	PM 2 0	Superior Electric M061 FF 6201B	2	$19.95 ea. 2/$37.50
6671	3.7	1 2	18	–	Mitsubishi 425H-32KOA	2	$9.95 ea. 2/$14.95
7630	1 8	3 0	200	PM	Superior Electric M092 FT 402	2	$34.50 ea. 2/$59.50

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With 60W power supply (fan cooled).
Can accommodate:
2 full ht. drives ... our Item #7928
2 floppy drives ... #1904
1 hard drive & 1 floppy ... #13250
Input: 115/230V, 50/60 Hz
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Item #14541 **$59.50**

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12VDC, green phosphor. Subassemblies. CRT, board & transformer incl. Comes w/ hook-up diagram.
Item #6811 **$19.95** New

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Alphanumeric & graphics display. Green phosphor. Input power req. 24 VDC. Bandwidth 22-72Khz. Consists of 2 subassemblies (monitor & board). Hook-up diagram incl. Mfr – Wells Gardner #15V7025.
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2114 45	1024 × 4 (450ns)	$ .99
2148-55		3 49
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2167S 45		3 95
HM6116LP-3	2048 × 8 (150ns)	1.89
HM6116LP-4	2048 × 8 (200ns)	1 85
6147P		2 95
6167P 6		4 50

Dynamic Rams

4116 200	16,384 × 1 (200ns)	$ .68
4116-250	16,384 × 1 (250ns)	.49
4164-150	65,536 × 1 (150ns)	1 28
TMS4164	65,536 × 1 (150ns)	1 95
TMS4416	16,384 × 4 (150ns)	3.75
4464-150	65,536 × 4 (150ns)	4.85
8118	16,384 × 1 (120ns)	.49
41256 150	262,144 × 1 (150ns)	2.85

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2764 250	8192 × 8 (250ns)	3.55
MCM68766	8192 × 8 (350ns)	15.95
27128A 25	16,384 × 8 (250ns)	5.00
27128 250	16,384 × 8 (250ns)	4.25
27C256	32,768 × 8 (250ns)	7 95
27256	32 768 × 8 (250ns)	5 95
27512	65 536 × 8 (250ns)	11.65

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8741	8.95
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***Adam* Computer** (Less printer) – No wiring necessary (just plugs together). Hook-up diagram included. Incl. keyboard, 1 cassette digital data drive, 2 game controllers, power supply & one cassette. Capable of running CP/M, has built-in word processor.
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***Adam* 5¼" Disk Drive** – Gives your Adam fast, reliable data storage & retrieval. Can hold up to 160K bytes of information. Uses industry-standard SS/DD disks. Connects directly to your Adam memory console. Comes w/disk drive power supply, Disk Manager disk, & owner's manual. Mfr – Coleco #7817
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Printer Power Supply – Item #6642 **$14.95**

***Adam* Cassettes** – (Consisting of Smart Basic, Buck Rogers & blank cassette) Item #7788
BAKER'S DOZEN – **$19.95**

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Circle 266 on Reader Service Card

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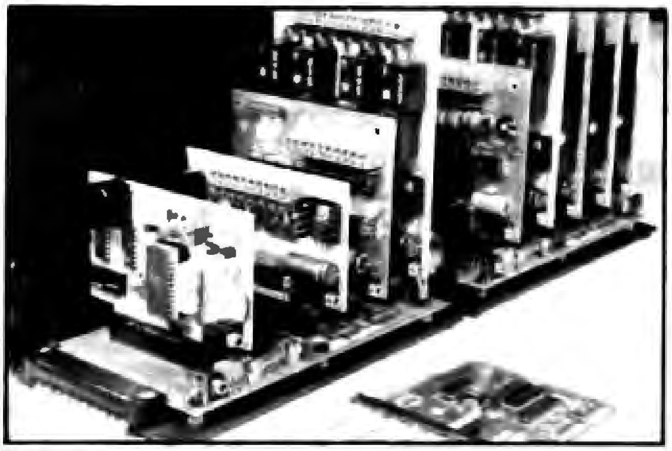

An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

Plug into the future

With the A-BUS you can plug your PC (IBM, Apple, TRS-80) into a future of exciting new applications in the fields of control, monitoring, automation, sensing, robotics, etc.

Alpha's modular A-BUS offers a proven method to build your "custom" system today. Tomorrow, when you are ready to take another step, you will be able to add more functions. This is ideal for first time experimenting and teaching.

A-BUS control can be entirely done in simple BASIC or Pascal, and no knowledge of electronics is required!

An A-BUS system consists of the A-BUS adapter plugged into your computer and a cable to connect the Adapter to 1 or 2 A-BUS cards. The same cable will also fit an A-BUS Motherboard for expansion up to 25 cards in any combination.

The A-BUS is backed by Alpha's continuing support (our 11th year, 50000 customers in over 60 countries).

The complete set of A-BUS User's Manuals is available for $10

About the A-BUS:

- All the A-BUS cards are very easy to use with any language that can read or write to a Port or Memory. In BASIC, use INP and OUT (or PEEK and POKE with Apples and Tandy Color Computers)
- They are all compatible with each other. You can mix and match up to 25 cards to fit your application. Card addresses are easily set with jumpers.
- A-BUS cards are shipped with power supplies (except PD-123) and detailed manuals (including schematics and programming examples)

Relay Card — RE-140: $129
Includes eight industrial relays. (3 amp contacts SPST) individually controlled and latched. 8 LED's show status. Easy to use (OUT or POKE in BASIC). Card address is jumper selectable

Reed Relay Card — RE-156: $99
Same features as above, but uses 8 Reed Relays to switch low level signals (20mA max). Use as a channel selector, solid state relay driver, etc.

Analog Input Card — AD-142: $129
Eight analog inputs 0 to +5V range can be expanded to 100V by adding a resistor. 8 bit resolution (20mV). Conversion time 120us. Perfect to measure voltage, temperature, light levels, pressure, etc. Very easy to use.

12 Bit A/D Converter — AN-146: $139
This analog to digital converter is accurate to .025%. Input range is −4V to +4V. Resolution: 1 millivolt. The on board amplifier boosts signals up to 50 times to read microvolts. Conversion time is 130ms. Ideal for thermocouple, strain gauge, etc. 1 channel. (Expand to 8 channels using the RE-156 card)

Digital Input Card — IN-141: $59
The eight inputs are optically isolated, so it's safe and easy to connect any "on/off" devices, such as switches, thermostats, alarm loops, etc. to your computer. To read the eight inputs, simply use BASIC INP (or PEEK)

24 Line TTL I/O — DG-148: $65
Connect 24 input or output signals (switches or any TTL device) to your computer. The card can be set for: input, latched output, strobed output, strobed input, and/or bidirectional strobed I/O. Uses the 8255A chip

Clock with Alarm — CL-144: $89
Powerful clock/calendar with: battery backup for Time, Date and Alarm setting (time and date); built in alarm relay, led and buzzer, timing to 1/100 second. Easy to use decimal format. Lithium battery included

Touch Tone® Decoder — PH-145: $79
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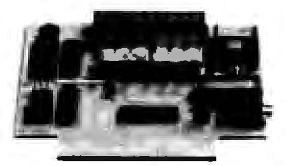
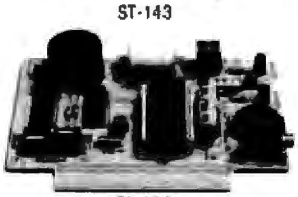
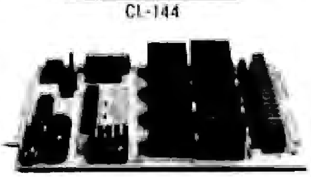
A-BUS Prototyping Card — PR-152: $15
3½ by 4½ in. with power and ground bus. Fits up to 10 I.C.s



ST-143

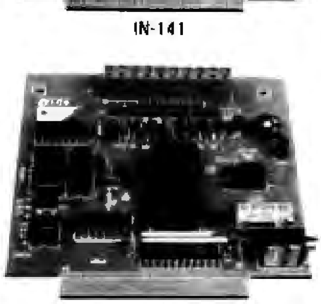


CL-144



RE-140

IN-141



AD-142

Smart Stepper Controller — SC-149: $299
World's finest stepper controller. On board microprocessor controls 4 motors simultaneously. Incredibly, it accepts plain English commands like "Move arm 10.2 inches left". Many complex sequences can be defined as "macros" and stored in the on board memory. For each axis, you can control: coordinate (relative or absolute), ramping, speed, step type (half, full, wave), scale factor, units, holding power, etc. Many inputs: 8 limit & "wait until" switches, panic button, etc. On the fly reporting of position, speed, etc. On board drivers (350mA) for small steppers (MO-103). Send for SC-149 flyer.

Remote Control Keypad Option — RC-121: $49
To control the 4 motors directly, and "teach" sequences of motions

Power Driver Board Option — PD-123: $89
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Breakout Board Option — BB-122: $19
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Special Package: 2 motors (MO-103) + ST-143 **PA-181: $99**

Stepper Motors — MO-103: $15 or 4 for $39
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Current Developments
Intelligent Voice Synthesizer, 14 Bit Analog to Digital converter, 4 Channel Digital to Analog converter, Counter Timer, Voice Recognition

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TRS-80 Model 102, 200. Plugs into 40 pin "system bus"	AR-136	$69
Model 100. Uses 40 pin socket. (Socket is duplicated on adapter)	AR-135	$69
TRS-80 Mod 3,4,4D. Fits 50 pin bus. (With hard disk, use Y-cable)	AR-132	$49
TRS-80 Model 4P. Includes extra cable. (50 pin bus is recessed)	AR-137	$62
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A-BUS Cable (3 ft, 50 cond.) — CA-163: $24
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Special cable for two A-BUS cards: CA-162: $34

A-BUS Motherboard — MB-120: $99
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• Call for cable prices
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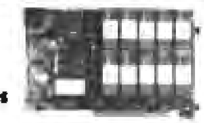

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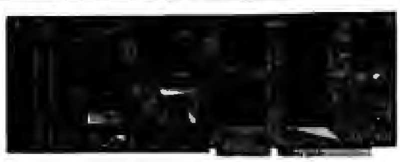

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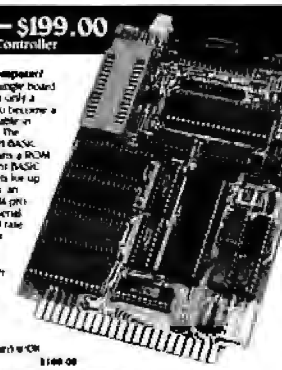

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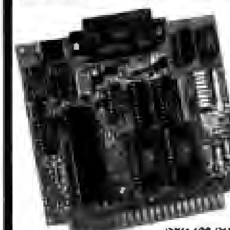

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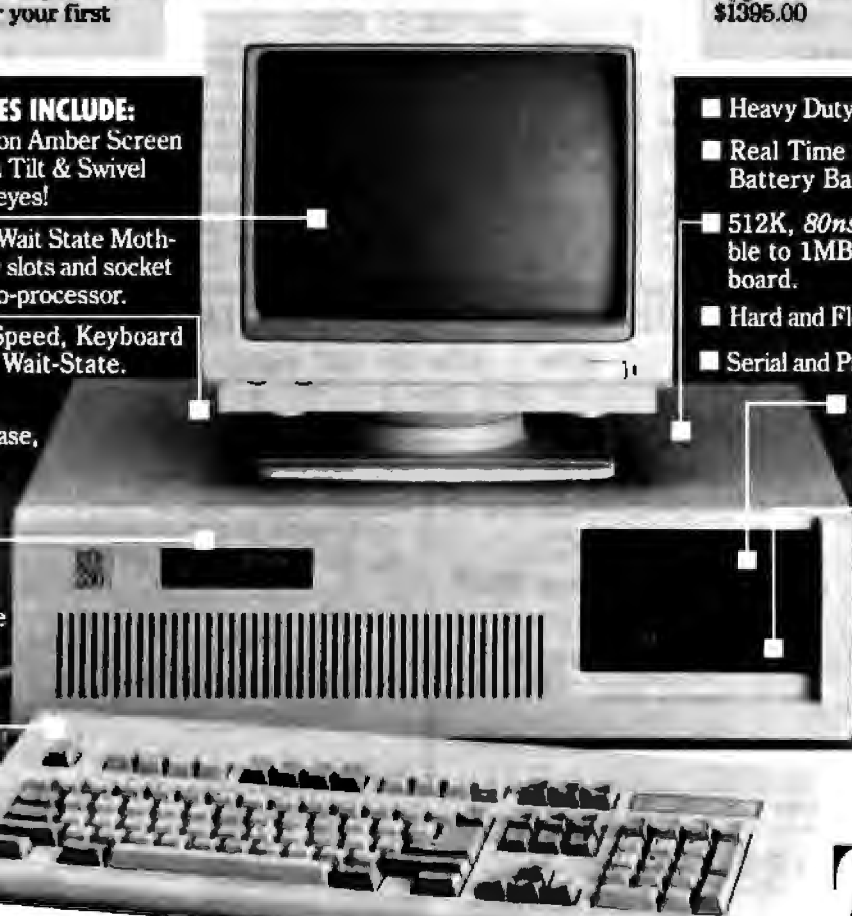

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74LS03	18	74LS124	2.75	74LS244	69
74LS04	16	74LS125	39	74LS245	79
74LS05	18	74LS126	39	74LS251	49
74LS08	18	74LS132	39	74LS253	49
74LS09	18	74LS133	49	74LS257	39
74LS10	16	74LS136	35	74LS258	49
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74LS12	22	74LS139	39	74LS260	49
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74LS37	26	74LS161	39	74LS367	39
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7400	19
7402	19
7404	19
7406	29
7407	29
7408	24
7410	19
7411	25
7414	49
7416	25
7417	25
7420	19
7430	19
7432	29
7438	29
7442	49
7445	69
7447	89
7473	34
7474	33
7475	45
7476	35
7483	50
7485	59
7486	35
7489	2.15
7490	39
7493	35
74121	29
74123	49
74125	45
74150	1.35
74151	55
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74F138	.79
74F139	.79
74F253	.69
74F157	.69
74F240	1.29
74S00	.29
74S02	.29
74S04	.29
74S08	.35
74S10	.29
74S32	.35
74S74	.49
74S86	.35
74S112	.50
74S124	2.75
74S138	.79
74S153	.79
74S157	.79
74S158	.95
74S163	1.29
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4024	49	4528	.79	74HCT32	.27
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4046	69	74HC10	.25	74HCT245	.89
4047	69	74HC14	.35	74HCT273	.89
4049	35	74HC32	.35	74HCT373	.89
4050	35	74HC74	.35	74HCT374	.89
4051	.69	74HC86	.45	74HCT393	.89
4052	.69	74HC138	.45	74HCT4017	1.19
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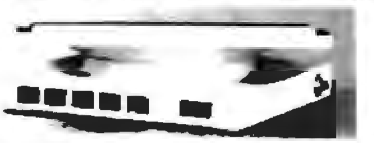

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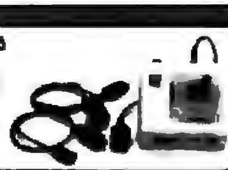

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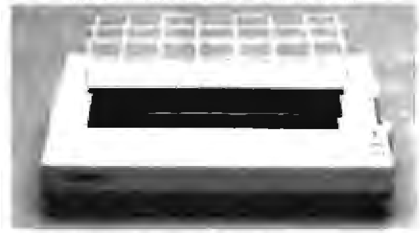

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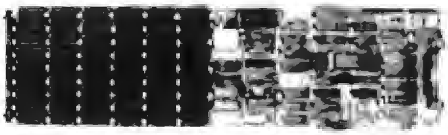

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- SERIAL PORT, CLOCK/CALENDAR WITH A BATTERY BACK-UP
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OR LPT2

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- SUPPORTS BOTH DS/DD AND DS/QD WITH DOS 3.2

MCT-HDC HARD DISK CONTROLLER **$79.95**

HD CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL
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- ALLOWS DATA TO FLOW FREELY FROM XTs TO ATs

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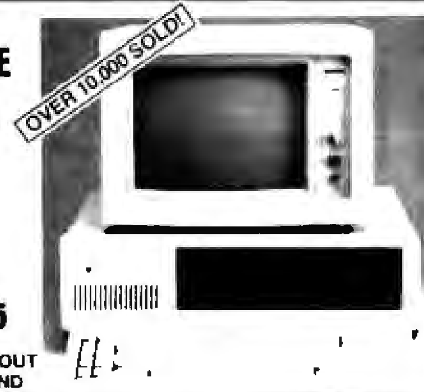

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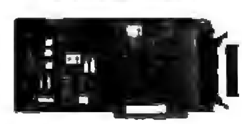

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EDITORIAL INDEX BY COMPANY

Index of companies covered in articles, columns, or news stories in this issue.
Each reference is to the first page of the article or section in which the company name appears.

COMING UP IN BYTE

Products in Perspective:

We begin this section with brief discussions of many new products in What's New. Short Takes will consider the following: Windows 2.0, Deskjet, Extra, Zenith Flat Screen, Sharp 4521, Oracle, and Sprint.

The Product Focus for April looks at 37 dot-matrix printers. If you're looking for a printer, check this out.

System reviews include the WYSE 386 and the Amiga 2000.

Hardware reviews cover liquid-crystal-shutter printers and two hardware debuggers, AT Probe and Periscope III.

Products up for discussion in software reviews are Microsoft C 5.0, FORTRAN 386, and Wendin DOS.

Application reviews feature Interleaf for the Macintosh and Byline.

Rounding out this section are the unique viewpoints of columnists Jerry Pournelle and Ezra Shapiro.

In Depth:

Our highlighted subject will be memory management, and the following topics will be covered: a memory management primer, OS/2 virtual memory management, implementing Unix on the 80386, and memory management on the Macintosh.

Features:

In Ciarcia's Circuit Cellar, Steve will present his SmartSpooler. Another article will look at Gordon Letwin's new book on OS/2, and we'll also provide information on a program called Fuzzy Prolog.

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* Correspond directly with company

Alphabetical Index to Advertisers

Continued

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Jameco Electronics (U.S. Subscribers)

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Using TIPS can bring product information as much as 10 days earlier.

SEND FOR YOUR SUBSCRIBER I.D. CARD

1) If you are a new subscriber or have lost your I.D. card, circle #1 on the Reader Service Card; **attach mailer label.** We will immediately send your personal TIPS subscriber card.

GET PREPARED

2) Write your Subscriber Number, as printed on your Subscriber I.D. Card, in boxes in Step 5 below. (Do not add 0's to fill in blank boxes)

3) Write numbers for information desired in boxes in Step 7b below. (Do not add 0's to fill in blank boxes.)

CALL TIPS

4) Now, on a Touch-Tone telephone dial: (413) 442-2668 and wait for voice commands.

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5) When TIPS says: "Enter Subscriber Number"
(Enter by pushing the numbers and symbols [# or * enclosed in the boxes] on telephone pad ignoring blank boxes)
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6) When TIPS says "Enter magazine code & issue code"
Enter [1] [#] [3] [8] [#] [#]

ENTER YOUR INQUIRIES

7a) When TIPS says "Enter (next) Inquiry Number"
Enter one inquiry selection from below (ignore blank boxes)

b) Repeat 7a as needed (maximum 17 inquiry numbers)

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5. ☐ ☐ ☐ [#] [#]

END SESSION

8) End session by entering [*] [*] [9] [1] [#] [#]

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Index to Advertisers by Product Category

Continued

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Advertising Supplement included with this issue:
Jameco Electronics (U.S. Subscribers)

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FREE Information Retrieval Service

To assist you in making your evaluations, purchasing decisions, or recommendations, you can request further information directly from the manufacturer or service company on products and services advertised in this issue. There is no charge, no obligation. Just complete and mail the attached post-paid, self-addressed reply card, and we'll do the rest.

1 Circle numbers on reply card which correspond to numbers assigned to items of interest to you.

2 Check all the appropriate answers to questions "A" through "F".

3 Print your name and address and mail.

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1 ☐ Business Owner, General Management, Administrative
2 ☐ MIS/DP, Programming
3 ☐ Engineering/Scientific, R&D
4 ☐ Professional (law, medicine, accounting)
5 ☐ Other

B. How many people does your company employ?
1 ☐ 25 or fewer
2 ☐ 26–99
3 ☐ 100–499
4 ☐ 500–999
5 ☐ 1000 or more

C. Reason for request: (Check all that apply).
1 ☐ Business use for yourself
2 ☐ Business use for your company
3 ☐ Personal use

D. Your next step after information is received:
1 ☐ Purchase order
2 ☐ Evaluation
3 ☐ Specification/Recommendation

E. Please indicate the product categories for which you influence the selection or purchase at your (or your client's) company or organization. (Check all that apply).
1 ☐ Microcomputers
2 ☐ Peripherals
3 ☐ Software
4 ☐ Accessories and supplies

F. For how many microcomputers do you influence the purchase of products at your (or your client's) company or organization?
1 ☐ 1
2 ☐ 2–4
3 ☐ 5–9
4 ☐ 10 or more

Name ____________
Title ____________
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3 ☐ Engineering/Scientific, R&D
4 ☐ Professional (law, medicine, accounting)
5 ☐ Other

B. How many people does your company employ?
1 ☐ 25 or fewer
2 ☐ 26–99
3 ☐ 100–499
4 ☐ 500–999
5 ☐ 1000 or more

C. Reason for request: (Check all that apply).
1 ☐ Business use for yourself
2 ☐ Business use for your company
3 ☐ Personal use

D. Your next step after information is received:
1 ☐ Purchase order
2 ☐ Evaluation
3 ☐ Specification/Recommendation

E. Please indicate the product categories for which you influence the selection or purchase at your (or your client's) company or organization. (Check all that apply).
1 ☐ Microcomputers
2 ☐ Peripherals
3 ☐ Software
4 ☐ Accessories and supplies

F. For how many microcomputers do you influence the purchase of products at your (or your client's) company or organization?
1 ☐ 1
2 ☐ 2–4
3 ☐ 5–9
4 ☐ 10 or more

Name ____________
Title ____________
Company ____________
Address ____________
City ____________ *State* ____________
Zip ____________ *Telephone* ____________

CIRCLE FOR FREE INFORMATION MARCH 483RSU

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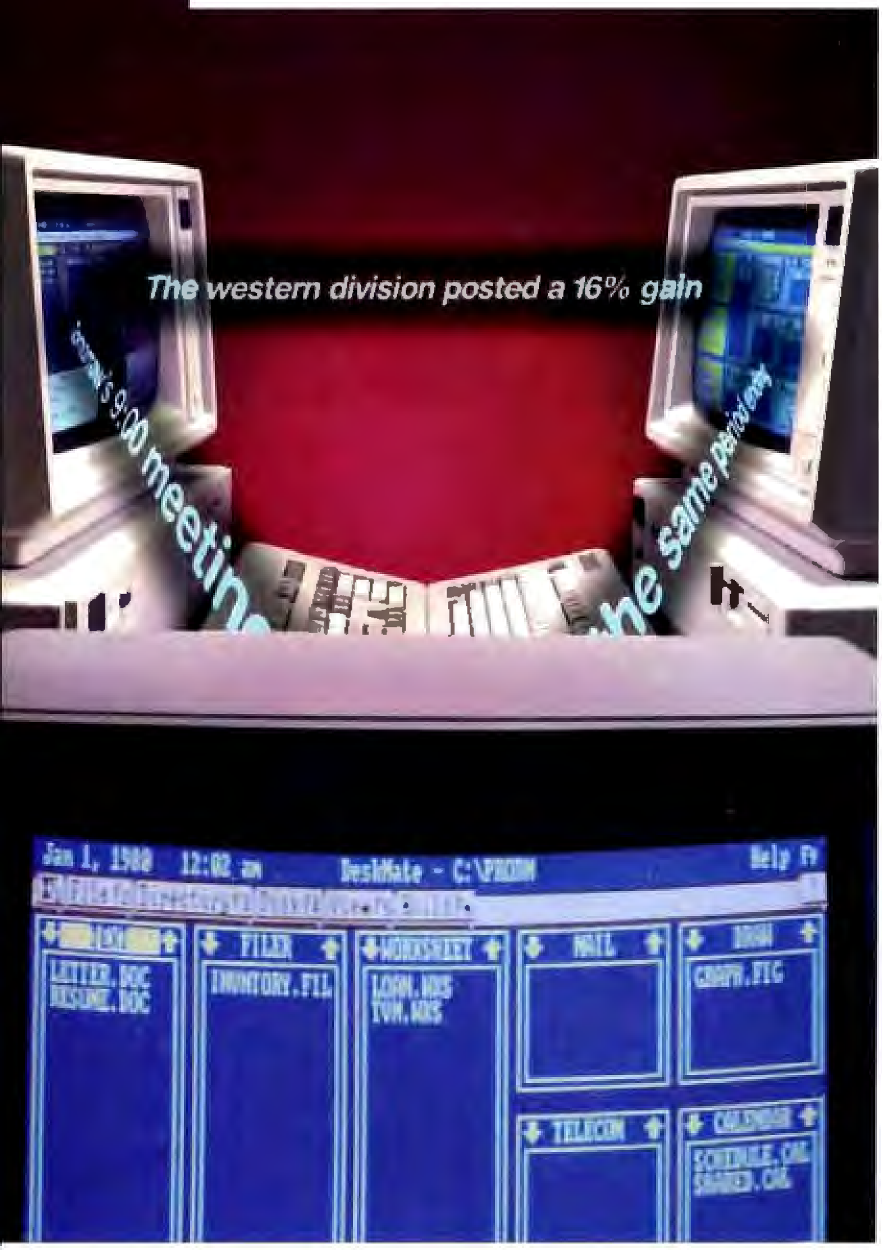

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