VOL. 13, NO. 4 APRIL 1988

BYTE

THE SMALL SYSTEMS JOURNAL®

PRODUCT FOCUS:
The Best 24-pin Printers

FIRST IMPRESSION

Microsoft's New OS/2 Languages:

- BASIC 6.0
- C 5.1
- FORTRAN 4.1
- MASM 5.1
- Pascal 4.0

IN DEPTH

How OS/2, Unix 386, and the Mac Manage Memory

$3.50 IN UNITED STATES
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0360-5280

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.

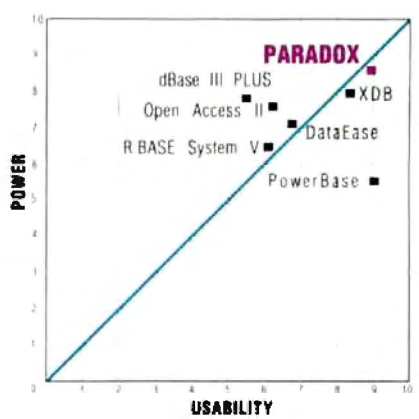
NSTL tested 12 different programs and amongst other results, discovered that Paradox is 3 times faster than dBASE; 6 times faster than R:BASE on a two-file join with subtotals test†.

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

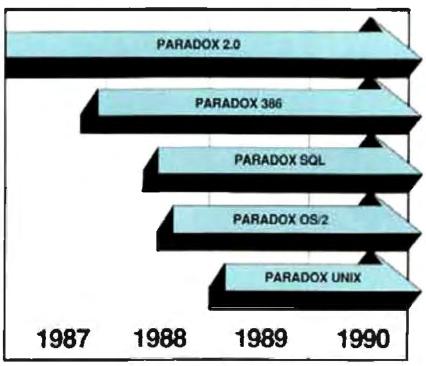
There's no power like Paradox Power

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 8/87

Paradox was a delight to use, both as a stand-alone 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: 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 preset 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

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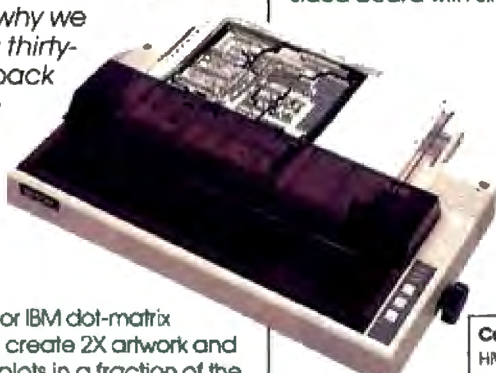

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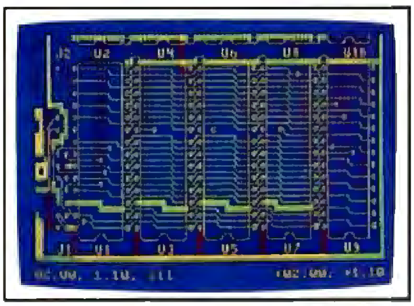

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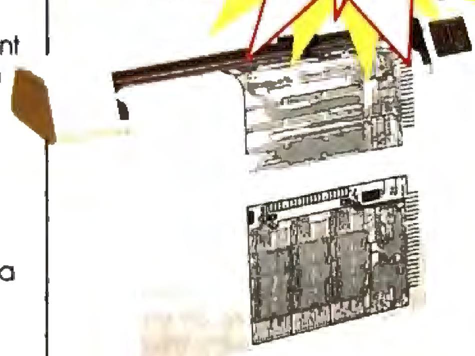

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- ☐ IBM Graphics Printer or Epson FX/MX/RX-series printer, and/or
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- ☐ Optional Microsoft Mouse

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EDITORIAL

The New BYTE Lab

We've never done much horn-blowing or flag-waving about our original microcomputer lab, which we've had for years, because it seemed obvious that any publication purporting to offer authoritative test results would have a well-equipped place in which to run tests and examine equipment without interruption or distraction. A basic computer lab should be standard equipment for any microcomputer publication—a basic lab is really no big deal.

Of course, BYTE isn't a "basic" computer publication, and as of late winter, neither is our lab. In order to provide meaningful and reliable analysis of increasingly sophisticated hardware and software, we're in the process of assembling a truly unique and innovative testing facility—one that will let us run tests that no other publication is doing, and that will let us present you with information of unmatched depth and accuracy on state-of-the-art computer systems and subsystems.

Senior Testing Editor Curt Franklin heads the new lab. Here's what he says about the capabilities the new facility will give us:

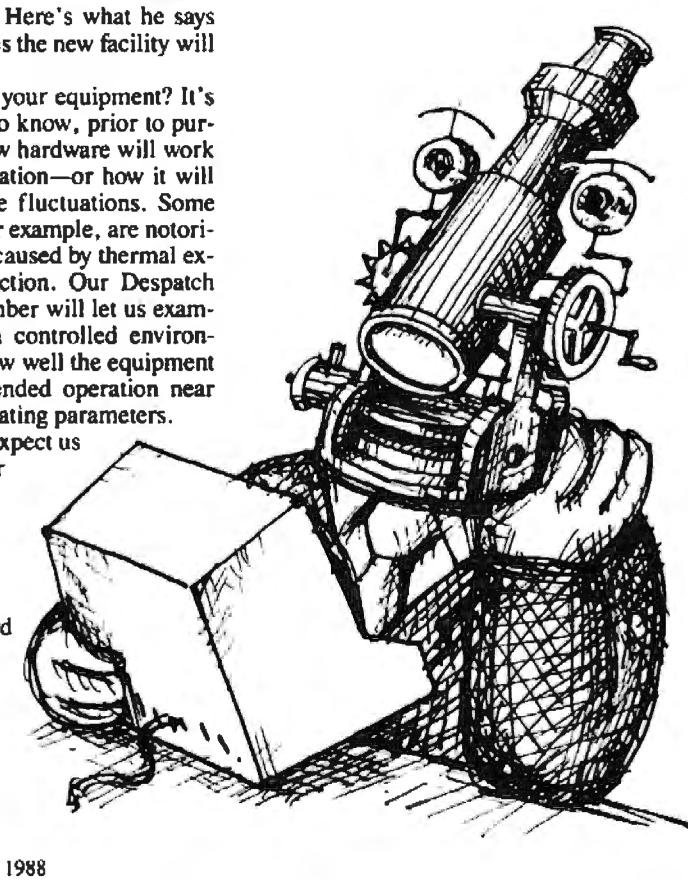
"How reliable is your equipment? It's almost impossible to know, prior to purchase, how your new hardware will work after extended operation—or how it will react to temperature fluctuations. Some hard disk drives, for example, are notorious for seek errors caused by thermal expansion and contraction. Our Despatch environmental chamber will let us examine equipment in a controlled environment and look at how well the equipment performs after extended operation near the limits of its operating parameters.

"BYTE readers expect us to open up computer systems for them, giving them information they can't find anywhere else. The Hewlett-Packard 16500A logic analysis system will let us do just that. We'll be able to do 25-MHz state analysis, timing analysis to 1 gigahertz, and look at waveforms at a rate of up to 400 megasamples per second. The capabilities of this equipment mean that we'll be giving our readers more accurate information than ever before on computer buses, memory and storage systems, and computer architectures.

"Modems and other communications equipment are increasingly important parts of most computer systems. The ability of a modem to deal with noise, dropouts, and other real-world problems may have more to do with communications throughput than the modem's maximum rated data transfer rate. We want you to know how well a modem really works. With a computer-controlled, automated test set (i.e., the Autotest 1A from AEA), we'll be giving BYTE readers objective, comparative test information on the next generation (or two or three) of modems.

"Each of us spends more time working with the computer monitor than with any other piece of personal computer equipment. In our February issue, George A. Stewart analyzed and compared a number of monitors using the Superspot 100 CRT analyzer from Microvision—the first truly objective monitor tests ever to appear in a microcomputer magazine. We now have a Superspot 100, so you can expect in-depth, accurate reviews of monitors like you've never seen before.

"In addition to the 'big' pieces of equipment in the lab, we've added numerous other items, like power line monitors (for testing uninterruptible power supplies and letting us factor power fluctuations into our other test results), hard disk and floppy disk analyzers, and other equipment that lets us bring readers the technical depth and accuracy they've come to expect from BYTE."



Curt's right. What's more, the lab we're building now is not a one-shot deal. We've made a major commitment to keep up with developing technology and to develop our own capabilities to look at the products you're interested in. For example, we are now looking into ways to objectively test and report on local-area networks, and we'll be adding a LAN test facility and other technology testing to our lab in the future.

Last—but certainly not least—are the people Curt has hired for our lab. Steve Apiki and Stan Diehl are electrical engineers who have joined us as testing editors; they'll help BYTE keep and improve its reputation as a magazine written by experts for experts.

Once the last pieces of equipment have been delivered and installed (as I write this, several of the large items, like the environmental chamber, are being built to our specifications), you'll start seeing the results of our new lab in the Reviews section.

The lab will also play a major role in helping us to analyze and examine brand-new architectures—like machines based on the 68030 and 80486 chips—as soon as they emerge.

It's all part of our commitment to keep BYTE your premier source of detailed, objective, authoritative information on both the state of the market and the state of the art.

You deserve nothing less.

—Fred Langa
Editor in Chief

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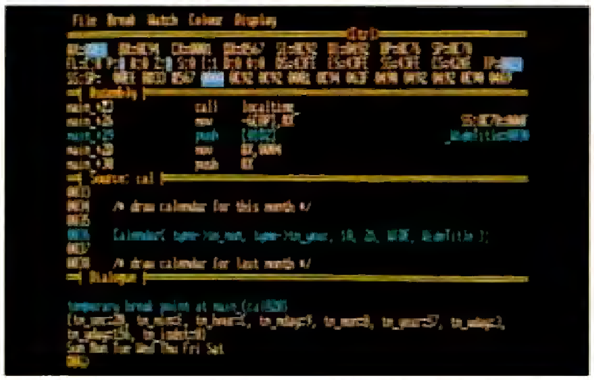

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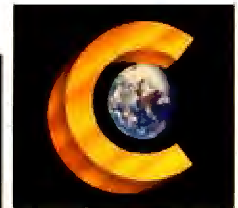

System Requirements

- System: IBM PC, PC XT, PC AT, PS/2, or true compatible
- Recommended memory: 512K
- Operating system: PC-DOS or MS-DOS, version 2.0 or later.

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Dhrystone	992 / 89.0	1246 / 98.0	1144 / 121.0

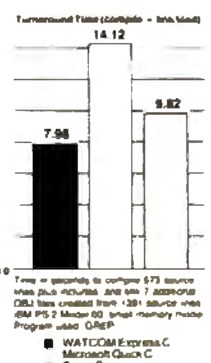
*IBM PC XT

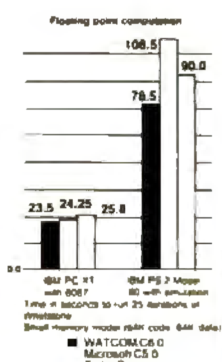
bytes / seconds

The fastest, tightest code (medium memory model*)

	WATCOM C6.0	Microsoft C5.0	Turbo C
25 Iterations Sieve	150 / 2.7	184 / 3.0	159 / 3.4
Dhrystone	1001 / 18.0	1232 / 19.0	1156 / 24.0

*IBM PS/2 Model 60





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

New Approach Could Bring Good Color to Micro Printers

While color display technology has sped forward, the printer technology needed to get color from screen to paper has not. But that could change in the near future if printer makers can successfully implement a new color technology, called Cycolor, being developed by Mead Imaging (Miamisburg, OH). Several well-known computer printer companies, including Brother and Seiko-Epson, have become "hardware partners" with Mead and are developing Cycolor-based printers.

The most immediate application for the technology will be color copiers and 35mm slide printers, with products expected to be available within the year. Chuck Davis, director of Mead Imaging's System Group, told Microbytes that color computer printers using the Cycolor process are at least 2 years away. Davis said some new printer designs will have to evolve, and he suggested that the use of fiber-optic CRTs and liquid crystal shutters are likely candidates for bringing reasonably priced Cycolor-based printers to the desks of personal computer users. He declined to speculate on end-user pricing.

Mead calls the Cycolor process a "photographic-like" film technology. Unlike conventional color photographic materials, which contain silver halide light-sensitive salt crystals, the Cycolor film is coated with millions of light-sensitive microcapsules called cyliths. Each cylith is about 1/10 the diameter of a human hair and contains a liquid monomer in which a color-forming substance called a leuco dye is dissolved. Individual cyliths are sensitive to either red, green, or blue light.

In a process close to normal photography, when the cyliths are exposed to visible light, a latent image is formed. But unlike conventional color film, developing the image involves no messy chemicals or precise temperatures. The Cycolor film and either special paper or transparency film are compressed together through rollers. In an additive color process, unexposed cyliths release dyes that mix together and react with a special coating on the paper or transparency film, producing a positive image. One final step—heating the positive image—"fixes" the image and brings out the maximum color brightness.

Microsoft Plans Object-Oriented Enhancements

We may not see a "Quick Smalltalk" in the near future. But Microsoft (Redmond, WA) does plan to add object-oriented enhancements to its language products. This is necessary in part, chairman Bill Gates said, because of the difficulty programmers are having, and will continue to have, writing sophisticated graphics-based applications.

"Because we've been using classic programming languages, it is particularly hard to write these applications," Gates explained. "That's something that Apple and the Macintosh market has not yet overcome, and that's something we've not overcome either. What we are going to do is extend our classic languages like BASIC and C to be object-oriented in the same strong sense that Smalltalk has been."

As an example, Gates described a word processor that allowed users to insert generic "objects" into a document. In the past, a programmer's task was relatively easy, said Gates. A programmer working on a word processor simply decided in advance exactly what sorts of things would be allowed inside a document, and nothing else mattered.

With the advent of objects like voice data, new image formats, drawings, charts, and so on, the programmer's job became more complex. The document might contain, for example, a voice object that takes advantage of the dynamic linking capabilities inside OS/2. When the user encounters the voice object, he or she clicks on it, the voice code is run through a hardware device, and the user listens to the object.

continued

Nanobytes

- Despite developers' pleas, **Apple Computer** (Cupertino, CA) continues to snub **Display PostScript** for its video monitors. Developers contend that QuickDraw-based images on the Macintosh screen don't match the printed output of PostScripted LaserWriters. If the screen used Display PostScript instead of QuickDraw, they say, users could have true WYSIWYG. But "Apple has no intention of supporting any imaging models other than QuickDraw at this time," says Apple vice president Jean-Louis Gassée. "We'll keep improving QuickDraw but there's no confusion; we won't support it [Display PostScript]."
- **Gallium arsenide** (GaAs) chips promise smaller, faster computers. New GaAs dynamic RAMs being licensed by **Research Corporation Technologies** (Tucson, AZ) could bring that promise closer to reality. The DRAMs, developed by James Cooper and colleagues at Purdue University, are one-transistor devices that take up 1/5 the space required by multitransistor static RAMs and can operate at up to 125 degrees C. The nonprofit RCT says the chips also make high-density dynamic memory available to GaAs designers.
- **Motorola** has published its **68030** user's manual, chock full of descriptions of those data and instruction caches, the memory management unit, applications information, and electrical specs. The manual costs $6. Contact Motorola's Literature Distribution Center, P.O. Box 20924, Phoenix, AZ 85036.
- **Anza Research** (Cupertino, CA) has put a **bibliography of neural network** references on disk. NeuralBase contains more than 2700 annotated entries. Fortunately, the program lets you

continued

search for information using 177 keywords. The disks, which run on the IBM PC and compatibles with at least 512K bytes of memory, sell for different prices, depending on which year you want; the entire set costs $300.

• **Migent** (Incline Village, NV), maker of that cute little Pocket Modem, has not had an easy first year. Lawsuits and layoffs tend to put a damper on things. The company had hoped to get some positive publicity with its **advanced publishing package**, Impact, which we've heard combines editing, graphics, and page composition. But at MacWorld Expo, where Impact was to make its debut, the company nixed the intro.

• Thirteen companies so far have signed up to participate in studies of electronic applications of **superconductors** at the Microelectronics and Computer Technology Corp. (Austin, TX). **MCC** said the baker's dozen consists of Bellcore, Boeing, Control Data, Digital Equipment, E. I. du Pont, Eastman Kodak, General Electric, Harris, 3M, Motorola, NCR, Rockwell, and Westinghouse.

• **Logitech** (Fremont, CA) has started shipping its package aimed at turning regular old PCs into **spiffy graphics systems**. The Logitech Graphics Subsystem provides a mouse, EGA board (640- by 480-pixel resolution), AutoSync monitor (normally $699), and Logitech Plus and PaintShow software. All that for $999.

• **IBM** (Rye Brook, NY) is offering a hardware setup that hooks to a PS/2 and voices what's on the screen. The $600 **Screen Reader**, designed for blind and visually impaired people, consists of a keypad, program, and documentation in disk or audiocassette form. A text-to-speech synthesizer is required. For more information, telephone (800) 426-2468.

• **CalComp** (Anaheim, CA) and **Minolta Camera** (Osaka, Japan) are teaming up to design and sell **color plotters** that fit on desktops. The A- and B-size plotters will use thermal-transfer technology. The companies say they'll start shipping the units soon.

For such applications to be developed, the operating system will have to provide object support. OS/2 will have added functionality that will enable the operating system to better help applications manage data, Gates said.

"In an object-oriented development environment," he explained, "the operating system has to get involved. You want the operating system to help you find things and keep track of where things are moved or tell you that you are deleting something that is being used in other places." He added that "the real hard part of this is sending around linked data, and nobody has been able to make that easy. You are not going to get the full leverage of applications working with applications until we get this inside the operating system."

Gates said Hewlett-Packard's NewWave system (see February Microbytes) is an embedded object system but that it falls short because the lack of a common subroutine library level prevents the object management capabilities from being fundamental to the system.

Although object-oriented languages like Smalltalk are available, Gates has doubts about introducing any new languages. "I question anyone's strategy of introducing new computer languages after 1988 and trying to get people to write applications in them," he said. "I really think that our current languages with object management extensions can permit us to deal with the graphical world. I think over the next year, we'll be able to make development of these new applications virtually as easy as normal types of development with older applications."

PostScript Will Get Faster

For those of you who've complained about how long it takes your PostScript printer to produce copy, be patient. Adobe Systems (Mountain View, CA) has come up with ways to speed up execution, and users should begin to reap benefits before the end of the year.

Adobe president John Warnock told Microbytes that the company realized a year ago that the version of PostScript used with laser printers simply wasn't fast enough for Display PostScript, the version of the language that creates images on a video monitor.

Instead of patching PostScript to work on the display, Adobe developed new algorithms that reduce overhead and reorganize the way Adobe PostScript works. Because of these changes, the program doesn't have to go into and out of the interpreter when performing low-level operations, said an Adobe programmer. Warnock said that later this year, the revised technology will be moved to the printer version of the language.

Adobe programmers would not comment on how much performance improvement users would enjoy, stating that there are too many variables (such as type of printer and complexity of image) involved to state speed gains definitively.

How soon will the faster version be available to end users? That depends on printer manufacturers, said one Adobe spokesperson. Warnock said it's scheduled to be delivered to printer makers in the fall but that he wants to make it happen sooner than that if possible. How current owners of PostScripted printers benefit from the performance increases will be left up to the individual printer manufacturers. Conceivably, manufacturers could produce new ROMs that would then be installed in their printers.

Chips Brings PS/2 Clones One Step Closer. . .

Chips & Technologies (San Jose, CA) has brought clones of IBM's PS/2 computers one step closer to reality with two new chip sets that it says are fully compatible with IBM's Micro Channel Architecture. Although he wouldn't name any specific PS/2 cloners, C&T chairman Gordon Campbell told Microbytes that users will begin seeing Model 50 and 60 clones by the end of the second quarter, perhaps by Spring COMDEX in Atlanta. He said Model 80 clones will be "a little behind" but should be available by the third quarter.

Personal computers that are compatible with IBM's PS/2 Model 80 and built around C&T's new Chips/280 chip set will be able to run at up to 25 MHz, will use memory of up to 16 megabytes, will provide better graphics than IBM's PS/2, and will be cheaper to build and sell, the company says. One reason a C&T-based Model 80 compatible will be less expensive is that it will require 75 devices on the system motherboard, 117 less than IBM's. Less-expensive 100-nanosecond dynamic RAM chips

continued

running at 16 MHz with 0.5 to 0.7 wait states can be used (as compared to the more expensive 80-ns, 16-MHz, one-wait-state DRAMs used by IBM) to further lower system costs.

C&T's new Model 80-compatible chip set, called the Chips/280, consists of a CPU/Micro Channel controller, an advanced memory controller, an advanced direct-memory-access (DMA) controller, data address buffers, a system peripherals controller, a multifunction controller, a hard disk controller chip set (from Adaptec), and a custom or standard micro chip.

C&T claims that its 280 chip set provides several enhancements over the IBM Micro Channel implementation, including multilevel arbitration control on the Micro Channel and high-performance DMA. On 16-MHz systems, for instance, Chips/280 DMA runs at 10 MHz, while IBM DMA runs at 8 MHz.

C&T says that machines built around its Model 50/60-compatible chip set, the Chips/250, will be able to run at up to 20 MHz and use memory of up to 8 megabytes. A C&T-based PS/2 compatible will require only 68 devices on the system motherboard, 51 less than IBM's. The chip set uses less expensive 200-ns 10-MHz DRAMs as compared to IBM's 120-ns 10-MHz memory chips. (The 250 can also use either 150-ns 12-MHz DRAMs or 120-ns 16-MHz memory.)

The 16-bit Chips/250 set uses a "matched memory" implementation that C&T claims provides 50 percent faster Micro Channel memory cycles than on the IBM equivalents. Because the 250 is tightly coupled with VGA, a fast VGA cycle cuts I/O and memory cycles by 50 percent as well, C&T engineers say.

Memory above 1 megabyte is treated as LIM 4.0 expanded memory, and applications requiring large amounts of memory can incorporate up to 8 megabytes. This includes on-chip EMS support with four mapping registers and up to four external EMS mapper chips for full implementation. Memory cycles that run at 187.5 ns are supported. A four-way page interleave memory architecture allows for slow DRAMs that can operate at higher clock speeds with wait states between 0.5 and 0.7. Address recovery and memory remapping logic are included, as is automatic BIOS reallocation of bad blocks.

. . . But Who Will Be First to Take That Giant Step?

The $40 Million Question is: Who will be the first to produce a Micro Channel clone? C&T's chief, Gordon Campbell, would not comment on who the company's customers might be for its Micro Channel–compatible chip set. But it's a good guess that C&T's current crop of OEM customers—companies like Tandy, for instance—would be possible cloners.

Tandy certainly seems like a good bet. Recently, a member of Tandy's R&D department told us that the company has big plans concerning product announcements in the third quarter, the time when the Texas company traditionally introduces new products. When asked what could be bigger than a 386 clone and a laser printer, which the firm introduced last year, the Tandy staffer would say only that those previous announcements would "pale in comparison" with the coming introduction. Industry watchers have said that the first to produce a PS/2 clone will be a company with enough money to fund the required research and engineering, as well as any legal fees that might arise if IBM claimed its property was being infringed upon.

With the tools now available to readily put together PS/2 clones, PC manufacturers—at least those who are C&T OEM customers—can now begin making more concrete plans and announcements. Manufacturers have privately told Microbytes Daily that they plan to introduce Model 60 clones first because they believe these machines offer the greatest sales potential. According to what potential cloners have told us, the second most popular PS/2 compatible will be the Model 80, while they see the Model 50 as offering the least market potential of the three systems. So far, only one manufacturer has indicated that it will focus first on a Model 80–type machine.

Game That Inspired *Red October* Coming to Computers

Back in 1981, a Maryland insurance agent by the name of Tom Clancy took some time out one weekend to play a board game called Harpoon, which involved naval warfare between NATO and the USSR. Within the next few weeks, Clancy became friends with Larry Bond, the game's author and a member of the Naval War College. Out of their friendship came *The Hunt for Red October* and *Red Storm Rising*, two of the best-selling books in this decade.

Bond's latest project is a computerized version of his board game, which we saw demonstrated at the winter Consumer Electronics Show. Bond is working with software developer Three-Sixty Inc. (Campbell, CA) to bring out both an MS-DOS and a Macintosh version of the game, which should be on the market soon and will sell for around $50.

As with the original game, the basic premise of the computer edition is NATO versus USSR in North Atlantic warfare. You act as commander of a major NATO task force. Soviet and American battle platforms (e.g., ships, planes, and missiles) in use today are part of the game, which is so up-to-date that simulated Soviet submarines incorporate the screw/drive mechanisms sold to the Soviets by Toshiba and Kongsberg Vaapenfabrik. You must learn about the strategy and tactical weapons at your disposal and acquaint yourself with the Soviet strengths and weaknesses.

To develop the software, Three-Sixty programmers transferred information relating to strategy and other necessary data from Bond's database (created with Odesta's Double Helix program) into Microsoft Excel for conversion to MSF format. They then loaded the data into McMax, a dBASE-like package for the Macintosh from Nantucket Corp., for manipulation and development.

Much of the work now under way at Three-Sixty involves data compression, particularly of the images of ships, aircraft, and submarines digitized from photos and scaled to size. To generate graphics, programmers created a library of high-resolution pictures (digitized from photos) of military hardware.

Although none of it is classified (the FBI regularly checks Bond's database), the game contains information rarely, if ever, seen by the general public, particularly the digitized photos and details of Soviet ships and submarines. For this reason, Three-Sixty president Tom Frisina told Microbytes, the game is in many ways a lesson in current events. "Harpoon is not a war-gamer's product. It is for the general public," he said.

continued


CITIZEN

Better Color Displays Through Chemistry

Research into photochemical reactions of color dyes applied to semiconductor materials could lead to the development of very thin flat-screen color displays. Chemists at the University of California at Irvine have found that by coating a substrate with a thin layer of dye and shining light on the surface, the dye reacts and changes color. Their studies are also pointing toward more efficient means of semiconductor processing.

John C. Hemminger, professor of chemistry at UCI and director of the recently formed Institute for Surface and Interface Science, said that one experiment consists of electrochemically depositing Prussian white dye on the surface of common semiconductor substrates, such as strontium titanate. Normally, electrons in the dye and semiconductor remain stable because they do not have enough energy for migration. But when light strikes the dye, the added energy causes electrons to migrate into the semiconductor material.

The loss of these electrons from the dye initiates a chemical reaction that changes the white dye into blue wherever the light hits the dye film. Applying a small neutralizing voltage returns the dye and substrate into their previously stable condition and changes the Prussian blue back to Prussian white. "What we are able to do is modify a dye film in a reversible manner and use it to write images on its surface," Hemminger said. Experiments have indicated that other dyes and wavelengths of light might react to produce a full color system.

The chemistry also shows promise for semiconductor processing. Experiments have shown that passivating—placing a protective coating on—semiconductor material can be accomplished without using complex masking and etching procedures. In the future, laser light might activate thin chemical films to produce protective coatings on a wide variety of materials. Hemminger said that already chemists have experimented successfully with passivation of the material used in infrared sensors.

Computer Companies Think There's No Place Like Home

Home offices and home-based businesses are quietly emerging as a major segment of the mass-market computer and electronics business. Companies like Blue Chip, Sharp, and NEC are all vying for a share of it. Sharp and NEC have already set up divisions targeting the home-office market.

What attracts companies is the size of the potential market. Most manufacturers believe the basic hardware requirements of a home office include a personal computer, printer, fax machine, copier, voice mail, and telephone. "People involved in home-based businesses spend an average of $5200 a year on business equipment and software,"

continued

Julian Cohen, chairman of the American Home Business Association, told Microbytes.

With over 13 million home businesses in operation today, that translates to a possible $67 billion industry. Cohen conceded that not all home-based businesses currently use personal computers, but he did claim that 70 percent of them do, up from 50 percent just 3 years ago.

Blue Chip president John Rossi said his company, which markets low-priced IBM-compatible computers and peripherals through mass-merchant channels such as Target and Wal-Mart, has made a major commitment for 1988 to attack the home-business/home-office market. Blue Chip will introduce a laser printer, a fax card, and a voice-mail card over the next few months.

Cohen and Rossi agree that software remains a stumbling block for home-based businesses. "The industry is not writing software for the comprehensive needs of the home business," said Cohen. "There are software programs to help individuals keep track of their personal investments. Why not programs designed specifically to help home-business owners keep track of the generic functions of their enterprises?"

"How does someone justify paying $500 for a software package when they only paid about $500 for the computer?" Rossi asked. (Blue Chip's entry-level personal computer sells for $599.) He added, however, that when the performance benefits justify it, home-business owners do buy the high-end word-processing and spreadsheet programs, even if they will be running them on low-price computers.

While there might be no place like home for working, the costs of setting up an office are not trivial. Some operators of home businesses estimate an outlay of $5000 to $7000. "You can get by pretty cheaply if you settle for used furniture," said one man who runs a business out of his house. "You can spend the money on a fax machine or a laser printer instead."

Some observers expect those costs to drop. As more companies get into the business of fax boards for personal computers, for example, they could drive the prices down.

However, some members of the computer industry, many of whom work at home, said they've heard it all before: another big booming business that goes bust. One industry watcher said, "Sure, there are lots of people who want to set up shop at home and who'd like to buy this equipment. But all it takes is one recession, or a couple months of less work than usual, to wipe out the savings that these people would use to buy this equipment. In their enthusiasm, some of the prognosticators forget to factor in things like reality."

TECHNOLOGY NEWS WANTED. *The news staff at BYTE is always interested in hearing about new technological and scientific developments that might have an impact on microcomputers and the people who use them. We also want to keep track of innovative uses of that technology. If you know of advances or projects that involve research relevant to microcomputing and want to share that information, please contact us. Call the Microbytes staff at (603) 924-9281, send mail on BIX to Microbytes, or write to us at One Phoenix Mill Lane, Peterborough, NH 03458.*

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Not to mention a wealth of wisdom from the Norton team of top programmers. (*PC Week* used the words "massive" and "authoritatively detailed" to describe the information contained in the Guides. If you'd rather see for yourself, you might take a moment or two to examine the data box you just passed.)

You can, of course, find most of this informa-

DATA AND FEATURES

OS/2 KERNEL API (1M of data)
- Kernel API: Describes all OS/2 API services: DOSx, KBDx, MOUx and VIOx.
- Structure Tables: Lists all of the OS/2 data structures used in the Kernel API.
- Conversion Guide: DOS-to-OS/2 table shows which OS/2 calls replace DOS and ROM BIOS services.

ASSEMBLY (600K of data)
- DOS Service Calls: All INT 21h services, interrupts, error codes and more.
- ROM BIOS Calls: All ROM calls.
- Instruction Set: All 8088/86 instructions, addressing modes, flags, bytes per instruction, clock cycles and more.
- MASM: Pseudo-ops and assembler directives.

BASIC (270K each database)
- IBM BASICA, Microsoft QuickBASIC and TurboBASIC.
- Statements and Functions: Describes all statements and built-in library functions.

C (600K each database)
- Microsoft C and Turbo C: Describes the C language.
- Library Functions: Detailed descriptions of all functions.
- Preprocessor Directives: Describes commands, usage and syntax.

PASCAL—Turbo (360K of data)
- Language: Describes statements, syntax, operators, data types and records.
- Library: Describes the library procedures and functions.

FEATURES (all versions)
- Memory-resident—uses just 71K.
- Full-screen or moveable half-screen view, with pull-down menus.
- Auto lookup and searching.
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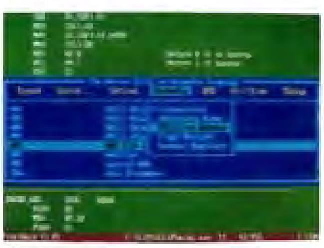
A Guides reference summary screen (shown in blue) pops up on top of the program you're working on (shown in green).


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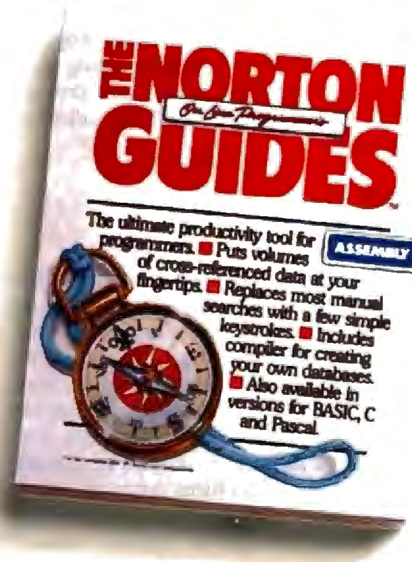

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This Time for Sure

Thank you for printing my letter ("Forth and the NC4016," Letters, December 1987). However, in transcribing the code from my letter to your magazine, numerous errors appeared. See listing 1 for the correct code.

When writing Forth code, it is important to keep the spacing between "words." If this code was entered as it appeared in the magazine, it would not run, because the interpreter would not be able to recognize the "words" defined. Also, in the word FIBTEST, the letter *O* was used instead of the number zero (0), which, of course, would play havoc with the interpreter.

Also, the last statement in the word FIBTEST would be better written in columnar form, as follows:

```
CR ." Fibonacci("
NUM 2 U.R ." ) = "U. ;
```

Douglas Ross
Greenbelt, MD

Listing 1: *Reader Douglas Ross's correct Forth code.*

```
100 CONSTANT NTIMES  ( NUMBER OF TIMES TO COMPUTE FIB VALUE )
 24 CONSTANT NUM     ( BIGGEST ONE WE CAN COMPUTE IN 16 BITS )

 : FIB ( U1 -- U2 )  RECURSIVE
     DUP 2 > IF DUP 1 - FIB SWAP 2 - FIB +
             ELSE DROP 1
             THEN ;

 : FIBTEST ( -- )
     CR NTIMES U. ." ITERATIONS: "
     0 ( MAKE SURE SOMETHING IS ON STACK )
     NTIMES 1 - FOR DROP NUM FIB NEXT
     CR ." Fibonacci("
     NUM 2 U.R ." ) = " U. ;
```

A Tale of Two Integers

As a delighted user of QuickBASIC versions 2.0 through the incredible 4.0, I find it an increasingly valuable programming tool. However, while running some existing GWBASIC programs through QuickBASIC 4.0, I found the following problem:

```
10 B%=30
20 A=B% * B%
```

will work perfectly, but changing B% to 300 will not. It seems that multiplying any two integers forces the product variable to integer type, regardless of declaring or implying it, using double-precision floating point, or whatever else you can think of. The same thing happens with addition if the sum is outside acceptable integer range. This turns out to be true in QuickBASIC 2.0 and 3.0 also, though it's not a problem in various "street" BASICs.

I wrote the people at Microsoft about this problem and asked if they had any solutions. A very pleasant fellow called, and, after going over it a bit, he guessed that it was a storage problem and said that the company would look into it.

I dislike modifying any debugged, lengthy programs unnecessarily; it takes so long to get the new bugs out. The best kludge I have found so far is to convert the integers to floating point before the calculation, as follows:

```
10 B%=300
15 B=B%
20 A=B * B
```

When this popped up, it drove me crazy until I remembered that an elderly PDP-11 FORTRAN compiler did something similar and, fortunately, was documented. I pass this along to apprise others of the problem and to see if anyone can suggest a more elegant solution.

Peter Crosby
Claremont, NH

Thanks for the IBM Issue

Congratulations for an uncommonly excellent IBM special issue (*Inside the IBM PCs*, Fall 1987). I have seldom seen a magazine issue that contains so many original features.

I concur with the tone of the lead editorial. Systems Application Architecture will be accepted when there are applications that use it, and these applications provide benefits that are not realized in any other way.

Michael Geary's "Spying on Windows" gets my vote as the best article. I know of at least six Windows developers who got a copy of Spy and put it to work immediately. Greg Weissman's "Comparing Disk-Allocation Methods" described differences between the DOS 2.x and 3.x file-allocation schemes that are little known outside of Redmond, Washington, and they're useful to me in my work. Ray Duncan's, Jeremy Sagan's, William J. Claff's, and Cohen and Hanel's articles all provided useful insights in their respective areas. Richard

continued

LETTERS POLICY: *When submitting a letter for publication, double-space it on one side of the paper and include your name and address. Express your comments and ideas as clearly and concisely as possible. We can print listings and tables along with a letter if they are short and legible.*

Because we receive hundreds of letters each month, we cannot publish all of them. We cannot return letters to authors. Generally, it takes four months from the time we receive a letter until we publish it.

Wilton's article on PS/2 video displays is commendable, too. More of the same!

Ben Myers
Harvard, MA

Byte, Dyte, Fyte

Whenever I read "16-bit word" or "32-bit word," I wonder, "Why not use something else instead of these cumbersome expressions?" My solution is to make new words. How about "dyte" for "16-bit word" (double byte) and "fyte" for "32-bit word" (four bytes)?

Wasya Maslyucoff
Irkutsk, East Siberia, USSR

Electronic Pen Pals

Congratulations to your editorial team for the well-written Microbyte on electronic mail at Coopers & Lybrand (January, page 12).

Your staff was able to highlight the content and capture the spirit of a lengthy address informatively, interestingly, and succinctly. E-mail is growing rapidly and will become increasingly visible over the next 3 years. The role of the personal computer has been and will continue to be vital to E-mail's success.

Walter E. Ulrich
Coopers & Lybrand
Houston, TX

Fascinating Fractals

"A Better Way to Compress Images" by Michael F. Barnsley and Alan D. Sloan (January) was fascinating, but the accompanying BASIC program didn't work under Microsoft QuickBASIC. I have made a few changes to automate x and y scaling for each IFS code sequence, handle sequences of any length, and speed up the program in general. The updated version (see listing 2) contains a section that needs to be run only once for any IFS code sequence. It calculates the x and y scale and offsets. In-line documentation explains its use.

P. Leslie Aldridge
Milltown, NJ

...Provocative, Too

I found "A Better Way to Compress Images" interesting. The concept of using fractals to reduce image storage by finding underlying patterns is provocative. It seems to me that in a large database there should exist compressible patterns, and Barnsley and Sloan's technique seems to be a good way to find those patterns.

With database compression, the object is also not just compression but to find an insert faster than before. I have begun to use this technique in experiments on small databases, and, even in the worst

continued

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DEALER INQUIRIES INVITED

Circle 258 on Reader Service Card (DEALERS: 259)

Listing 2: *Automated scaling program.*

```
DIM a(4), b(4), c(4), d(4), e(4), f(4), p(4) DATA 4

          a      b       c          d     e     f       p
DATA     .85,   .04,   -0.04,     .85,   0,   1.6,    .85
DATA     .2,  -0.26,     .23,     .22,   0,   1.6,    .07
DATA   -0.15,   0.28,  0.26,      .24,   0,    .44    .07
DATA     0,      0,     0,        .16,   0,   0,      .01

         READ m%
         pt = 0
         FOR j% = 1 TO m%
              READ a(j%), b(j%), C(j%), d(j%), e(j%), f(j%), pk
              pt = pt + pk
              p(j%) = pt
         NEXT j%
         SCREEN 2

         x = 0
         y = 0
         maxy = 0: maxx = 0: miny = 0: minx =0:
         '
         '    For each new set of IFS codes:
         '
         '    To get the proper values for xscale, yscale,
         '  xoffset, yoffset remove the comment
         '  characters from the FOR loop below and run
         '    breaking at the end of the loop after the
         '  calculations for scaling.
         '
         'FOR n% = 1 TO 2500
              'pk = RND
              'FOR k% = 1 TO m%
                           'IF pk <= p(k%) THEN EXIT FOR
              'NEXT k%
              'newx = a(k%) * x + b(k%) * y + e(k%)
              'newy = c(k%) * x + d(k%) * y + f(k%)
              'x = newx
              'y = newy
              'IF x > maxx THEN maxx = x
              'IF x < minx THEN minx = x
              'IF y > maxy THEN maxy = y
              'IF y < miny THEN miny = y
         'NEXT n%
         'xscale = 640 / ABS (maxx - minx)
         'yscale = 200 / ABS (maxy - miny)
         'xoffset = ABS(minx * xscale)
         'yoffset = ABS(miny * yscale)
         '
         '  To get the proper values for scaling and offset
         '    breakpoint here
         '
         xscale = 132.5282: xoffset = 288.6708: yscale =
                               20.00657: yoffset = 0
         x = 0: y = 0
         CLS
         FOR n% = 1 TO 10
              pk = RND
              FOR k% = 1 TO m%
                           IF pk <= p(k%) THEN EXIT FOR
              NEXT k%
              newx = a(k%) * x + b(k%) * y + e(k%)
              newy = c(k%) * x + d(k%) * y + f(k%)
              x = newx
              y = newy
         NEXT n%
         FOR n% = 1 TO 10000
              pk = RND
              FOR k% = 1 TO m%
              IF pk <= p(k%) THEN EXIT FOR
```

continued

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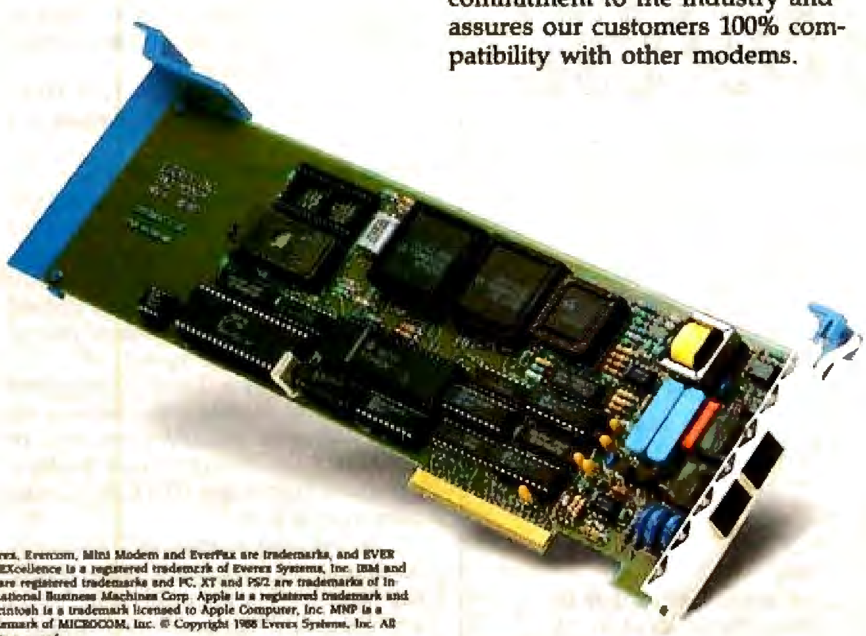

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Circle 95 on Reader Service Card (DEALERS: 96)

```
     NEXT k%
     newx = a(k%) * x + b(k%) * y + e(k%)
     newy = c(k%) * x + d(k%) * y + f(k%)
     x = newx
     y = newy
     PSET (x * xscale + xoffset, y * yscale + yoffset)
NEXT n%
LOCATE 24, 35
PRINT "End.";
WHILE INKEY$ = ""
WEND

SCREEN 0
END
```

case, compression seems to be 100 to 1, which translates into access times being sped up at least 100 to 1. I wonder if anyone with a truly large database would be interested in helping out with such experiments.

Robert McLaughlin
Leesburg, VA

Fast Data Access

In response to the article entitled "Fast Data Access" by Jonathan Robie (January), I would like to offer the following suggestions:

Any programmer competent in BASIC, dBASE, or other languages can build indexes to a large database where an index requires only 2 bytes of memory and/or disk per record, even when the index represents several fields and hundreds of characters of data. Virtually any number of indexes can be "open" at the same time, since all the index stacks can be written to a single file.

These are known as "string-stack" indexes, and their performance is easy to calculate. Using a 20-millisecond access hard disk drive, the time needed to add a record to an existing 60,000-record database is less than 0.5 seconds per index. Finding the first record in a sequence takes about 0.3 seconds, and subsequent records in indexed order are retrieved at the rate of 50 records per second.

Flat-file management takes on a whole new meaning when a user can feasibly maintain 10, 20, or more multifield indexes on-line at all times. Even the relational systems could use this technique by including an extra byte to point to different files.

Fully implemented examples of this system are available in a number of BASIC dialects and should convert easily to other common languages.

Dale Thorn
Ventura, CA

From Humber Beginnings

Thank you for "Managing Immense Storage" by Theodor H. Nelson (January). I found the concept of "humongous numbers," or "humbers," as the author termed them, intriguing. After finishing the article, I sat down and started playing with humbers at my computer.

As of this writing, I have implemented algorithms in Modula-2 that provide the basic arithmetic and I/O operations for humbers. I am willing to make available my source code to any BYTE reader who cares to write to me.

I did the programming in Workman & Associates' FTL Modula-2 (Large Memory Module), but it should be usable in any Modula-2 environment because I

continued

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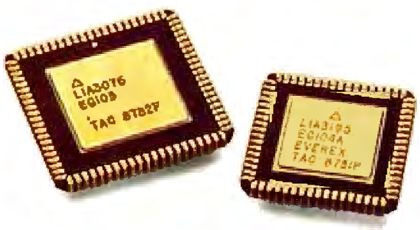

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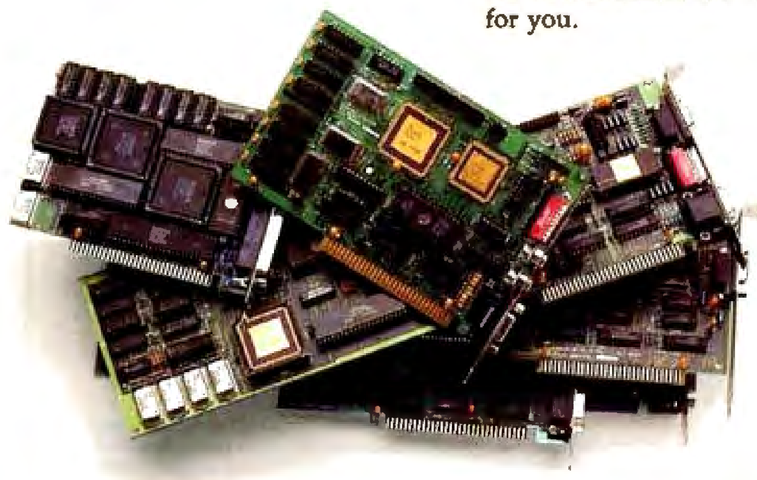

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Circle 97 on Reader Service Card (DEALERS: 98)

didn't use extensions. My system runs on IBM PC-DOS 3.3, so the disks will be DOS-compatible. Readers should enclose a check for $7.95 to defray the cost of the disk, postage, and so on.

Mark S. Niemczyk
Arete Systems Inc.
2431 Aloma Ave., Suite 111
Winter Park, FL 32792

Context Sensitivity

In "Natural-Language Processing" (December 1987), Klaus K. Obermeier, in discussing whether English is a properly context-sensitive language, gives the following example string: "The programs compiles slowly." He then comments, "You can add additional rules to the grammar that would disallow such sentences, but these rules would destroy its present simplicity." This is both incorrect and irrelevant. It is incorrect because all the grammar types under discussion are monotonic—addition of rules can only increase (or leave unchanged) the set of strings generated, not decrease it. And it is irrelevant, since the simplicity of a grammar for a language has no bearing on whether the language is, or is not, properly context-sensitive. Nor is the size of the set of rules required relevant. If a grammar with a finite set of context-free rules can be given for a language, then that language is not properly context-sensitive.

Obermeier also refers to the grammar in his figure 2 as "a simple context-sensitive grammar," which is true, but misleading. The grammar concerned is, in fact, a context-free grammar and thus trivially also a context-sensitive grammar. However, referring to it as a "context-sensitive" grammar, as Obermeier does, implies that it is not (merely) context-free.

Gerald Gazdar
Professor of Computational Linguistics
The University of Sussex
Brighton, UK

FIXES

• In the February BYTE on page 236, we labeled XLISP as "public domain," and we neglected to mention its author, David Betz. XLISP is actually a copyrighted program that is freely distributable for noncommercial use.

• The phone number we published for Toshiba America in the review of the Toshiba T3100/20 (January) is wrong. The correct number is (714) 583-3000.

• The NEC MultiSync Plus, which we included in the review of multiscan monitors (February), is not intended for use with CGA. The unit worked fine in our CGA test, but NEC says the unit might not work with all CGAs. The same holds true for the MultiSync XL. NEC says its MultiSync II ($899) is intended for use with CGA and higher-frequency adapters, such as EGA and PGC.

We said the Mitsubishi AUM 1371A had a 17 percent change in line displacement, and the NEC MultiSync Plus and Conrac 7250 monitors had 0 percent change. That should be a 0-millimeter change for the NEC and Conrac and a 0.17-mm change for the Mitsubishi.

Finally, Taxan's Multivision 770 Plus monitor has a maximum resolution of 800 by 600 pixels, not 640 by 480 as stated in the review.

• SuperMac Technology's phone number that we published in "Screening Macintosh II Color Monitors" (March) is incorrect. The correct number is (415) 964-8884, and the scanning frequency of its monitor is 48 KHz by 60 Hz. ■

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Circle 102 on Reader Service Card (Dealers: 103)

CHAOS MANOR MAIL

Jerry Pournelle answers questions about his column and related computer topics

Wants Electronic Support

Dear Jerry,

I have been reading BYTE and other computer magazines since 1984, and I have noticed one very large problem with computer manufacturers. They rarely electronically support their software, and when they do, it's usually through a service that costs lots of money. Only one commercial company that I know of supports its customers via a free service: USRobotics, the founder of the FidoNet National Communications Echo.

Why don't other companies get involved in such phenomena? Certainly they're cheaper, and you probably get a larger segment of the *human* communicating population. It certainly would be nice if, once the companies have got our money, we didn't have to pay even more money to ask them questions.

I have also read your gripes about Microsoft Word. I wrote this letter using Word, and I like it. I think I know why you have a problem with it and I don't. I use the original IBM PC keyboard, and I *don't* use a mouse. I also type with 5.33 fingers. This means that all the keys are easy to reach (to delete this parenthetical remark, I'd reach over with my left pinky, hit the F6 and F8 keys in rapid succession, then reach over with my right pinky and hit the Delete key). Maybe the new keyboard is not so enhanced after all.

I also don't like the cost of sending you this letter. If you had (or, at least, published) a FidoMail or Usenet address, it would cost me only 14 cents. If the folks at BIX gave us FidoNet people a link into their mail system, it would still cost only 14 cents. As it is, this letter costs 22 cents. Eight cents can add up quickly.

Garrett A. Wollman
Burlington, VT

It's a lot easier for me to deal with paper mail when the time comes to select mail for replies. I doubt that I could handle the volume I'd get on FidoNet or Usenet.—Jerry

Merely a Z-100

Dear Jerry,

A while back, you were looking for an IBM PC-compatible that could read your 8-inch disks. I am writing this letter on just such a machine. In earlier times, it was a *mere* Z-100. Now, with the Scottie board and the Heath User Group ZPC software, it runs most IBM PC programs right out of the box, giving me adequate compatibility with the IBM PC XT at work.

The text processor is the IBM PC version of Galahad, originally made for the Zenith at Clarkson College and ported to the PC. I regularly run VP-Planner, VP-Info, and the PC version of Turbo Pascal using the ZPC simulator. With a few keystrokes, the machine again becomes the old reliable 768K-byte Z-100. The 8-inch disks can be used from either side.

I know you have mentioned this machine before. It will be some time before I outgrow it. When I bought the 8-inch disk drives, they were less expensive than a hard disk drive. Also, I was sharing the machine with other family members. As long as each one of us kept our world on a pair of 8-inch disks, we could never harm each other's worlds.

For disk-intensive activity, I pay a penalty. But other than that, I have 2.5 megabytes available at any time, and when a long session is over, a simple `COPY C:*.* D:` does a neat job of creating a second, reliable copy of everything that happened.

This machine is what we euphemistically call "mature technology"—not the very latest, but it works and works and works. And for a few of us mavericks, that is what counts.

Leon R. Case II
Portland, CT

The Z-100 is still one of the best machines around, provided that you know something of what you're doing. Of course, Zenith brought it out just before IBM decided to saturate the market with its DOS machines, and it took a long time before the need for, and the ability to have, PC compatibility was achieved. By then, even Zenith had sort of given up on the Z-100; but it's sure a nice machine. —Jerry

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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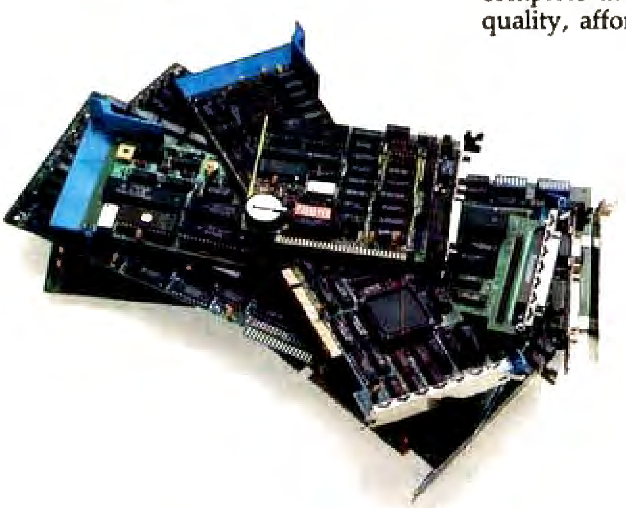

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Circle 104 on Reader Service Card (DEALERS: 105)

Another RAM-Resident Solution

Dear Jerry,

In the September 1987 column, you wrote about having troubles with your resident software and gave an example of a batch file that rewrites the AUTOEXEC.BAT file. I think I've got a better solution.

The Norton Utilities (at least the advance edition) includes a program called Ask, which can be used to solve problems like yours in a tidy way. Ask lets you build menus in a batch file, input into the batch file, and set the error level according to your input. A better solution to your problem could look like this:

```
ECHO 1. Ready!, SuperKey, SideKick
ECHO 2. Lightning, SideKick
ECHO 3. DESQview
ECHO 4. Windows
ASK "What shall I load", 1234
if errorlevel 1 then goto ___
if errorlevel 2 then goto ___
```

If you want to stick to your method, you could write a little program that reboots the system via interrupt 25.

I do almost all my editing with the Norton Editor, which can do all you need and is very small. It also supports a mouse if one is connected. Just press the left mouse button, and you can move the cursor around; press the mouse again, and you drop the cursor at the new location. I find that very useful.

When it comes to output, I use TeX. My second choice is MicroStar from the Turbo Editor Toolbox; it cooperates with Lightning nicely.

Konrad Neuwirth
Vienna, Austria

Your solution is more elegant. Among other things, it takes up a lot less memory, since the minimum size file under DOS 3.x is 2K bytes.

I fear you are beyond me with TeX; I have so far found it to be a black art. —Jerry

WordStar 4.0 Wrinkles

Dear Jerry,

I wrote to you previously to describe a problem with WordStar 4.0 not properly supporting the extended character set when used for program source codes. Further investigation shows that WordStar 4.0 assigns three characters for each extended character. A hexadecimal dump of a WordStar 4.0 file that has the extended characters shows that each extended character is preceded by hexadecimal 1B and followed by hexadecimal 1C.

MicroPro has notified me that it will provide a program to take a file having the extended character set and print it to disk so that the offending 1B and 1C codes surrounding each graphics character are removed. This solution should be workable, but it seems awkward. A better solution seems to be to use a program such as WordStar 2000, which does not have this feature. Other than this anomaly, I have found WordStar 4.0 to be an excellent program.

One other point that is somewhat frustrating is that the version of Word Finder supplied with WordStar 4.0 supports only WordStar 4.0. Micrlolytics's generic version of Word Finder does not support WordStar 4.0, so if I want to use Word Finder with other programs, such as SideKick, I have to maintain two Word Finder programs and dictionaries on my hard disk. This seems ridiculous, since the dictionaries appear to be identical. I suppose this is another form of copy protection.

Thomas S. Cox
Greenville, SC

I expect it is some kind of publication protection scheme. The chaps at Microlytics are generally good guys and don't use copy protection. I'll have to ask about this.

People who like WordStar seem to like WordStar 4.0 a lot. There's a dance in the old girl yet.—Jerry

CP/M Plus Source?

Dear Jerry,

I bought a TeleVideo I Portable with CP/M Plus, and although I wrote to the Professional Computer Group in Bangor, Maine, no one ever answered. (I have written several letters—even one with receipt requested, which was received but not answered.)

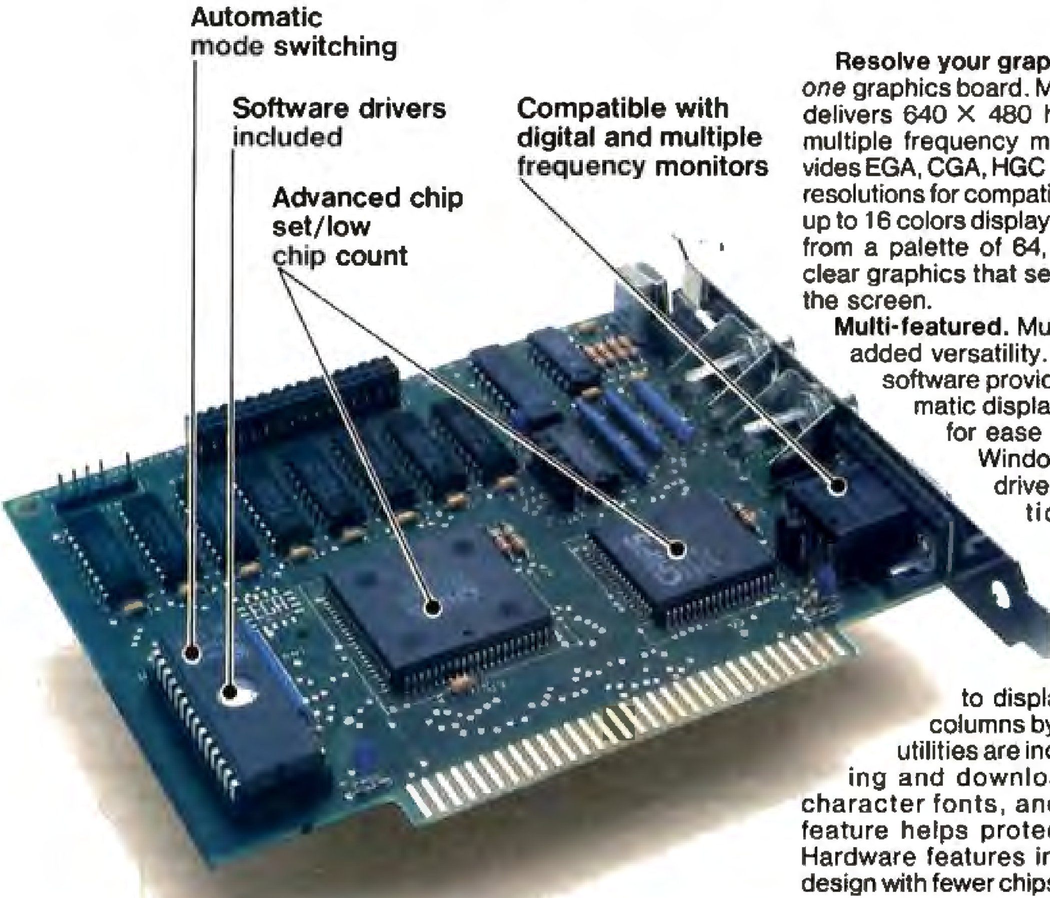
The problem is that the CP/M Plus software is for a different machine, so the 128K bytes is useless!

Is there anybody in the U.S. who is willing to support the old CP/M? Is there anything like the Norton Utilities for CP/M?

Alex Korth
Buenos Aires, Argentina

Workman and Associates (1925 E. Mountain St., Pasadena, CA 91106, (818) 791-7979) and Spite Software (4004 Southwest Barbur Blvd., Portland, OR 97201, (503) 228-8223) try to support CP/M systems. There are probably others, but I don't know who.—Jerry ■

One for all.



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Circle 37 on Reader Service Card (DEALERS: 38)

ASK BYTE

Circuit Cellar's Steve Ciarcia answers your questions on microcomputing

Seeing-Eye Computers

Dear Steve,

Practical speech synthesis appears to be lagging behind image processing. A blind social worker here at Texas A&M University would benefit greatly from a talking computer. We can easily access the hospital mainframe, but we've had difficulty locating a good speech-synthesis system. Those that have been called to our attention seem outdated.

Do you know of any hardware or software that will enable a sightless person to effectively use a computer? Just making it talk is not enough. The system must be able to use word-processing and data-management software—preferably under MS-DOS—and possibly interface with a high-level language. We might start with a desktop model, but a laptop is our ultimate goal.

David Lemper
Temple, TX

I think the current state-of-the-art speech-synthesis hardware is quite capable of generating understandable speech. The real problem you are referring to is the ability to use this hardware technology in an integrated fashion to remove the barriers a sightless person has in using a computer. Perhaps the real need is for software, such as a word processor, to function with a speech module as an output device to replace the visual information normally received from the screen.

There is far more involved here than merely echoing the screen information. In fact, the words on the screen represent only part of the information, since positioning and other visual clues are just as important.

While I have seen some limited demonstration software, I have not seen a truly general-purpose solution to your problem. I think this type of question deserves a broader research effort than I can give you. But let me make some specific suggestions about where you can look.

Two computer retrieval databases cover your area of interest: ABLEDATA and REHABDATA. Both are supplied by the National Rehabilitation Information Center, located at the Catholic University of America in Washington, DC. You can access these databases through commercial on-line research services, such as Dialog Information Services (3460 Hillview Ave., Palo Alto, CA 94304, (800) 334-2564; in California, (415) 858-2700) or BRS (1700 Route 7, Latham, NY 12110, (518) 783-1161). You may want to contact a research librarian at Texas A&M for more information.—Steve

Hand-Holding for a Hand-Held

Dear Steve,

I have a Texas Instruments CC-40 hand-held computer. Unfortunately, there are no service manuals available for it—at least not here in Austria. According to the user's manual, I could program the computer in assembly language, but I don't have any information about how to do this. Do you know the address of a TI retailer or computer club that I could write to? I've already written to TI's customer service department, but I've received no reply.

Walter Schrabmair Jr.
Salzburg, Austria

For the most part, TI has been out of the retail computer business for some time. However, users groups still flourish here in the U.S. to support TI machines.

TI PPC Notes (P.O. Box 1421, Largo, FL 34294-1421) supports programmable calculators made by TI. The Houston TI Users Group (c/o Kim Peterson, 3107 Bafing, Houston, TX 77099-2244) primarily supports the TI99-4A computer. I think you might be able to get some useful information for your machine from these sources.—Steve

Bit by Bit

Dear Steve,

I have tried for a long time to buy a computer, but I can't come up with the big chunk of cash necessary. I have therefore decided to buy it piecemeal, component by component. I would like to end up with something more than an IBM PC XT, or at least something that I could simply upgrade by just a motherboard replacement. This precipitates several questions.

First, do XT and AT cases accept different motherboards? If so, do you know of an XT-compatible motherboard (preferably with an 8088-1) that fits in an AT case, has keyboard-selectable 10-MHz speed, and uses an AT power supply so that I can turn my system into a 286/386 machine with a simple motherboard swap? Finally, what is the difference between regular ATs and so-called mini- or baby-ATs?

Jim Freeman
Salt Lake City, UT

For the most part, XT and AT cases accept different-size motherboards. However, some firms do sell AT motherboards that fit into XT cases. I can't make any recommendation on particular boards because I am not familiar with them. However, if you search through Computer Shopper *magazine, you will find many clone vendors.*

Regarding your second question, I am not aware of any XT motherboards that fit your exact description. But consider that an XT clone motherboard might sell for $100 to $200 and an AT motherboard for $300 to $500. You might be better off to bite the bullet and get the AT right from the start.

A regular AT has a larger motherboard and case compared to a mini- or baby-AT. The intent is to have a smaller footprint on your desk. Functionally, they are the same, though the mini-AT may have fewer expansion slots.—Steve

It's All in the Handshaking

Dear Steve,

I need to know how to test my printer's status—whether it is on-line, off-line, turned off, or otherwise unavailable—

continued

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

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These Fujitsu Daisy Max 830 were manufactured for Motorola's Computer Division. The purchase order was canceled and Fujitsu was forced to liquidate these 80 character per second daisy wheel printers at "fire sale" prices.
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HPGL • 11" by 17"

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Western Graphtec Model 2000 operates under the Hewlett Packard graphic language and has both parallel and serial interface. Size "B" plotter, 11" by 17" flat bed with eight self capping color pens. Maximum plotting speed 10" per second, resolution .05mm with repeatability of .004".
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PLOTTERS

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

	One	Two	Ten
TEC501 ½ height sgl.side	49	39	35
TANDON 65L/2 360K, ½ ht.	79	75	72
TANDON 101/4 full ht. 96 TPI.	99	89	79
FUJITSU 5¼" half height	95	89	82
MITSUBISHI new 501 half ht.	119	109	105
MITSUBISHI 504A AT comp.	149	139	135
TEAC FD55BV half height	109	99	89
TEAC FD55FV 96 TPI, half ht.	119	109	105
TEAC FD55GF for IBM AT	149	139	135
PANASONIC 455 Half Height	109	99	89
PANASONIC 475 1.2 Meg./96	119	115	109
Switching power supply			49
Dual enclosure for 5¼" drives			59
3½" DISK DRIVES			
SONY MP-53W 720K/Byte	129	125	119
SONY MP-73W, 2 Meg.	159	149	call
TEAC 35FN 720 K/Byte	129	119	115
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QUME 842 double sided	189	179	175
QUME 841 single sided	119	109	99
SHUGART 851R dbl. sided	319	309	299
REMEX RFD4000 dbl. sided	189	179	165
OLIVETTI 851	189	179	165

Xerox Laptop $189

The Xerox Sunrise 1810/1815 is by far the best value we have ever seen in a laptop computer. This is the ideal computer for students, journalists or anyone who has to capture data away from their desk. The Sunrise is a self contained battery and AC portable. The Xerox Sunrise was originally priced at $2995. Xerox has since elected to drop the computer from their product line. California Digital has purchased all the remaining inventory and is making the unit available at a fraction of its original cost.
This laptop features a built in three line 80 column liquid crystal display, 64K of memory along with both RF monitor and television outputs. The internal 300 baud Bell 103 full duplex and 1200 baud Bell 202A half duplex modem is capable of auto dialing. The units has both centronics parallel and a serial port programmable to 19,200 baud. Self contained micro cassette is capable of capturing data from the keyboard as well as doubling as a audio recorder for dictating messages.
An optional dual floppy disk drive module is available for only $159. Also available, for $59 is an 80 column printer that mounts in the drive module. The Sunrise features a CP/M operating system which allows the operator to use any program in Xerox 5¼" format and over 5000 CP/M programs available in public domain. While files from the Sunrise may be transferred to IBM/PC type computers, the 1810 is **NOT** compatible with the IBM/PC computer.

HEWLETT PACKARD

LASER JET II $1725

Standard features of the new Hewlett Packard Series II Laser printer: 512 K byte memory expandable to 4 Megabytes, both serial and parallel ports. List price $2495 California Digital price $17 l5. Memory upgrade, type fonts and toner cartridges available.

Other Laser Printers available

Texas Instruments • Okidata • Apple • Ricoh • Qume • AST Research • QMS • Xerox • Canon • Quadram • Centronics • CIE C.Itoh • DataProducts

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Compact disk is a relatively new medium for storage of read-only digital data. One removable disk is capable of storing over 500 megabyte of data on a disk the same size as an audio CD.
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Other CD/ROM Products Available: Amdek Laserdrive/1 system $679; Hitachi CDR-1503SUY external with IBM host adapter and MS ext. DOS $699. Also WORM drives and CD/ROMs of other manufacturers. Ask for list of published software, Encyclopedias and technical publications available on compact disk.

Dragon Computer $89

Compatible with most Radio Shack Color Computer software. Manufactured by the Tano Corp. under license of the British Broadcasting Company.
The Dragon comes complete with 64K Byte of memory, serial modem port along with a Centronics printer interface. This unique microcomputer features Motorola's advanced 6809E microprocessor and comes standard with Microsoft Color Basic, data base manager, and a complete word processing package. The computer outputs color composite video along with R.F. video that allows the unit to be used in conjunction with any color television.

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The Amdahl synchronous modem is CCITT compatible and operate 9600 bps on a four wire dedicated phone line.
Amdahl suggested price is $1495. Limited quantities available at only $379.
Also available 19.2 kbps units. Please phone for additional information.

Smarteam 2400 $239

The Smarteam 2400 offers all the features of the Hayes Smart Modem 2400 for a fraction of the price. Now is your opportunity to purchase a 2400 baud modem for only $239. **Also available:** The MiniTeam 1200 at only $129

MODEMS

Avatex 1200E external, Hayes compatible	89
CTS 1200 baud modem	69
Hayes Smartmodem 2400 baud modem	529
Smarteam 2400 Hayes Compatible	259
Smarteam 1200 Hayes Compatible, 300/1200	119
Smarteam 1200B IBM 1200 baud card	119
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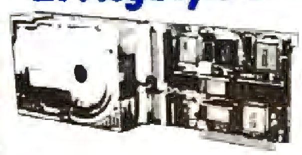
Prometheus 1200 super features	289
U.S. Robotics 9600 bps. Courier HST	199
Signalman Mark VI, 300 baud internal PC	35

21 Megabyte Gold Card $379



The Gold Card from Silicon Valley Computers features shock mounted automatic head unloading, 15 watt drive coupled with a 2K/byte sector buffer and advanced OMTI controller for maximum reliability. 30,000 hour MTBF and full 2 year warranty – the best cost per megabyte hardcard available.
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SEAGATE 4051 51 M. 35mS.	695	659
SEAGATE 4096 96 M. 35mS.	795	779
MINISCRIBE 3425 25 m 85ms.	279	247
MINISCRIBE 3650 50m 61 ms.	419	399
MINISCRIBE 6085 90 meg.	795	779
FUJITSU 2242 55 M. 35mS.	1299	1229
FUJITSU 2243 86 M. 35mS.	1695	1619
RODIME RO-204E 53 Meg.	895	859
MAXTOR XT1140 140 Meg.	2195	2129
TOSHIBA MK56 70 M. 30mS.	1789	1729

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WESTERN DIGITAL WD/1002WX2	89
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XEBEC 1410A 5¼" foot print	211
WESTERN DIGITAL 1002-05E 5¼"	201
OMTI 20L	89
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Listing 1: *Skeleton of Turbo Pascal code needed to query printer status.*

```
Program...
type
  Register_Type = record
    case integer of
      1: (AX,BX,CX,DX,BP,DI,SI,DS,ES,Flags :
                              integer);
      2: (AL,AH,BL,BH,CL,CH,DL,DH     : byte);
                  end;
var
  Registers : Register_Type;
  Status : integer;
...
    with Registers do begin
      AH:=$2;
      DX:=$lptn;  { 0 for LPT1, 1 for LPT2,
                              etc. }
      Intr($17,Registers); { Call the BIOS   }
      Status:=AH;          { Get result byte}
    end;
```

Table 1: *Bit settings and their significance for the* Status *variable returned in listing 1.*

Bit	Indication
7	Not busy
6	Ack has been received from printer to acknowledge last character sent
5	Paper out
4	Printer selected, on-line
3	I/O error
2	Not used
1	Not used
0	Time-out error

from within a program. It's irritating to have the system hang up while attempting to send a command to the printer when it turns out the printer was off-line.

I am using Turbo Pascal 3.01. My printer is a Star SG-10, set up as LPT1:, and my computer system is an XT clone with 640K bytes of memory and two floppy disk drives.

Bruce Bauder
Tillamook, OR

You need to call a BIOS routine to return the printer status. In Turbo Pascal, the code would look like that in listing 1. The variable Status *will have certain bits set, based on the printer's condition (see table 1). By decoding these bit combinations, you can alert the operator to the printer's condition. Also, although this is undocumented, bit 1 seems to indicate a nonexistent device.*—Steve

Not a Good Day for Printers

Dear Steve,

Recently, I tried to use my IBM PC compatible with my Smith Corona TP2 daisy-wheel printer. After printing a certain number of characters (about 260 to 320), the printer loses two characters, always in the same place. If I use the MS-DOS PRINT SCREEN command, the printer loses one character.

If I execute mode lpt1:,,p, the problem goes away. As explained in the DOS manual, the p option causes the operating system to continually try sending output if the printer is not ready. I thought the parallel interface protocol required an acknowledge from the printer before the computer would send another byte.

The problem occurs when I'm running the computer at 8 MHz or 4.77 MHz. The printer has a 256-byte buffer. What is it about the Centronics interface that I don't understand?

Robert Ziller
New Richmond, WI

Troubleshooting a problem from a distance is sometimes difficult. Your IBM compatible/Smith Corona TP2 problem could be due to several possible causes.

The lost characters (every 260 to 320), coupled with the fact that the TP2 has 256 bytes in its buffer, indicate a buffer overflow condition (the difference in the error position may be due to varying line lengths and return time). Thus, the primary failure is probably in the handshaking between the computer and the printer.

The Centronics format actually supplies three possible controls to the printer:

- *ACK (pin 10): A low on the pin indicates that the printer has finished processing the current character.*
- *BUSY (pin 11): A high on this pin indicates a buffer-full condition.*

continued

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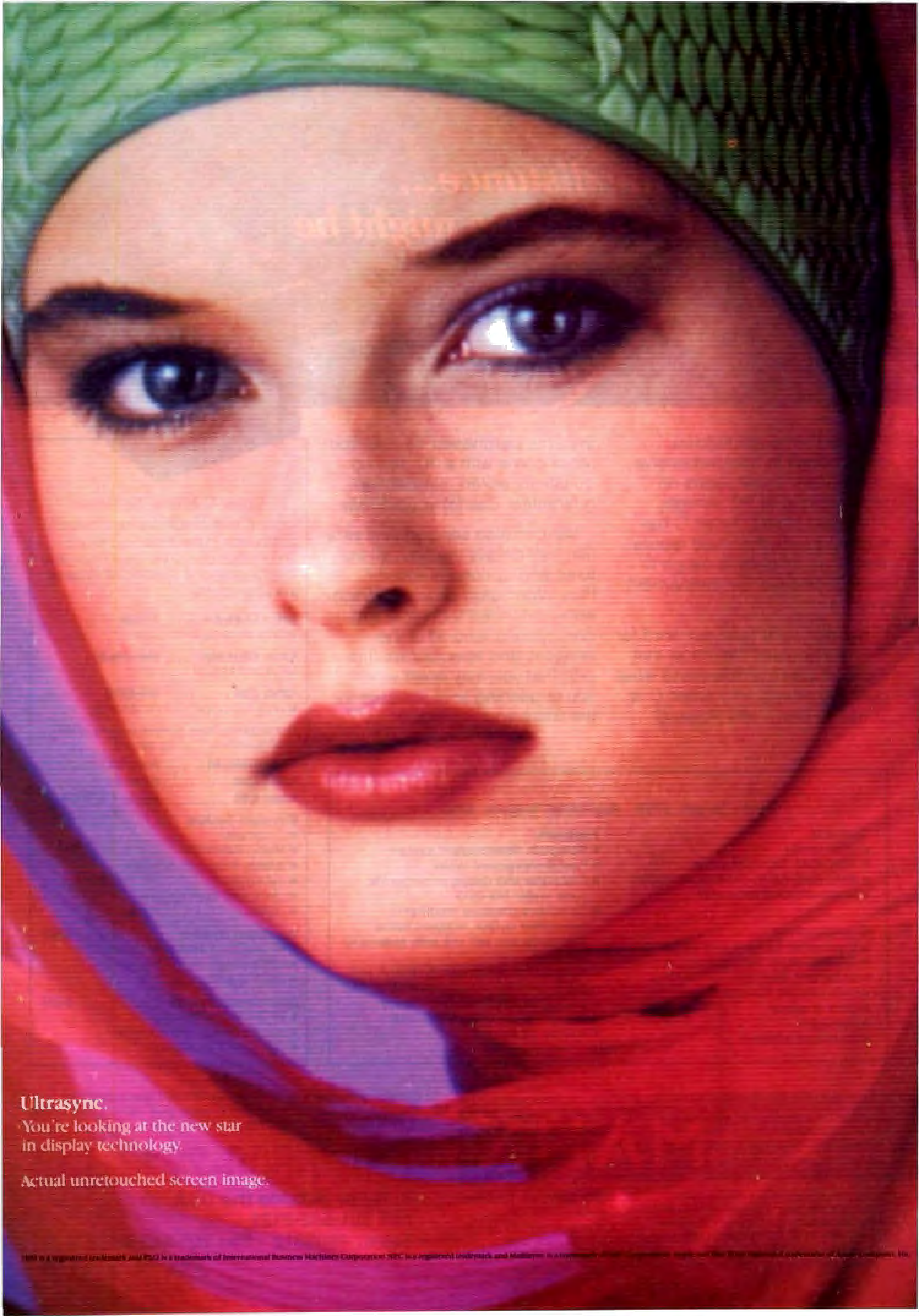

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Circle 212 on Reader Service Card

• FAULT (pin 32): A low on this pin indicates that some problem exists (sometimes this pin goes low when the buffer is full; it depends on printer design). Note: This pin's data is valid only for some custom-made cables; the standard IBM Centronics-to-DB-25 cable leaves this pin open.

Your printer manual will show the DIP-switch configuration changes necessary to implement handshaking. First, check the configuration of the printer, then verify the cable connections (pins 10 and 11 correspond to the connections on each end of the standard IBM cable. If the pin 32 connection is implemented, it should be DB-25 pin 11).

You can't rule out a failure of either the port or the printer hardware. Ask a friend (or your friendly local computer store) to test the printer on another machine (try to use WordStar with a document that you know fails). This will let you determine which is at fault—the printer or the computer.—Steve

Cheap 200-watt UPS Wanted

Dear Steve,

How about coming up with a 200-watt uninterruptible power supply (UPS) for us IBM XT/AT users? It should use gel-cell batteries of the type widely available in the surplus market and should cost less than $100.

William Schreiber
Kailua-Kona, HI

The world seems to be afflicted with power problems, if my mail is an accurate reflection. There is considerable interest in such devices as constant voltage transformers and uninterruptible power supplies.

Small uninterruptible supplies with 60-Hz sine-wave output are relatively easy to design and build (see the January issue of Radio-Electronics *for a 40-watt UPS construction project). As the supplies get larger, the linear amplifiers needed to support the output grow larger and more complex, and they generate more heat. These factors increase the expense to an extent that is most efficiently countered by the economies of high-volume production. Thus, I'm afraid your desire for a 200-watt UPS for less than $100 is a bit unrealistic.*

The economies of volume production have made such supplies available at prices much lower than in the past. SM Industries (535 West Wise Rd., Schaumberg, IL 60193, (312) 894-5331) is currently advertising a 200-watt unit for $179, for example. The advertisements in publications such as Computer Shopper *magazine show comparable prices for similar units from various other sources. These units make more sense than something I could design and feature as a Circuit Cellar project.*—Steve

Dialing for Digits

Dear Steve,

I plan to build and use your ImageWise video digitizer (May 1987 Circuit Cellar) to transfer pictures over the telephone with modems, and I have a few questions in this regard. What is the most economical modem I can use? How long will it take to transmit a picture (at various data transfer rates)? Finally, can you give me some idea of the transmission time you save by compressing the image?

R. Blau
Brooklyn, NY

You'll find that 2400-bit-per-second modems are getting cheaper all the time. Many are now priced at under $200.

At 1200 bps, an uncompressed picture requires about 8.6 minutes of transmission time; at 2400 bps, it's 4.3 minutes; and at 9600 bps, it's about 1 minute. But 300 bps is out of the question—the transmission time is about 40 minutes. The 2400-bps modems with MNP (Microcom Network Protocol) error correction have an additional advantage: they prevent nearly all errors from phone-line noise from garbling the picture.

Data compression reduces the size of the image 2 to 4 times, so a 1200-bps transmission would take 2 to 4 minutes. The compression factor depends on the complexity and detail of the image, as well as the amount of noise in the video camera. A well-lit scene produces less noise in the camera, so ultimately it reduces transmission time.—Steve

Meteorology on the Micro

Dear Steve,

I have a couple of unrelated problems that I hope you can help me with.

I have an Amiga 1000 (512K bytes of RAM) with one external 3½-inch floppy disk drive and one external 5¼-inch floppy disk drive. I am using one of the old Epson MX-80 printers (circa 1982 to 1983) with Graftrax installed. I have Amiga BASIC, True BASIC, Lattice C, and Amiga Pascal as programming languages.

I am a weather forecaster with the U.S. Air Force stationed in Myrtle Beach, South Carolina. Myrtle Beach is a typical tourist town with more fast food, beachwear stores, and golf courses than you can shake a stick at. Unfortunately, the amount of research material available is severely limited.

I am interested in receiving the Navy

continued

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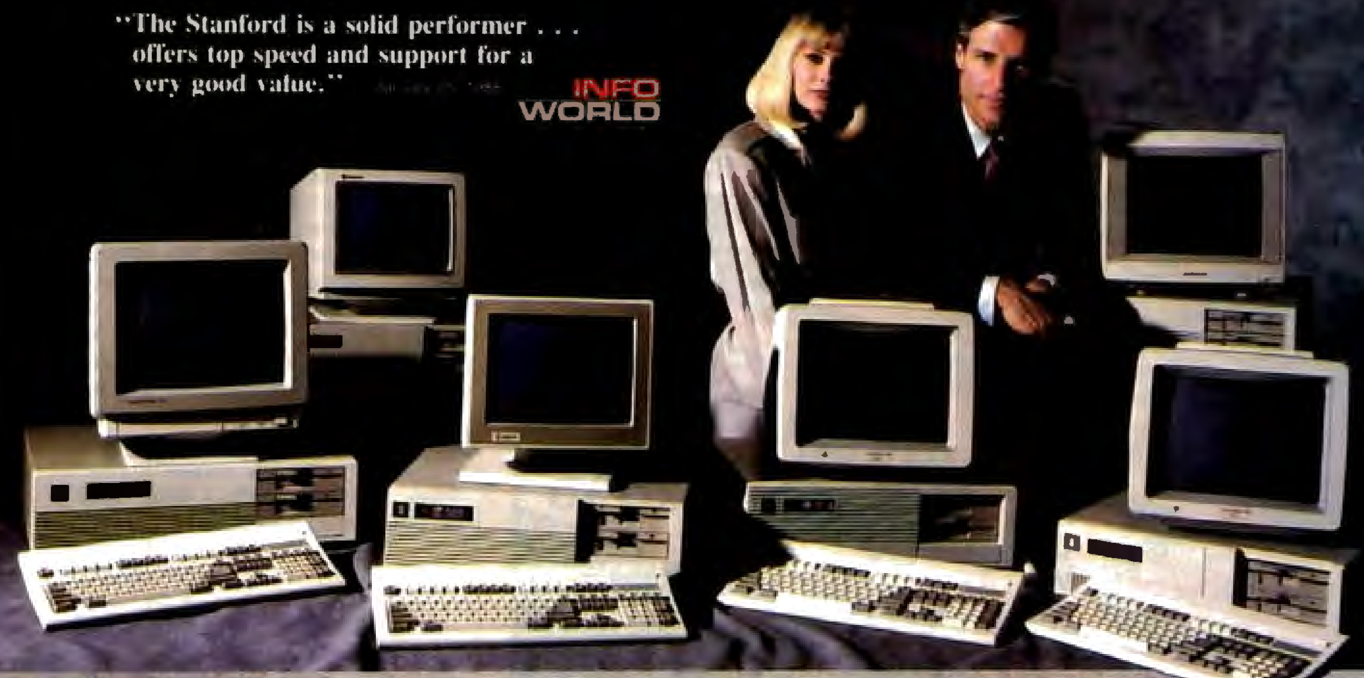

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*System price does not include memory (DRAMS).

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weather facsimile maps at home and displaying them on my Amiga. I ordered the transmission schedule from Alden Electronics (it's free, and the people there were very friendly), so I know the frequency and schedule, but I don't know the format. What I need is a guide to help me decode the signals and build the required hardware. The programming end would be no problem if I could only find the information. (If any of your readers want to contact Alden, the address is Alden Electronics, 40 Washington St., Westborough, MA 01581.)

The second problem concerns hardware. I need to know if there is any way to construct a device (without any exotic parts) that will "clamp" to a phone line and let me pick up a 1200-bps signal without any physical connection to the wires. In other words, I don't want to have to cut the phone line.

Michael Street
Myrtle Beach, SC

Weather facsimile maps on the high-frequency band are fairly easy to receive with any HF shortwave radio, as you may have noticed from the information supplied to you by Alden Electronics. You can accomplish conversion of the signal to a printable format in many ways.

The signal itself is an AM-modulated carrier, centered at 2400 Hz, with the picture information moving at about 4 lines per minute. Several articles have appeared in amateur radio magazines on assembly of WEFAX (weather facsimile) converters to use with a computer; you might check your local library for back issues of QST *and* 73 *magazines. Also, check out Keith H. Sueker's article, "Apple Fax: Weather Maps on a Video Screen" in the June 1984 BYTE.*

I have found that The Weather Satellite Handbook *(third edition) by Dr. Ralph Taggart is a good overall source of information on this subject. While the book is aimed at satellite WEFAX reception, you can apply many of the techniques and circuits to HF reception. Copies are available for $12 plus 50 cents for shipping and handling from Dr. Ralph Taggart, 602 South Jefferson, Mason, MI 48854.*

If you would prefer to use a preconstructed unit, Advanced Electronic Applications (P.O. Box 2160, Lynnwood, WA 98036) sells a multimode data controller (model PK-232) that will decode WEFAX HF transmissions and pass them to your printer or computer. Price varies with the dealer; you might consult a recent copy of QST *or* 73 *or a local amateur radio operator for the location of a dealer in your area.*

With regard to your desire to induc-

continued

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Z-280		299.50	1250.00			600.00	2250.00	150.00	250.00
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1802	199.50	199.50	995.00						
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65c02	199.50	199.50	995.00						
65816		299.50	1250.00						
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6801,3	199.50	199.50	995.00	149.50	499.50	500.00	2000.00	150.00	250.00
6804	199.50	199.50	995.00						
6805	199.50	199.50	995.00						
6809	199.50	199.50	995.00	149.50	499.50	500.00	2000.00	150.00	250.00
68c11	199.50	199.50	995.00			500.00	2000.00	150.00	250.00
68000,8,10	299.50	299.50	1250.00						
68020		399.50	1500.00			700.00	2500.00	150.00	250.00
8400/c00	199.50	199.50	995.00						
8044/51/52	199.50	199.50	995.00	149.50	499.50	500.00	2000.00	150.00	250.00
80451	199.50	199.50	995.00			500.00	2000.00	150.00	250.00
80515	199.50	199.50	995.00	149.50	499.50	500.00	2000.00	150.00	250.00
8080	199.50	199.50	995.00	149.50	499.50				
8085	199.50	199.50	995.00	149.50	499.50				
8086/88	99.50	99.50	1250.00						
8096	199.50	199.50	1250.00						
80186/286	199.50	199.50	1250.00						
80386		299.50	1250.00						
83351	199.50	199.50	995.00	149.50	499.50	500.00	2000.00	150.00	250.00
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tively couple to a phone line to enable use of a modem, various methods have attempted to accomplish this feat, with minimal success. The connection is simply not reliable enough to warrant the specialized circuitry required.

Finally, my new publication, Circuit Cellar Ink, *is running a series of articles on just this subject. Volume 1, issue 3 has an article that deals exclusively with weather facsimile services and techniques for displaying these weather photos on a personal computer.*—Steve

Hot-Rodding the Apple

Dear Steve,

In the August 1987 Ask BYTE, Bernard Paul Sypniewski asked if it was possible to switch the 65802 and 6502 processors to get more power from his Franklin ACE computers. You answered that he would have timing difficulties and would not notice any difference unless he did his own programming.

JDR Microdevices advertises a 3-MHz version of the 6502 called the 6502B. Can I replace my 6502 (or 65C02) with a 6502B and make my Apple run 3 times faster?

Michael de la Maza
Irvine, CA

While a 6502B microprocessor will run at 3 MHz, you have to feed it a 3-MHz clock signal to make it do so. The Apple computer provides a nominal 1.023-MHz clock speed that you cannot change without messing up the video timing. Thus, while you could plug a faster 6502 into your motherboard's microprocessor socket, it would execute programs no faster than what you have now.

The most practical way to speed up your Apple computer is to add an accelerator board containing a faster processor and separate RAM; this would avoid the video timing problems that you would encounter if you changed the main Apple board. Several good speed-up cards use processors ranging from fast 6502s to 68000s. One of the more popular cards is the Transwarp from Applied Engineering (P.O. Box 798, Carrollton, TX 75006), which contains a 3.6-MHz 65C02 and fast RAM, with an optional 65816 processor upgrade.

As with any hardware changes, software compatibility problems are a distinct possibility, and you should run tests to be absolutely certain that the software you want to use is compatible (prior to purchasing the upgrade, of course).

The November 1987 issue of The APPLE Review *contains a report on Transwarp, including a discussion of known software compatibilities and incompatibilities.*—Steve ■

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BOOK REVIEWS

DEBUGGING C
Robert Ward

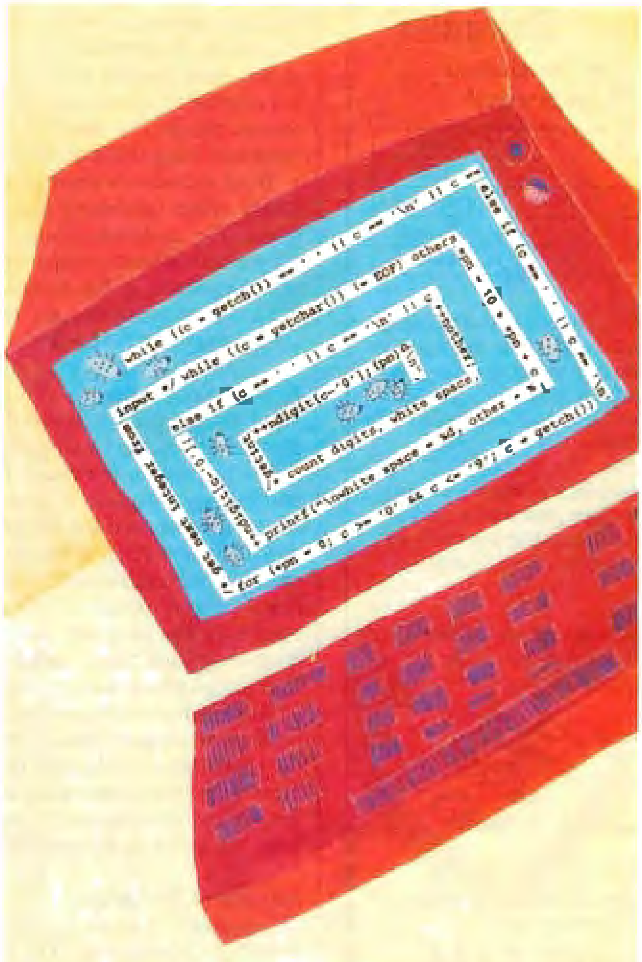
THE PROGRAMMER'S GUIDE TO WINDOWS
David Durant, Geta Carlson, and Paul Yao

FAST ACCESS\ WORDPERFECT
Rhyder McClure

DEBUGGING C

Reviewed by Rudy Bazelmans

Que Corp., Indianapolis, IN: 1987, ISBN 0-88022-261-1, 400 pages, $19.95



In *Debugging C*, author Robert Ward says, "To write programs that work, you must know how to debug. It's that simple. In fact, if you produce working programs, you will spend at least half your time debugging." He goes on to say that "good debugging skills are requisite to successful programming." With regard to C programming, this statement seems especially true.

Debugging C discusses general techniques for debugging programming errors and, specifically, how to debug the most common C programming errors. The author accomplishes this with an easy-to-read writing style that includes numerous examples and just the right amount of metaphorical references.

The information is easily accessible. Ward's examples of actual executions and transcripts of debugging sessions use such tools as static analyzers, debuggers, and interpreters. He also uses charts, itemized lists, and clear diagrams. He clearly has a good understanding of C and the problems of programming.

But *Debugging C* is not without its faults. In a book on debugging, it's a shame to find numerous examples of poor programming style, which leads to programming errors. For example, page 175 of the book contains four examples of poor programming style: the use of multiple statements on a single line, especially `if` statements; poor indentation style used for control constructs; poor use of white space to separate lines of related function; and a scarcity of in-line comments. Ward should have read Thomas Plum's book *C Programming Guidelines* (Prentice-Hall, 1984), which spells out a more readable and less error-prone coding style.

Ward begins *Debugging C* with a discussion of the foundations used in the debugging process. He then describes program testing and how to recognize bugs. Three chapters concern language-independent techniques for locating bugs, and they are followed by three chapters that discuss why debugging C is difficult and how to apply to C the general techniques described in the previous chapters. The final two chapters discuss several commercial debuggers and an interpreter and how to use them in debugging.

Although this organization of the material makes sense, the links between chapters are weak. As I read the book, I had very little sense of its progression. This flaw is particularly obvious because the book does not clearly follow the taxonomy of debugging described in the chapter on foundations.

According to Ward, at varying levels, *Debugging C* is for everyone, and I agree. Beginners will find the book useful, even though some of the advanced sections are confusing. Experienced programmers will also find a number of chapters worth reading. Readers will need a good understanding of C to comprehend the entire book. I think non-C programmers will also find parts of this book interesting—particularly the introductory chapters on foundations, testing, and general debugging techniques.

A Four-Step Process

Ward divides the task of debugging into four phases: testing, stabilization, localization, and correction.

Testing, the process of discovering which bugs exist, should precede debugging (the actual process of removing the bugs). As such, I think Ward made a mistake in including a chapter on testing. He should have relegated the topic of testing to other texts, as he did with other topics, such as design techniques. His 20-page discussion on testing is completely inadequate, especially compared to a definitive discussion on testing such as Glenford Myers's *The Art of Software Testing* (John Wiley & Sons, 1979). Ward's discussion on testing would be more appropriate if he reduced the scope to testing as it specifically relates to debugging.

continued

Illustration by Trisha Larkin

Stabilization, the act of producing an easily reproducible test case to demonstrate a bug, is a prerequisite to finding a bug. Unfortunately, the discussion on the stabilization of bugs is lost in the chapter on testing techniques.

Localization involves narrowing down the test cases sufficiently to find the problem, and Ward's separation of this topic from stabilization makes sense.

The final phase of debugging is correction, during which the bug is fixed. Ward trivializes this phase by first saying that most bugs are easy to fix and then by devoting only two paragraphs to the topic. If correction is a phase of debugging, then Ward should have devoted at least a small chapter to it. I also consider it a mistake to ignore the retesting requirements during the correction phase. I'm sure I'm not the only person to add one or more new bugs while attempting to remove an existing bug.

Ward introduces another useful concept, that of proximity: Every effect (problem) in a program is proximate (near) the cause. The proximity can be based on the distance between the source code of two routines, the distance between the execution of two routines, or the distance between two references to a data item. These principles are well defined, and the concepts are used throughout the book.

How to Spot a Bug

Ward divides his discussion on bug searching into finding compilation errors and finding coding errors.

For beginners, the chapter on finding compilation errors is particularly helpful. I haven't seen this material discussed anywhere else, and the chapter has some good advice. In addition to the compiler, Ward describes several other programs that can help programmers find compilation errors. These include a brace checker (used to find mismatched or incorrectly nested braces), a lint program (used to find examples of poor coding style or obscure bugs), and the compiler's preprocessor (used to find macro processing errors).

Ward also describes techniques that you can apply with little or no tool support. Much of the discussion surrounds tracing program execution through the instrumentation of control structures with print statements and the clever use of the C macro facility to control levels of trace output. Although tracing source code is a useful technique, Ward seems preoccupied with it.

Advanced Techniques

Debugging C does an excellent job of addressing the issues involved in C debugging. The process is difficult for a number of reasons: C is a weakly typed language that allows mismatched variables on expressions and mismatched function parameters; the use of pointer variables is error-prone; uninitialized variables are not flagged by the compiler; subscripts on arrays are not checked at run time; and in unprotected environments, stray pointers can accidentally modify code.

Ward discusses how to recognize and find each of these problems. In a table on page 209, he has the start of a great debugging aid. The table lists the commonly observed program behaviors, their probable causes, and suggested debugging techniques for each one. Ward should have expanded this gem to include more entries.

Particularly informative is the section on organizing the stack during the execution of C programs. The diagrams and related text are clear and well organized.

Debugging Tools

In the tools section, Ward discusses three popular debugging tools: sdb (the source-level debugger for System V Unix by AT&T), CodeView (the new multiwindow source-level debugger for MS-DOS from Microsoft), and C-terp (the interpreted C

continued

environment for MS-DOS from Gimpel Software).

Here, the book is weak. The coverage of sdb should have been an overview of the capabilities; instead, it is a poor tutorial with a description of each debugger command, which seems unnecessary in a general book on debugging C. The author would do better to talk about features and leave the description of the command set to a more complete tutorial.

Compared to the 40 pages that Ward devotes to sdb, the 8-page discussion on the more interesting debugger, CodeView, seems to be an afterthought. Nor are the discussions of sdb and CodeView structured alike.

I found the discussion of C-terp more interesting than those of sdb or CodeView. Ward discusses the differences between interpreters and compilers, along with the debugging functions of C-terp and some of the commands. The relevance of the commands and functions to finding particular bugs is clear and supported by short examples.

Source Code and Other Resources

Debugging C contains an annotated resource list of texts on C and software development. Although the books and articles referenced are popular, the list is inappropriate for a book on debugging. The only ones that seem somewhat appropriate are the sections related to C.

Ward also provides the source code for a full-featured debugging system. The debugger is a small command interpreter that is linked with your program. The commands control the watch and stop points that you code into your program. Ward also includes the source code to a poor man's Ctrace, a text filter that you can insert into your program calls to a debugging system like the one supplied. It is amusing to note that the coding style requirements on the programs input to Ctrace will not accept the author's programs because the `break` and `return` statements are concatenated on the ends of other statements. This is contrary to the statement in the text that says that the programs comply with Ctrace's input requirements.

The book contains 30 pages of source code listings in the appendixes and a reference to a public domain brace checker. The publisher should have considered offering readers a copy of the source code on disk.

Since I am interested in doing further reading on debugging, I checked out the bibliography. To my disappointment, there wasn't a single reference to an article or book on debugging.

A Good Buy

Although *Debugging C* has flaws, it contains many useful insights for C programmers. Many of the topics it covers—the discussion on finding C bugs, the discussion on proximity of errors, the explanation of tracing techniques, and the explanation of the organization of the stack during run time—are difficult to find elsewhere. In sum, the book is worth its cost.

Rudy Bazelmans, a software engineer for Wang Laboratories, lives in Nashua, New Hampshire.

THE PROGRAMMER'S GUIDE TO WINDOWS

Reviewed by David Hart

Sybex, San Francisco, CA: 1987, ISBN 0-89588-362-7, 645 pages, $21.95

If you are a programmer working with Microsoft Windows, or you'd like to be working with it, *The Programmer's Guide to Windows* is for you. An introduction to and explanation of the complex world of Windows programming, the book is meant to

continued

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complement, rather than replace, the documentation included with the Microsoft Windows Software Development Kit.

Authors David Durant, Geta Carlson, and Paul Yao have divided the book into three major sections. The first section introduces the Windows system and emphasizes the programmer's concern with the various features. The discussion is lucid and complete, so readers gain a basic understanding of the Windows system necessary to begin learning the specifics. This kind of explanation isn't available elsewhere.

The Microsoft documentation, on the other hand, written by those who know the system inside out, assumes that you are familiar with parts of Windows not yet introduced. As a result, gaining a working understanding is a difficult and frustrating challenge. The overview in *The Programmer's Guide to Windows* alleviates most, if not all, of that frustration.

Sample Programs

The last chapter of the first section presents a program named `Skeleton`. As its name suggests, `Skeleton` is a framework upon which to build full-blown Windows programs. All the sample programs in the book are based on `Skeleton`, which generates an empty window and displays an "About..." dialog box on request. The program to accomplish that is over 500 lines long. While it doesn't do much useful work, `Skeleton` takes care of the housekeeping—opening, displaying, repainting windows, and so on—that all Windows programs require. `Skeleton` also provides a sound structure with places clearly marked to add code for initialization, repainting, and responding to messages.

The bulk of *The Programmer's Guide to Windows* is the second section, a collection of chapters that introduce specific features of Windows with a sample program. The authors discuss each topic briefly, then present a program to illustrate the feature. They explain in detail each element of the program's code not previously introduced. This example-rich approach makes understanding the topic much easier than the dry explanations of the Microsoft manuals would have us believe.

This section covers all the topics of interest to Windows programmers: text display, menus, dialog boxes, mouse input, graphics output, child windows, file and printer I/O, memory management, dynamic libraries, and data transfer. The description of dialog boxes in particular is especially revealing because it is so much more understandable and detailed than the coverage in the Microsoft documentation. As is too often the case, the Microsoft manuals describe each function well but fail to provide an adequate overview. The explanation of Microsoft's much-touted Dynamic Data Exchange (DDE) also stands out for the same reason. DDE isn't mentioned in the Microsoft documentation, but it is fully explained with a set of sample programs in *The Programmer's Guide to Windows*.

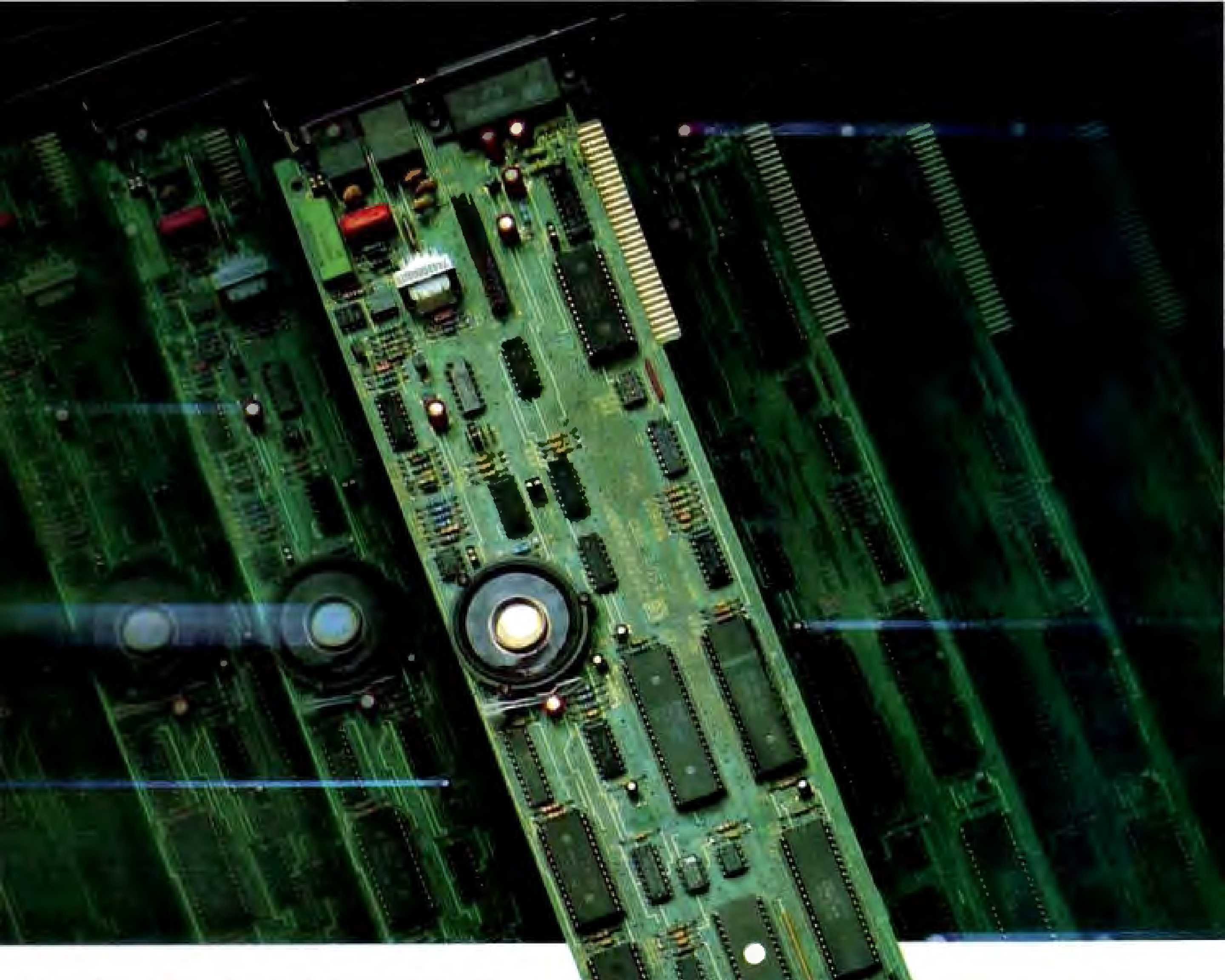
All the examples from the book—along with a few extras, including a Windows version of the Game of Life—are available separately from the authors on one 1.2-megabyte floppy disk for $25 or on four 360K-byte disks for $30.

The disk does have some irritating minor errors. For one thing, all the programs were developed from the `Skeleton` program, and many of them still have comments identifying them as the `Skeleton` program. `Printer`, the sample printing program, contains in its resource script file a reference to `Graphics.h` that should be a reference to `Printer.h`. As a result, the program doesn't compile. The authors should have taken more time to double-check their disk.

Programming Tools

The last section of *The Programmer's Guide to Windows* explains the operation of the programming tools used to develop Windows programs. Sample command lines are given for the

continued



Microsoft C Compiler, the Windows Linker (`Link4`), and the Windows Symbolic Debugger (`Symdeb`).

The Microsoft C command lines given in the book are different from those on the optional disk, though they are functionally equivalent. The `Link4` command lines in the book are also different from those on the disk. In this case, however, the book's version is incorrect. One of the command-line switches (parameters) is in the wrong place, so the linker gives an uninformative error message. Most of the `Link4` command lines on the disk are correct, but a few follow the example of the book, and therefore they don't work. The `Symdeb` command lines are all correct. The moral here is to follow the examples from the Windows Software Development Kit disks.

The Programmer's Guide to Windows is a useful book that can save many hours in training programmers new to Microsoft Windows. It is also a useful reference for a quick brush-up on a particular topic. The optional disk costs more than the book, but its cost isn't difficult to justify if you plan on doing much Windows programming, since it could save hours of typing in examples. The erroneous `Link4` command lines in the book and the errors on the disk are irritating, but if you're doing serious Windows programming, you don't want to be without the book or the disk.

David Hart lives in Chestertown, Maryland, and writes frequently about Windows and Windows applications.

FAST ACCESS\WORDPERFECT

Reviewed by John Unger

Brady Books, a division of Simon & Schuster, New York, NY: 1987, ISBN 0-13-307489-7, 200 pages, $12.95

Fast Access\WordPerfect by Rhyder McClure takes advantage of the fact that WordPerfect, like other powerful word-processing programs, is not easy to learn to use in an intuitive way. The book is designed to help beginning WordPerfect users overcome some of the hurdles that prevent them from getting the most from this software. Experienced WordPerfect hands will not get much from the book; there are no arcane secrets to be learned here.

McClure's writing style is light and easy to read. The book is organized alphabetically into separate chapters from one to six pages long. The chapters describe major WordPerfect commands, such as `Cut/Copy a Column`, `Go to Key`, or `Undelete`. Each chapter follows the same format: First the author presents a clear explanation of the WordPerfect command, then at least one easy-to-follow example and a description of the result of the command's action.

The final 40 pages of the text contain step-by-step examples of 11 useful WordPerfect macros; this section will give readers the confidence to use this powerful feature of WordPerfect for their own applications.

Presumably, because of the book's A-to-Z structure, McClure decided that an index would be superfluous. This was an unfortunate oversight, because the absence of an index seriously reduces the book's usefulness. An index should be an essential part of a reference text like *Fast Access\WordPerfect*. If WordPerfect's on-line help is too terse for you and the WordPerfect manual is too difficult and time-consuming to use routinely, then a book like *Fast Access\WordPerfect* may be just what you need to get the most out of WordPerfect. ■

John Unger lives in Hamilton, Virginia. He writes graphics software and uses computers to study the structure of the earth's crust.


123
123
123

PC Transporter taps into the world's largest software library. Now your Apple can run most of the IBM software you use at work. And it opens a new world of communications programs, games and bulletin boards.

A universal disk drive controller.

PC Transporter supports 3.5" and 5.25" MS-DOS and ProDOS formatted diskettes. You'll shift instantly between Apple ProDOS and IBM MS-DOS.

You'll need our versatile 5.25" 360K drive system to run IBM applications from 5.25" floppy disks. Use your Apple 5.25" drive for Apple 5.25" disks.

An Apple Disk 3.5 Drive will support the new 3.5"disks whether they're IBM MS-DOS formatted or Apple ProDOS formatted. The PC Transporter acts like an Apple Disk 3.5 Drive disk controller for IIGS, IIe, and II Plus users.

PC Transporter supports up to 5 drives in a number of combinations.

For example, you can connect a 5.25 Applied Engineering 360K dual-drive system directly to the card. Then plug two daisy-chained Apple 3.5 Drives (not the Apple UniDisk 3.5) to the dual-drive system. For a fifth drive, use a ProDOS file as an IBM hard disk.

PC Transporter controls Apple and IBM compatible disk drives. It supports 3.5" and 5.25" MS-DOS and ProDOS formatted diskettes.

Versatile data storage.

PC Transporter reads MS-DOS and translates it into Apple native ProDOS. You can store IBM programs and data on any ProDOS storage device including the Apple 3.5 Drive, Apple UniDisk™ 3.5, Apple 5.25" drive, SCSI or ProDOS compatible hard drives. (You can use the Apple UniDisk 3.5 with its own controller card for storing programs and data, but not for directly booting an IBM formatted disk.)

You can even use our 360K PC compatible drive for ProDOS storage and a 143K Apple 5.25" drive for MS-DOS storage.

Make your Apple speak IBM.

PC Transporter memory choices.

RAM in Apple mode:	RAM in IBM mode:	Price:
384K	**256K**	**$489.00**
512K	**384K**	**529.00**
640K	**512K**	**569.00**
768K	**640K**	**609.00**

Note: The IBM mode is 128K less because the PC Transporter uses 128K for system memory.

IIGS Installation Kit	**49.00**
IIe/II Plus Installation Kit	**39.00**
PC Transporter Accessories	
5.25" IBM Format 360K Drive Systems	
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Dual-Drive System	**399.00**
Half-Height Drive (add to Single-Drive system to make Dual-Drive)	**135.00**
IBM-Style Keyboard (required for Apple II Plus. Requires IBM Keyboard Cable.)	**139.00**
IBM Keyboard Cable	**34.00**
Sony RGB Monitor	**499.00**
Analog RGB Cable (for use with Sony monitor)	**39.00**
Digital RGB Cable (for use with Sony monitor)	**39.00**
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ColorSwitch (included with IIGS Installation Kit)	**44.00**
128K ZIP PC Transporter Memory Expansion Chip Set	**40.00 per set**
8087-2 Math Co-processor Chip	**229.00**
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PC Transporter produces better IBM graphics than IBM. Analog is sharper than digital. So with an analog RGB monitor, PC Transporter's CGA graphics and text are superior to IBM's digital display — even while running IBM software!

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The brains behind PC Transporter were also behind your Apple II.

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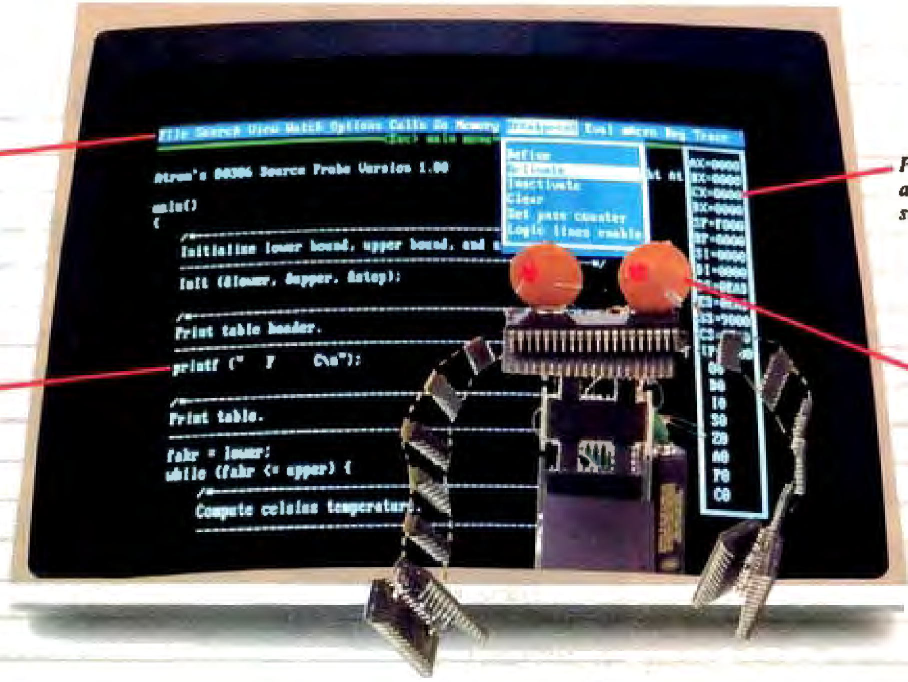
Products in Perspective

IT'S TIME TO DO SOME SERIOUS 386 BUGBUSTING!



Welcome to your nightmare. Your company has bet the farm on your product. Your demonstration wowed the operating committee, and beta shipments were out on time. Then wham!

All your beta customers seemed to call on the same day. "Your software is doing some really bizarre things," they say. Your credibility is at stake. Your profits are at stake. Your sanity is at stake.

THIS BUG'S FOR YOU

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.

Now, with the 386 PROBE, you have the capability to set a *qualified breakpoint*, so the breakpoint triggers only if the events are coming from the wrong procedures. So you don't have to be halted by breakpoints from legitimate areas. You can even detect obscure, sequence-dependent problems by stopping a breakpoint only after a specific chain of events has occurred in a specific order.

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.

COULD A GOOD NIGHT'S SLEEP PUT YOU IN THE TOP TEN?

Look at it this way. Nine of the top-ten software products in any given category were created by Atron customers. Maybe their *edge* is — a good night's sleep.

Call and get your free, 56-page bugbusting bible today. And if you're in the middle of a nightmare right now, give us a purchase order number. We'll FEDEX you a sweet dream.

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SYSTEMS

Mac Tower Packs Gigabytes

The Giga Tower from Giga Cell Systems/NuData is a line of ultra-high-capacity hard disk systems that incorporate Apple's complete Macintosh II system, including the monitor and keyboard. Besides the heart of the Mac II, the basic setup includes a 40-megabyte tape backup system, a 10-megabyte removable-media drive, and a single 800K-byte 3½-inch floppy disk drive.

The Tower's hard disk storage is available in five flavors: 270 megabytes, 580 megabytes, 870 megabytes, 1.16 gigabytes, and 1.45 gigabytes. The entire system comes with a full range of software including memory management, hard disk compression and optimization, and full backup software.

Price: From $18,950 to $34,950.

The Giga Tower includes a Mac II.

Contact: Giga Cell Systems/NuData Inc., 4201 Burton Dr., Santa Clara, CA 95054, (408) 727-1049.

Inquiry 751.

Unicorn Gallops at 30 MHz

This Unicorn runs Unix at 30 MHz.

The Unicorn B/200 is Microproject International's multiuser system that runs at 30 MHz using AT&T's WE 3220X chip set. Supporting 50-plus users, the Unicorn is object-code- and media-compatible with AT&T's 3B computers, which have over 1000 applications programs available.

The Unicorn runs Unix System V/VME 3.1, which has new features including shared executable libraries, remote file sharing, media independent networking, and a streams communications interface.

The system includes a VME processor board with the 30-MHz WE 32200 processor, the 3.5-MWHETS WE 32206 math coprocessor, and the WE 32201 MMU/cache, which combines a 99.8 percent hit rate, multiuser, memory management unit with 4K bytes of two-way set-associative, zero-wait-state, physical data cache.

To reduce bus traffic and speed data transfers between peripherals and main memory, the Unicorn also has a 68020-based disk controller that has a 32-bit direct-memory-access (DMA) controller and 128K bytes of buffering. There's also a serial communications module to assist interrupt-intensive tasks.

Unicorn includes 4 to 16 megabytes of RAM, a SCSI interface, multiple hard disk drives with capacities of 85 to 760 megabytes, high-density floppy disk drives, a 9-track or streaming-tape cartridge, 2 to 66 RS-232C serial ports, and Ethernet.

Price: $20,000 to $45,000.

Contact: Microproject Corp., 4676 Admiralty Way, Suite 610, Marina del Rey, CA 90292, (213) 306-8000.

Inquiry 752.

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We'd like to consider your product for publication. Send us full information, including its price, ship date, and an address and telephone number where readers can get further information. Send to New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Information contained in these items is based on manufacturers' written statements and/or telephone interviews with BYTE reporters. BYTE has not formally reviewed each product mentioned.

Hyundai's First File Server

The Super-286, Hyundai's first LAN-related product, is also configurable as a stand-alone personal computer. It has six 16-bit and six 8-bit expansion slots, and space for five half-height drives.

The speed of the Hyundai is switchable between 8 and 10 MHz with zero wait states. Standard features include 1 megabyte of RAM on the motherboard, a single 1.2-megabyte floppy disk drive, a 101-key keyboard, MS-DOS 3.2, and GWBASIC 3.2. An 80287 math coprocessor is optional, and Hyundai has optional hard disk drives available in capacities of 20, 30, 40, or 70 megabytes.

Price: $1999.

Contact: Hyundai Electronics America, 4401 Great America Parkway, Santa Clara, CA 95054, (408) 980-7561.

Inquiry 753.

continued

PERIPHERALS

Remove That Hard Disk

If you own an Amiga, Atari, or Macintosh, you can hook it up to Supra Corp.'s SupraDrive FD-10, a 10-megabyte hard disk system that uses 5¼-inch floppy disks.

With an average access time of 80 milliseconds, the company says the FD-10 approaches the speed of a normal (nonremovable) hard disk while letting you easily transport data or make backups. The FD-10 comes with software and cables ready to plug in and use. On the Amiga and Macintosh, it connects to the SCSI interface; on the Atari, it connects to the DMA port.

Price: For Atari and Macintosh, $895; for Amiga, $1095.
Contact: Supra Corp., 1133 Commercial Way, Albany, OR 97321, (503) 967-9075.
Inquiry 754.

Add a hard disk drive to your Amiga, Atari, or Mac.

Apple Wages Laser War

Apple's new laser printers are named the LaserWriter IINTX, the LaserWriter IINT, and the LaserWriter IISC. They range from a $6599 model to a $2799 PostScriptless model. In the middle is a $4599 PostScript model. You can upgrade the low- and mid-range printers for more functionality by simply slipping out and replacing their controller boards.

The three printers each weigh 45 pounds. They are built around the Canon LBP-SX printer engine and print at a maximum rate of 8 pages per minute. The NT and NTX models both come with 2 megabytes of RAM; the SC has 1 megabyte.

Apple has also improved the paper-handling capabilities of its laser printers with these new models; the LWII line has automatic paper handling with a 200-sheet paper cassette with face-up or face-down output trays. Each input cassette can hold up to 200 sheets of 20-pound paper; letter, legal, A4, B5, and envelope cassettes are available.

According to Apple, the duty cycle provides for a minimum life expectancy of 300,000 pages with unlimited monthly output.

Price: LaserWriter IISC, $2799; LaserWriter IINT, $4599; LaserWriter IINTX, $6599.
Contact: Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (408) 996-1010.
Inquiry 755.

Husky Mac Displays Assault the Old Standard

Two large-screen monitors for the Macintosh are becoming more prevalent. Each takes a vastly different approach for users with different needs.

The MacGenius is a 15-inch full-page display that's designed to work with the Macintosh 512, Plus, and SE. With a black-on-white page display, the monitor displays up to 720 by 1008 pixels at 100 dots per inch using a 1-to-1 aspect ratio.

Compatible with virtually all Macintosh software, you can use the MacGenius in concert with the Mac's built-in 9-inch screen. With both screens active, you can use the Mac's main screen to hold desk accessories, tool palettes, and document windows.

The monitor is noninterlaced, with a 60-Hz refresh rate. Its horizontal scan frequency is 62.76 kHz, and it has a video bandwidth of 100 MHz.

Price: $1795.
Contact: Micro Display Systems Inc., 1310 Vermillion St., P.O. Box 455, Hastings, MN 55033, (800) 328-9524; in Minnesota, (612) 437-2233.
Inquiry 756.

The MacLarger takes a slightly different, lower-cost approach to big Mac screens by simply enlarging the image 60 percent over the standard Mac screen while retaining the Mac's standard 512- by 342-pixel resolution.

The monitor is shipped along with a video board that the company says you can install in about 15 minutes without making any major modifications to your Mac 512, Plus, or SE. Another standard feature is that the video board has a composite video output, which you can use to drive a standard monitor or projection television (though, of course, at much lower resolution than the standard Mac screen).

Price: $449.
Contact: Power R, 1606 Dexter Ave. N, Seattle, WA 98109, (206) 547-8000.
Inquiry 757.

A Duet of Drives for the Mac SE

If you own a Macintosh SE, you now have an increasingly wide selection of hard disk drive options for your electronic beast, with higher and higher capacities fast becoming the norm. Here are two examples:

Jasmine Technologies' InnerDrive 40/SE is a 40-megabyte drive that you install inside the SE's case. It sits above the Mac's dual internal drives, so you don't need to remove a floppy disk drive for it.

According to its manufacturer, the InnerDrive 40/SE has an average access time of 29 ms. It's shipped with a mounting bracket, cables, and other installation hardware, as well as 9 megabytes of public domain and shareware programs, and a backup program.

Price: $999.
Contact: Jasmine Technologies Inc., 555 De Haro St., San Francisco, CA 94107, (415) 621-4339.
Inquiry 758.

If you have gigantic Macintosh data-storage needs, Relax Technology is shipping what it claims is the fastest and largest hard disk drive for the Mac SE. With a capacity of 91 megabytes, the Relax SE 91 has an average access time of 16.5 ms.

The SE 91 takes the place of the upper 800K-byte drive in the SE, and you'll have to have a dealer install it. The drive comes with firmware self-diagnostics that automatically locate, isolate, and reallocate bad sectors.

You can also install the Relax SE 91 in a Mac II.

Price: $1795.
Contact: Relax Technology Inc., 3101 Whipple Rd., Suite 22, Union City, CA 94587, (800) 848-1313; in California, (415) 471-6112.
Inquiry 759.

continued

PERIPHERALS

Draw Easy with EASYL

EASYL PC is a pressure-sensitive 1024- by 1024-pixel tablet that you can use to draw or trace directly into your computer just like using a normal pen or pencil on paper. Typical applications include desktop publishing, presentation systems, design, art, animation, and touch control. It sends coordinate pairs to your computer at speeds of up to 200 pairs per second.

EASYL PC runs on any IBM PC or compatible and is designed to run in either EGA or CGA mode using most graphics software such as PC Paintbrush or Dr. HALO. It also works with software that runs under GEM or Windows.

The tablet comes with its own driver software, but it can also emulate both the Summagraphics MM961 and Bit Pad One. You set all EASYL PC options via software; there are no DIP switches.

With the EASYL PC tablet, you also get a half-length interface card. The card has two ports: one for the graphics tablet, and one for any standard RS-232C serial device such as a mouse, modem, or serial printer.

Price: $539.

Contact: Inforite Corp., 1670 South Amphlett Blvd., Suite 201, San Mateo, CA 94402, (415) 571-8766.

Inquiry 760.

Laser Printer Tackles the Big Jobs

Outputting 15 pages per minute and with a rated monthly output of 40,000 copies, the Kentek K-2+ laser printer is designed for heavy-duty use. The printer is shipped with a megabyte of internal RAM for full-page 300- by 300-dpi graphics. RS-232C, RS-422, and parallel interfaces are standard. The K-2+ also has a built-in 1.2-megabyte floppy disk drive that lets you load customized data into the printer's memory, including up to 30 font sets, and macros for images such as forms, signatures, or logos.

Although the K-2+ uses the proprietary Kentek Command language, it also emulates the HP LaserJet Plus, Diablo 630, and Plot 10. GSS/CGI emulation is optional.

One unique feature of the printer is a job-recovery function that lets you reprint the page that's stored in the printer's memory even in the event of a printer error. A bit-mapped page remains in the printer's internal memory until it receives a signal indicating that paper has exited.

You can feed up to 550 sheets of letter- or legal-size paper from the primary cassette, and up to 250 sheets from the secondary cassette. Optional 1200-sheet primary and 550-sheet secondary cassettes are available. The Kentek K-2+ weighs 132 pounds and measures 14 by 26½ by 18½ inches.

Price: $8970.

Contact: Kentek Information Systems Inc., 6 Pearl Court, Allendale, NJ 07401, (201) 825-8500.

Inquiry 761.

Two Color Printers from Honeywell

Honeywell Bull Italia has two new color printers: the 4/40 and the 4/41, which use standard-width and wide-width forms, respectively. Both have three print modes: draft at 300 characters per second, near-letter quality at 180 cps, and letter quality at 70 cps.

Both printers have bottom-feed push tractors that let you load fanfold paper from rear or bottom trays, and a straight paper path that makes it easy for you to use heavy paper stock, multipart forms, or labels. And speaking of multipart forms, the printers use what the company calls a stored-energy print head to handle up to six-part forms with a thickness of up to two hundredths of an inch.

The printers let you feed individual sheets, cut forms, and envelopes without having to unload fanfold paper. If that isn't enough, you can get any of three optional cut-sheet feeders. Both the 4/40 and 4/41 emulate the Epson JX-80, IBM Proprinter XL, and the IBM Graphics Printer. Using the front panel and its alphanumeric display, you can choose the printer setup as well as set the page format and print modes.

Price: 4/40, $1195; 4/41, $1395.

Contact: Honeywell Bull Italia, 120 Howard St., Suite 800, San Francisco, CA 94105, (415) 974-4340.

Inquiry 762.

continued

FORCE STICK BORROWS MILITARY TECHNOLOGY

What has to be the Cadillac of joysticks isn't even called a joystick. Tactron Scientific calls its device the Tactron F3 Series Force Stick. More conventional pointing devices such as joysticks, trackballs, tablets, or mice usually employ wheels, mechanical linkages, or optical sensors. But the Force Stick uses semiconductor strain gauges: very expensive yet sensitive and accurate circuits that are integrated into the Force Stick's apparently rigid control rods.

The strain gauges are virtually identical to those used in military applications, such as the control stick on the Air Force's F-16 fighter jet. Unlike ordinary pointing devices, which sense position, the strain gauges in the Force Stick sense the force applied. The company says the result is that the Force Stick has the seemingly contradictory capability of being so sensitive yet easy to control and position.

Each Force Stick is 5¾ by 7¾ inches and is housed in a jet-black anodized aluminum case. Two models—2- and 4-axis versions—are available, each with six microswitches. Hidden in the case are an on-board microprocessor and signal-conditioning circuitry that lets you choose linear or accelerated force modes. The Force Stick plugs directly into an RS-232C port and emulates the Microsoft Mouse, Mouse Systems Mouse, and the Summagraphics MM series.

Price: 2-axis version, $765; 4-axis version, $965.

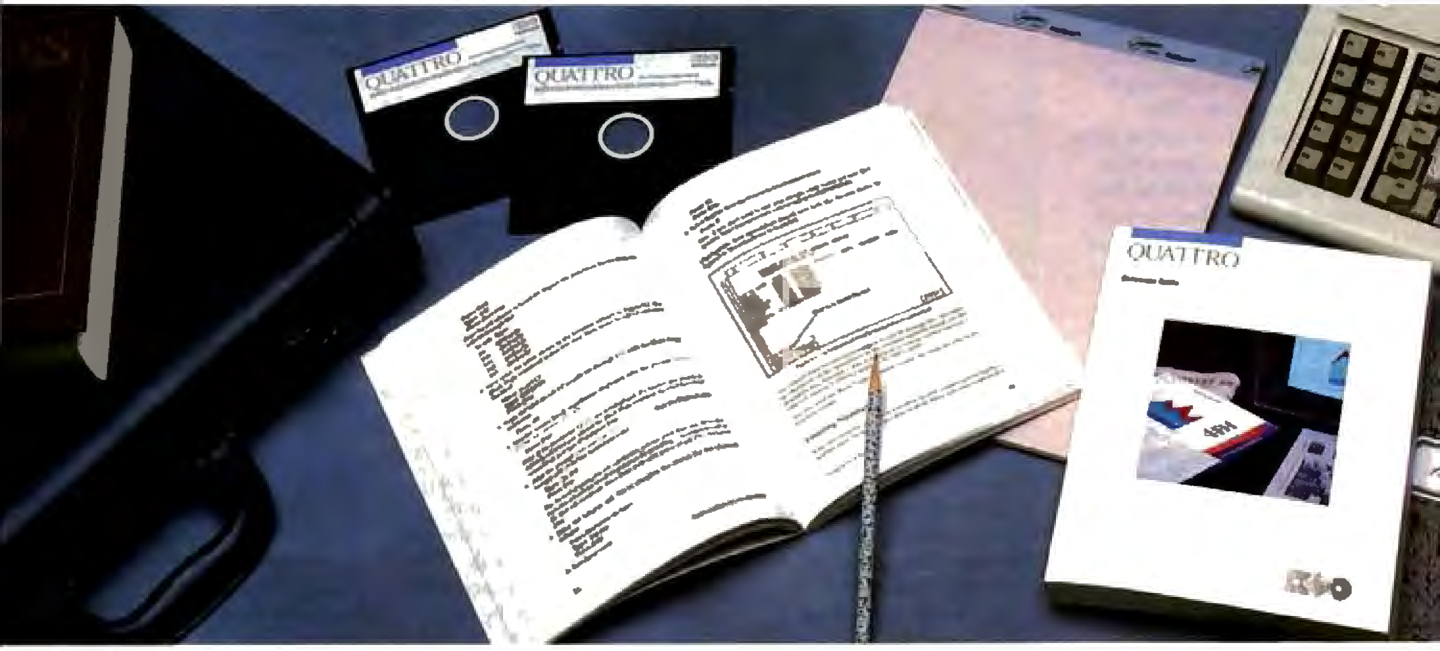
Contact: Tactron Scientific Inc., 7265 Mountain Trail, Dayton, OH 45459, (513) 434-4117.

Inquiry 763.

Force Sticks are the closest thing to flying an F-16.

"Those who are considering purchasing 1-2-3 will be better off with Quattro"

—John Walkenbach, InfoWorld



Here's what InfoWorld had to say about Quattro

"There are some clear advantages in choosing Quattro over the 1-2-3 of today: easier installation, no copy protection, improved speed, much better macros, excellent graphics, a customizable command interface, and direct compatibility with industry standard file formats. If cost is a factor, you can get five copies of Quattro for the same money that would buy two 1-2-3 packages."

Features: Improving the industry standard

"Quattro takes the industry standard and improves upon it in the areas that count most. It addresses many of the weaknesses of 1-2-3 and adds quite a few of its own unique touches."

"Perhaps Quattro's main advantage over most other spreadsheets is its minimal recalculation capability. When you make a change in your spreadsheet, only affected cells are recalculated, greatly speeding things up in most cases."

"Other Quattro features that improve upon the 1-2-3 standard include auto-record macros, vastly superior graphics, and easy installation."

Performance: Markedly superior to 1-2-3

"Our benchmark tests show Quattro markedly superior to 1-2-3 in file saves and retrieves."

"Quattro's graphics are a sight to behold."

"Quattro makes working with macros practically painless. If you're into complex 1-2-3 macros, the debugging feature alone is good reason to make the switch to Quattro."

"No one can argue that Quattro is anything less than an excellent spreadsheet value."

Excerpts from John Walkenbach's review of Quattro™ in InfoWorld, January 11, 1988.

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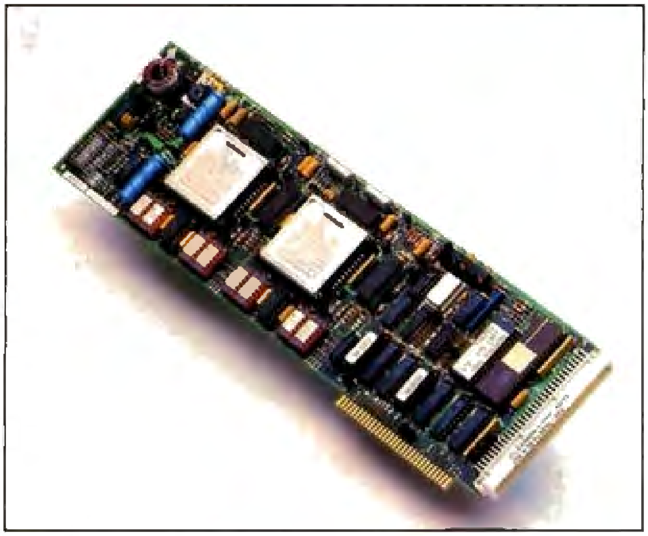
ADD-INS

Get a Safety Bubble for your PC

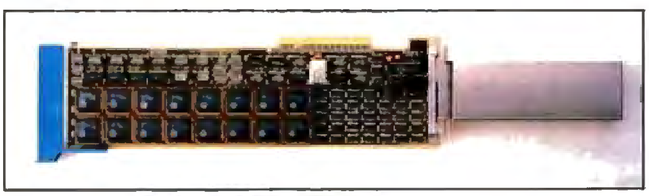
Designed primarily for use in harsh environments or where memory downtime would cause critical problems, the PCB-76 PC bubble expansion board from MemTech adds solid-state, nonvolatile bubble memory to your IBM PC, XT, AT, or compatible. The card needs a full-length slot and comes in either 512K-byte or 1-megabyte sizes.

The board is shipped with an I/O driver in EPROM that makes the board look to your computer like a standard hard disk drive, albeit with a much slower access speed. The driver is compatible with versions 2.0 through 3.2 of both MS-DOS and PC-DOS. If your application calls for read-only use, you can use a jumper to write-protect the individual 512K-byte bubble memory devices.

Price: 512K, $995; 1 megabyte, $1695.
Contact: MemTech, 3000 Oakmead Village Dr., Santa Clara, CA 95051, (408) 980-5300.
Inquiry 764.



MemTech adds up to 1 megabyte of bubble memory.



Add 16 serial ports to your PS/2.

A Port Bonanza for the Micro Channel

If the single serial port that's included with your IBM PS/2 Model 50, 60, or 80 isn't sufficient for your I/O needs, the DigiBoard PS-COM/X is a full-length Micro Channel card that comes in two models to add 8 or 16 serial ports to the system.

If even 16 ports aren't enough, you can use up to four boards to provide up to 64 ports. Designed for multiuser systems, multiple-point data acquisition, and other multi-I/O applications, the DigiBoard PS-COM/X mounts up to 16 RJ-45 connectors in a compact shielded extension of the board that extends through the card slot.

The board comes with COMWare, the DigiBoard communications device driver, and software utilities. COMWare lets MS-DOS access up to 64 communications ports. OS/2 support is also available. Software drivers are available for SCO-Xenix/286 and /386, and the company says it's developing drivers for the PS/2 versions of Unix, Xenix, PICK, THEOS, QNX, and PC-MOS.

Price: 8 ports, $895; 16 ports, $1295.
Contact: DigiBoard Inc., 6751 Oxford St., St. Louis Park, MN 55426, (800) 344-4273; in Minnesota, (612) 922-8055.
Inquiry 765.

The Shack Accelerates the 1000

If you own a Tandy 1000 SX or one of the original Tandy 1000 personal computers, you too can join the era of speed and power with Tandy's 286 Express accelerator card. Developed by PC Technologies, Tandy claims the 80286-based board increases the performance of the 8088-based 1000 and 1000 SX between 200 and 600 percent—making its speed approximately equivalent to an 8-MHz IBM PC AT.

The 286 Express is a half-slot card that runs at 7.2 MHz. It has 8K bytes of on-board cache memory and a socket for an optional 80287 math coprocessor. Using keyboard commands, you can choose either 8088- or 80286-based processing modes, and you can turn the cache on and off. Tandy says the card is also compatible with all IBM PC hardware and software, including EGA, expanded-memory-specification (EMS), and LAN boards.

Price: $399.95.
Contact: Tandy Corp./Radio Shack, 1800 One Tandy Center, Fort Worth, TX 76102, (817) 390-3700.
Inquiry 766.

Mac Accelerators Exceed the Speed Limit

Radius, a company known mainly for its large-screen monitors, now has a 68020-based accelerator card that runs at 25 MHz and, the company claims, boosts the performance of a standard Mac SE by a factor of 6. The Accelerator 25 card also supports an optional 68881 floating-point math coprocessor that, when installed, can execute numeric operations considerably faster than a standard SE.

To achieve the performance gains, Radius uses write-through logic with a high-speed cache that consists of 32K bytes of static RAM. This provides a 32-bit-wide data path and zero wait states for high-speed access to the display buffer. Additionally, the company credits some of the performance gains to the software algorithms built into the board's firmware.

Price: Under $2000.
Contact: Radius Inc., 404 East Plumeria Dr., San Jose, CA 95134, (408) 434-1010.
Inquiry 767.

Meanwhile, Aox claims its DoubleTime-16 accelerator card doubles the speed of a Mac SE. At the same time, the company claims, the board provides complete hardware and software compatibility at a comparatively low price.

The board uses a 68000 microprocessor running at 16 MHz and a proprietary cache system. It plugs into the SE's option-card slot, with no cables to connect or chips to remove. It also has a socket for a 68881 math coprocessor chip. You can switch the accelerator between 16 MHz and the native 8 MHz by using a Control Panel desk accessory.

Price: $395.
Contact: Aox Inc., 486 Totten Pond Rd. Waltham, MA 02154, (617) 890-4402.
Inquiry 768.

continued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They picked Proteus computers for their Goddard Space Flight Center in Greenbelt, Maryland.
NASA is a regular customer of Proteus. So are Xerox, RCA, GE, Dupont, GM, Revlon, General Dynamics, the U.S. government, the United Nations, MIT, Harvard and Cornell. And the list doesn't stop there either.
Even leading computer manufacturers like Digital Equipment Corporation, Honeywell, ITT and Prime buy regularly from Proteus.
They know Proteus computers have a price/performance ratio that's light years ahead of IBM and the other desk-top computer makers. And the computer magazines agree.
Personal Computing magazine had this to say, "Prices for the different models and peripherals classify Proteus as a low-ball clone, but its speed, expansion capability and service contract put it in a class with the big boys."
CUSTOM BUILT
What's more, every Proteus computer is custom built to exact specifications. Your specifications.
Tell us which drives to use, which EGA adapters to put in. And we'll match your needs. Just as we have for NASA.
MADE IN AMERICA!
Proteus computers are engineered and manufactured right here in the USA.
They have the power and speed needed to get big jobs off the ground. Featuring 8088/80286/80386 models ranging from 6MHz to a whopping 20MHz!
This high speed, plus our timing and IBM standard Bus design, give Proteus machines supreme hardware compatibility and adaptability.
Every Proteus computer is guaranteed IBM compatible or your money back!
Proteus computers are also guaranteed compatible with OS/2, UNIX, XENIX, NOVELL, 3COM, PICK, THEOS and all major operating systems.
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PROTEUS COMPUTERS!

PROTEUS 386A

16MHz / 20MHz, Ø-wait-state

This very fast 80386 based computer utilizes advanced Cache memory and special memory mapping techniques to bring you the power of a minicomputer.

InfoWorld magazine named the Proteus 386A one of the top 100 products of the year! Calling it, "A 16-MHz, Ø-wait-state 80386 hot rod."

The Proteus 386A is perfect for CAD/CAM, desktop publishing, file serving, data base management or multi-user and LAN operating environments.

16MHz $2595
20MHz $3190

386A standard features:

- 80386 CPU, 16/20MHz, Ø-wait-state.
- 64K Cache memory.
- 1024K RAM expandable to 4MB of 32-bit RAM on systemboard.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply, 110/220V.
- ROM based setup and diagnostics.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive. Free replacement with 3.5" or 360K drive.
- Optional hard disk. See chart.
- 101-key enhanced keyboard.
- 15-month warranty on parts and labor.
- Free on-your-site maintenance.
- 30 day, money back guarantee.
- Made in U.S.A.

386A monochrome system $2842*
386A EGA color system $3229**

***Monochrome systems include:** 14" high res. monitor and a 720x348 Herc. compatible graphics card with an additional parallel port.
****EGA color systems include:** High res. EGA color monitor and a 710x 420/680x480 EGA adaptor.

PROTEUS 286GTX

12MHz, Ø-wait-state

The 286GTX is perhaps the fastest 12MHz computer around. It provides perfect compatibility with an overall throughput of 16MHz.

InfoWorld said of the Proteus 286GTX, "It is a superb value, scores high in our benchmark tests, and Proteus has the best warranty and technical support."

This high speed 80286 based computer is ideal for networking, CAD/CAM, desktop publishing or business applications.

12MHz $1750

286GTX standard features:

- 80286 CPU, 12MHz, Ø-wait-state.
- 32K Cache memory.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200-watt power supply, 110/220V.
- ROM based setup and diagnostics.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive. Free replacement with 3.5" or 360K drive.
- Optional hard disk. See chart.
- 101-key enhanced keyboard.
- 15-month warranty on parts and labor.
- Free on-your-site maintenance.
- 30 day, money back guarantee.
- Made in U.S.A.

286GTX monochrome system .. $1997*
286GTX EGA color system $2374**

PROTEUS 286F

10MHz, Ø-wait-state

This 80286 based AT compatible is a fast, zero wait state computer roughly 15% faster than our model 286E.

PC Magazine said, "The 286F is an extremely fast 10MHz machine that does what it claims to do and backs that up with an aggressive support plan."

The 286F is perfect for network or business applications.

10MHz $1495

286F standard features:

- 80286 CPU, 10MHz, Ø-wait-state.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply, 110/220V.
- ROM based setup software.
- Reset switch.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive. Free replacement with 3.5" or 360K drive.
- Optional hard disks. See chart.
- 101-key enhanced keyboard.
- 15-month warranty on parts and labor.
- Free on-your-site maintenance.
- 30 day, money back guarantee.
- Made in U.S.A.

286F monochrome system $1742*
286F EGA color system $2129**

THE PROTEUS TOTAL SATISFACTION GUARANTEE

All of our products are guaranteed to give 100 percent satisfaction in every way. Return anything purchased from us at any time during the first 30 days if it proves otherwise. We will replace it, refund your purchase price or credit your credit card, as you wish. In addition, there is a **15-Month warranty** on labor and parts. Plus **Free on-your-site service.** If something goes wrong with your Proteus computer during the first two months, we'll send a qualified technician. There's also a **toll-free technical support hotline** and a 24-hour electronic support line.

24-HOUR CATALOG

Just dial (201) 288-8577 using your modem set to 1200B/N/8/1.

PROTEUS 286E

10MHz

Our 286E provides performance and value unbeatable by any other comparably priced machine.

InfoWorld magazine said, "For best machine in power, the Proteus 286E is the clear winner. We recommend it."

The 286E is ideal for home or office.

10MHz $1295

286E standard features:

- 80286 CPU, 10MHz.
- 1024K RAM.
- Clock, calendar and battery backup.
- Dual floppy and hard disk controller.
- 200 watt power supply, 110/220V.
- ROM based setup software.
- Socket for coprocessor.
- 2 serial and 1 parallel port.
- 1.2MB floppy drive. Free replacement with 3.5" or 360K drive.
- Optional hard disk. See chart.
- 101-key enhanced keyboard.
- 15-month warranty on parts and labor.
- Free on-your-site maintenance.
- 30 day, money back guarantee.
- Made in U.S.A.

286E monochrome system $1542*
286E EGA color system $1929**

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Seagate	40MB	28ms	$595.00
Miniscribe	44MB	28ms	$665.00
Miniscribe	72MB	28ms	$965.00
Priam RLL	100MB	24ms	$Call
Maxtor	140MB	18ms	$Call
Maxtor/ESDI	150/340MB	15ms	$Call

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HARDWARE • OTHER

A LITTLE MAC MUSIC

Apple Computer now has a MIDI device for connecting the company's computers to electronic musical instruments. The diminutive unit—measuring 3 by 2 by 1¼ inches—is aimed at professional musicians and educational institutions.

The Apple MIDI Interface doesn't need a separate power supply, and you can connect it to any model Macintosh or Apple IIGS computer using the computer's modem port. The device has one 8-pin DIN connector that attaches to the computer and two MIDI connectors: a MIDI-in plug and a MIDI-out plug.

According to the company, the Apple MIDI Interface is compatible with most MIDI software currently available for the Macintosh and Apple IIGS.
Price: $99.
Contact: Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (408) 996-1010.
Inquiry 773.

Watch My (AC) Line

The slings and arrows of outrageous AC power can play havoc with your valuable computer equipment. And since information is power, the Tasco AC Monitor will give you the power to know all about what's coming out of the outlets on your wall.

The AC Monitor plugs into any AC outlet and has a console that displays a number of present and past conditions. There's a readout of your current voltage in 5-volt increments, lights that lock on when voltage goes above 135 volts or below 105 volts, a light that shows if a high-voltage spike has occurred, and a power-failure light.

Used regularly, the AC Monitor may tell you more than you want to know about your local utility company and the possibility of computer damage.
Price: $138.
Contact: Tasco Ltd., 2875 West Oxford Ave., Suite 5, Englewood, CO 80110, (303) 762-9952.
Inquiry 769.

Matchbook-Size I/O

Into a package that measures 1½ by 2 by ¾ inches, the Tattletale Model V squeezes 11 10-bit A/D channels, 17 individually programmable digital I/O lines, a UART (universal asynchronous receiver/transmitter), and 28K bytes of RAM. The unit's 10-bit converter can sample and store all 11 channels at 100 Hz.

The Tattletale needs a battery-supply voltage of between 6.5 and 15 volts. If you're using it for a typical application with an external current drain of about 3 milliamperes, you can expect about a 5-day battery life from a 9-volt alkaline battery, or 20 days from six AA cells.

If you're familiar with BASIC, you can connect the Tattletale Model V to a computer or terminal and start developing applications immediately. The board's built-in TTBASIC operating system has special functions for data storage and retrieval, analog and digital I/O, and timekeeping and synchronization. There's also an in-line symbolic assembler for developing speed-critical subroutines.
Price: $395.
Contact: Onset Computer Corp., 199 Main St., P.O. Box 1030, North Falmouth, MA 02556, (617) 563-2267.
Inquiry 770.

Tattletale Model V communicates with the real world.

ADBridge Bypasses Mac Peripheral Problems

If you own an old-style (pre-II/SE) Macintosh, you don't need to feel left out by the blizzard of new accessories available for the Apple Desktop Bus (ADB). At the same time, if you have a Macintosh II or SE, you don't need to consign your old accessories to the trash heap.

Solutions to both of these problems come in the form of a product called ADBridge, a hardware interface that works both ways. If you're a Mac 512E or Plus owner, you can use the new Apple Desktop Bus mice and new keyboard (including the Apple Extended). If you own a Mac SE or Mac II, you can connect older devices such as trackballs, tablets, and joysticks to your newer Apple computers.

ADBridge has six connections for input and output. If you're a Mac SE or II owner, all you need to do is plug ADBridge into an ADB port and connect your peripherals. If you're a 512E or Plus owner, your setup will vary depending on what you want to do.

The makers of ADBridge claim that it's fully compatible with all software applications and all input devices. It's shipped with a software utility that does automatic configuration and lets older-machine users address the additional function keys that are available on the new Apple keyboards.
Price: $129.
Contact: Olduvai Corp., 7520 Red Rd., Suite A, South Miami, FL 33143, (305) 665-4665.
Inquiry 771.

Switch to Your Heart's Content

Patton Electronics says its line of data switches are a new breed that are simple to use and useful for complex applications.

The Micro Matrix Switches come in both 2-input/4-output (Model 24) and 4-input/4-output (Model 44) versions. You can use the two models to connect two or four computers, respectively, to any combination of four printers, plotters, terminals, or modems. The switches are all electronic and have no moving parts. They use DB-25 connectors and work with serial and parallel devices.

You can switch any 4, 8, 12, or 24 conductors on each connector, and the Micro Matrix switch can handle data rates up to 500 kilobits per second. The units handle voltages between +15 and −15 V DC, and there's a momentary-power-loss indicator on the front panel.
Price: Model 24, $345 to $595; Model 44, $495 to $995.
Contact: Patton Electronics Co., 7958 Cessna Ave., Gaithersburg, MD 20879, (301) 975-1000.
Inquiry 772.

continued

SOFTWARE • PROGRAMMING

GEOS GOES APPLE

Berkeley Softworks has ported GEOS (graphical-environment operating system), originally developed for the Commodore 64 and 128, over to the Apple II. This development provides a graphical interface and operating environment for the Apple IIe, IIc, and IIGS.

The system desktop has one Clipboard for text and one for images. It also organizes folders on pages, with eight to a page. Also included are geoPaint, geoWrite, and geoSpell: geoPaint is a MacPaint-like program; geoWrite is a WYSIWYG (what you see is what you get) word processor; and geoSpell is a 28,000-word dictionary and spelling checker. Other utilities and programs include a conversion utility for accessing word-processing files, a LaserWriter/PostScript printer driver, and desktop accessories including a calculator, notepad, alarm clock, and disk organizer.

Berkeley Softworks reports that it will release a database, spreadsheet, and programming utility later in the year.

To run GEOS on an Apple II, you need an 80-column card and 128K bytes of RAM. The system is limited, at this time, to monochrome.

Price: $129.95.
Contact: Berkeley Softworks, 2150 Shattuck Ave., Berkeley, CA 94704, (800) 443-0100; in California, (415) 644-0883.
Inquiry 780.

FORTRAN for the 386

Develop programs with up to 16 megabytes and run them in protected mode on 386 systems with SVS FORTRAN-386 from Science Applications International. SVS includes a native-code compiler, a run-time I/O system, a source-level debugger, and VM-RUN, which is a 386 run-time monitor. The program supports the Intel 80287/80387 and Weitek 1167 math coprocessors.

Science Applications International reports that SVS cuts the run time of a typical program by at least half when compared to using a 16-bit compiler running under DOS or OS/2.

The program supports FORTRAN 77 and incorporates IEEE floating-point operations, including single- and double-precision and complex arithmetic. Compiler directives and command-line options let you compile applications that use common, nonstandard FORTRAN conventions. The debugger lets you examine source code, access and modify variables by symbolic names, set breakpoints and tracepoints, and view the traceback environment.

Price: $895.
Contact: Science Applications International Corp., 5150 El Camino Real, Suite C-31, Los Altos, CA 94022, (415) 960-3322.
Inquiry 774.

Low-Cost Prolog on the Amiga

UNH Prolog, ported from the VAX-11/780 to Sun workstations and the IBM PC, is now running on the Amiga. The UNH Prolog interpreter is based upon the Edinburgh standard with extensions, including real numbers. It supports over 100 built-in predicates, including predicates for debugging and tracing.

To run UNH Prolog, you need an Amiga with at least 512K bytes of RAM, although at least 1 megabyte is recommended.

Price: $75.
Contact: The Department of Computer Science, University of New Hampshire, Durham, NH 03824, (603) 862-3778.
Inquiry 775.

A FORTRAN Tool for Every Purpose

FORTRAN BASIC Utilities contains two libraries of tools that provide a BASIC-like function for screens or interface control. Each tool is also CodeView-compatible.

One library is assembled for CodeView, and one is without debugging capabilities. The program includes a set of test programs and source code.

To run the FORTRAN BASIC Utilities, you need an IBM PC or compatible, DOS 3.0 or higher, and Microsoft FORTRAN 4.0. The company says that you don't need an assembler.

Price: $49.95.
Contact: Silver State Software, 1000 East William St., Suite 100, Carson City, NV 89701, (702) 855-8922.
Inquiry 776.

Copernicus Does DOS

Copernicus is a knowledge-engineering tool, according to Tecknowledge, and it has its own programming language and hooks for high-level languages. The knowledge system, previously run only on mainframes and workstations, is now available in a DOS version. It runs under Microsoft Windows on an 80286 or 80386 system and includes a DOS extender that lets you execute in protected mode.

Price: About $12,000.
Contact: Tecknowledge, 1850 Embarcadero Rd., P.O. Box 10119, Palo Alto, CA 94303, (415) 424-0500.
Inquiry 777.

Find Those Files

Execloc is a utility that helps you find MS-DOS .EXE files. According to Virtual Software, the program relocates all the segments as needed to within the 8088/8086 1-megabyte memory map. And it's not limited to locating just .EXE files, but can use any extension as it checks for a proper header signature in the file itself.

You can operate Execloc from the command line or from menus. The program includes a binary-to-hexadecimal conversion utility.

Execloc runs on the IBM PC and compatibles with DOS 3.0 or higher. The program is not copy-protected.

Price: $29.95.
Contact: Virtual Software, 51 Oak Ave., Richmond Hill, Ontario, Canada L4C 6R5, (416) 881-7665.
Inquiry 778.

A SANE FORTRAN Compiler for the Mac II

Language Systems Corp. reports that its FORTRAN compiler is the first FORTRAN implementation that fully supports Apple's SANE (Standard Apple Numeric Environment) floating-point routines. The compiler runs on the Mac II and also supports the full ANSI Standard FORTRAN 77 language, plus extensions and engineering number formatting.

Arrays can exceed 32K bytes, limited only by memory available, the company reports. Options let you accept Hollerith and other elements of FORTRAN 66 syntax and specify in-line 68881 object code.

Price: $295 (includes the MPW shell).
Contact: Language Systems Corp., 463 Carlisle Dr., Herndon, VA 22070, (703) 478-0181.
Inquiry 779.

continued

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SOFTWARE • SCIENTIFIC AND ENGINEERING

Data-Acquisition and Control Software

Control EG, an automation program for measurement and control systems, works with systems with up to 256 I/O points. Versions of the program are available for PC-based hardware from Analog Devices and MetraByte.

The program combines the features of data loggers, programmable controllers, and closed-loop PID controllers.

You can use Control EG to monitor analog and digital inputs, and you can graph and log temperatures to disk in real time. The program automatically handles linearization and/or engineering unit conversion. You can use your own equations or use PID calculations to set analog and digital outputs. You can define calculated points that are a mathematical function of other analog or digital inputs. Control EG lets you mix transcendental functions, Boolean functions, alarm conditions, and historical values within the same formula.

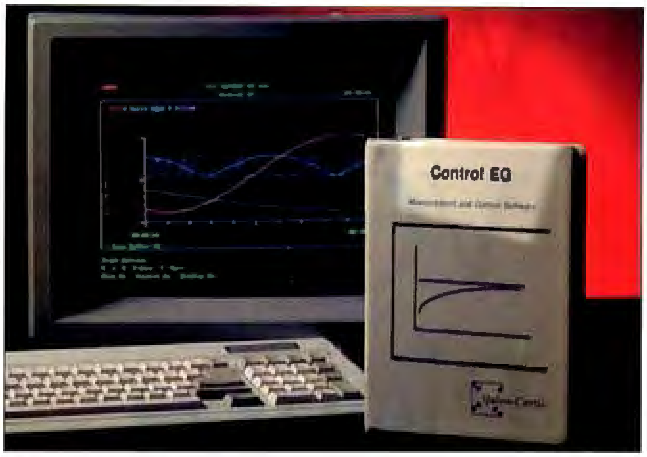
Displays include 16-channel bar graphs, scrolling history, *x,y* cross-plot, annunciator, tag summary, operator, and sequencer status.

Control EG runs on the IBM PC, XT, AT, and compatibles with two 360K-byte floppy disk drives or one floppy drive and one hard disk drive. You also need at least 512K bytes of RAM (640K is recommended). A CGA, EGA, or Hercules graphics board is required, along with DOS 3.0 or higher. It supports the Intel 8087 or 80287, though it does not require either.

Price: $500.

Contact: Quinn-Curtis, P.O. Box 10, Newton Center, MA 02159, (617) 444-7721.

Inquiry 781.



Control EG automates measurement and control systems.

Survey the Mac Way

Cogo Mac is a land-surveying program from Compuneering, the company previously known as Erez Anzel Software. Cogo Mac is not to be confused with MacCogo, a geometric calculation program from the same company.

Cogo Mac lets you lay out real estate or other area plans and calculate area and elevations. Information is displayed graphically and numerically when you enter it. You can use the mouse or keyboard to change or move points. Its calculations are precise to 15 digits, the company reports.

Cogo Mac is written in MacAPP and is compatible with MultiFinder, LaserWriters, and networks, according to Compuneering. It runs on Macs with 512K bytes of RAM and will make use of color on the Mac II.

Price: $595.

Contact: Compuneering Inc., 113 McCabe Crescent, Thornhill, Ontario L4J 2S6, Canada, (416) 738-4601.

Inquiry 782.

A Star Is Born

STAR (structural testing, analysis, and reporting) is a set of four subprograms that work with Microsoft Windows in analyzing structures. The subprograms include a modal system, a structural-analysis system, a dynamics display station, and a computer-aided measurement-acquisition system.

The modal program, STAR Modal, integrates curve-fitting capabilities with the graphics of the display station and the data-acquisition capability of transferring and saving data acquired with the fast-Fourier-transform analyzer, STAR Test.

The structural-analysis system, STAR Struct, integrates the modal-analysis capability of STAR Modal plus SDM (structural dynamics modifications) and FRS (forced response simulation). With the structural-analysis system you can predict how the dynamic properties of a mechanical structure will be affected by mass, stiffness, and damping modifications.

STAR View is the display station that offers you graphics tools for viewing modal data from modal and finite-element sources. Its capabilities include measurement display, real-time animated-mode shape display, and data handling.

The computer-aided measurement-acquisition system, STAR Test, includes the capabilities of STAR View, plus the ability to transfer and save data acquired with an FFT analyzer. All other STAR system products can access the data acquired with STAR Test.

STAR uses vibration data acquired from a test structure as input, and it then identifies the modes of vibration of the structure from this data. The modes are displayed in a real-time, animated display.

Microsoft Windows enables you to work in STAR and other applications simultaneously by switching between windows. You can also cut and paste STAR graphics displays or data tables into other Windows programs.

STAR runs on the IBM PC AT and compatibles with at least 1 megabyte of RAM. It also runs on PS/2s.

Price: $6500 to $20,000.

Contact: Structural Measurement Systems Inc., 651 River Oaks Parkway, San Jose, CA 95134, (408) 263-2200.

Inquiry 783.

FINITE ELEMENT ANALYSIS ON THE MAC II AND SE

MacNeal-Schwendler, a leader in finite-element-analysis (FEA) software, has released version 1.98 of MSC/pal for the Macintosh II and SE. The FEA method breaks a structure into discrete elements that the computer can study for responses to stress, vibration, and pressure.

Running on the Mac II, version 1.98 lets you use up to 256 colors. On both the II and SE, you can make use of shaded contours and hidden-element plots.

The company also announced that a version of its new interactive modeler, MSC/mod, is in the works for the Macintosh.

Price: MSC/pal 1.98, $1495; MSC/mod, $495.

Contact: The MacNeal-Schwendler Corp., 815 Colorado Blvd., Los Angeles, CA 90041, (213) 259-3875.

Inquiry 784.

continued

SOFTWARE • SCIENTIFIC AND ENGINEERING

A Schematic Design Program for $395

CapFast CF1000 from Phase Three Logic designs printed-circuit boards and programmable-logic-device applications. The EGA-compatible program includes a schematic editor, symbol editor, symbol library, netlist extractors, a parts-list program, and a plotting utility. The symbol library has over 2000 parts in IEEE and ANSI formats.

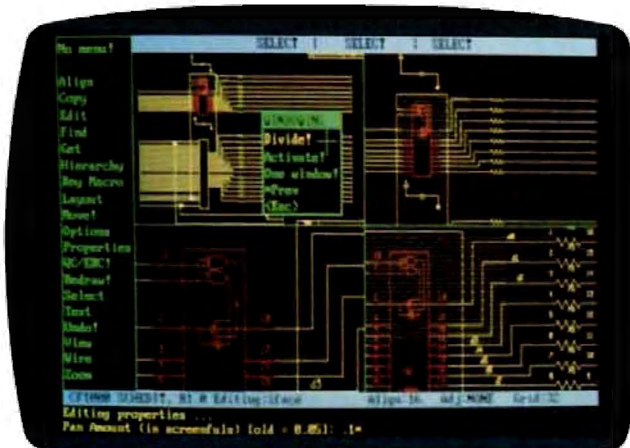
Phase Three Logic calls it an entry-level program, but it offers unlimited design levels with multiple-page schematic editing at any level, comprehensive symbol-attribute handling, on-line electrical-rules checking, scalable vector text, split-screen capability, dynamic panning, and keyboard macros. In addition, with its ASCII database, you can integrate files with other applications.

CF1000 runs on the IBM PC AT and PS/2s.

Price: $395.

Contact: Phase Three Logic Inc., P.O. Box 985, Hillsboro, OR 97123, (503) 640-2422.

Inquiry 785.



Entry-level schematic design with CF1000.

Application Design and Modeling Program

PC-Proto II lets you build and change system models and create reports that can become the basis for specifications. The program takes the completed model and extracts the design details, cross-references, source code, views for data modeling, and a data dictionary.

System models are built from subsystems linked by a main menu and submenus. You can invoke and test each subsystem as a stand-alone system model.

You can demonstrate the model without the data files, and the program also supports sequential and keyed file processing. PC-Proto II supports file inquiry and updates (insert, replace, and delete).

The program includes a screen painter that supports Windows and fill screens, alpha and numeric editing, range checking, variable names, and date and time functions. The program's database manager supports hierarchical and relational databases. A report writer enables you to print reports in external index sequence and to send reports to the printer.

PC-Proto II runs on the IBM PC, XT, AT, and compatibles with 640K bytes of RAM, DOS 2.0 or higher, and two floppy drives or a hard disk drive.

Price: $1000.

Contact: Kartech Data Services Inc., 165 Pinewood Ave., Toronto, Ontario M6C 2V6, Canada, (416) 656-2032.

Inquiry 786.

Acquire and Control Data with LabLog

LabLog works with the Industrial Computer Source ML-16, an analog and digital I/O card. You can define data-acquisition and control parameters by selecting from a menu. One selection presents a real-time trend line of up to three channels with an animated bar graph of one selected point. Another display code provides four bar graphs for individual points. When channels are displayed, you can send data to disk or to a printer in either ASCII, binary, or a Lotus 1-2-3–compatible format.

According to Industrial Computer Source, the board that LabLog works with offers 16 single-ended or 8 differential inputs multiplexing into a 10-microsecond, 8-bit A/D converter. It offers two 8-bit analog output channels and eight digital I/O channels. An optional screw termination board and interconnect cable are available.

The software runs on the IBM PC, XT, AT, and compatibles with at least 256K bytes of RAM and a graphics adapter.

Price: $100 (includes source code); ML-16 I/O card, $289; termination board and cable, $99.

Contact: Industrial Computer Source, 5466 Complex St., Suite 208, San Diego, CA 92123, (619) 279-0084.

Inquiry 787.

Filtering Data

HEM Data Corp. added a digital filtering program to its series of data-acquisition, storage, analysis, decision-making, and filtering software, which includes Snapshot Storage Scope and Snap-Calc.

Snap-Filter offers low-pass, high-pass, band-pass, and band-reject filters. You can specify them as FIR (finite impulse response) filters that produce a linear-phase response, thereby preserving the time relationship of different signal components. Or you can specify them as IRRs (infinite impulse response filters), which emulate common analog filters such as Butterworth and Chebyshev, according to HEM. You can also specify low-pass filters as Hanning moving-average-type filters to smooth data.

To run Snap-Filter, you need an IBM PC, XT, AT, or compatible with at least 256K bytes of RAM.

Price: $395 for Snap-Filter (for current users of Snap-Calc); $1185 for entire series.

Contact: HEM Data Corp., 17025 Crescent Dr., Southfield, MI 48076, (313) 559-5607.

Inquiry 788.

Spectrometer Reading

Interactive Microware's Spectrochart-PC works with IMI's Adlab-PC data-acquisition board in recording and analyzing voltage signals from the recorder output of any spectrometer. A method file controls data acquisition and the analysis according to your protocols. You can also analyze ASCII data files from any source. And you can send data and results as ASCII files for use with other programs.

Spectrochart runs on IBM PS/2s.

Price: $595.

Contact: Interactive Microware Inc., P.O. Box 139, State College, PA 16804, (814) 238-8294.

Inquiry 789.

continued

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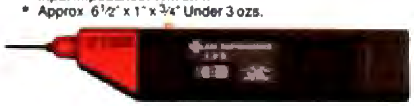

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Perfect for the field service technician. Shirt pocket size without compromising features or accuracy. Large, easy to read ½" LCD display. Fully overload protected for safety. 2000 hour battery life with standard 9v cell. Probes and battery included.

- Basic DC accuracy: plus/minus 0.5%
- DC voltage: 2v–1000v, 4 ranges
- AC voltage: 200v–750v, 2 ranges
- Resistance: 2k ohms–2M ohms, 4 ranges
- DC current: 2mA–2A, 4 ranges
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- Fully overload protected
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SOFTWARE • BUSINESS

Lotus Tunes Symphony and Jazz

Symphony, the integrated business program for the IBM PC, now includes word-processing enhancements, new spreadsheet and database features, and bundled add-ins.

Symphony 2.0's new word-processing features include automatic word wrap and paragraph reformatting; accelerator keys for editing tasks such as deleting, inserting, and moving blocks of text; and a store-and-paste facility that restores text if accidentally erased.

The spreadsheet in version 2.0 recalculates only cells affected by changes to the worksheet. The database management forms in version 2.0 support up to 256 fields.

Bundled add-ins include Symphony Text Outliner, Symphony Spelling Checker, a network file-locking utility, and a VT-100 terminal emulator.

Symphony 2.0 is not copy-protected and runs on the IBM PC with at least 384K bytes of RAM (512K bytes is necessary to run the spelling checker and other add-ins). The program is available on 3½- and 5¼-inch disks and runs on PS/2 Models 30, 50, and 60 with DOS 3.3.

On the Macintosh front, Lotus is planning the release of Modern Jazz, an update of the Macintosh business package. The worksheet, graphics, database, word-processing, and communications capabilities are upgraded, and additions include a command language, macros, and a new forms function. In addition, Modern Jazz supports the 68020 math coprocessor, 68881 floating-point coprocessor, and SANE, Apple's numeric package.

The Jazz function HotView is expanded in Modern Jazz. It provides dynamic data integration between worksheets, graphs, databases, forms, and word-processing documents.

The Modern Jazz command language is a library of more than 200 macro commands.

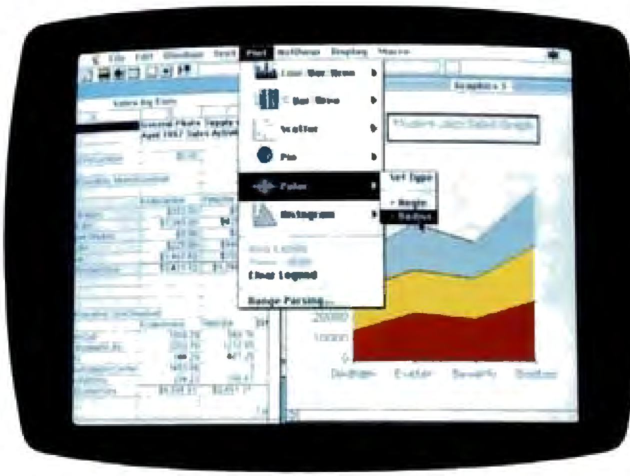
Other benefits of Modern Jazz include the ability to address all available RAM and to share information with IBM PCs as it reads and writes Lotus 1-2-3, Symphony, Microsoft SYLK, and ASCII files.

Modern Jazz runs on the Mac Plus, SE, or II. An 800K-byte floppy disk drive and a hard disk drive are recommended.

Price: Symphony 2.0, $695; Modern Jazz, $395.

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

Inquiry 790.



Lotus announces Modern Jazz.

WYSIWYG Spreadsheet

Innovative Software calls Wingz the first WYSIWYG integrated spreadsheet. It lets you generate numbers, text, charts, and graphs, and lay them out on a page.

The spreadsheet features 32,768 rows by 32,768 columns and offers over 180 functions for business, scientific, financial, and general applications.

The program has 21 chart types, a choice of 256 colors from a palette of 16 million, and three-dimensional rotation of images. You can pop up a graph by defining a block of numbers in the spreadsheet, and define the area where you want to place the graph. You can mix graph types, add text with the word processor, or use images you've scanned into the Mac. Innovative Software reports that Wingz has three times as many basic graph types as Excel.

Wingz lets you use any type font, style, or size in a single cell. You can have as many as 256 custom style sheets attached to any one spreadsheet.

Wingz also has its own programming language called Hypersheet that lets you create any number of new applications as you need them. It offers an unlimited array of colors and type styles.

The program reads and writes in WKS, WK1, SYLK, DIF, ASCII text, and SMART formats.

To run Wingz, you need a Mac Plus, II, or SE. It makes full use of color displays on the Mac II. PostScript drivers will be incorporated into the final release of the program, scheduled for the second quarter of this year, according to Innovative Software.

Price: Between $395 and $495.

Contact: Innovative Software Inc., 9875 Widmer Rd., Lenexa, KS 66215, (913) 492-3800.

Inquiry 791.

WORDPERFECT FOR THE MAC

WordPerfect Corp.'s Macintosh word processor takes full advantage of the mouse and Mac graphics interface. The Mac version of WordPerfect offers you all the keyboard functions of the IBM version, and you can access them from the keyboard or from pull-down menus. Keystroke equivalents appear on-screen beside menu options to simplify keyboard access.

Enhancements to the Mac version include the ability to reconfigure the program without exiting. You can read in and edit graphics images and preview printed output on the screen. Unlike the IBM edition, you can see all fonts and other graphics-based text enhancements directly on the screen. Text appears in all fonts, sizes, and styles that the Mac supports. You can also have an unlimited number of documents open at any one time. You can also read in WordPerfect files from Apple II, Amiga, Atari, IBM, VAX, and Data General machines.

Other features include a 115,000-word spelling checker, the ability to have up to 24 columns, automatic text formatting and table-of-contents creation, and a macro capability. Thesaurus and merge facilities are also standard WordPerfect features.

Price: $395.

Contact: WordPerfect Corp., 288 West Center St., Orem, UT 84057, (801) 225-5000.

Inquiry 792.

continued

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SOFTWARE • OTHER

Replacing COMMAND.COM

Command Plus 2.0 replaces the COMMAND.COM in DOS 2.0 and higher. The new version includes enhanced DIR, COPY, and DEL, as well as a block-structured batch-processing language that has a Pascal-like syntax.

Command Plus 2.0 is compatible with 3Com and Novell networks. It runs on the IBM PC, XT, AT, and compatibles with DOS 2.0 or higher, two floppy disk drives, and 50K bytes of RAM. It also runs on PS/2s.
Price: $79.95.
Contact: ESP Software Systems Inc., 11965 Venice Blvd., Suite 309, Los Angeles, CA 90066, (800) 992-4377; in California, (213) 390-7408.
Inquiry 793.

Command Plus 2.0 features a block-structured language.

A Collage of Desktop-Publishing Utilities

Inner Media's four utilities, combined in one program called Collage, let you connect a variety of applications in a PC-based desktop-publishing environment.

Snap is a memory-resident utility that can save screens to graphics or text files without leaving the application you are in. If you save a screen to a graphics file, you can paste it into documents. If you save it to a text file, you can view or edit the screen using most standard text editors. The Snap graphics format (PCX) is compatible with PC Paintbrush and Publisher's Paintbrush. You can also use Snap with Windows and GEM applications, AutoCAD, Lotus 1-2-3, Framework, and other environments.

The Show utility displays PCX files in color so you can view one or more graphics screens that you saved with Snap or other graphics programs.

Smooth is a file-reading tool that scrolls text forward and backward.

The MultiLine utility lets you select the number of lines of text you want displayed. When using an EGA or compatible display adapter, you can choose from 16, 25, 35, 43, or 50 lines per screen; using a VGA adapter or a PS/2 system, you can choose from 16, 25, 36, 44, or 50 lines per screen.

Collage runs on the IBM PC, XT, AT, and compatibles with at least 256K bytes of RAM, an EGA or VGA, and DOS 2.0 or higher. It also runs on PS/2s. Inner Media recommends 640K bytes of RAM and a hard disk drive.
Price: $89.95.
Contact: Inner Media Inc., 60 Plain Rd., Hollis, NH 03049, (603) 465-3216.
Inquiry 794.

See the Music

As you play notes on a MIDI keyboard, Coda's program Finale automatically transcribes them to the screen or printer in standard notation. Coda says that built-in transcription and notation intelligence let you manipulate music data. You can play in any tempo, and the program uses a proprietary "time tagging" method to print notes in the proper time signature and cleft.

Finale handles complex time signatures and binding of lyric syllables to notes, according to Coda. It also features automatic placement of hyphens, knowledge of triplets and tuplets, reverse stemming, cross-staff stemming and beaming, angled beaming, and custom stemming and beaming.

The program runs on the Mac and the IBM PC, XT, AT, and compatibles with at least 1 megabyte of RAM.
Price: $795.
Contact: Coda Music Software, 1401 East 79th St., Bloomington, MN 55420, (612) 854-1288.
Inquiry 795.

COMPUTERIZED DARKROOM FOR THE MAC

Silicon Beach reports that Digital Darkroom is the first program that converts bit-mapped images to object-oriented graphics on the Mac, and the first instance of gray-scale bit maps being converted to objects on any personal computer.

The program has image-enhancement features that let you adjust the brightness and contrast with slider controls. You can pass the image through filters that blur, sharpen, remove noise, and enhance edges. You can bring in bit-mapped images from paint programs or scanners and use AutoTrace to convert them into draw-based objects. The objects you convert the images to, including Bézier curve information, can be manipulated in draw programs.

You can remap gray values to produce special effects such as posterizing, equalizing, and inverting. You can get more precise effects by manipulating gray values within a graph or a dialog box.

Tools such as the Magic Wand let you select a region according to the gray value by pointing and clicking. You can use the scissors tools for clipping and deleting portions of active selections. You can paste selections in front of an existing image, blend with it, or paste behind it.

Digital Darkroom imports and exports files in PICT, PICT-2, TIFF, MacPaint, SuperPaint, and Thunderscan formats. You can also export in the EPS or Adobe Illustrator file format. The program converts 1-bit-deep black-and-white Paint files or multiple-bit gray-scale TIFF files to 7-bit gray-scale images. You can also print halftones on PostScript printers by specifying screen angles, resolution, and screen patterns.

The program runs on the Mac 512, Plus, SE, or II. A Mac II is recommended for gray-scale viewing.
Price: $295.
Contact: Silicon Beach Software, 9770 Carroll Center Rd., Suite J, P.O. Box 261430, San Diego, CA 92126, (619) 695-6956.
Inquiry 796.

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REGIONAL SECTION

PACIFIC COAST

Liquid-Crystal Shutter Printer Offers Laser Quality

CrystalPrint Series II uses liquid-crystal-shutter technology to provide a resolution of 300 dots per inch while printing 6 pages per minute. The printer features Hewlett-Packard LaserJet Plus emulation and includes 512K bytes of RAM (expandable to 1.5 megabytes).

The printer is based on a Casio printer engine and uses fixed optics technology, which allows pixel sizes and light source/drum clearance to remain uniform across the entire line. The organic photoconductor drum prints up to 10,000 pages and is replaceable.

Other CrystalPrint Series II features are Bitstream fonts (up to 48 points in size), two font cartridge slots, a 100-sheet-capacity paper tray, and forms-overlay capability for automatic forms printing. Options include an upgrade that supports Hewlett-Packard LaserJet Plus and Series II emulation in addition to fonts and an additional megabyte of memory; and cartridge-based command and font emulations for the Diablo 630, Epson FX-85, HP 7475A, and IBM ProPrinter II.

The CrystalPrint Series II measures 15¾ by 13½ by 9 inches.

Price: $1995; Hewlett-Packard LaserJet Plus and Series II emulation, $499.
Contact: Data Technology Corp., 2551 Walsh Ave., Santa Clara, CA 95051, (408) 727-8899.
Inquiry 797.

Two New R:base Versions

Microrim's R:base for DOS and R:base for OS/2 include Structured Query Language (SQL) commands and extensions based on IBM's DB2 system. Among the SQL Data Definition Language (DDL) commands are `Create Table`, `Create View`, `Select`, `Update`, `Delete`, `Insert`, `Declare`, and `Fetch`. You can also perform `Group By`, `Order By`, and `Distinct` options, and `Sum`, `Average`, `Minimum`, `Maximum`, and `Count` functions.

Both new R:bases are written in C, but you can generate applications without programming via the Express System. Developer's Express, a pseudocompiler, enables you to compress and encrypt code, so you can bypass the interpreter and run applications directly off the R:base engine.

The programs provide password protection and `Grant` and `Revoke` commands that enable a LAN administrator to designate database access privileges. Support is now provided for Lotus/Intel/Microsoft Expanded Memory Specification. Among the LAN capabilities are simultaneous database or table access with automatic locking and simultaneous record and item access with concurrency control.

R:base for DOS supports up to three users; also available are the Network Six Pack, which supports six users, and the Network Unlimited version, which supports an unlimited number of users on a single LAN.

continued

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16 MHz (80386)	$1950	$2450

Monographic System:

Basic system features plus monographics card with printer port and 12" amber monochrome monitor with tilt/swivel base.

Super EGA System:

Basic System features plus EGA deluxe graphics card (640 x 480 and 752 x 410) and Mitsubishi Diamond Scan Multisync monitor with tilt/swivel base.

Other system packages are available, call for prices.

SF-286-8 MHz Super VGA Special $1649

Basic System features plus: Everex EVGA graphics board (640 x 480, up to 256 colors) and Mitsubishi Diamond Scan multisync monitor with tilt/swivel.

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Super VGA Bundle $749

Everex VGA Graphics board, 640 x480 and 800 x 600, 132 columns PLUS Mitsubishi Diamond scan with tilt/swivel.

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PACIFIC COAST

The programs run on the IBM PC and compatibles as well as the PS/2s. The single-user versions require DOS 2.0 or higher and 512K bytes of RAM; the LAN versions require DOS 3.1 or higher and 640K bytes of RAM. Each also requires a hard disk drive or two 3½-inch floppy disk drives. Both 5¼- and 3½-inch floppy disks are provided.
Price: R:base for DOS, $725; Network Six Pack, $995; Network Unlimited, $2695; R:base for OS/2, $895.
Contact: Microrim, 3925 159th Ave. NE, Redmond, WA 98052, (206) 885-2000.
Inquiry 798.

C-Zar for the CZ: Power to Make Music

C-Zar is a music editor and librarian for the Casio CZ-101 and CZ-1000 keyboards. It provides over 200 instruments and sound effects. You can tune the keyboard's six eight-step envelopes; pitch, tone, and loudness envelopes are color-coded and drawn in eight colors in a 1024- by 200-pixel area. You can display more than one envelope at once.

The program provides a time display that's calibrated from 4 milliseconds to 1000 seconds and is scaled logarithmically. You can use the mouse to drag segments of an envelope around the screen. The program also enables you to record sequences and automatically play them back, and maintain a library with up to 6000 sounds.

Other C-Zar features include line copying and detuning, key transpose, key follow, pitch bend, vibrato, modulation, portamento, and waveform selection. Eight programmable tone mixes are provided in every bank of sounds.

C-Zar runs on the Amiga with 512K bytes of RAM and a MIDI. A Casio CZ-101 or CZ-1000 keyboard is also required.
Price: $195.
Contact: Diemer Development, 12814 Landale St., Studio City, CA 91604, (818) 762-0804.
Inquiry 799.

Neural Network Picks Up and Pigeonholes Patterns

AR/NET is a version of the Adaptive Resonance Network, a neural network that is designed for unsupervised recognition and classification of arbitrary patterns. When used with the ANZA Neurocomputing Coprocessor System (which is required to run the program), it enables you to construct a self-programming system that can create and organize its own categories from patterns presented to it. The program includes AR1 for binary signals and AR2 for analog signals.

When AR/NET doesn't recognize an input, it either signals you or creates a new category for it; it can learn a pattern from only one exposure. The program's tolerance of small variances is directly proportional to the pattern's complexity. You can also manually set the amount of error that will be tolerated.

AR/NET runs on the IBM PC AT and compatibles with DOS 2.1 or higher, 512K bytes of RAM, and an ANZA Neurocomputing Coprocessor Board.
Price: $600.
Contact: Hecht-Nielsen Neurocomputer Corp., 5893 Oberlin Dr., San Diego, CA 92121, (619) 546-8877.
Inquiry 800.

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- User's manual
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- Monochrome/Graphics card with printer port
- HI-RES Monochrome Monitor
- User's manual
- 1 year warranty

ALTEC-286jr System

$1,095

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- 200W power supply
- ATjr style case
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SHORT TAKES

BYTE editors offer hands-on views of new products

Low-Cost Sharp Laptop Sprouts a Hard Disk

As goes the desktop, shortly follows the laptop. Hard disk drives, now de rigueur on desktop personal computers, are rapidly becoming required equipment on laptops. The new **Sharp PC-4521** is evidence of this trend.

This new system is currently the high end of Sharp's low-priced crop of IBM-compatible laptops. The system is almost identical to Sharp's dual-floppy-disk-drive system, the PC-4502, but with a 20-megabyte hard disk drive in place of one of the older system's 720K-byte 3½-inch floppy disk drives. The new system also comes standard with more memory (640K bytes), is about 2 pounds heavier (12.4 pounds total), and has a shorter battery time (2 hours compared with 2½ hours on the older system). Naturally, the list price is also higher ($2995).

All other features of the two systems are the same, including a high-contrast electroluminescent backlit liquid-crystal-display screen, a 7.16-MHz 80188-compatible processor, an 88-key keyboard with separate numeric keypad, a parallel printer port, one 720K-byte 3½-inch floppy disk drive, and a connector for an external 5¼-inch floppy disk drive. Unfortunately, neither system includes a serial port or an RGB connector, although both are available as options.

The 7.16-MHz 80188-compatible processor pushes the system at speeds about 50 percent faster than a standard 4.77-MHz IBM PC. In our Sieve test, the new system was 20 percent faster; in the Dhrystone test, the result was 59 percent faster. The best performance was in our floating-point test, where the new system was 73 percent faster.

The screen on the new system seems a little slow during fast scrolling, for example, during a directory listing. But the dark-blue-on-light-blue characters are easy on the eyes. The resolution is 640 by 200 pixels. The screen does not seem to be able to display shades of gray.

The keyboard differs slightly from a standard IBM PC keyboard. The function keys are arranged in two horizontal rows above the main keyboard. A numeric keypad (lacking the minus and plus keys) appears in the upper right. In addition, an inverted T of cursor keys has wedged itself into the lower right of the keyboard. Strangely, there are two pairs of Insert and Delete keys.

The Facts:

Sharp PC-4521
$2995

Sharp Electronics Corp.
Sharp Plaza
Mahwah, NJ 07430
(201) 529-8731
Inquiry 859.

Options:
1200-bit-per-second internal modem, $399; serial I/O card, $99; expanded memory card (with 1 megabyte), $599; RGB adapter, $255.

Inside the 4521 is a short, proprietary expansion slot. Here, you can add one of several options for the system. One problem, of course, is that you cannot add both a serial card and a modem at the same time.

The system I used was in the prototype stage, but it looked sturdy and performed admirably. If you have special needs and require, say, both a modem and a serial port, or a modem and an RGB connector, you should see other systems. But for most situations, the PC-4521 will no doubt be very useful.

—*Rich Malloy*

A Third-Generation Word Processor

In the beginning there was EMACS, one of the very first word processors for some of the very first small computers (and still going strong in the public domain). EMACS begat FinalWord, an enormously powerful but difficult-to-learn MS-DOS-based word processor. Borland International bought the rights to the FinalWord engine and—with some major upgrading and the addition of an artful, easy interface—produced EMACS' slick grandchild: **Sprint**.

Sprint retains and enhances its ancestors' power and flexibility: It lets you produce anything from plain ASCII text files to elaborate desktop-publishing-style documents with text in "snaking columns." Like Microsoft Word, Sprint lets you manually embed formatting commands or use style sheets to clone formats from one document to another. Sprint lets you have up to 24 documents and up to six on-screen windows open at once.

It has a built-in dictionary and thesaurus. It can

continued

semiautomatically generate indexes and tables of contents for long documents. It's fast (on an IBM PC AT-class machine, I jumped from the top to the bottom of a 17,000-byte test file in a few tenths of a second—virtually instantaneously). And it automatically and unobtrusively stores your work every 3 seconds or so (writing to a swap file on disk) to save your bacon in the event of a power failure or similar disaster.

Sprint also retains a few quirks whose origins trace back to the days when RAM cost dearly. For example, Sprint is "partially what you see is what you get," in that you see most, but not all, of your formatting. To preview the final appearance of your document, you load and run a separate formatter routine to—in essence—print it to the screen.

Fortunately, the familiar Borland interface—menus of menus, with in-context help at every turn—makes it all simple. But unlike other incarnations of the Borland interface, Sprint's is reconfigurable, so you can make Sprint appear and act like any other word processor. (The beta version I tested came with alternate interfaces for WordStar- and WordPerfect-like operation.)

Sprint's default interface is logical enough that almost anyone can sit down and poke around the menus to turn out presentable documents with essentially zero learning time; experienced users can access Sprint's advanced features via the menus or more quickly with command-key shortcuts.

Because the interface is reconfigurable, people already familiar with another word processor can use Sprint without having to unlearn one set of commands and relearn another. As a side benefit, an office can use Sprint to standardize on a single word processor (and therefore a single file format) and yet still let people use another interface.

Sprint retains Borland's typical aggressive pricing: Less than $200 gets you a fast, powerful, flexible, chameleon-like word processor with a built-in dictionary and thesaurus.

I've been looking for a new word processor for some time—and if the production version lives up to the beta version, Sprint may be it.

—Fred Langa

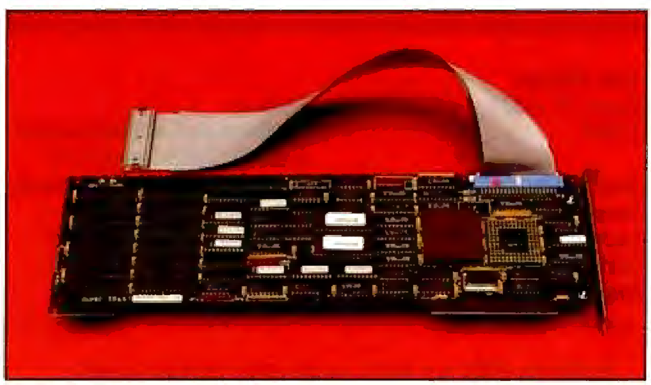
The Facts:

Sprint 1.0 (version tested: beta E.02)
$199.95

Borland International
4585 Scotts Valley Dr.
Scotts Valley, CA 95066
(408) 438-8400
Inquiry 858.

Requirements:
Not final at press time, but the beta version required 256K bytes of RAM and a hard disk drive (the program's modules are supplied on five 360K-byte floppy disks); it supported monochrome and color monitors; it was not copy-protected.

A Boost for Your Old System



The Facts:

Quad386XT
$995

Quadram
One Quad Way
Norcross, GA 30093
(404) 564-5566
Inquiry 856.

Requirements:
IBM PC, XT, or compatible computer

Options:
2-megabyte 32-bit RAM daughterboard, $775

Putting the **Quad386XT** board in your old IBM PC or PC XT is like putting a much larger engine in your old car. It offers a boost to your old system, but it could leave you feeling delighted or disappointed with the change in performance.

Essentially, the Quad386XT can upgrade your 8088-based PC or XT into an 80386-based computer. You must be familiar with the layout and chip location on the PC motherboard before you can install the Quad386XT. You must remove the 8088 CPU (and, if present, the 8087 math coprocessor) from the PC motherboard. You insert a special adapter module into the 8087 socket and insert the Quad386XT connector cable into the 8088 socket. The full-length Quad386XT board plugs into any empty slot in your PC or XT. You then plug the connector cable from the 8088 socket into the board. The 80386 then becomes the PC's CPU.

The board comes with an 80386 running at 16 MHz, 1 megabyte of 120-nanosecond RAM, the BIOS in two 27256 EPROMs, and a socket for an optional 80287, 80387, or Weitek 1167 math coprocessor. An optional daughterboard containing 2 megabytes of 32-bit RAM is available (for $775); an 8-megabyte daughterboard is planned for the future.

Included in the package is a disk with the QVM.SYS driver program and the QVM.COM program for switching from 80386 real mode to the 8086 virtual mode. The disk also includes a selection of diagnostic software, a Dhrystone benchmark program, a RAM disk, a print spooler, and other utility software.

In operation, the Quad386XT gives mixed results in speed tests. The BYTE 80386 benchmark programs do not run because of a conflict with the QVM.COM program. The Norton SYSINFO program gives the Quad386XT a rating of 13.3. When I used IBM's BASICA to run the BYTE Calculations and Sieve BASIC benchmark programs, they gave disappointing times: 1 minute, 26 seconds for Calculations, and 4 minutes, 26 seconds for the Sieve. BASICA uses the ROMs on the PC motherboard, thus slowing down the program's execution. When I used GWBASIC, which can reside completely in RAM on the Quad386XT board, the times improved to 7.6 seconds for the Calculations program and 25 seconds for the Sieve program.

—Stan Wszola

continued

A Quiet Ink-Jet Printer

The Facts:

DeskJet
$995

Hewlett-Packard
3000 Hanover St.
Palo Alto, CA 94303
Call your local dealer.
Inquiry 852.

Options:
15 font cartridges, $75 to $125; Epson FX-80 printer-emulation cartridge, $75; 128K-byte RAM cartridge, $150.

The **DeskJet** is based on Hewlett-Packard's almost silent ink-jet technology. It has 128K bytes of built-fin RAM, a 16K-byte buffer, and both parallel and RS-232C input. It can run at 240 characters per second (draft mode) with a resolution of 300 by 150 dots per inch or at 120 cps (letter-quality mode) with a resolution of 300 by 300 dpi. This provides near-laser-printer-quality output for $995.

The printer uses a third-generation, thermal ink-jet, drop-on-demand print cartridge. In contrast to previous Hewlett-Packard ink-jet printers that required special paper for the best-quality output, the DeskJet print cartridge can print on regular bond, photocopier, and Hewlett-Packard's special ink-jet papers. One print cartridge can print from 500 to 800 pages, depending on the font selected or the type of graphics printed. Replacement cartridges cost $18.95.

The printer features an automatic cut-sheet feeder, and the built-in paper tray can hold 100 sheets. It can handle U.S. letter- or legal-size and European A4 paper sheets. You can also manually feed it #10 business envelopes.

The printer is simple to operate. All the diagrams for loading paper and print cartridges and setting function and front-panel keypad switches are located under the printer's front cover. The front panel has switches for formfeed, font selection, draft or letter-quality mode, and forward or backward linefeed. It also has a button to start new printer cartridges and a reset button.

The DeskJet has the Courier, Courier Bold, and Courier Compressed fonts at 10, 16.67, and 20 characters per inch. You can make all font selections from the front panel. Two cartridge slots on the front panel hold optional font cartridges, a printer-emulation cartridge, or a 128K-byte RAM cartridge.

In operation, the DeskJet is almost silent. Print quality is comparable to laser-printer output. The DeskJet appears to be ideal for the small business that wants laser-quality output at a dot-matrix price.

—Stan Wszola

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WordStar Strikes Yet Again

Since it was first released in 1984, WordStar 2000 has been the serious-business big brother of the venerable old standard WordStar. But despite rave reviews and a huge marketing effort, WordStar 2000 never seemed to reach the level of acceptance of arch competitors like MultiMate, WordPerfect, and Microsoft Word. With **WordStar 2000 3.0**, that situation may change. MicroPro has taken a shocking approach for a software company: It has actually incorporated user suggestions into the upgrade and has fixed a bevy of complaints.

WordStar 2000 3.0 has 662 features, oodles of them new and improved. But listing even a small subset would take more room than I have for this entire review. If you can think of it, it's probably there, including a spelling checker, thesaurus, and even a telecommunications program. But I'll concentrate on a couple of high points.

First, those control-character commands that have always been the curse and blessing of WordStar are significantly improved in version 3.0. Commands are actually mnemonic now. For example, quit and save is now Control-Q-S instead of the maddening Control-K-D. And in what's still a unique WordStar feature, you can choose whether to have help screens stay or pop up after a time delay that you define. You can also use single-letter commands, which may be simpler when you're first starting out.

The program comes with custom support files for some 400 printers, and laser-printer support places this release plainly several steps ahead of its competitors. Setting fonts and selecting sizes are simple tasks, and the program comes with Inset, a utility that merges text and graphics. Put them together, and you have a more-than-basic desktop-publishing package.

Then there's the speed. When WordStar 2000 first hit the shelves, I gave it up in disgust because doing anything useful with it required patience. But I was pleased to find that version 3.0 is quick and actually functional. Scrolling through long files and doing search/replace functions now are virtually instantaneous, and when you perform a function that requires extensive reformatting, the program does its thing in the background while you keep working away.

The disadvantages? The program is huge. It took me about half an hour to install, and when I was done I had 296 files in various automatically created subdirectories, taking up a total of nearly 4 megabytes of disk space. Even a minimal installation takes 2.5 megabytes. WordStar 2000 does just about everything, and that too is a disadvantage. How do you learn all the ins and outs? The answer is that you don't—right away. As is true with all feature-rich software, it's an evolutionary process. You find and learn the features as you require them. In that regard, MicroPro is now offering toll-free customer support 7 days a week at no extra charge. It's radical for MicroPro, and too long awaited.

—Stan Miastkowski

The Facts:

WordStar 2000 3.0
$495

MicroPro International
33 San Pablo Ave.
San Rafael, CA 94903
(415) 499-1200
Inquiry 855.

Requirements:
IBM PC, XT, AT, PS/2, or compatible with 320K bytes of RAM (512K bytes for Inset text/graphics integrator); a hard disk drive is recommended.

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Thin Is In

The Facts:

ZCM-1490: Flat Technology Monitor
$999

Requirements:
15-pin analog RGB input

Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(800) 842-9000, ext. 1
Inquiry 853.

Everyone's saying it, and it's true: You have to see the **Zenith Flat Technology Monitor** (ZCM-1490) to believe it. The colors are brilliant, the screen has no glare, and the flatness is quickly addictive. It's hard to go back to the average bulging monitor screen that lets you count the ceiling lights reflected on its surface—very hard.

The ZCM-1490 is a 14-inch high-resolution flat-tension-mask color analog monitor designed to support the VGA output from IBM's PS/2 computers and comparable video cards. It also supports CGA, EGA, Monochrome Display Adapter, and Hercules software via Zenith's Z-449 video card. The monitor handles the standard 80-character by 25-row text output. Its resolution is 640 by 480 pixels, and it has a horizontal-scan frequency of 31.5 kHz.

Two dials on the top control brightness and contrast, and a switch on the back lets you operate at either 120 or 240 volts AC. The on/off switch is located on the rear, as is an IBM PS/2-compatible 15-pin RGB cable connector.

I tested the ZCM-1490 on a PS/2 Model 80 and played with one of the many paint packages. When you first sit down to a flat monitor, your eyes are so accustomed to a curved screen that the flat one appears concave. This deception disappears in a few minutes.

The colors on the Zenith are clear and crisp. I would say they are "true," but I'm speaking subjectively. I didn't actually compare them with color charts. Color selection is governed by the video input to the monitor and is not restricted by the monitor itself. The black background default screen is indeed black instead of the usual dark gray. In fact, the black, added to its lack of glare, gives it almost a matte finish.

I was very impressed with Zenith's ZCM-1490: the colors, the clarity, the lack of glare—and it's easy on the eyes.

—Jane Morrill Tazelaar

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Microsoft Windows 2.0 is an update of the original Windows designed to allow at least limited compatibility among all the Microsoft graphical interfaces.

Most users will see few differences between version 2.0 and earlier versions of Windows. The major feature in the new version is the ability to use expanded memory to swap programs. In older versions, programs were swapped to disk, resulting in slow performance that could degrade if your hard disk became fragmented. Swapping to expanded memory allows programs to swap in times that more closely approximate a genuine multitasking system.

If your system has both expanded memory and extended memory, you can get even better performance by swapping programs to expanded memory and using the SMARTdrive disk-caching program that comes with Windows in extended memory. The other user-apparent changes in version 2.0 are minor, including improvements in the speed and ease of use in the keyboard command "shortcuts" and the ability to size windows from the fat borders.

The major changes in Windows are in the applications programmer level. Microsoft's original intention of having well-behaved Windows applications run unaltered under the OS/2 Presentation Manager has changed, but Windows now has file structures and programming hooks that are similar to those in OS/2, so that ports from Windows to OS/2 will be, if not easy, at least possible.

In all, Microsoft has updated Windows in ways that maintain a great deal of compatibility with earlier versions of the environment, while providing features that make it more useful for many users.

In moving from the Windows Operating Environment to the Windows Presentation Manager, Microsoft has opened a door of new features to applications programmers, but without leaving earlier Windows users standing alone in the cold. ■

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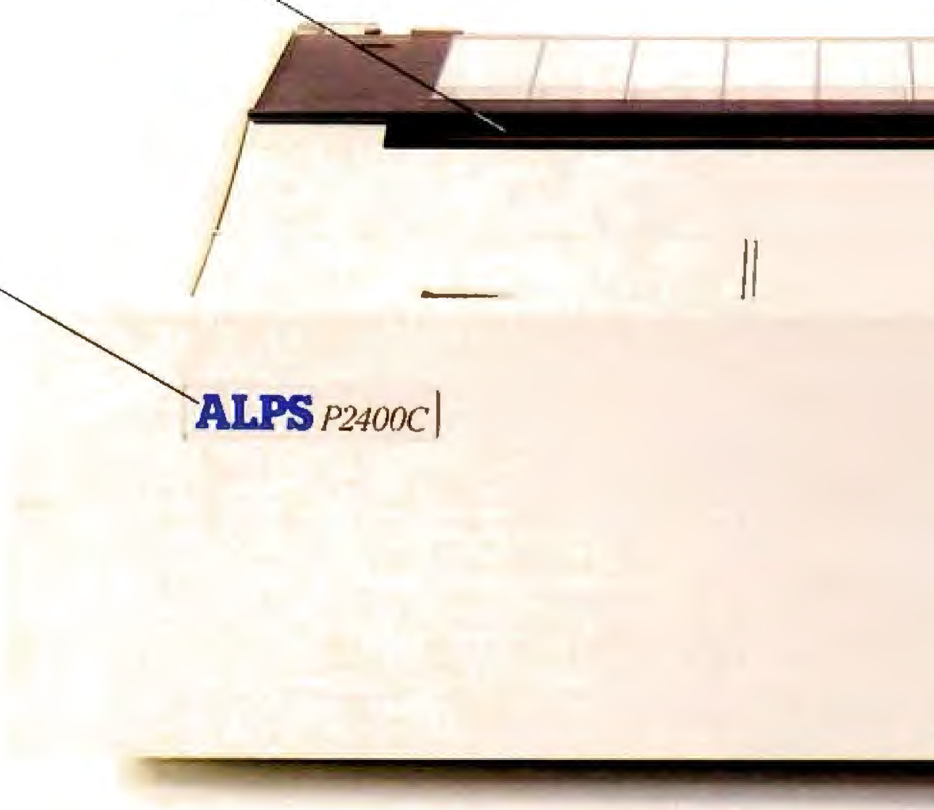

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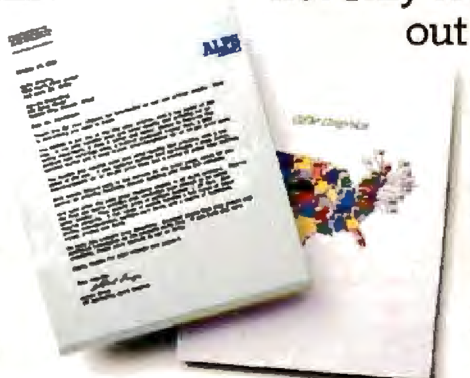

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BYTE Staff

Microsoft Languages Update

New prerelease versions of old friends offer a bridge to OS/2

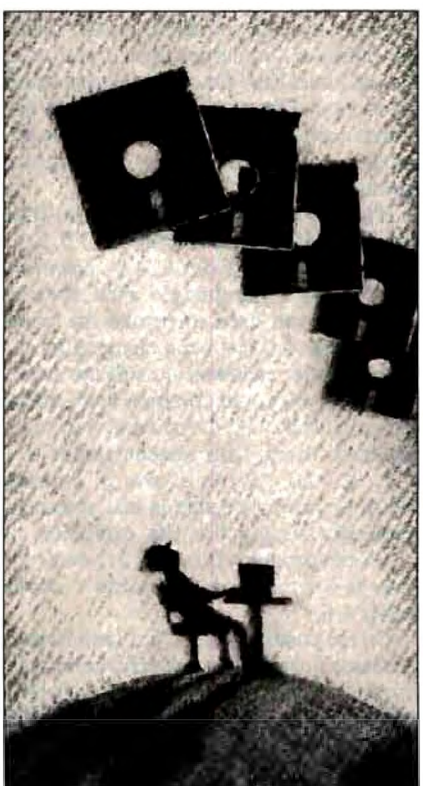
It's not every day that a software company unleashes a barrage of language upgrades the likes of which Microsoft introduced earlier this year. The company wanted to provide its languages with OS/2 functionality so that programmers could write applications for use with the new operating system or turn it into a development platform for MS-DOS applications. In doing so, Microsoft has announced new versions of five language products and two development kits:

- C Optimizing Compiler 5.1
- BASIC Compiler 6.0
- FORTRAN Optimizing Compiler 4.1
- Macro Assembler 5.1
- Pascal Compiler 4.0
- OS/2 Programmer's Toolkit
- Windows 2.03 Software Developer's Kit

Furthermore, the company introduced at about the same time a new COBOL Compiler 3.0 (actually developed by Micro Focus but marketed by Microsoft) that also provided OS/2 functionality. The only Microsoft languages not directly affected by the OS/2 upgrades were, in fact, QuickC and QuickBASIC. However, Microsoft has said that it is simply a matter of time before OS/2 versions of these languages are developed as well.

While the basic objective of the revisions was to bring OS/2 functionality to the languages, an added aim was to do so without sacrificing MS-DOS compatibility. The intent behind this plan was to provide programmers with a single implementation of each language instead of separate versions for OS/2 and DOS. To accomplish this, enhancements had to be made that affected all elements of the development cycle, from the editor to the debugger.

One of the most noticeable changes, at least for programmers familiar with past Microsoft languages, is that a common program editor—the M editor—has been added to each language. (Other than the Quick products, this is the first time Microsoft has delivered languages that have integral editors.) Among other things, the M editor allows multiple windows and multiple files, and it is configurable so that it can look like editors you may already be familiar with. (Configuration files are included that enable emulation of the Brief, Epsilon, WordStar, and QuickC/QuickBASIC-style editors.) The M editor has macro capabilities to automate frequently used operations, and it creates a history file that automatically logs in the changes made to a program, the type of changes they were, and who made them. Additionally, other programs can be invoked from within the M editor.



On the compiler side, the revised compilers emit Intel 80286 instructions when running in OS/2 protected mode. Also added were special software libraries that take advantage of unique OS/2 capabilities—primarily the ability to work with dynamic linked libraries (DLLs) and multithreaded applications.

Dynamic links are the primary method by which OS/2-system and nonsystem services are obtained. They let you postpone making external references until load time or run time. DLLs allow libraries of routines to be linked to applications at execution time. Since DLLs can be shared among programs, those programs can be much smaller. Multithreading is an OS/2 feature that allows more than one path of execution through the same instance of an applications program. OS/2 allows a maximum of 255 threads in use by the system at any one time.

In general, libraries included in the compiler let system calls be made directly to OS/2 functions. Typical calls might be to open a file, allocate memory, and so on.

Because OS/2 enables you to write much larger programs, the linker was revised so that, among other things, it is easier to make frequent changes to large code modules. You can also specify that programs be linked so that they run under either OS/2 or MS-DOS. (A unique OS/2 utility called BIND.EXE lets you associate a program with either environment. Such a program is said to be "bound" to OS/2 or to MS-DOS.)

Part of the significance of this is that

continued

Illustration by Kevin Hawkes

Table 1: *Programs created with the Microsoft C Compiler 5.1 and "bound" with a utility program can run under OS/2 and MS-DOS. The same binary image of each sample program was run under OS/2 and then in the MS-DOS window. The programs run 10 percent to 28 percent faster in the MS-DOS window because background processing is suspended. Because we tested prerelease software, these are not true benchmarks; they simply give a rough idea of relative performance.*

	OS/2 window	DOS 3.x window
Dhrystone*	3125	4059
Fibonacci	70	62
Sieve	11	8
Sort	21	18

* Larger number indicates better performance. All times are in seconds, except for the Dhrystone, which is in Dhrystones per second. One hundred iterations were run for the Fibonacci, Sieve, and Sort benchmarks. The Dhrystone version is 1.1; no registers were used, and 50,000 iterations were run.

MS-DOS programs can be written under OS/2 with the resulting benefit that programmers can undertake several concurrent development tasks—execution in one window and debugging in another, for instance—and considerably speed the development process. The programmer would then use BIND.EXE to marry that application to MS-DOS. Microsoft says it will also supply prepackaged libraries of code for simple things like I/O access to the operating system, and has indicated that the company will provide additional libraries (e.g., graphics libraries) in the future.

Microsoft readily admits that debugging OS/2 programs can be extremely difficult, particularly with multithreaded programs that can have dozens of threads. CodeView, the Microsoft debugger, now provides thread-level control of breakpoints and tracing. Breakpoints can be set on a program level or on a thread level. If set on a program level, the complete execution sequence stops when a breakpoint is encountered. You can, however, set a breakpoint at the thread level by specifying the thread on which execution is to halt. Similarly, tracing can be applied to either the overall execution sequence or only to the path of a specific thread.

C Optimizing Compiler 5.1

Among the new features included in the Microsoft C Optimizing Compiler 5.1 are run-time library enhancements, OS/2 support, and the BIND.EXE utility that modifies a program so that it can run under either MS-DOS or OS/2. Microsoft C 5.1 itself runs under either OS/2 or MS-DOS 3.x.

We installed a prerelease version of the compiler on a Compaq Deskpro 386 with a 40-megabyte hard disk drive and running Microsoft's OS/2 version 1.0. The C 5.1 installation package has grown from four 360K-byte 5¼-inch floppy disks that composed the version 5.0 package to thirteen 360K-byte 5¼-inch floppy disks and one 1.2-megabyte 5¼-inch floppy disk. That's the bad news. The good news is that a sophisticated setup program manages the details of getting the software from the floppies to your computer's hard disk.

The setup program asks you questions about the type of run-time support you want (OS/2, real-mode/DOS, or both), types of math libraries desired (coprocessor, emulation, or alternate), the memory models you need (small, medium, compact, or large), and if you want QuickC installed. Once you've answered these (and a few other) questions, it becomes a simple matter of inserting the appropriate disks as the setup program prompts for them.

If you're already using C 5.0, you'll be familiar with the operation of C 5.1. If you're upgrading from C 4.0, however, you're in for some changes. First, the `msc` command you used to invoke the compiler under 4.0 has been changed to `cl`. The compiler switches are still the same, but while you could combine them under 4.0 (e.g., `msc/AL/G2 sieve`), you must separate them with spaces under 5.1 (i.e., `cl /AL /G2 /Gs sieve.c`). Perhaps the most jarring change is that you must explicitly supply the file extension of `.c` for the program file or C 5.1 can't locate it—something that didn't occur under 4.0.

On the positive side, C 5.1 (and its predecessor 5.0) applies powerful code optimization techniques to compile your programs, and it supports the new ANSI C standard. Unlike C 5.0, C 5.1's run-time support has been expanded to include OS/2, and new C keywords let you access certain OS/2 functions. For example, `spawn()` creates and starts a new child process, and `cwait()` stops the calling process until a specific child process completes. A `signal()` function lets you choose one of several ways for a process to deal with interrupts from the operating system. Some of these signals—floating-point error, for example—can be dealt with under OS/2 or MS-DOS, while others, such as process flags, are applicable only under OS/2.

A new compiler switch, `L`, lets you link code for either OS/2 protected mode (`Lp`) or DOS 3.x real mode (`Lr`). If you compile and link a C program using only the protected-mode options, you can use the bind utility to modify the executable so that it can run under either OS/2 or MS-DOS.

However, for BIND 1.0 to locate the required `API.LIB` and `DOSCALLS.LIB` libraries, you have to provide it with explicit path names to these files. Depending on your file directory structure, these path names can get quite involved, so we resorted to a `.CMD` file (OS/2's equivalent of a `.BAT` file) to invoke BIND.EXE. The C 5.1 update documentation states that a `/Fb` switch lets you invoke the bind utility from the C compiler command line, but try as we may, the compiler insisted that it was an unknown option, and we had to bind the files manually.

To test this dual-mode capability of the C 5.1 compiler, we compiled sample programs using the protected-mode option and then bound them. (In this case, we used several BYTE benchmark programs to check dual-mode operation, not to establish benchmark results.) Next, we ran the programs under OS/2 and recorded the times. Finally, we switched to the DOS window, ran the same executable files again, and recorded the times.

No problems were encountered running the programs in either mode. See table 1 for the results. Only one OS/2 screen and the MS-DOS window were present during the timing tests. The programs executed 10 percent to 28 percent faster in the DOS window because background processing is suspended while the program runs in the MS-DOS window.

Despite the minor glitches mentioned here, C 5.1 ran capably in both the OS/2 and the MS-DOS windows. With the added OS/2 support and the bind utility, it makes a useful bridge between the old and new operating systems.

BASIC Compiler 6.0

The previous release of Microsoft's generic MS-DOS BASIC compiler (almost 4 years ago) was the no-hardware-hooks BASCOM 5.36. The new BASIC Compiler 6.0, which sits astride the MS-DOS and OS/2 operating systems, has features and functions that let you access the world of multitasking.

With OS/2, BASIC leaves the single-threaded, real-mode safe harbor of MS-DOS and enters the turbulent waters of multiple-threaded protected mode where event trapping, interprocess communication, and dynamic linking become important. For BASIC programmers, "OS/2 programming" will become synonymous with "complexity."

Like Microsoft's other updated languages, BASIC 6.0 comes on several disks—seven in this case. However, a prompt-driven setup program makes the installation of the program relatively easy. In addition to new statements and functions to facilitate interprocess communication and multitasking, BASCOM 6.0 lets you call OS/2 functions directly from BASIC. You can use event-trapping functions in either real or protected mode.

BASCOM 6.0 is really QuickBASIC 4.0 in another guise; the BASIC part of BASCOM 6.0 is functionally the same as QuickBASIC 4.0. The QuickBASIC 4.0 environment, including editor and threaded p-code interpreter, comes with the distribution disks for BASCOM 6.0. The documentation for BASCOM 6.0 is the QuickBASIC 4.0 manual set.

Even though BASCOM 6.0 offers two environments, only one runs in protected mode. The QuickBASIC 4.0 environment runs exclusively in real mode; you can create programs in that environment and then compile the resulting source code in protected mode with the BASCOM 6.0 compiler, `BC.EXE`. You can also invoke `BC.EXE` in real mode and the compiler automatically emits an object file suitable for real mode; invoked in protected mode, `BC.EXE` creates an object file for protected mode. The one thing that `BC.EXE` cannot do, however, is create programs that run in both real and protected mode, programs that Microsoft calls "bound applications."

With the addition of seven new keywords to support OS/2 programming, the new Microsoft Editor, CodeView, and a new segmented linker, BASCOM 6.0 is more than a simple enhancement to QuickBASIC 4.0. With the additional tools, programmers can choose the QuickBASIC 4.0 development environment, or they can opt for using the Microsoft editor and the stand-alone compiler and linker.

The new BASCOM version doesn't support `IOCTL/IOCTL$`, `INP`, `OUT`, `PALLETTE/PALETTE USING`, `PEN`, `PLAY`, `SOUND`, `STICK`, or `WAIT` in protected mode. Some statements—`BLOAD/BSAVE`, `CALL`, `PEEK/POKE`, and `VARSEG`—function somewhat differently in protected mode. BASCOM 6.0 also does not offer EGA, VGA, or Hercules graphics support in protected mode. Otherwise, BASCOM 6.0 mirrors QuickBASIC 4.0. Like QuickBASIC 4.0, BASCOM 6.0 offers two options for arithmetic support in either real or protected mode. One option emits in-line code for use by a math coprocessor, if present, or emulates coprocessor functions in software when no coprocessor is present. The other option offers a software-only math package that uses a subset of IEEE-754 Binary Floating-Point Standard number formats.

The major difference in the two versions of BASIC lies in the way you create programs for real and protected mode. Linking under OS/2 is much more involved than under MS-DOS. BASCOM 6.0's linker can be used in either real or protected mode, but in protected mode the number of linking options is greater. This increased number of options lets you modify libraries, override default libraries, combine libraries, and create extended run-time modules of your own functions. You can call OS/2 functions from within your BASCOM 6.0 programs by using the `DOSCALLS.BI` file, added to your program with a `#include: DOSCALLS.BI` statement. This file contains declarations for OS/2 function calls and type definitions for data structures used by OS/2.

While BASCOM 6.0 lets you use some of OS/2's facilities, it will not let you create multiple threads from within a protected-mode BASIC program. You can call external routines or create a process that creates multiple threads. Multiple threads within a BASCOM 6.0 program are not possible because BASCOM 6.0 run-time routines are not reentrant.

BASCOM 6.0 provides record- and

continued

The Facts

Product	Minimum system requirements	Price
C Optimizing Compiler 5.1	448K bytes of RAM One double-sided floppy drive and a hard disk drive OS/2 1.0 or MS-DOS 2.1 (or higher)	$450 5.0 owners - free 4.0 owners - $150
BASIC Compiler 6.0	320K bytes of RAM Two double-sided floppy drives OS/2 1.0 or MS-DOS 2.1 (or higher)	$295 5.36 owners - $99
FORTRAN Optimizing Compiler 4.1	320K bytes of RAM Two double-sided floppy drives OS/2 1.0 or MS-DOS 2.1 (or higher)	$450 4.0/4.1 owners - $50 3.xx owners - $150
Macro Assembler 5.1	320K bytes of RAM Two double-sided floppy drives OS/2 1.0 or MS-DOS 2.1 (or higher)	$150 5.0 owners - $15 4.0 owners - $75
Pascal Compiler 4.0	320K bytes of RAM Two double-sided floppy drives OS/2 1.0 or MS-DOS 2.1 (or higher)	$300 3.32 owners - $40 3.3 (or before) - $75
OS/2 Programmer's Toolkit	320K bytes of RAM One double-sided floppy drive and a hard disk drive OS/2 1.0	$350
Windows 2.03 Software Developer's Kit	640K bytes of RAM One double-sided floppy drive and 2 megabytes of available storage MS-DOS 3.0 (or higher) Graphics adapter card Windows 2.0 (or higher) Windows/386 (optional) Microsoft-compatible mouse	$495

Table 2: *Results of sample program execution with Microsoft's FORTRAN Compiler 4.1. File sizes for the compiled program gauss were slightly larger in the bound version and ran a little slower. When running two copies of the program, the second copy slowed down significantly more than the first.*

	File size (bytes)	Execution time (seconds)
Real mode	45818	53
Protected mode	50318	60
Bound version, running under OS/2	61070	60
Bound version, multitasking, first copy	61070	76
Bound version, multitasking, second copy	61070	113

file-locking features in both real and protected modes. These features work well for networked applications in real mode; however, record and file locking are more important in protected mode for multiprocessing file operations.

With BASCOM 6.0, programmers now have a way to port their BASIC programs to the OS/2 protected-mode environment.

FORTRAN Compiler 4.1

Microsoft's newest version of its optimizing FORTRAN compiler lets you create .EXE programs that run under MS-DOS 3.0 or higher (including the DOS compatibility box of OS/2), OS/2 protected mode, or under both operating systems. The package also supports the use of DOS and OS/2 environment variables to specify frequently used command-line options, and it includes switches for compiling and linking under OS/2 or DOS.

As a further convenience for software developers who will be compiling for a wide variety of systems, the FORTRAN compiler lets you specify, on the command line, that a particular default library not be searched during linking. You can even set up code overlays on the command line.

Installation of the 10-disk package takes a few minutes but is fairly simple, thanks to the well-designed installation program. We found it particularly helpful be able to run through the entire setup procedure on a "dry run" basis, using an option presented at the beginning of the setup procedure. At various points during the process, the program gives you the option of learning more about a given subject before making a crucial setup decision; for instance, whether to install for 80x87 hardware or emulation, and whether to build a medium- or large-memory model library.

While testing a prerelease version of the package on a Compaq Deskpro 386/20 running OS/2 version 1.0, we put many of these new features to use. For instance, the commands to compile, link, and bind a test program called gauss.for were

```
FL /AL /FPc /Od /Zi /c gauss.for
 link /NOD:llibfore.lib llib-
 fep.lib gauss+c:\lib\apilmr,,,,;
```

and

```
bind gauss c:\lib\api.lib
 c:\lib\doscalls.lib
```

To see how the various compiling options worked, we used the 300-line numerical approximation program gauss.for and compiled the program for real mode, protected mode, and both (using the bind utility). Table 2 summarizes the results. Not surprisingly, .EXE file sizes were largest on the bound version and smallest on the real-mode version. The real-mode version ran 15 percent faster than the OS/2 versions, which is also to be expected due to the greater overhead of the multitasking OS/2 operating system.

Just to demonstrate the latter feature (multitasking), we started a second copy of the program running while the first copy was running. This slowed down the times somewhat, but otherwise everything worked fine. (The second copy ran considerably slower than the first, because the first copy was assigned to the active window group and thus had a higher priority in the multitasking scheduler.)

FORTRAN 4.1 may be the first tool to open up OS/2 systems to mainframe applications. According to Microsoft spokesman Greg Lobdell, beta testers of FORTRAN 4.1 in the aerospace industry have been especially pleased with the OS/2 version, which lets them run IBM VS and DEC VAX mainframe applications requiring very large memory spaces (up to 128 megabytes) on their 80286/80386 personal computers. (In practice, the upper limit for virtual memory may be less, depending on the amount of free space on the disk drive.)

Macro Assembler 5.1

Gone are the days when assemblers seemed geared to programmers who were apparently happy to work with the software equivalents of flint axes and bone-bladed knives. Microsoft's latest release of its macro assembler, MASM 5.1, arrived on five disks filled to the gunwales with the assembler and supporting utilities: LIB (the library manager), LINK, the CodeView symbolic debugger, Microsoft's program editor, an entire disk of CodeView tutorial, demonstration programs with "glue code" for attaching assembly language routines to high-level languages, and more.

MASM 5.1's foremost improvement over MASM 5.0 is, of course, its support for and ability to run under OS/2. There are actually two versions of the MASM.EXE program provided with 5.1—one that runs only under MS-DOS, and a bound version that executes under DOS 3.x as well as OS/2.

The documentation we received contained about seven pages covering OS/2 and included sample code fragments illustrating OS/2's calling convention. If you're counting on using MASM to create programs that run under either MS-DOS or OS/2, you'll discover most of your work will go into creating judicious macros governed by assembly switches to emit code based on the target operating system.

The update information for MASM 5.1 also boasted that the MS-DOS version of the assembler was faster than its ancestors thanks to a better use of far memory, while the OS/2-compatible version was billed as being slightly slower. Although there's no way we knew whether 5.1 uses memory more intelligently than its predecessors, we did run a sample assembly of the same 62K-byte source file under both MASM 5.0 and a prerelease version of 5.1.

On a Compaq 386 running Compaq DOS at 20 MHz with a 40-megabyte hard disk drive, all assemblies (we ran three—one for 5.0 and one each for the two new 5.1 versions) yielded identical object

continued

It could be that the best news about the latest macro assembler is that there is no bad news.

files (that was a relief) in around 8.5 seconds; any difference in the times was immeasurable. We should point out that the code we were compiling did not use any new OS/2 features, so the resulting object file was for MS-DOS only. Had we added the DOS bindings (in the file DOSCALLS.LIB) when we assembled with 5.1, the resulting object code would certainly have been larger.

MASM 5.1's most attractive new features, however, have to be the numerous embellishments its designers have added to macros and compiler directives: extensions to the PROC and MODEL directives to ease interface to high-level languages, a new LOCAL directive for creating and manipulating stack-based local variables, and ELSEIF—which lets you considerably simplify complex IF constructs in conditional assemblies.

MASM 5.1 also adds predefined text macros that allow a program to query its intended environment at assembly time. For example, if you've set the target CPU for an assembly using an assembly language directive (such as .286), you can perform conditional assembly based on the value of @CPU. This value's bit settings indicate which processor and/or coprocessor you've selected. Finally, with MASM 5.1 you can explicitly indicate pointers within data declarations; this lets you properly view the data item as a pointer when debugging with CodeView.

Overall, this is an update for MASM that was certainly called for by the oncoming OS/2, and we're happy to see that MASM's designers are paying attention to everyone out there attaching assembly language routines to high-level languages. What we're saying here is "no big surprises," and it could be that the best news about MASM 5.1 is that there is no bad news.

Pascal Compiler 4.0

In Pascal these days, the key number is 4—as in Turbo Pascal version 4, and now the Microsoft Pascal Compiler version 4. Faced with keen competition from the low-cost Turbo product from Borland, Microsoft has enhanced its own Pascal with a number of key features, including OS/2 support, the CodeView debugger, and a text editor.

The new compiler's support for OS/2 will probably be its most noteworthy feature. Most of the significant programs included with the compiler are bound, meaning that they can be run under either MS-DOS or OS/2. In addition, you can choose to have your own programs bound, or you can link them so that they are specifically tailored to either MS-DOS or OS/2. Thus, you can develop OS/2 programs in the familiar MS-DOS environment. Or, you can develop MS-DOS programs under OS/2. The latter approach should not be overlooked, since the OS/2 environment should allow more memory for debugging purposes and multitasking.

Note, however, that one should be careful when programming for multitasking. The procedures and functions in the Pascal library are not reentrant. Thus, you should be careful not to enter a particular function until you are sure that no other part of your program is using it.

The new Pascal also features CodeView for the first time. This version of Microsoft's source code-level debugger now includes the ability to evaluate some Pascal expressions. It also uses virtual memory, which suggests that memory limitations should not occur even under MS-DOS.

Another new feature for Microsoft's Pascal is a text editor. Like the other new language products, the new Pascal includes Microsoft's Editor, a fairly straightforward text editor that reportedly can be linked to the compiler. According to Microsoft, you can run the compiler from the editor and instruct the compiler to pass error information back to the editor. The result should be a rough approximation of the programming environment provided by the Turbo languages. The editor is a bit complicated, however, and many programmers will probably opt to configure it to suit their own preferences or to use their own favorite editors.

The older versions of Microsoft Pascal required two passes to compile a program, each pass performed by a separate program (December 1986 BYTE). Three passes were needed if you wanted an object code listing. The new version still does at least two passes, but you can call all three passes and the linker program with a single driver program called the "PL driver." This obviates the need to construct complex batch files. Note, however, that you can still pass command-line options to the individual passes and to the linker via the command line that invokes the PL driver.

A number of other goodies are probably included in the other new languages. These include a MAKE program, which should automate the process of checking

continued

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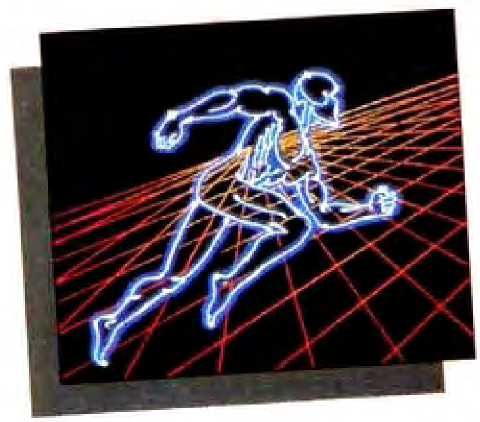

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to be sure that a program is based on the latest source and object files.

As for performance, we did some tests using a prerelease version of the compiler running under MS-DOS. A full analysis of the speed of the program under both MS-DOS and OS/2 will have to wait for a full review, but Microsoft assured us that any benchmark results we obtained would be similar to those of the shipping product.

On our Sieve test, an MS-DOS program executed in 3.77 seconds on a PC AT clone, about 3 percent faster than the same program compiled under the previous version of Microsoft Pascal (version 3.32). A bound version of the program running under MS-DOS ran at the same speed as the DOS-only version. By contrast, the same program produced by Turbo Pascal version 4 required 33 percent more time.

As for program size, the DOS-only version of the Sieve program weighed in at 31K bytes, while the bound version was 42K bytes. The same program produced by the previous version of Microsoft Pascal was 32K, but the Turbo version was a mere 3K.

For floating-point calculations, the new compiler has a numeric-coprocessor-emulator option similar to that used on the older versions of the compiler. When a program is compiled with this option set, it will use an 8087 or 80287 coprocessor if found, or it will emulate these coprocessors if they are not present. To get a rough idea of the performance in this area of computations, we ran a floating-point benchmark without a coprocessor. The benchmark ran 10 percent faster than a similar program compiled under the previous Microsoft Pascal. The Turbo version, however, was 26 percent faster than the new version.

One other feature of the new Pascal compiler is that it should have less of a tendency to run out of memory. It now uses far memory to store the table of symbol names, instead of storing these names in a single segment along with the stack. This should mean that the symbol table is limited only by system memory and that the stack can grow much larger.

Microsoft Pascal 4.0 comes on nine 5¼-inch floppy disks and, when completely loaded on your hard disk, takes up about 2.5 megabytes. This alone is an indication of significant change—the last version consisted of only two disks.

Development Kits

In addition to OS/2 language functionality, Microsoft has introduced software tools to further encourage the development of OS/2-based applications. For the most part, these development packages consist of lots of documentation with some accompanying software.

The OS/2 Programmer's Toolkit, for instance, can be used with any of the five language compilers described earlier and is made up of three manuals: The OS/2 Programmer's Reference Manual is a comprehensive description of OS/2 system functions, structures, and file formats; the OS/2 Programmer's Learning Guide describes OS/2 programming techniques; and the OS/2 Programming Tools explains the software tools and utilities provided with the Toolkit. Among those tools are the BIND.EXE utility (described earlier), API.LIB (a library used in conjunction with BIND.EXE, containing the functions for applications that can run in both MS-DOS and OS/2 environments), and IMP.LIB (a utility that helps programmers create DLLs).

The Windows 2.03 Software Developer's Kit (SDK) also consists of three manuals: the Windows Programmer's Learning Guide, the Windows Programmer's Reference Manual, and the Windows Extension Manual. (Version 1.04 of the SDK did not include a Learning Guide.) The SDK provides information ranging from a description of all the Windows functions, messages, data types and structures, and file formats to a step-by-step guide to creating Windows applications. It also provides an exhaustive discussion of the Tag Image File Format (TIFF) and Dynamic Data Exchange (DDE) characteristics.

In terms of the software, the differences between the SDK 1.04 and 2.03 are a new API, which provides 15 new functions and messages; updated utilities, including new font and dialog box editors; and a new screen-capture feature called SNAP that lets you copy selected regions of the screen instead of the entire screen (as did the 1.04 SLAPJR utility). Additionally, a debugging aid called SPY has been added to let you "spy" on messages passed from Windows to the application. This debugging tool is selective in that you can specify the type of message (i.e., DDE, mouse, Clipboard, and so on) to monitor.

Furthermore, a couple of new files have been added, particularly an assembly language include file (1.04 had only C and Pascal include files), new floating-point libraries, and the capability to instill within applications the automatic checking of host personal computers to see if a math coprocessor chip is present. ■

This article was written jointly by the following BYTE editors: Jonathan Erickson, Richard Grehan, Rich Malloy, George A. Stewart, Tom Thompson, and G. Michael Vose.

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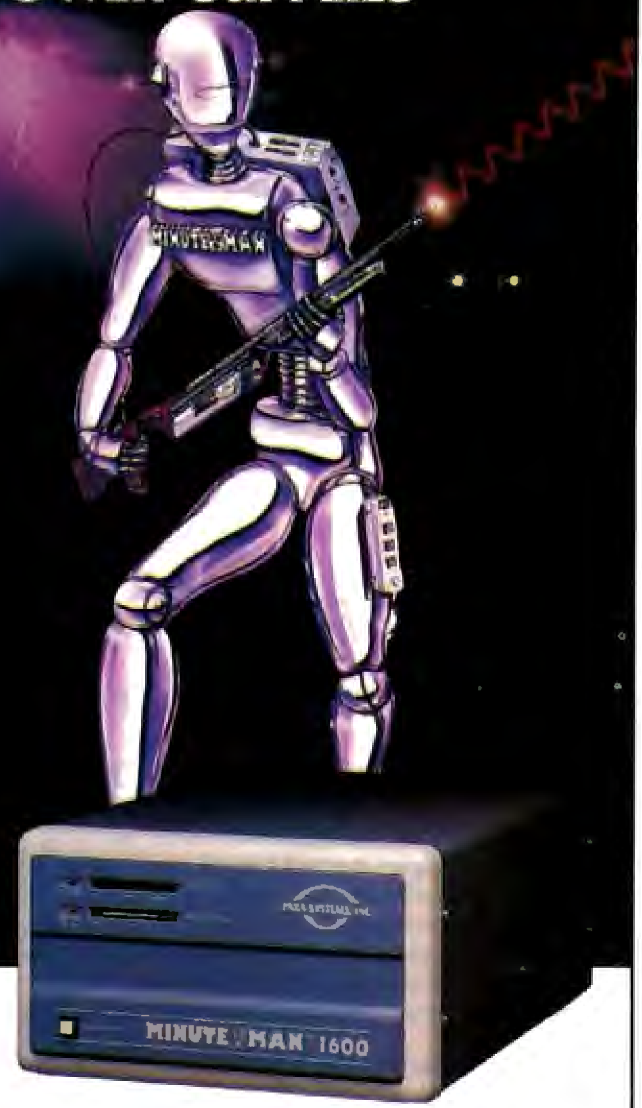

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Nicholas Baran

dBASE IV: A Paradox Killer?

Ashton-Tate's long-awaited new edition of dBASE ups the ante against competitors like Paradox and R:base

Faced with strong competition from rival database managers, Ashton-Tate is reasserting its leadership in the database market with the release of dBASE IV.

In addition to major new features such as Structured Query Language (SQL) support, a source code compiler, and a greatly improved user interface, dBASE IV appears to meet or beat the capabilities of its main competitors while preserving complete compatibility with dBASE III. Indeed, Ashton-Tate claims that all databases, forms, reports, and applications developed in dBASE III will run without modification in dBASE IV.

Ashton-Tate is billing dBASE IV as the crucial first step in developing complete database connectivity between personal computers, "workgroup environments," and mainframe SQL databases. But, although dBASE IV supports a complete set of SQL commands either in interactive command mode or as embedded commands in dBASE programming code, there is no provision for transferring data between dBASE and SQL databases. In other words, the SQL implementation is useful only for developers who want to write code that they can eventually port to SQL environments.

True portability of SQL and dBASE IV databases will have to wait for the SQL Server system planned for OS/2, which was announced in January in conjunction with Microsoft and Sybase. Ultimately, Ashton-Tate's goal is to make dBASE the database of choice on Unix and VMS file servers as well as on MS-DOS and OS/2 systems.

Leaving the Past Behind

While dBASE IV might be a stepping stone to the future, it is also a major break with the past. Until now, dBASE has always had a reputation for being hard to learn and hard to use, requiring a great deal more programming than its competitors. Ashton-Tate has answered this criticism with a completely redesigned menu-driven user interface (though you can still use the familiar dot prompt if you want) plus an improved applications generator, keyboard macros, and a query-by-example (QBE) feature similar to that found in Paradox.

In addition, new reports and form generators include menu-driven screen designers, calculated fields, data validation, box and line drawing, and other new features for customizing input and output screens. The new dBASE also includes a facility for automatically generating graphs and charts on Ashton-Tate's Chart-Master graphics software. You do have to exit from dBASE, however, to run Chart-Master.

The dBASE IV database structure is fully compatible with earlier dBASE versions but includes a new floating-point data type with 64-bit numerical precision. Also, you can now manipulate data in memo fields as you would other text

continued

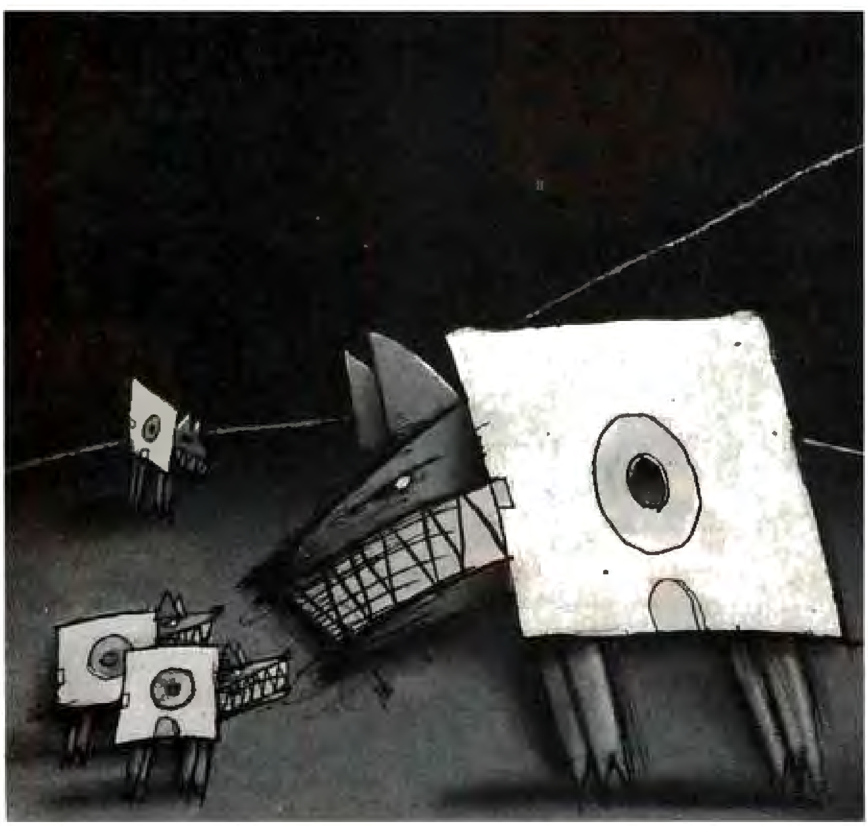

Illustration: James Yang © 1988

fields, which you could not in dBASE III.

Another enhancement to the database structure is the ability to combine multiple databases into a view or "pseudo" database, which looks like any other database. This means you can work with forms, reports, and application code that access the view and automatically extract and update data from the databases linked to the view. This feature makes relational operations far less complex than in earlier dBASE versions. However, you can have only one view or database on the screen at a given time, unless you resort to programming.

The latest dBASE also has automatic indexing with up to 47 indexes per database file. Although you can still create your own NDX index files, the automatic indexing feature eliminates the need for them in most situations.

The dBASE IV package includes upgrades to the dBASE programming and command language. These include a library of financial and mathematical functions, a "template language" for customizing the applications generator, commands for creating windows with pop-up and pull-down menus, and a new multiple-window debugger. The windowing capability allows applications developers to create windows on the screen that can display multiple databases simultaneously.

Object-Code Compiler Adds Speed

The new package also includes a compiler of sorts. dBASE IV's new compiler produces a type of object code that, according to Ashton-Tate, makes dBASE programs execute up to 9 times faster than in dBASE III.

The compiler produces files with a `.DBO` file extension rather than the `.EXE` or `.COM` files produced by most other compilers. A special Build utility in a developer's version allows you to link compiled programs together.

Finally, dBASE IV includes improvements for multiuser applications. These include transaction processing, error recovery, password security and encryption, and automatic record and file locking, with an indicator identifying which workstation is locking the file or record.

dBASE IV will be available for both MS-DOS and OS/2. The MS-DOS version requires 640K bytes of RAM and automatically uses extended or expanded memory, if either is present.

When dBASE ships in July, it will be in two editions: the standard dBASE IV ($795) for productivity users, and the Developer's Edition ($1295) for serious programmers and applications developers. The two are the same except that the Developer's Edition includes additional documentation for programmers and developers, plus the Build utility for linking compiled source code, unlimited runtime support, and LAN keys for testing multiuser applications.

A report provided by Ashton-Tate summarizing the differences between dBASE IV and dBASE III is over 50 pages long. There obviously isn't space here to discuss all the other new or enhanced commands and functions. But it is clear that Ashton-Tate's objective is to silence its critics and to expand its already overwhelming share of the database market. ■

[Editor's Note: *We based this First Impression on product demonstrations and early documentation provided by Ashton-Tate. We are planning to provide a more detailed review of the product in the near future.*]

Nicholas Baran is an associate technical editor of news and technology at BYTE's San Francisco office.


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The Best of the 24-pin Printers

George A. Stewart

Speed and print-quality tests reveal the best values among 37 dot-matrix printers

Selecting a dot-matrix printer can be a maddening experience. You have to weigh differences in price, speed, and print quality, and then hack your way through a morass of specifications and descriptions of font cartridges, buffer sizes, emulations, and control panels.

But the factors that really matter are speed and quality, and if you insist on having both in one printer, you'd better focus your attention on 24-pin dot-matrix printers. Traditionally the top of the line in terms of price and quality, some of the new models rival 9-pin printers in both speed and price.

To help you in the selection process, we tested 37 of the newest 24-pin dot-matrix printers. We've grouped them into four categories so you can quickly focus on the ones that fit your budget: low ($499 to $999), middle ($1000 to $1499), high ($1500 to $1999), and deluxe ($2000 to $2499).

The good news is that bargain hunters have the widest choice: Almost half the units fall into the low-price category. In last year's dot-matrix-printer roundup (April 1987 BYTE), only four 24-pin printers, out of 15 tested, fell into that range. Further good news is that the character-per-second (cps) speeds are up. Last year's top three ratings in "top quality font" throughput at 10 characters per inch (cpi) were 94, 96, and 104 cps; this year, the top three were timed at 103, 118, and 138 cps. Speeds in draft and graphics modes also showed similar increases.

All the printers we tested meet certain minimum standards. For example, character pitches of 10, 12, 17.1, and proportional spacing are universally available. All the units have parallel interfaces; serial interfaces are also available on all the printers, either as an option or standard.

All the printers emulated at least one 9- or 8-pin printer, typically an IBM Proprinter, an IBM 5152 Graphics Printer, or an Epson FX printer. However, these emulations will not give you the full capability of a 24-pin printer. For that, these printers need to emulate a 24-pin standard like the Epson LQ or the Toshiba P351. All the printers we tested had one or more emulation modes for taking advantage of 24-pin capabilities. When more than one standard was available, we selected the emulation that gave the best results.

For this review, we selected wide-carriage models (using up to 15-inch-wide paper) unless only a narrow-carriage model was available. Narrow-carriage models (using 8½-inch-wide paper) are generally $200 to $300 less than their wide-carriage counterparts. Thus, if you don't need the wide-paper capability, you can save some money without sacrificing anything in terms of performance or quality.

Table 1 lists the printers by price category, along with individual specifications and features. One significant specification is the MTBF (mean time between failure) rating, a manufacturer's rating of the durability of a printer.

One relatively new feature for printers is forms parking, the ability to automatically retract one type of paper already in the printer—like multipart forms—to let you insert and print on a single sheet like letterhead, and then to automatically reload the multipart forms. This feature, available on only a few printers we tested, increases the versatility of a printer for office use; 24-pin printers are often called upon to do letters as well as forms printing. Another extra-cost option offered for most of these units is an automatic sheet-feeder bin.

Testing Criteria

We measured throughput, sound level, and print quality on each printer, using an IBM PC AT running at 8 MHz to drive the printers.

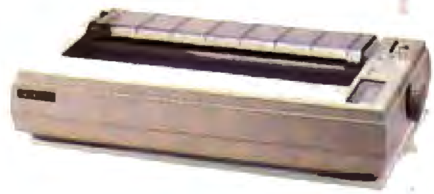
80-column text throughput. This is a realistic measurement of print speed using a typical document. Our 80-col-

continued

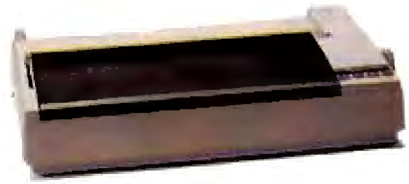
OUTSTANDING BUYS

Low/Middle Price

Epson LQ-500



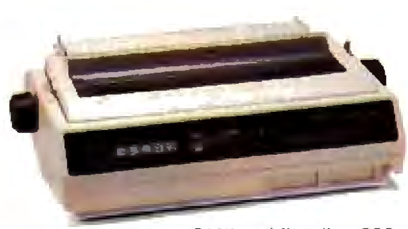
Fujitsu DL3400



Copal WriteHand 6700

High/Deluxe Price

HP RuggedWriter 480



Okidata Microline 393

Fujitsu DL5600

Table 1: *The 37 24-pin dot-matrix printers we tested vary widely in price. The printers are grouped here according to price category, with other key specifications and features listed.*

Manufacturer/Model	Price	Carriage	Resident fonts¹	Plug-in font cartridge	Draft-quality/ top-quality switch²	Forms parking³
Price category: Low						
Epson LQ-500	$499	narrow	3	●	○	●
NEC P2200	$499	narrow	5	●	●	●
Seikosha SL-80AI	$549	narrow	1	○	●	●
Copal WH 6700	$795	wide	1	●	●	○
Epson LQ-850	$799	narrow	3	●	○	○
Printronix P1013	$895	narrow	1	●	●	●
Panasonic KX-P1524	$899	wide	1	●	●	●
Brother M-1724L	$949	wide	1	●	●	●
Citizen Tribute 224	$949	wide	1	●	●	○
ALPS ALQ324	$995	wide	1	●	●	○
Fujitsu DL3400	$995	wide	1	●	●	○
NEC P7	$995	wide	2	●	○	○
Sanyo PR-241	$999	wide	7	○	●	●
Star Micronics NB24-15	$999	wide	1	●	●	●
Toshiba P341SL	$999	wide	3	●	○	○
Price category: Middle						
IBM Proprinter XL24	$1049	wide	1	●	●	●
Dataproducts 9044	$1099	wide	2	●	●	○
Epson LQ-1050	$1099	wide	3	●	○	○
Facit B3450	$1245	wide	2	●	○	○
C. Itoh C-715A	$1295	wide	1	●	●	○
Nissho NP-2405	$1295	wide	2	●	○	●
ALPS P2400C	$1395	wide	1	●	●	○
Okidata Microline 393	$1399	wide	2	●	●	○
Star Micronics NB-15	$1399	wide	1	●	●	○
Epson LQ-2500	$1449	wide	6	●	○	○
Fujitsu DL2600	$1495	wide	1	●	●	●
NEC P5XL	$1495	wide	2	●	○	○
Toshiba P351SX	$1499	wide	4	●	○	○
Price category: High						
Radio Shack DMP-2120	$1599	wide	1	○	●	○
AT&T 477	$1695	wide	1	●	●	○
Hewlett-Packard RW 480	$1695	wide	2	●	○	●
Nissho NP-2410	$1745	wide	2	●	○	○
NEC P9XL	$1795	wide	2	●	●	○
Mannesmann Tally MT330	$1799	wide	1	●	●	●
C. Itoh C-815	$1995	wide	2	●	○	○
Price category: Deluxe						
Fujitsu DL5600	$2195	wide	1	●	●	○
Japan Digital Laboratory JDL-850	$2495	wide	2	●	●	●

Notes
NA—Information not available from manufacturer.
●—Feature is available.
○—Feature is not available.

¹ The number of built-in 10-pitch fonts.
² Draft-quality/top-quality switch implies that each font can print in draft quality or top quality.

umn ASCII document consists of five pages (330 lines) of single-spaced text with 1-inch margins, indented paragraphs and ragged right margins, and with three tables on the last page. The text contains no special attributes like underlining or boldface.

As with all the tests, we transferred the data from a hard disk file to the printer using the PC-DOS copy *file* command. We started the timer when the command was entered and stopped the timer when the last line was printed.

We timed the printers in draft-quality mode and in top-quality mode (variously referred to by manufacturers as letter quality, near letter quality, or correspondence quality; we always used the highest quality available).

132-column text throughput. To test the printers on 132-column text, we used a full page (66 lines) of numbers divided into 11 columns, similar to a financial report or spreadsheet. We measured the time for draft quality and top quality at 10 cpi. To allow testing of the narrow-carriage printers, we also ran the test using

Maximum copies[4]	Input buffer standard	Input buffer optional	MTBF[5]	Dimensions (inches) height by width by depth	Weight (pounds)	Comments[6]
3	8	0	4000	6 × 15 × 13	15	Pitch-select by software only
3	8	0	4000	6 × 15 × 11	11	Front-load cut sheets; compact
3	16	0	3200	6 × 16 × 13	15	Pitch-select by software only
3	18	32	4000	5 × 23 × 15	24	Light-duty tractor mechanism
4	6	32	4000	6 × 17 × 14	20	
3	2	0	4000	5 × 16 × 12	19	24-pin hammer-bank mechanism
4	13	32	4000	6 × 24 × 15	35	Versatile paper handling
4	0	32	4000	5 × 20 × 12	19	Versatile paper handling
4	24	0	5000	5 × 23 × 14	17	NC model Tribute 124, $699
4	7	64	5000	6 × 19 × 16	31	NC model ALQ224, $695
3	24	0	8000	5 × 23 × 14	27	NC model DL3300, $795
4	18	32	5000	4 × 22 × 13	25	NC model P6, $699
4	10	0	8000	4 × 22 × 13	20	Awkward to configure
3	5	16	NA	5 × 23 × 15	33	NC model NB24-10, $749
3	32	32	NA	4 × 16 × 15	18	NC model P321SL, $749
2	6	0	NA	5 × 23 × 14	27	NC model Proprinter X24, $799
4	32	0	5000	5 × 23 × 13	27	NC model 9034, $899
4	16	32	6000	6 × 24 × 14	26	NC model LQ-850, $799
4	16	0	4000	7 × 25 × 16	33	Versatile paper handling
4	32	0	7200	5 × 25 × 15	38	Plug-in emulation cards
5	6	30	6000	8 × 24 × 15	33	Full-feature control panel
6	4	252	6000	7 × 25 × 18	44	Versatile paper handling
4	30	0	4000	7 × 16 × 22	37	Versatile paper handling
3	16	16	NA	5 × 23 × 15	33	
4	8	32	6000	6 × 23 × 15	26	
5	8	0	6000	6 × 22 × 15	40	
4	8	32	7000	6 × 23 × 15	37	
6	32	32	NA	6 × 23 × 16	33	Versatile paper handling
5	0	64	3000	8 × 23 × 15	50	Manual forms parking
5	8	0	6000	6 × 22 × 15	40	Easy configuration dialogue
4	2	16	20,000	8 × 24 × 14	35	Front-loading forms
5	6	48	6000	6 × 24 × 17	41	Versatile paper handling
6	16	32	7000	6 × 23 × 15	37	Automatic paper loading
4	0	32	4800	7 × 24 × 17	55	Difficult ribbon loading
4	42	0	7200	6 × 23 × 16	33	
8	24	0	8000	7 × 24 × 15	45	Versatile paper handling
4	128	0	4000	8 × 26 × 17	43	Includes HP plotter emulation

[3] Refers to automatic forms parking only.
[4] Maximum copies includes original and applies to carbonless forms.
[5] Mean time between failures, in hours, as quoted by manufacturer; the rating systems vary among manufacturer—most are for a 25 percent duty cycle.
[6] NC stands for narrow-carriage counterpart.

17.1 cpi, draft mode, producing 8-inch instead of 13-inch lines. (At 17.1 cpi, draft mode is of higher quality than at 10 cpi because of the higher dot density.)

Throughput values are inevitably lower than the cps speeds quoted by the manufacturers. The manufacturer's rating is actually the highest speed the printer is capable of on a single line. Our tests take into account the time required to advance the paper and position the print head to the start of the next line.

Table 2 presents all the throughput figures in cps and lines per minute (lpm). The cps figures are given to ease comparison with last year's results; lpm is a more standard unit of measurement for throughput. Characters per second is simply the document length in bytes divided by the number of seconds to print it. Lines per minute is the document length in lines divided by the number of minutes required to print it. Keep in mind that 66 lpm is equivalent to one page per minute, in either 80-column or 132-column printing.

continued

Table 2: *Throughput ratings for 80-column and 132-column text reveal clear leaders in each price category. Higher numbers signify faster performance.*

Manufacturer/Model	80-column throughput				132-column throughput					
	draft, cps	draft, lpm	top, cps	top, lpm	draft, cps	draft, lpm	top, cps	top, lpm	cond., cps	cond., lpm
Price category: Low										
Epson LQ-500	101	124	44	54	*	*	*	*	124	55
NEC P2200	85	105	39	49	*	*	*	*	95	42
Seikosha SL-80AI	56	69	30	37	*	*	*	*	60	26
Copal WH 6700	102	126	50	62	138	61	60	27	130	58
Epson LQ-850	148	183	64	79	*	*	*	*	173	77
Printronix P1013	107	132	42	52	*	*	*	*	130	58
Panasonic KX-P1524	107	132	48	59	140	62	52	23	124	55
Brother M-1724L	107	132	49	60	128	57	48	21	111	50
Citizen Tribute 224	122	151	55	68	149	67	61	27	157	70
ALPS ALQ324	105	130	50	62	147	66	58	26	128	57
Fujitsu DL3400	146	180	58	71	188	84	57	25	155	69
NEC P7	111	137	50	62	138	61	54	24	121	54
Sanyo PR-241	90	111	49	61	130	58	54	24	85	38
Star Micronics NB24-15	113	139	50	61	147	66	55	25	79	35
Toshiba P341SL	110	135	47	58	145	64	53	23	136	60
Price category: Middle										
IBM Proprinter XL24	159	196	64	79	173	77	63	28	147	66
Dataproducts 9044	121	150	61	75	184	82	72	32	149	67
Epson LQ-1050	147	181	64	79	180	80	66	29	176	79
Facit B3450	134	166	56	69	176	79	66	29	149	67
C. Itoh C-715A	131	162	63	77	201	90	74	33	166	74
Nissho NP-2405	139	172	64	79	188	84	73	32	276	123
ALPS P2400C	146	180	73	90	215	96	87	39	188	84
Okidata Microline 393	184	227	89	110	232	104	92	41	315	141
Star Micronics NB-15	140	173	62	77	192	86	72	32	109	48
Epson LQ-2500	128	158	61	76	173	77	73	32	116	52
Fujitsu DL2600	146	180	73	90	188	84	76	34	196	88
NEC P5XL	132	163	57	71	78	35	43	19	82	37
Toshiba P351SX	165	204	77	96	232	104	88	39	221	99
Price category: High										
Radio Shack DMP-2120	150	185	74	91	196	88	77	34	201	90
AT&T 477	146	180	73	90	192	86	76	34	201	90
Hewlett-Packard RW 480	191	236	138	171	253	113	155	69	227	102
Nissho NP-2410	169	208	103	127	239	107	132	59	294	132
NEC P9XL	170	210	82	101	232	104	90	40	196	88
Mannesmann Tally MT330	205	253	72	88	252	113	72	32	**	**
C. Itoh C-815	182	225	91	112	252	113	116	52	184	82
Price category: Deluxe										
Fujitsu DL5600	236	291	118	146	315	141	124	55	368	165
Japan Digital Laboratory JDL-850	169	208	95	117	226	101	106	47	166	74

*Test not applicable on narrow-carriage printers.
**Would not complete test due to software incompatibility.

Complex text printing speed. To compare the printers' speeds on more complicated text, we used a document consisting of various combinations of underlining, bold, italic, superscript, subscript, pica, and elite fonts. We generated the print file using the XyWrite III Plus word-processing program configured with printer drivers for Epson LQ, Toshiba P351, or IBM 5152 graphics printers, depending on the emulation in each printer.

These results are not directly comparable to the 80-column text throughput results because the style test is an unrealistically dense mix of printing styles. It is definitely not a throughput test. Table 3 lists these results in cps only. What is significant about this test is how it ranks the printers within the same price category.

Graphics speed. Two tests measured graphics speed. The first test consisted of printing four graphs (two scatterplots containing lines and circles, a bar chart, and a pie chart) on a single page. We produced the print file using STATA 1.5, a statistical-analysis and data-presentation program, configured with a printer

Table 3: *Epson and Fujitsu printers, along with several others, did well on the style, graphics, and gray-scale tests (higher numbers are preferable). In the sound-level ratings, where lower numbers are preferable, each 3-decibel increase corresponds to a doubling in the intensity of the sound.*

Manufacturer/Model	Style, cps	Graphics, cps	Gray scale, cps	Top-quality sound level, dBA
Price category: Low				
Epson LQ-500	67	850	692	72
NEC P2200	46	830	920	72
Seikosha SL-80AI	*	451	329	68
Copal WH 6700	59	450	312	69
Epson LQ-850	100	1350	1548	71
Printronix P1013	65	683	1173	78
Panasonic KX-P1524	61	850	826	75
Brother M-1724L	65	931	413	72
Citizen Tribute 224	71	917	*	73
ALPS ALQ324	52	562	420	69
Fujitsu DL3400	92	1440	627	63
NEC P7	55	1255	1024	65
Sanyo PR-241	52	955	611	68
Star Micronics NB24-15	39	705	627	72
Toshiba P341SL	38	905	404	70
Price category: Middle				
IBM Proprinter XL24	58	195	299	73
Dataproducts 9044	34	687	371	72
Epson LQ-1050	105	1367	1548	71
Facit B3450	52	1090	790	72
C. Itoh C-715A	39	1186	516	74
Nissho NP-2405	60	650	855	71
ALPS P2400C	70	1000	920	70
Okidata Microline 393	80	2400	*	67
Star Micronics NB-15	45	658	430	75
Epson LQ-2500	78	1459	1192	70
Fujitsu DL2600	105	1588	1399	69
NEC P5XL	66	1421	1276	68
Toshiba P351SX	59	2117	876	70
Price category: High				
Radio Shack DMP-2120	76	465	932	68
AT&T 477	109	1301	1515	69
Hewlett-Packard RW 480	68	542	854	69
Nissho NP-2410	66	683	1039	71
NEC P9XL	87	1928	1914	68
Mannesmann Tally MT330	*	1069	826	63
C. Itoh C-815	100	2823	673	71
Price category: Deluxe				
Fujitsu DL5600	171	3176	2273	68
Japan Digital Laboratory JDL-850	72	497	836	63

*Would not complete test due to software incompatibility.

driver for Epson LQ, Toshiba P351, or IBM 5152 graphics printers. The first two drivers take advantage of the 24-pin high-dot-density capabilities and were used wherever possible. (Only the Radio Shack DMP 2120 required us to fall back to the IBM graphics printer driver, since that unit's 24-pin graphics command set is unique to Tandy.)

The second graphics throughput test consisted of a series of gray-scale patterns written for 9-pin printers with IBM 5152 Graphics Printer emulation. This is a very stressful test because the print head is constantly working. Some printers had to slow down to cool off, reducing their effective throughput. For example, the Brother M-1724L came to a complete stop several times to cool off during this test.

Table 3 includes cps results for both graphics tests. Keep in mind that, here, cps should more properly be called bytes per second, since the test file is binary, not ASCII.

Sound level. We measured the sound level of each printer during draft-quality and top-quality text printing (80-column ASCII file) and for graphics speed printing (gray-scale test).

Our test device, the Radio Shack sound-level meter (Model #33-2050), was positioned on a tripod 2 feet in front of the test unit, at ear level for a person sitting in front of the printer. We used the meter's A weighting, which models an average person's auditory frequency response.

Our numbers are higher than those quoted in the manufacturer's specifications because we used a small office rather than the standard environment prescribed for sound-level measurements; however, our numbers are consistent and valid for making comparisons. The results for sound levels during the top-quality-mode test are given in table 3; the results were comparable for the draft-quality-mode and graphics tests.

Print quality. Finally, we subjectively evaluated the print quality of text and graphics from each printer. For text quality, we used a few pages from the top-quality-mode 80-column throughput test and the complex text-printing speed test. For graphics quality, we used both graphics speed tests: the four-graph printout and the gray-scale printout.

We posted the 74 samples along two walls, museum style, numbered for reference but unlabeled as to manufacturer. Twenty-two BYTE staff members rated samples on a scale of 1 (worst) to 5 (best) (see figure 1), using the following criteria:

Text:
- Uniform print density (no variation in density)
- Uniform shape of characters (a given letter always looks the same)
- Clarity (easy to read)

Graphics:
- Straight lines and smooth curves
- Solid, uniform filled-in black areas
- Fineness of lines
- Uniform density of filled-in areas (no variation in density)

Each printer's final score was the numeric rating (1 to 5) that its print sample received most frequently from the BYTE staff.

continued

Photo 1: *As with most of these printers, the NEC P2200 is small and light, yet it offers numerous advanced features.*

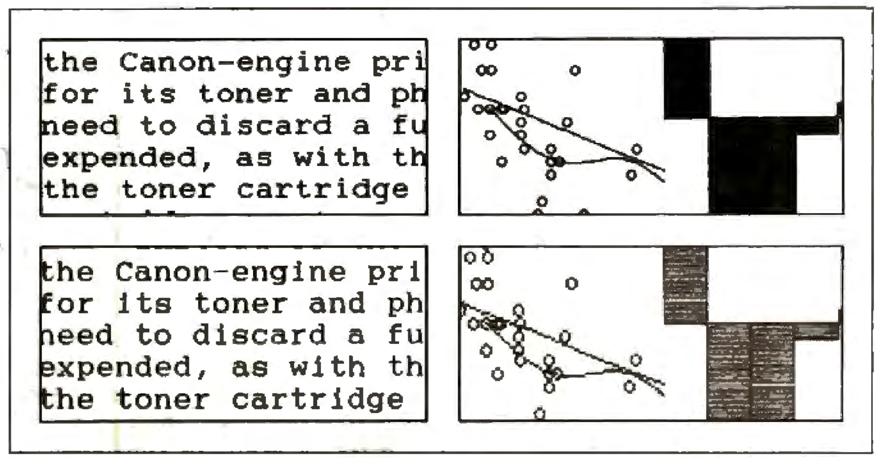


Figure 1: *In our ratings of top quality and graphics printing, the two samples on top received a score of 5; the two on the bottom received scores of 3 (left) and 1 (right).*

The Proof Is in the Printing

In general, throughput goes up with price; however, a few exceptions are noted below. Sound levels are generally highest in the low-price range. One surprising fact is that text quality is generally highest among the middle-price printers.

Print quality. Among low-cost printers, the Fujitsu DL3400, the Panasonic KX-P1524, and the Printronix P1013 rated highest, with 4s for text and graphics. Among middle-price units, the NEC P5XL had perfect 5s for text and graphics, while the C. Itoh C-715A, the Okidata Microline 393, and the Nissho NP-2405 had 4s in both categories. Among high-priced printers, the Hewlett-Packard RuggedWriter RW 480 and the Nissho NP-2410 had two perfect 5s. The Fujitsu DL5600 won in the deluxe-price category with a 4 and a 3 in text and graphics, respectively.

Throughput, 80-column, draft quality. As shown in table 2, the Epson LQ-850 and the Fujitsu DL3400 won in the low-price category, with rates of 148 cps and 146 cps, respectively. The Okidata Microline 393 won in the middle-price category by a wide margin, with 184 cps; the Toshiba P351SX followed at 165 cps. The high-price category also had a clear leader, the Mannesmann Tally MT330 at 205 cps; the Hewlett-Packard RW 480 was second at 191 cps. The Fujitsu DL5600 achieved a blistering 236 cps in the deluxe-price category, equivalent to approximately 4.4 pages a minute.

Throughput, 80-column, top quality. Although the speeds were slower by about half, the fastest printers in this test were the same units that won the 80-column draft test, except in the high-price category, where the Hewlett-Packard RW 480 was the clear winner (138 cps), followed by the Nissho NP-2410. Surprisingly, the Mannesmann Tally MT330, which won the draft test, dropped to last in its category in this test.

Throughput, 132-column, draft quality. The winner list in this category resembled that of the 80-column draft test, except for the narrow-carriage Epson LQ-850, which could do only the condensed-font (17.1 cpi) test.

Throughput, 132-column, top quality. The wide-carriage units in the low-price category ranked close together, with speeds ranging from the Brother M-1724L's low of 48 cps to the Citizen Tribute 224's high of 61. Results in the middle-price range were equally close, except for the NEC P5XL, which turned in a 43-cps rating, less than half that of the Okidata Microline 393's top-rated 92 cps. The Hewlett-Packard RW 480 again won in the high-price category by a wide margin. The Fujitsu DL5600 outperformed the Japan Digital Laboratories JDL-850 in the deluxe-price class, 124 cps to 106 cps.

Throughput, 132-column, condensed font. Rankings followed the 80-column top-quality results fairly closely, except among high-price printers, where the Nissho NP-2410 at 294 cps was almost 30 percent faster than the next-ranked Hewlett-Packard RW 480.

Style test. The only surprises were in the middle-price range, where the Epson LQ-1050 and the Fujitsu DL2600 won by a clear margin at 105 cps, and in the high-price range, where the AT&T 477 won with 109 cps.

Graphics tests. The cps ratings in both tests varied over a wider range than with the other throughput tests, from a low of 312 cps to a high of 3176 cps. For the four-graph printout, the winners were: low price, Epson LQ-850 and Fujitsu DL3400; middle price, Okidata Microline 393; high price, C. Itoh C-815; and deluxe price, Fujitsu DL5600. Gray-scale test winners were: low price, Epson LQ-850; middle price, Epson LQ-1050; high price, NEC P9XL; and deluxe price, Fujitsu DL5600.

Sound level. Low-price units exhibited

continued

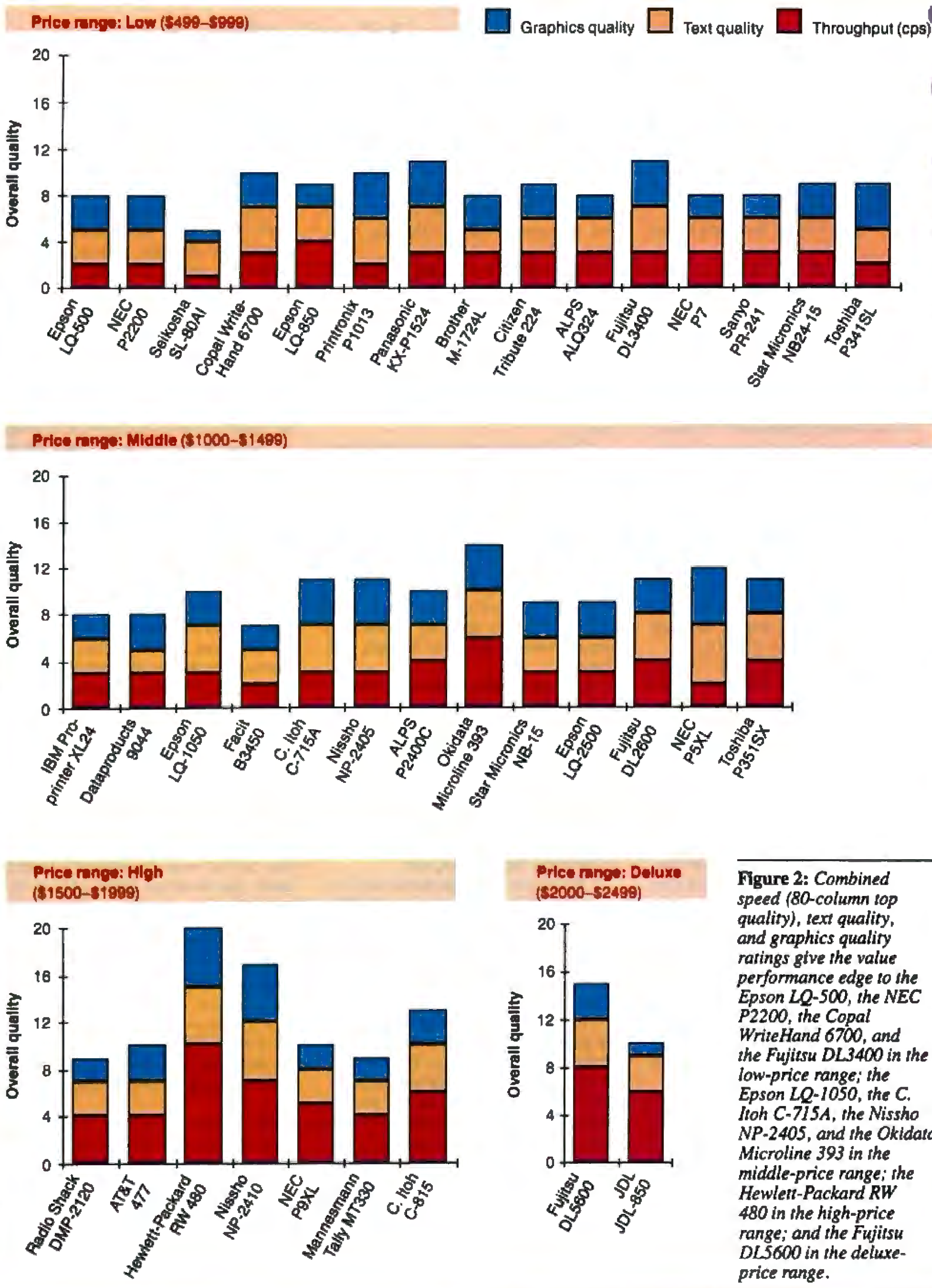


Figure 2: *Combined speed (80-column top quality), text quality, and graphics quality ratings give the value performance edge to the Epson LQ-500, the NEC P2200, the Copal WriteHand 6700, and the Fujitsu DL3400 in the low-price range; the Epson LQ-1050, the C. Itoh C-715A, the Nissho NP-2405, and the Okidata Microline 393 in the middle-price range; the Hewlett-Packard RW 480 in the high-price range; and the Fujitsu DL5600 in the deluxe-price range.*

Views from BIX: Dot-Matrix Printers

Despite claims of an imminent paperless society, printers are still an essential peripheral for most of us. Everyone has his or her favorite. These comments were taken from the IBM.PC conference on BIX and are based on actual user experience.

—*Stan Wszola, Technical Editor*

LARRY HAMBY [hamby]: "Anybody want to recommend a dot-matrix printer that gives the best correspondence-quality type for the least price? I don't need to type that many great-looking letters, but when I do I hate for them to look so 'computerish.' I want to spend next to nothing, of course. Thanks."

PETE WHITE [petewhite]: "The LQ series of printers from Epson are great. The LQ-800 is reasonable in price, and the LQ-2500 is for me an expensive dream printer."

PATRICIA HENSON [phenson]: "I've read BYTE's April 1987 survey of printers, and from what I could tell it looks as though the Panasonic KX-P1092i is a really good buy if you want good NLQ text. Does anyone have any experience with the KX-P1092i?"

LARRY EMERY [lemery]: "I have owned both a KX-P1091 and a KX-P1592, which are excellent printers for the price. I think the new models (the "i" series, e.g., 1092i) are even better than the old. If so, the NLQ will be real hard to tell from LQ. The 1092 at work is also very nice, but it lacks a compressed print switch on the front panel. They may have corrected this on the 1092i. For all-around quality in construction, print quality, speed, and convenience features, I have yet to see a printer that beats the Panasonics."

NICHOLAS BARAN [nickbaran]: "I highly recommend the IBM Proprinter. I particularly like the single sheet/envelope feeder that you can use without removing the tractor-feed paper. It prints 200 cps in draft mode and about 50 cps in letter-quality mode. You can get a Proprinter for about $350."

ROEDY GREEN [roedy]: "This is an open letter to the designers of dot-matrix printers describing the sorts of features I would like to see in the new crop of printers and also the blunders in design I would like them to avoid.

"I'm familiar with about a hundred models of printers used in Canada, the U.S., Sweden, India, and Australia. I have written drivers for about 50 of them. My dream printer is mostly a combination of the best existing features.

"Make sure you fully support the Centronics interface (specifically pins 12 and 13), so the computer can detect whether or not the printer is off-line or out of paper. Roland, Okidata, take note.

"When the user is adjusting the paper or rollers, under no circumstances should the printer start moving. Toshiba, take note.

"When the printer is off-line, the New Page and Line Feed buttons *should* work. Kudos to Hewlett-Packard for inventing the idea and to Roland for copying it.

"The printer manual should show command sequences in ASCII, decimal, hexadecimal, octal, and CHR$ forms, complete with one realistic example for each form. The examples should show the actual print results of commands.

"For printers with design-your-own fonts, the manual should also show enlarged pictures of the dots on a grid so you can use them as models to design variants. Kudos to Okidata and Epson.

"The paper path should be as straight as possible, with at least 4 pins per side for tractor-feed paper engaging at all times. The paper-threading path instructions should be printed or embossed on the printer where they cannot get lost. Make sure the in and out paper paths are sufficiently separated that the out paper doesn't easily get sucked back in the input. Epson, take note.

"The ribbon cartridge should have no more than 1 cm of ribbon exposed. This makes it almost impossible to misthread the ribbon. Please do not invent yet another cartridge design. Kudos to Toshiba for sticking with a great design through all its models.

"It should be possible to read what the printer has just typed without having to waste a sheet of paper. The Okidata Microline 292 solves this by automatically rolling the paper up for you to look, or tear off, then rolling it back down when you resume printing.

"It should be possible to make microalignments both horizontally and vertically while the printer is printing. The Sujata, a printer manufactured in India and designed by Printek, has such features.

"If the printer does not receive any new characters for a few seconds, it should go ahead and print rather than holding characters in its buffer waiting for a carriage return. Kudos to Okidata.

"If a printer cannot do all possible combinations of attributes, it should use the following priorities: First, get the pitch right. Then worry about getting the type width right. If you don't get these right, things will look a mess because they will not align. Once you've got that right, worry about getting italic and boldface right. Then, finally, handle NLQ. Better still, allow all combinations. Kudos to the IBM 5152.

"Support Epson 8-bit graphics.

"Downloadable character sets should be saved in battery-backed RAM while the power to the printer is turned off to clear a jam or to reset top of form. Kudos to Okidata. Toshiba, take note.

"Make sure there is a way to print every last item in the IBM 256-character set so that a decent Print Screen is possible. Ideally, use the IBM codes untranslated.

"To make single-sheet feeding easy, there should be a simple lever to turn off the paper-out detect. It should not be necessary to remove the tractor and set a DIP switch. Toshiba, take note.

"Redesign the printer until the proper print ribbon thread path is the one naturally selected by naive users 95 percent of the time. Toshiba, take note. Kudos to Seikosha and Sujata.

"When designing your printer, make the presumption it is in a different room from where the computer is. Anything you can do from the printer's control panel, you should be able to do from the computer.

"Finally, what kind of name is KX-P1595C or MP-1300AI for a printer? How are you supposed to pronounce it? Remember it? Do they really plan to manufacture $26\times26\times26\times10\times10\times10\times10\times26$ = 45,686,760,000 different models of printer? That's even a little optimistic for a serial number. Get serious, Panasonic and Seikosha."

[Editor's note: *Views from BIX presents a variety of informal, diverse opinions from users of a selected class of products. Messages chosen for publication may be edited for length or clarity. The views expressed are those of each message's author and do not necessarily reflect those of BYTE or BYTE's reviewers.*]

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The drawing shown below was produced on the HP DraftMaster with AutoCAD software

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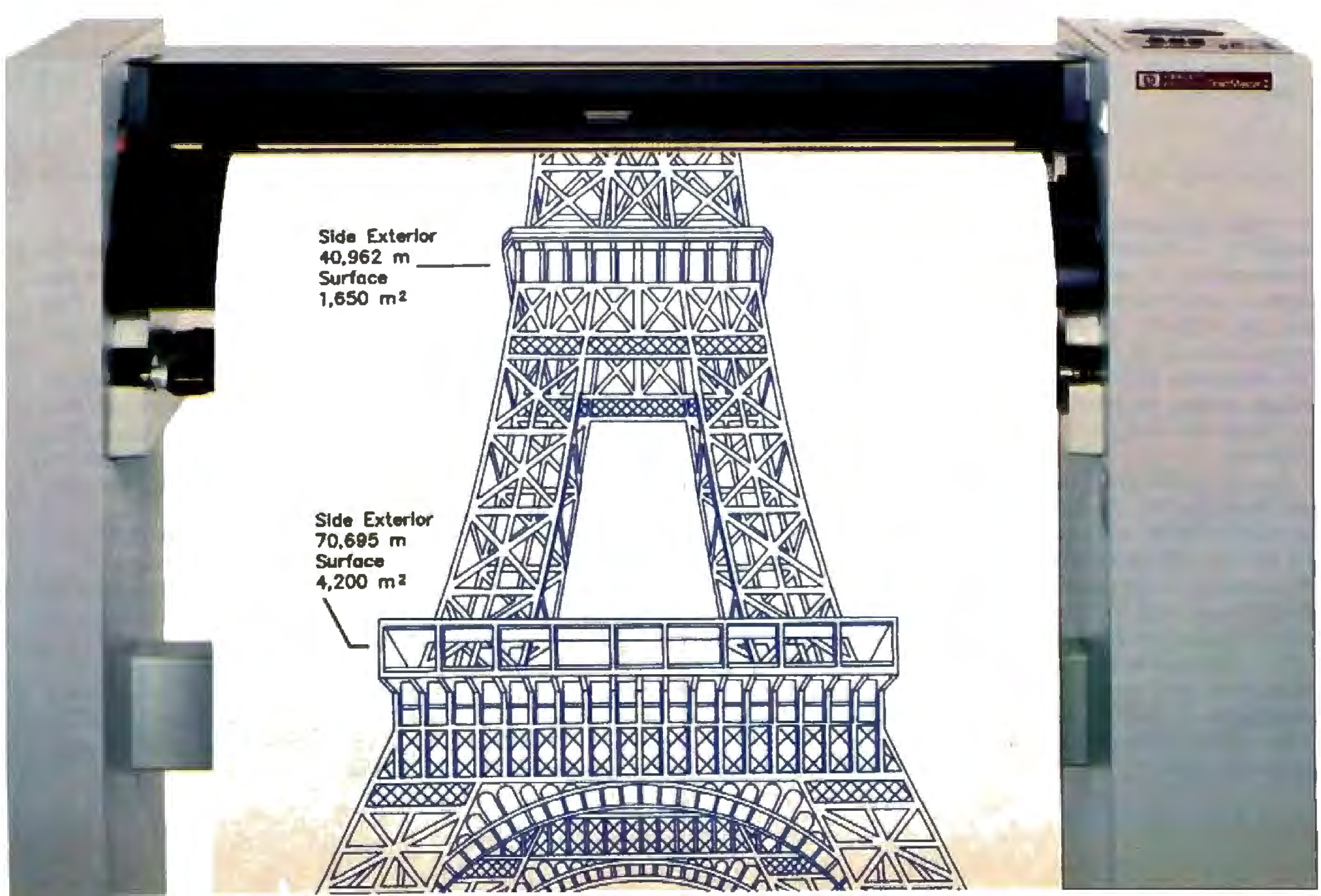

Company Information

ALPS America
3553 North First St.
San Jose, CA 95134
(408) 946-6000
Inquiry 907.

AT&T
4513 Western Ave.
Lisle, IL 60532
(312) 971-6000
Inquiry 908.

Brother International
8 Corporate Place
Piscataway, NJ 08855
(201) 981-3000
Inquiry 909.

C. Itoh Digital Products
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Irvine, CA 92714
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Citizen America
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Suite 105
Torrance, CA 90501
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Woodland Hills, CA 91365
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Inquiry 913.

Epson America
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Inquiry 914.

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Fujitsu America
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San Jose, CA 95134
(408) 432-1300
Inquiry 916.

Hewlett-Packard
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Palo Alto, CA 94303
(415) 857-1501
Inquiry 917.

IBM
900 King St.
Rye Brook, NY 10573
(800) 426-2468
Inquiry 918.

Japan Digital Laboratory (JDL)
2649 Townsgate Rd.
Suite 500
Westlake Village, CA 91361
(805) 495-3451
Inquiry 919.

Mannesmann Tally
8301 South 180th St.
Kent, WA 98032
(206) 251-5524
Inquiry 920.

NEC Information Systems
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Boxborough, MA 01719
(617) 264-8000
Inquiry 921.

Nissho Information Systems
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Suite 100
Cypress, CA 90630
(714) 952-8700
Inquiry 922.

Okidata
532 Fellowship Rd.
Mount Laurel, NJ 08054
(609) 235-2600
Inquiry 923.

Panasonic
Two Panasonic Way
Secaucus, NJ 07094
(201) 348-7000
Inquiry 924.

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Irvine, CA 92713
(714) 863-1900
Inquiry 925.

Radio Shack
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Fort Worth, TX 76102
(817) 390-3100
Inquiry 926.

Sanyo Business Systems
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Moonachie, NJ 07074
(201) 440-9300
Inquiry 927.

Seikosha America
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Mahwah, NJ 07430
(201) 529-4655
Inquiry 928.

Star Micronics
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Suite 3510
New York, NY 10166
(212) 986-6770
Inquiry 929.

Toshiba America
9740 Irvine Blvd.
Irvine, CA 92718
(800) 457-7777
Inquiry 930.

the widest sound-level range of all the categories. Considering the top-quality measurements, as well as the draft and graphics sound levels not shown in the table, the NEC P7, the Fujitsu DL3400, and the Seikosha SL-80AI were quietest. The Printronix P1013 was clearly the noisiest printer, its graphics sound level reaching 84 decibels with the A weighting.

Among middle-price units, the Okidata Microline 393, the NEC P5XL, and the ALPS P2400C were quietest overall, and the Star Micronics NB-15 was loudest. Among high-price units, the Mannesmann Tally MT330 was quietest, and the Nissho NP-2410 and the C. Itoh C-815 were loudest overall. The quietest deluxe-price unit was the Japan Digital Laboratories JDL-850; this is the only rating in which this unit outperformed the Fujitsu DL5600.

No Need for Apologies

The ideal printer should have a high throughput, excellent print quality, and low cost. Are there any candidates among the 37 printers tested?

If you're willing to pay the price, you can definitely find speed and quality in one unit. The Hewlett-Packard RW 480 ($1695) offers the highest text throughput (top quality) and achieved top ratings in text and graphics quality.

The middle-price category as a whole outperformed the other price ranges in terms of quality ratings (a greater percentage of 4 ratings). The Okidata Microline 393 ($1399) looks more like a high-price unit in terms of 80-column throughput and quality.

Among low-price units, the Epson LQ-500 ($499), the Copal WriteHand 6700 ($795), and the Fujitsu DL3400 ($995) each offer bargain hunters good combinations of speed and quality.

Figure 2 shows the relative score for each printer, taking speed and both text and graphics quality into account. This single graph can point you to the best value in each price range.

If quality alone is your consideration, the NEC P5XL ($1495) may be your best buy; it rated a 5 in both text and graphics quality. Dropping down just one notch in quality, you can look at the Printronix P1013 ($895), the Panasonic KX-P1524 ($899), or the Fujitsu DL3400 ($995), all scored 4s on text and graphics quality.

Finally, you don't have to apologize for using a dot-matrix printer for business communication. ■

George A. Stewart is a technical editor for BYTE. He can be contacted at BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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HEWLETT PACKARD

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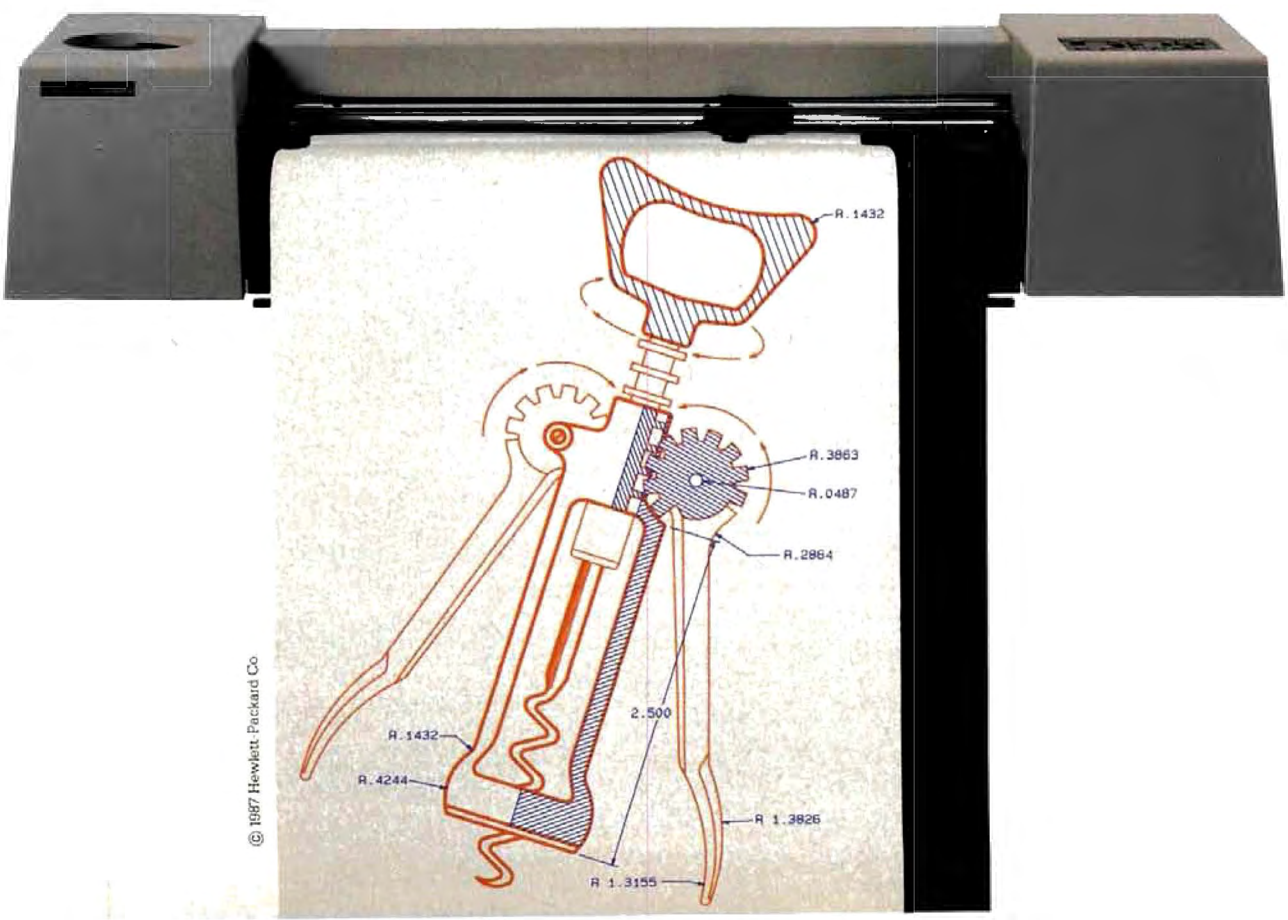


The WYSEpc 386

Ed McNierney

A classy 80386-based system priced to rival machines from the big boys

What do you do if you can't afford a top-of-the-line 80386 system like the IBM PS/2 Model 80 or the Compaq Deskpro 386, but you want something a little classier than the 386 systems from the usual clone makers? You could try the WYSEpc 386, a 16-MHz 80386 system with an attractive design, performance to match, and a price tag that beats the 386 systems from IBM and Compaq handily.

At $4999, the WYSEpc 386 (Model 3216-40) comes with Intel's 80386 processor running at 16 MHz, 1 megabyte of RAM expandable to 6 megabytes, a half-height 1.2-megabyte 5¼-inch floppy disk drive, a half-height 40-megabyte hard disk drive, a 102-key modified AT-style keyboard, one parallel port, and two serial (9-pin male) ports. The review unit also came with an EGA-compatible display adapter and a monitor, bringing its price to $6247. You can add an 80287 (6-MHz or 10-MHz) or 80387 (16-MHz) coprocessor, but these are not available from WYSE.

Made to Upgrade

The WYSEpc 386 is a standard AT-size unit with a detached keyboard and front-panel controls. The system is based around a backplane design rather than a motherboard system—the CPU and all memory boards sit in expansion slots so they can be repaired or upgraded easily (see photo 1). The system has 10 expansion slots: three 8-bit slots and seven 16-bit slots.

In a standard system configuration, the CPU and the memory board occupy two of the 16-bit slots, and the serial/parallel port board occupies an 8-bit slot. The review unit also had a half-length WYSE EGA-compatible display adapter in one of the other 8-bit slots. The combination floppy/hard disk controller board lies in front of the backplane board on the bottom of the case and connects to the backplane through a special edge connector, so it doesn't take up any expansion slots.

Missing from the WYSEpc 386 are 32-bit slots. Most manufacturers of 80386-based microcomputers use 32-bit slots chiefly for connecting high-speed RAM expansion boards to maximize system performance. WYSE has taken a slightly different approach, putting the 32-bit extensions on a separate bus that runs across the top of the expansion boards rather than on the backplane. A special rigid connector couples adjacent 32-bit boards together to allow rapid communication.

The standard system comes with the CPU board connected in this way to the memory board, which holds 1 megabyte of 100-nanosecond (ns) static-column dynamic RAM (DRAM) operating at 16 MHz with zero wait states. You can add an additional megabyte of RAM to the standard board, and you can also plug a second memory board (up to 4 megabytes) into the backplane.

The serial/parallel board connects to the main CPU board with a ribbon cable, and a second serial connector is located on the CPU board. While this makes convenient use of the CPU board's slot space, the two boards are installed as far apart as possible and the cable is strung along the back of the case. The cable gets in the way a bit, but you can remove it if you don't need the second port.

In addition to the basic floppy and hard disk drives, you can install another full or half-height floppy disk drive under the floppy drive, and a second half-height hard disk drive above the original hard disk drive, for a total of four devices driven by the controller board.

The average access time of the 40-megabyte drive is 28 milliseconds (ms), and the Coretest utility showed a slightly slower-than-average data transfer rate of 165K bytes per second. The drive's track-to-track seek time is only 4 ms, and the disk's overall performance is good. The drive is very quiet; when running disk-test software, I had to put my ear to the front panel to hear the disk heads moving—a welcome improvement over many of the scratchy and clattery hard disk drives currently available.

The unit's keyboard connects to the back panel of the CPU board with an RJ-11 telephone jack. The keyboard interface is otherwise compatible with the AT keyboard, and WYSE provides an adapt-

continued

WYSEpc 386

Company
WYSE Technology
3571 North First St.
San Jose, CA 95134
(408) 433-1000

Components
Processor: Intel 80386 processor running at 8 or 16 MHz; socket for 80287 (6-MHz or 10-MHz) or 80387 (16-MHz) coprocessor
Memory: 1 megabyte of 100-ns, zero-wait-state DRAM, expandable to 6 megabytes
Mass storage: One half-height 1.2-megabyte 5¼-inch floppy disk drive; one half-height 40-megabyte (28-ms access time) hard disk drive in the Model 3216-40
Keyboard: 102-key modified AT-style
I/O interfaces: One parallel port; two serial (9-pin male) ports; seven 16-bit expansion slots; three 8-bit slots

Size
21 inches by 18 inches by 6½ inches; 41 pounds

Software
Enhanced MS-DOS 3.21; GWBASIC 3.2; SETUP and TEST utilities

Options
EGA adapter: $499
EGA monitor: $749
1-megabyte memory expansion: $500
2-megabyte memory expansion: $1200
Floor stand: $165

Documentation
103-page Enhanced MS-DOS User's Guide; 71-page Installation and Assembly Manual

Price
Model 3216-01 (base system, with a 1.2-megabyte 5¼-inch floppy disk drive and 1 megabyte of RAM): $3799
Model 3216-40: $4999
System as reviewed (Model 3216-40, plus an EGA adapter and a monitor): $6247

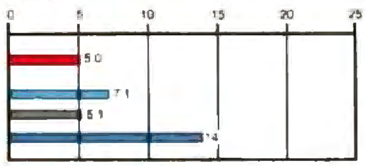
Inquiry 883.

	Dhrystone*	Fibonacci	Float	Savage	Sieve	Sort
WYSEpc 386	3982	50.32	34.71	295.52	5.65	6.68
PS/2 Model 80 (80387-16)	3626	57 26	1 62	9 49	6.45	7 74
Compaq 386 (80387-16)	3748	53.11	1 43	8.95	5.98	5.58
Compaq 386 (80287-8)	3748	53.12	6.80	21 53	5.99	5.58
IBM PC AT (80287-8)	1590	126.22	10.98	37.30	24.60	43.17

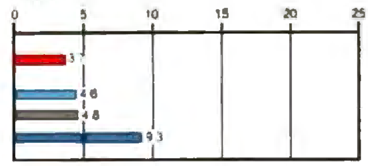
*For the Dhrystone test only, higher figures denote faster performance.

DISK ACCESS IN BASIC (IN SECONDS)

WRITE

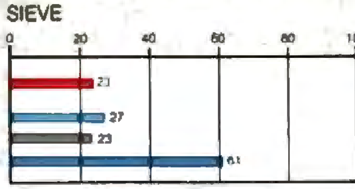


READ

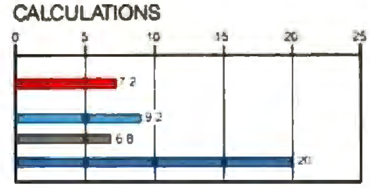


BASIC PERFORMANCE (IN SECONDS)

SIEVE

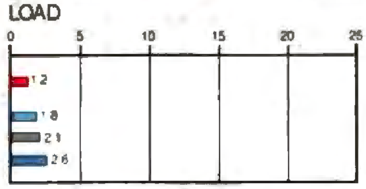


CALCULATIONS

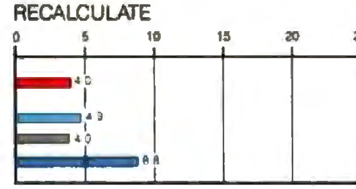


SPREADSHEET (IN SECONDS)

LOAD

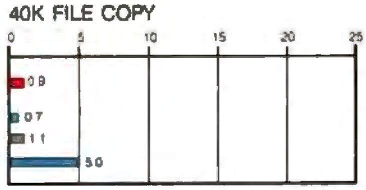


RECALCULATE



SYSTEM UTILITIES (IN SECONDS)

40K FILE COPY



WYSEpc 386
IBM PS/2 MODEL 80
COMPAQ DESKPRO 386
IBM PC AT (8 MHZ)

The table contains the results of the 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 Enhanced MS-DOS 3.21 and GWBASIC 3.2 on the WYSEpc 386; PC-DOS 3.3 and BASICA 3.11 on the PS/2 Model 80 and the IBM PC AT; and Compaq DOS 3.1 and Compaq BASIC 3.11 on the Compaq Deskpro 386.

er plug that lets you connect an aftermarket keyboard to the WYSE jack. The keyboard, which closely resembles those available on WYSE terminals over the last several years, has a light and slightly clicky touch. I would prefer a more IBM-like keyboard with better tactile feedback, but for me the WYSE keyboard is a reasonable compromise.

The keyboard's layout belongs to the "modified enhanced" class, resembling the 101-key keyboard standard on all IBM machines. The two exceptions to this layout are both mistakes, in my opinion: The Alt keys (one on either side of the space bar) have been shrunk considerably—they are no bigger than the standard alphabetic keys—while the Control keys next to them are the largest keys on the keyboard other than the space bar. Since both Control and Alt are popular application shift keys, I can see no reason for the change. Also, a Select key has been added at the upper right of the keyboard. The documentation says this key has an application-defined usage, but none of the software supplied with the WYSEpc 386 uses it, and since the key is found only on WYSE keyboards, few, if any, third-party software developers are likely to support it.

Displaying Its Options

Since WYSE has had years of experience building terminals, the quality of the optional EGA monitor (Model WY-640) that came with the review unit is not surprising. The 640- by 350-pixel display is bright and crisp, with clear pixel separation and no trace of fuzziness. The monitor has brightness controls and a color-selection switch that lets you selectively disable some of the RGB inputs to the monitor, changing otherwise white text to either amber or green. This is a nice convenience for monochrome applications, but it makes some color combinations disappear entirely.

The monitor is attached to a tilt-and-swivel base that holds the power switch and supply. You can connect the power cord to an outlet on the rear of the system unit and control the entire system with one power switch.

On the front panel of the system unit, three push buttons let you interact with a 15-character LED display directly above them. The display shows the current date or time and the system processor speed (8 or 16 MHz). You control the date/time and speed toggles with the push buttons, and you can change them at any time, even in the middle of an application. The third push button switches the LED to a "CPU usage" display, which shows a single bar growing and shrinking in response to CPU load. Other than for amusement value, this display mode is useless; the CPU load doesn't translate into any practical measurement, and all you can do is watch the bar wiggle back and forth as an application runs.

You can, however, use the LCD panel to display programmable messages that either are static or scroll across the screen. Such messages could be useful for monitoring the progress of long batch files or for notifying you of the system's status.

Enhanced DOS

The WYSEpc 386 comes with WYSE's version of MS-DOS 3.2, called Enhanced MS-DOS 3.21; it contains a few enhancements and a number of new utilities not included in the standard MS-DOS package. Enhanced MS-DOS provides support for disk devices larger than 32 megabytes (the review unit was set up for a single 40-megabyte hard disk drive). You can set partition sizes and adjust them with the standard FDISK utility, and you can create multiple MS-DOS partitions if you prefer smaller disks instead of one large one.

A disk optimization program called DISKPACK assists hard disk performance by compressing files into contiguous space for faster sequential access. For security reasons, DISKPACK works with a floppy disk in drive A serving as a temporary storage area. If a power failure occurs while you're running DISKPACK, you can restart the system and run DISKPACK with the /R switch to resume operation with no loss of data.

As in most 80386 machines, the standard 1 megabyte of RAM in the WYSEpc 386 is divided into 640K bytes for DOS and 384K bytes of leftover RAM. WYSE gives you a number of options for taking advantage of this otherwise orphaned 384K bytes of memory; these include the standard MS-DOS VDISK, which lets you create a RAM disk in that memory, and a disk cache that you can install in either extended or conventional memory.

The disk cache can be dynamically loaded and unloaded at any time, and a special command option makes it display a helpful set of statistics about the current cache hit rate and usage, along with an estimate of the performance improvement gained by using the cache. The cache requires 12K bytes of system memory even if the buffer itself is in extended memory, but the boost in disk performance is worth it: MicroCalc, the sample spreadsheet that comes with Turbo C (approximately 7700 lines of C source code) required 48 seconds to completely compile and link without a cache; installing a 256K-byte cache in extended memory reduced that time to 35 seconds—an improvement of over 25 percent.

If you don't want caching, WYSE provides a device driver that uses the 80386's memory management capabilities to make extended memory appear to be Enhanced Expanded Memory Specification (EEMS) memory, accessible to applications as data storage areas.

Although you can control the processor speed from the front panel, a SPEED utility lets you select high or low speed (or disable the front-panel switch en-

continued

Photo 1: *The WYSEpc 386 is designed around a backplane rather than a motherboard. All system cards, including the 80386 CPU card, insert into 8- and 16-bit expansion slots in the backplane and communicate via 32-bit connectors that run across the top of the boards.*

tirely) from the keyboard. An LCDPANEL utility lets you send text to the LCD panel display. You can also install an LCDPANEL.SYS driver in your CONFIG.SYS file; this creates the DOS character device LCDDEV, which lets applications write to the LCD display just as they write to a file. You can even redirect DOS commands to the LCDDEV device; for example, the command DIR > LCDDEV causes the current directory display to scroll across the panel.

Rounding out the complete set of MS-DOS utilities are a Help system (which provides information about any MS-DOS command, internal or external), a combination lock program, and an equipment check utility.

Finally, a SETUP utility lets you run system configuration and tests. Since one of the more difficult steps in setting up a hard disk system is determining the appropriate drive type for the disk, SETUP provides a list of drive types along with associated characteristics (e.g., size, number of heads, and number of cylinders) from which you can choose the proper type.

Included with WYSE's Enhanced MS-DOS is GWBASIC 3.2, along with some simple batch files that let you start the interpreter with the commands BASIC, BASICA, or GWBASIC.

How Compatible Is It?

The WYSEpc 386 is reliably compatible with all the PC software I tested, including Turbo C 1.0, SideKick 1.56A, Lotus 1-2-3 version 2.01, Lotus Symphony 1.2, Microsoft Word 3.0, Brief 2.0, and Microsoft Windows 1.03 and 2.0. I encountered no problems with these packages, except when installing Lotus 1-2-3 on the hard disk: Even when the processor speed was slowed to 8 MHz, the INSTALL utility could not set up 1-2-3 to run directly from the hard disk drive. However, I was able to use 1-2-3's COPYHARD utility to achieve the desired result.

Microsoft Windows/386 had interesting difficulties. The Windows/386 SETUP procedure lists the WYSEpc 386 as a compatible computer, but installed software refused to run, displaying an error message indicating that the current DOS version (MS-DOS 3.21) was not supported. If I booted the system under IBM PC-DOS 3.3, Windows/386 ran but would not let me start COMMAND.COM in a window, claiming that an incorrect DOS version was in use. WYSE technical support did not return either of the two calls I made to investigate the problem. However, a company spokesperson said later that WYSE has corrected the incompatibility with Windows/386 in Enhanced MS-DOS 3.21 version 1.03, which now comes with the system.

WYSE Guides

The documentation supplied with the WYSEpc 386 came as two booklets, Enhanced MS-DOS User's Guide and the Installation and Assembly Manual. The MS-DOS manual was clear and well indexed, with descriptions of the standard DOS commands as well as WYSE's extensions. The manual's biggest deficiency was its lack of documentation for the DEBUG, LINK, and EDLIN programs included with DOS. These programs are given only one line apiece in the entire manual, which otherwise does an excellent job of documenting DOS functions.

The Installation and Assembly Manual is an outstanding example of its class of documentation. It is simple, clearly written, and well illustrated, and it presents information in the order that you can expect to need it. Information on jumper settings and adding new boards and coprocessor hardware is complete. The manual is not very large, but it still seems to have all the right bits of information.

Among the Fastest

The WYSEpc 386 performed well in all the BYTE benchmarks. Since the review unit did not have a math coprocessor, its floating-point performance was not optimal. In other tests, the system ranks among the faster 16-MHz 80386 systems. It clearly outperformed the IBM PS/2 Model 80 and the Compaq Deskpro 386 (as the graphs and table on page 132 show), though it did not reach the speed of machines like the PC Designs GV-386 (January BYTE). For consistency, I ran all disk benchmarks with the disk cache disabled; with the cache installed, the Disk Read tests ran 15 percent faster (3.12 seconds), while the Disk Write speed did not change at all.

An Excellent 386 Alternative

The WYSEpc 386 is an attractive 80386 system. It looks good, performs well, and comes with complete documentation and a robust set of enhancements to MS-DOS. The standard list price of $4999 for the 40-megabyte hard disk system is a little on the high side, compared to 80386 systems from companies like PC Designs and Kaypro, but it's a bargain next to comparable systems from IBM or Compaq. If you want a solid, reliable, hassle-free system with lots of nice touches and attention to detail, the WYSEpc 386 is an excellent alternative. ■

Ed McNierney is a principal engineer at Lotus Development Corp. in Cambridge, Massachusetts.

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CLEO

Commodore Opens the Amiga

Charlie Heath

Will a new open architecture and IBM PC compatibility spur the Amiga 2000 to success?

The Amiga 2000 is poised to be a player in an IBM PC–compatible world. Unlike Commodore's Amiga 1000, the 2000 is expandable through internal slots and space for additional disk drives. Moreover, when equipped with the optional PC-compatible Bridgeboard, the 2000 can run MS-DOS software and use PC peripherals. Commodore has coupled these additions with the Amiga's existing strengths—superb graphics capabilities and a multitasking operating system—and has priced the base system at $1995.

Based on the same CPU and video hardware as the Amiga 500 and 1000, the 2000 uses a 7.14-MHz 68000 and supports it with a set of custom direct-memory-access (DMA) coprocessors for graphics, audio, and disk I/O. The standard 2000 comes with 1 megabyte of RAM, one 880K-byte 3½-inch floppy disk drive, and 256K bytes of ROM. The machine has the same display architecture and software compatibility as the 500 and 1000.

The 2000 adds an IBM PC–compatible coprocessor capability to the bus, which has seven expansion slots (see photo 1). Five of the slots form a 100-pin Amiga-compatible bus; two of these also accept AT-compatible boards, and you can place the Bridgeboard in either of them. The two remaining slots are XT-compatible. In addition to the seven main slots, an 86-pin CPU coprocessor slot connects directly into the 68000 bus and is intended for use with enhancements such as a 68020 card. Finally, a custom video slot brings out most of the Amiga's video signals for use with boards such as genlocks or video enhancements.

Also new on the 2000 is space for three drives: two 3½-inch floppy disk drives and one half-height 5¼-inch floppy or hard disk drive. The review system had 3 megabytes of RAM, consisting of 512K bytes of 150-nanosecond chip RAM, 512K bytes of on-board 150-ns fast RAM, and 2 megabytes of 150-ns RAM on an expansion card. The system also had a 4.77-MHz 8088-based Bridgeboard with a 5¼-inch floppy disk drive, the A1084 analog and digital RGB/composite monitor, an optional 2090 hard disk controller, and a 20-megabyte ST-506 hard disk drive. (Commodore doesn't sell a hard disk drive for the 2000, preferring to let dealers configure the system.) Depending on the price of the hard disk drive, a comparable system costs about $4000.

An Improved Design

Commodore designed the original 2000 in Germany but redesigned the unit before shipping it in the U.S. (For a full technical description of the original 2000, see the preview in the March 1987 BYTE.) The redesigned system uses a custom animation chip, known as the "Fat Agnus," from the 500. This custom chip incorporates several support chips from the original Agnus DMA controller, the heart of the Amiga's coprocessing system.

The redesign also enhances the video slot. The new slot brings out all 12 bits of RGB video data to the edge connector and incorporates control logic from the peripheral bus. In addition, the company redesigned the 86-pin CPU coprocessor slot to improve system stability and to allow a coprocessor to work in a bus-sharing coprocesssor mode.

The 2000 has room for an internal hard disk drive and can use relatively inexpensive PC-compatible ST-506 hard disk drives. This solves one of the more difficult problems with add-on hardware for earlier Amigas: Hard disk drives for the 1000 were expensive and not particularly reliable. Most of the drives for the 1000 use Macintosh-compatible SCSI boxes and a custom controller card.

You still need to add a hard disk controller to the 2000, which has no built-in SCSI port. Commodore's 2090 controller, which has two SCSI connectors, lets you attach up to nine devices (two ST-506–compatible and seven Macintosh-compatible SCSI devices). By the time this review appears, several controllers should be available from other companies, including ASDG and MicroBotics. The delay in getting third-party controllers for the 2000 is partly due to the fact that Commodore is still finalizing the specs for auto-booting devices; the cur-

continued

Amiga 2000

Company
Commodore International
1200 Wilson Dr.
West Chester, PA 19380
(215) 431-9100

Components
Processor: 68000 running at 7.14 MHz
Memory: 1 megabyte of RAM, expandable to 9 megabytes
Mass storage: One 880K-byte 3½-inch floppy disk drive; space provided for two additional disk drives
Display: Optional (see below)
Keyboard: Detached 94-key keyboard with 10 function keys, cursor keypad, and 18-key numeric keypad
I/O interfaces: One RS-232C serial port; one DB-25 parallel port; two DB-9 joystick ports; two audio outputs (RCA type); DB-23 RGB analog or digital output; monochrome video output (RCA); external disk drive connector; five Amiga expansion slots, two IBM PC AT slots (shared with two Amiga slots), and two IBM PC XT slots; CPU coprocessor slot; custom video slot
Other: Optomechanical two-button mouse; battery-backed clock/calendar; 200-watt power supply

Size
17½ by 15¾ by 6¼ inches;
28½ pounds

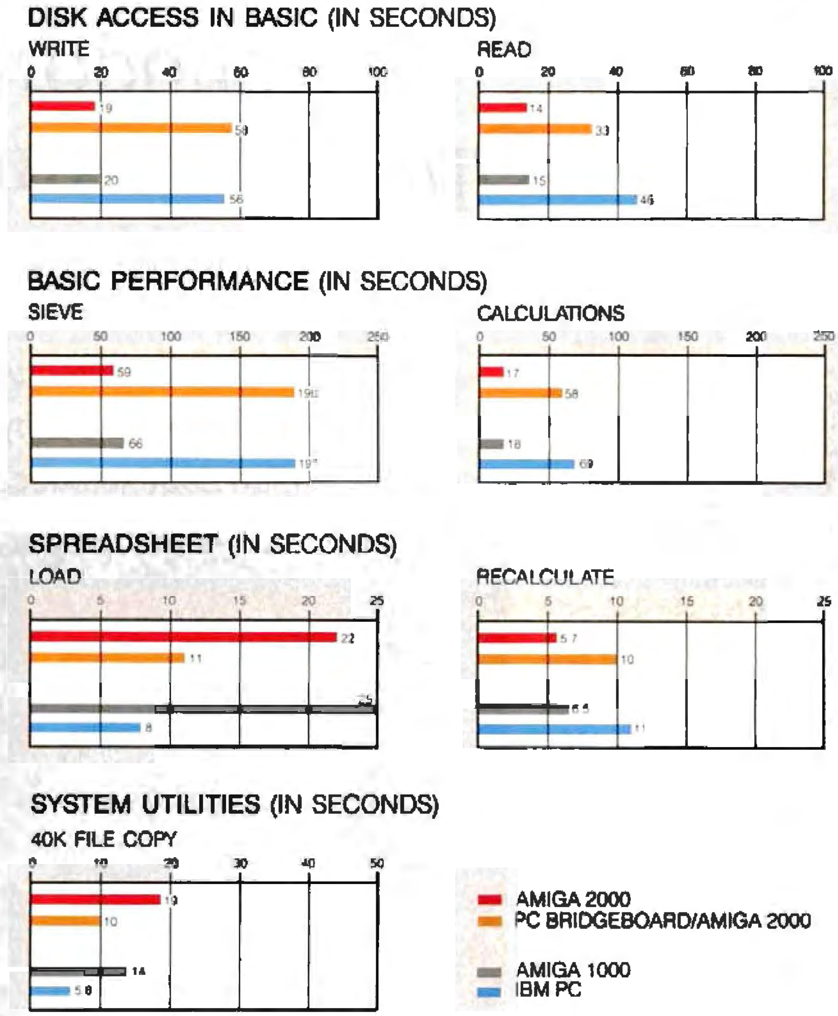
Software
AmigaDOS 1.2, including Kickstart 1.2 in ROM, Workbench 1.2, Amiga BASIC 1.2, and utilities

Options
Internal and external 3½-inch and 5¼-inch floppy disk drives: $199.95 to $299.95
Hard disk controller: $399.95
2-megabyte RAM expansion card: $499.95
Bridgeboard (includes 5¼-inch floppy disk drive): $699.95
Analog and digital RGB/composite monitor: $399.95

Documentation
300-page Introduction to the Commodore Amiga 2000; 291-page Amiga BASIC

Price
Base system: $1995
System as reviewed (excluding 20-megabyte hard disk drive): $3995

Inquiry 884.



The Disk Access benchmarks write and then read a 64K-byte sequential text file to a floppy 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 25- by 25-cell spreadsheet. The 40K File Copy benchmark copies a 40K-byte file using the system utilities. All tests on the Amiga 2000 and 1000 were run using Kickstart/Workbench 1.2; the Amiga spreadsheet tests were run with Lattice's Unicalc 1.0. Amiga BASIC 1.2 was used for BASIC tests on the Amiga 2000; ABasiC 1.0 was used on the Amiga 1000. Tests on the Amiga Bridgeboard and IBM PC were run with MS-DOS 3.2 and GWBASIC 3.2; the spreadsheet tests were run with Multiplan 1.0.

rent system software requires that the system make the initial boot from the internal floppy disk drive. Commodore is also designing a new file system that the company says will run as much as 4 times faster with DMA hard disk drives. The new file system is slated to ship sometime this spring as part of a Workbench 1.3 upgrade.

All the Amigas—the 500, the 1000, and the 2000—come with built-in serial and parallel ports. The original 1000 had connectors that are the reverse of connectors normally used with IBM PC-compatible systems; thus, it was difficult to get the correct custom cables. With the 2000, as well as with the 500, the ports are redesigned so that the pins supplying power are current-limited, making it safe to plug in nearly any IBM-compatible printer or modem.

This redesign also has an impact on NewTek's Digi-View video digitizer, one of the driving forces behind the market the Amiga dominates: desktop video. Digi-View lets you digitize in color by doing separate passes of a video image with a black-and-white television camera. The hardware plugs into the parallel port and uses the power available on the port to run the digitizer. The redesigned ports on the 2000 mean that you can use Digi-View with a cable adapter available from NewTek for $21.95.

Currently, the system software for the 2000 is practically identical to that for the 1000. The 2000 includes a few extra programs, such as the Setclock program to read the built-in battery-backed clock. The 2000 also has Kickstart 1.2 in ROM.

A Nitpick or Two

The 2000 has a 94-key keyboard, expanded from the 1000's original 89-key keyboard. The additions, which include a numeric keypad, make the keyboard more suitable for use as an IBM PC-compatible system. Compared to the 1000's keyboard, though, the 2000's keyboard does not have as nice a feel; the keys are stiff, and they bottom out abruptly. Commodore says it is now shipping a new keyboard with the 2000; it has the same layout, but it may have a different feel.

The fan on the 2000 is louder than the 1000's fan, which was so quiet you couldn't tell it was there. The 2000's fan is quieter than those on most AT clones, but compared with the 1000's it's a howler. However, you might not notice it if you install a hard disk drive, most of which are even noisier than the fan.

Amiga versus Amiga

As the benchmarks show (see page 138), the Amiga 2000's performance is almost identical to the 1000's, except for differences due to fast RAM. The 2000's memory bus is mapped into different areas, with 512K bytes of chip memory (which is addressed by the custom graphics and audio chips) and 512K bytes of fast memory on a separate bus. On the 1000, programs usually run in chip memory because the entire 512K bytes of internal RAM is chip memory. By loading programs into fast memory, the 2000's CPU can avoid bus contention with the custom chips in chip memory. This results in programs running about 3 percent faster than on the Amiga 1000 right off the bat, and over twice as fast when a lot of custom chip memory contention occurs, such as with a high-resolution 16-color display.

The current design lets the Amiga's custom chips address 512K bytes of chip memory; this memory gets used up pretty quickly when you're doing animation and desktop video. The Fat Agnus chip has the external enhancements to address at least 1 megabyte of chip RAM, but it still can handle only 512K bytes internally. However, the 2000's design will eventually be able to accommodate replacement plug-in chips that address a full megabyte of chip RAM.

With the Fat Agnus, unfortunately, the first 512K bytes of fast memory is controlled by the same logic as the chip memory bus. If you try to access programs or data in this area of fast memory, it will run at the same speed as a chip memory access. Commodore supplies a program called SlowMemLast that designates this first 512K bytes of fast RAM as the last fast RAM allocated; this gives you the best CPU performance.

I recommend getting at least 2 megabytes of additional RAM with a 2000. The extra RAM gives the system the room it needs to run software quickly and reliably. Setting up a RAM disk can give the system near-instantaneous response and let software run without pushing the limits of the machine.

No problems showed up on the 2000 with existing Amiga software. I estimate that 99 percent of all software that works on the 1000 will work on the 2000. Some game programs that directly access the keyboard may fail because of slight timing changes, but software that uses the ROM routines as advised by Commodore will not have this problem. Glitches could also occur with a few programs, such as those for audio digitizers, with tight timing loops that don't adjust to the presence of fast RAM or that can't work with a faster CPU.

Amiga versus PC

The 2000's Bridgeboard is a good coprocessing implementation, letting two completely different systems run in one box at the same time (see photo 2). The Bridgeboard comes with a 4.77-MHz 8088 processor, a socket for an 8087 math coprocessor, an IBM PC-compatible Phoenix BIOS enhanced to work with AmigaDOS and MS-DOS, and 512K bytes of RAM. The board also comes with a 360K-byte 5¼-inch floppy disk drive, installation software, and MS-DOS 3.2 and GWBASIC 3.2. With the Bridgeboard installed, you can add up to three PC or AT expansion cards, including memory boards such as Intel's Above Board, graphics adapters, internal modems, hard disk cards and controller cards, RS-232C serial cards, and network boards.

To an MS-DOS program, the Bridgeboard looks just like a normal PC-compatible system, with a couple of differences. Most notably, the Bridgeboard uses the interrupts for the second COM port on a PC to synchronize with the Amiga. This can be a problem if you want to hook up a plotter or mouse that usually uses the second COM port. On the

continued

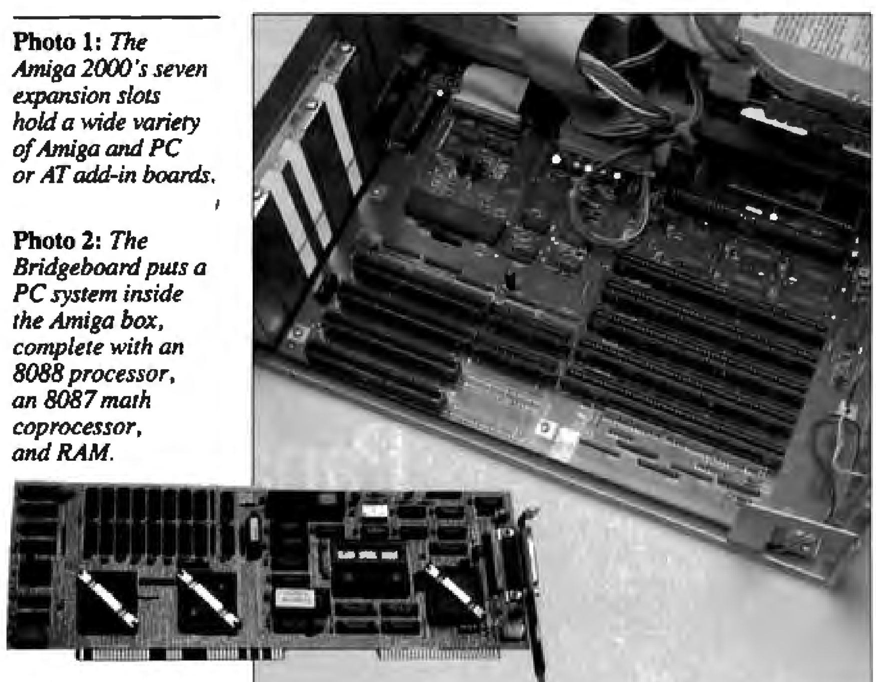


Photo 1: *The Amiga 2000's seven expansion slots hold a wide variety of Amiga and PC or AT add-in boards.*

Photo 2: *The Bridgeboard puts a PC system inside the Amiga box, complete with an 8088 processor, an 8087 math coprocessor, and RAM.*

Amiga side, things are a bit more complex because the Amiga needs to provide keyboard and display facilities for the Bridgeboard. The Amiga's existing multitasking windowing software handles all this, letting the PC run as a window within the Amiga.

How well does this work? The most noticeable difference is that the Bridgeboard's PC display is a bit slower than that of a normal PC. This is because the Amiga needs to convert the PC monochrome or color graphics display into a bit-mapped display—a very processing-intensive operation. Unlike software emulations, however, the 8088-based board still runs at full speed; the display is just updated a fraction of a second slower than usual.

The main impact on performance comes on the Amiga side, where the PC looks like a graphics-intensive operation. Depending on the application, Amiga programs may slow down since the Amiga has to keep the display refreshed. For example, the BASIC Calculations benchmark took 17.2 seconds when running on the Amiga without the Bridgeboard. I also ran this benchmark while running a short BASIC program (i.e., `10 for i=0 to 100000: print i: next i`) on the Bridgeboard in monochrome mode. This time, it took 62.34 seconds—a nearly worst-case time that reflects the effect of an "active" display task on the Bridgeboard. When I ran the benchmark with the same program on the Bridgeboard with no display updating (i.e., `10 for i=0 to 100000: next i`), the time was 17.28 seconds, practically the same as without the Bridgeboard.

Generally, the software interface between the Amiga and PC sides worked well. When my review machine first arrived and I tried to run the Bridgeboard, I got the cryptic error message `Library not found`. This turned out to mean that the Bridgeboard was not properly seated in its socket and was not initializing. As a result, the board's Janus library (which handles Amiga/Bridgeboard communications) wasn't installing itself during the auto-configuration. Opening the box and reseating the Bridgeboard solved the problem.

Several nice additions to the Bridgeboard let you use some features of AmigaDOS and Intuition (the underlying part of Workbench) when you're running programs on the Bridgeboard. For example, you can cut and paste with the Amiga's clipboard anywhere in an MS-DOS text window. Another nifty addition is the ability to freeze a window display and then keep running in another window. This way, you can get a graph from Lotus 1-2-3, freeze the window, and plot another graph in another window. You can then look at either the old frozen window or the current window. The result of this interaction is a system that's more useful and convenient than a plain MS-DOS operating environment.

You can also set up virtual disks that reside either in RAM or on disk on the Amiga side of the system and can be accessed by MS-DOS. Similarly, you can partition an MS-DOS hard disk so that AmigaDOS uses one of the partitions as a disk drive.

I ran my Lotus 1-2-3 version 2.01 spreadsheets, and everything came up the same as it does on my Compaq Portable. To use a printer from the Bridgeboard, you need to run a program on the Amiga to swap control of the printer over to the Bridgeboard, but once that's done it works fine. Brief 1.03 also ran without a hitch. My company's golf game Mean 18 (the CGA-only version) ran on the board, although the display latency can be a problem with action games that have fast-changing animation. But then, who'd want to play a game on the Bridgeboard with the Amiga only a bus connector away?

More Horsepower to Come

Commodore has announced a 10-MHz 80286 Bridgeboard and a 14-MHz 68020 board that fits into the 2000's coprocessor slot. According to the company, the 68020 board includes a 68881 math coprocessor, a 68851 memory management unit, and 2 megabytes of RAM, and it is supposed to run Unix. The company expects to ship the 80286 board in May or June and the 68020 board in the fall, but prices are not yet set. Other 68020 boards are available, including one from Computer System Associates.

One of the most talked-about deficiencies of the Amiga 1000 has been the quality of National Television System Committee (NTSC) interlaced video. The same thing that makes the Amiga so appealing to video engineers that need an NTSC video signal and genlock makes the display poor as an engineering workstation: The high-resolution (over-400-line) display uses interlaced video that results in a 30-Hz display update rate, and this introduces flicker. (Display monitors need a refresh rate of at least about 50 Hz to avoid flicker.)

MicroWay has announced a display deinterlacer that will take the Amiga's video and buffer it so it can be displayed on MultiSync-style monitors at double the normal display rate. This should result in a flicker-free display that's equivalent to IBM VGA monitors; with overscan, you can display about 704 by 470 pixels. MicroWay will sell this board, which should be available by the time you read this, for about $600.

Commodore is also working on the A2024 monitor with a 1008- by 800-pixel 15-inch display, but only in four shades of gray. The monitor actually captures standard Amiga display output and converts it for redisplay at higher resolution at a 15-Hz refresh rate. The A2024, though, has only a 14-inch screen, and most people prefer a somewhat larger display to match the high resolution. The A2024 will be great for desktop publishing and CAD applications, but some software will require special programming to access the high resolution. The monitor should be available in May or June.

The Difference Is Worth It

The Amiga 2000 is a powerful system with a lot of promise, particularly with its video animation and multitasking. But is the 2000 worth 50 percent more than the original 1000? From a software and performance perspective, the two machines are practically identical. The difference is in expandability. The 2000 lets you expand with internal components, making for a more compact footprint than a similarly expanded 1000. You can also expand the 2000 more reliably due to its more robust bus architecture.

Finally, expansion boards and hard disk drives for the 2000 are less expensive than equivalent 1000 expansions. The 2000 can use off-the-shelf hard disk drive components, and the system's expansion cards do not require a complete expansion box, just a PC card. And given the 2000's PC compatibility, the choices are wide open.

If you need an expandable Amiga system, especially with MS-DOS compatibility, the 2000 is worth the extra cost. For desktop video, the Amiga 2000 can outperform Macintosh IIs and 80386-based machines at an affordable price. ■

Charlie Heath, vice president of Microsmiths Inc. in Cambridge, Massachusetts, has developed several Amiga programs, including TxEd, Mean 18, FastFonts, and ARP.

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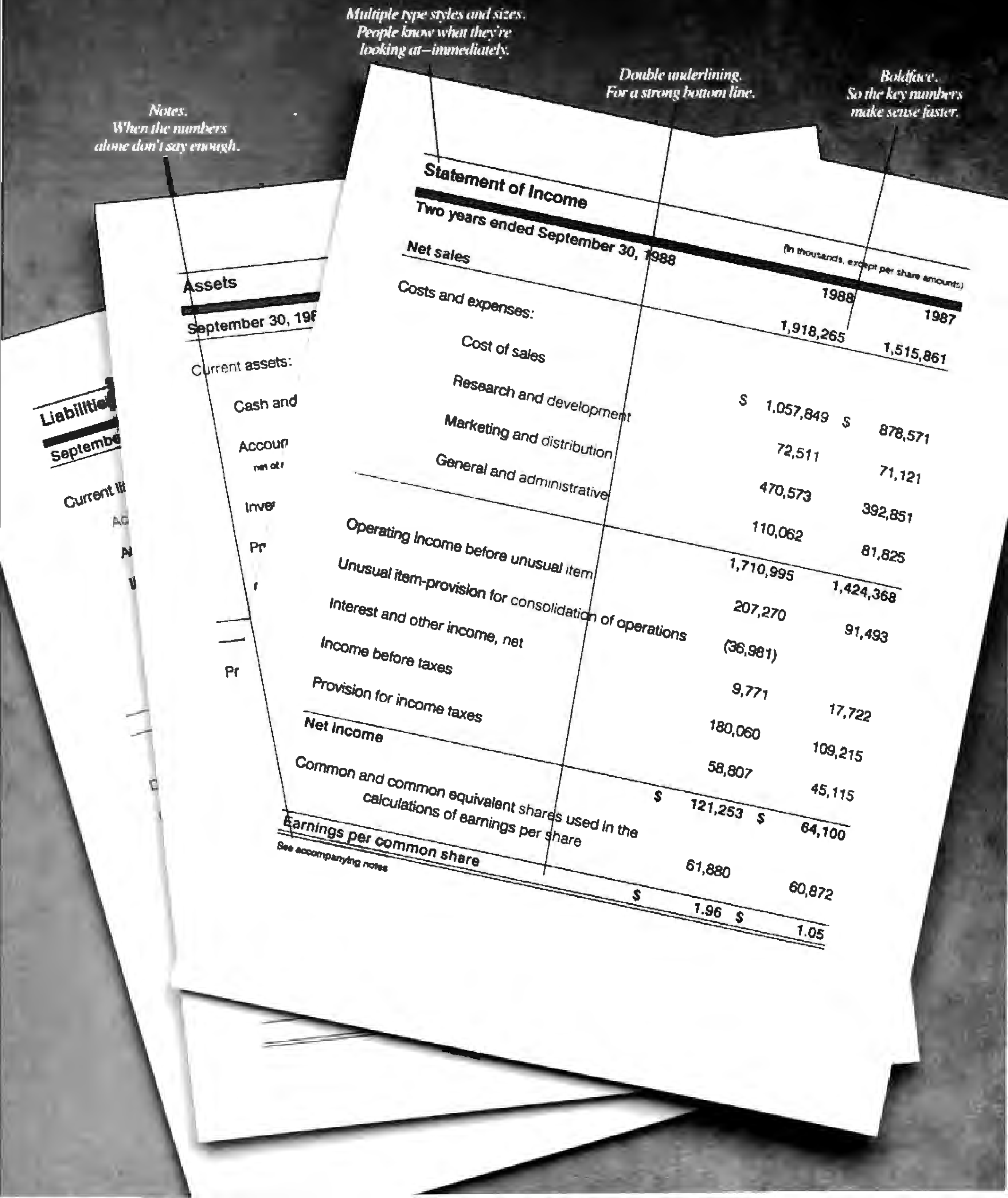

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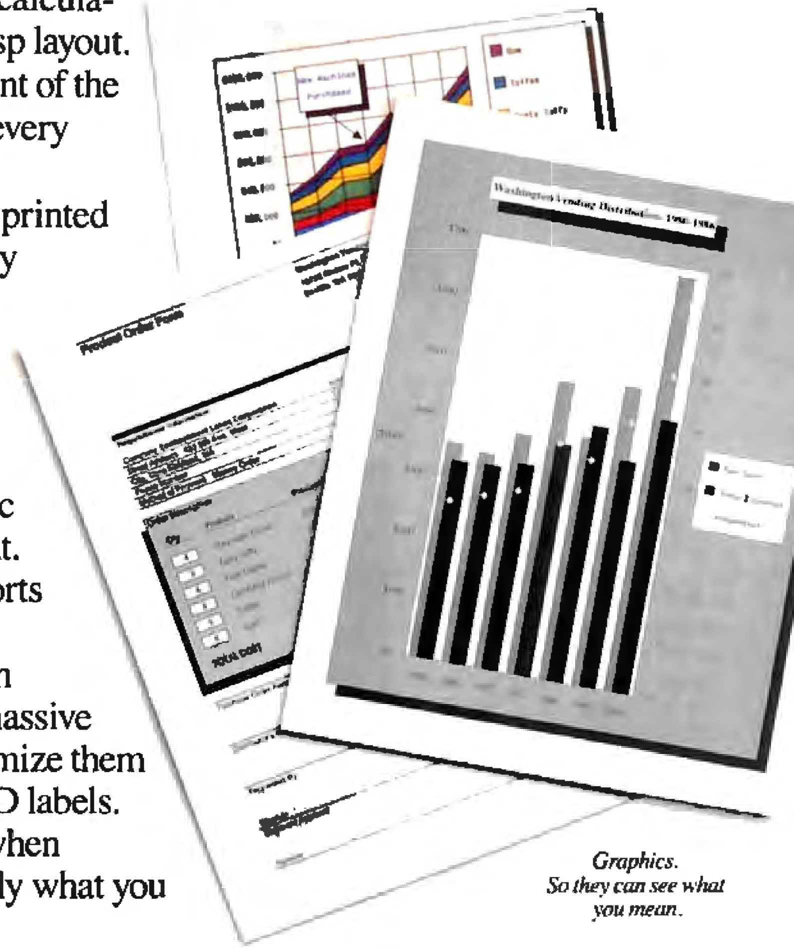

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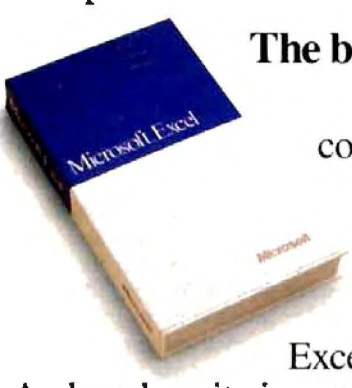

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The CrystalPrint VIII and the Crystal Jet offer alternatives to laser printers


The Taxan Crystal Jet LCS printer.

results between the LaserJet and the CrystalPrint are about what would be expected due to the differences in the setups. The Crystal Jet was slower because it depends so heavily on the host computer's CPU.

Taxan Crystal Jet

The Crystal Jet is a solid page printer. It's more flexible than the CrystalPrint VIII; it's also somewhat more difficult to set up. At $3495, it is more expensive, too, but the price includes the PS2.0 printer controller/scanner interface board—a full-length PC card with 2 megabytes of 120-nanosecond RAM. The Crystal Jet also comes with CrystalControl 3.0 software, the Fontware font program for Ventura Publisher, and a cable to connect the printer to the interface card.

The Crystal Jet can print 300-dot-per-inch (dpi) text and graphics. With 2 megabytes of memory on the interface card, it can easily handle full-page graphics.

The front panel includes a two-digit LCD for error and status messages, six LEDs to indicate various conditions (e.g., ready or data being transmitted), and four push buttons to place the printer on- or off-line, select the mode, and control automatic paper-feed.

The installation process is of average difficulty for a laser printer, and the manuals adequately cover the details. The process involves inserting the PS2.0 interface card in the computer, attaching the cable, and running the installation software. The software consists of a driver program and the CrystalControl program.

The Crystal Jet is designed to work only through the CrystalControl program supplied with the printer; there is no way to run the printer without it. Through the CrystalControl program, you can select the printer emulation, set page parameters, and select type fonts and printer ports. CrystalControl comes in both memory-resident and conventional versions. The pop-up version is 91K bytes, while the conventional version is 97K bytes. With the memory-resident version, you can pop into the Setup program from within another program to set page parameters or select an emulation. This is handy, but don't expect to call it from a program that redefines the keyboard, such as SuperKey.

CrystalControl's menus make the Crystal Jet easy to use, but you give up some control over your system parameters. When you install CrystalControl, the program rewrites your `AUTOEXEC.BAT` file and resets some parameters (e.g., files=15) in `CONFIG.SYS`. This is fine if you don't mind programs that go tromping through your `AUTOEXEC.BAT` and `CONFIG.SYS` files, but we would prefer to set the parameters ourselves.

CrystalControl also creates a dummy printer port called `JET`. Your computer thinks it is talking to `LPT1`, but actually it is running through `JET`. This means that CrystalControl will not work with the `Mode` command enabled. It also has the potential for raising sophisticated hell with software that directly accesses the printer port hardware.

The Crystal Jet differs from other printers in that the electronics that control the printer are installed in the host computer. The PS2.0 interface board includes 2 megabytes of RAM (not expandable), the printer interface, and the scanner interface. The board is thick (it's actually two boards joined together), and it may be a tight fit if placed next to a modem or a hard disk drive card.

One unusual aspect of the Crystal Jet is that the PS2.0 board uses the computer's CPU to produce the bit map for printing (see photo 1). Unlike the CrystalPrint VIII or the LaserJet, which have internal microprocessors to handle such jobs, the Crystal Jet's speed depends directly on the processing speed of the host computer. Thus, the Crystal Jet limps when it's attached to a standard IBM PC running at 4.77 MHz. It takes the processor so long to build the bit map of each page that the printer's speed suffers badly, as you can see in the benchmark results in table 1. When we reset the computer to run at 7.1 MHz, the printer's speed improved accordingly, although it still lagged behind the CrystalPrint and the LaserJet, especially on graphics jobs.

Based on the 4.7-MHz and 7.1-MHz timings, we estimate that on an 8-MHz AT the Crystal Jet should be about as fast as the CrystalPrint or the LaserJet. On 80386-based systems, it should run even faster. We would not recommend using this printer with anything slower than an 8-MHz AT-class computer.

continued

Laser Printing Without Lasers

Rick Cook and Paul Schauble

They look and act like laser printers, but the Taxan Crystal Jet and the Data Technology CrystalPrint VIII don't use lasers. Both are liquid-crystal-shutter (LCS) printers that use a different xerographic method to produce a printed page.

Laser printers use a laser beam reflected off a rotating mirror to write text or graphics images on a photosensitive drum. LCS printers have a print bar holding 2400 individually controlled liquid crystal shutters. These individual shutters turn on and off to control the high-intensity light that writes text or graphics images onto the photosensitive drum.

In theory, an LCS printer should have a few advantages. The LCS array is smaller, lighter, and more compact than a laser engine, and that means that LCS printers can be smaller. The printers can also be less expensive to make because the basic mechanism is simpler and doesn't require the same precision that a laser printer calls for. A laser printer needs a synchronized, multifaceted mirror and fairly sophisticated optics to focus the image on the drum; an LCS printer replaces all that with a fairly simple shutter array. (For more information on page printer technology, see the September 1987 BYTE.)

Data Technology Corp.'s CrystalPrint VIII LCS printer.

The theory sounds good; in fact, however, the Crystal Jet and the CrystalPrint VIII are no different in size, weight, and price from laser printers in the low-to-medium price range: The Crystal Jet lists for $3495, and the CrystalPrint VIII costs $2495. According to Taxan, LCS printers will be cheaper to make than conventional laser printers once the manufacturers get their volumes up.

Both of the reviewed printers are based on the 8-page-per-minute Casio LCS engine, which uses separate drum and toner cartridges. The print quality of both printers is fairly good but slightly inferior to the quality of the Hewlett-Packard LaserJet. Inspection under a magnifier revealed that gray scales weren't as good, images were less sharp, and there were more "freckles" in the white parts of images. The grays appeared decidedly washed out compared with the LaserJet's. However, except for the gray scales, none of these differences are likely to be apparent to the untrained observer, and both printers do an excellent job of emulating the LaserJet. Like the LaserJet, neither of these systems is PostScript-compatible.

The Crystal Jet and the CrystalPrint VIII eject their output face up, which is less convenient than the LaserJet's face-down presentation. Each printer has an optional automatic feeder that attaches to a door on the printer's back. The automatic feeder lets work pass straight through the printer, avoiding the 180-degree turn required with the conventional feeder. This is especially convenient for such items as envelopes and transparencies. The back door is also very handy for clearing paper jams, although neither printer jammed during our tests.

Like the LaserJet, the reviewed printers use a two-character LCD readout on the front panel to display error codes and printer status information. This may be the standard, but a cryptic code that you must look up in a manual is decidedly less convenient than a display that tells you exactly what's happening. However, both companies list the most common error codes on a chart that you can place on top of the printer.

About the Tests

We tested the printers using a 30-page text file, measuring the time each took to print the entire file, to print one page from the file, and to print 30 copies of that single page. For mixed text and graphics, we used a file called SCOOP, supplied as an example file with Ventura Publisher. It contains the now-famous pictures of the space shuttle and the nozzle, as well as a mixture of type sizes and styles laid out in a 1-page newsletter format. Finally, we ran the full Ventura Publisher example file, which consists of 30 pages of material designed to show off everything Ventura Publisher can do.

We printed all test files to a disk file first and then sent them to the printers using the DOS PRINT command and the HP LaserJet emulation; with this procedure, the test timings did not count the time Ventura Publisher took to compose the files. All timings are in hours:minutes:seconds (see table 1).

We ran the tests on PC XT-compatible computers running at 4.77 and 7.1 MHz, and we timed the printers at both speeds. For comparison, we had an HP LaserJet with 512K bytes of RAM connected to an 8-MHz AT compatible driving the printer via a parallel port. The differences in

Outstanding Flexibility

Unlike many page printers, the Crystal Jet does not use font cartridges. Instead, the CrystalControl program loads fonts into the interface board's memory. This is arguably less convenient than font cartridges but, given CrystalControl's ease of use, not onerously so. It is also much cheaper than buying font cartridges at $150 to $200 apiece.

The printer package includes four resident fonts, and you can add others. In addition, the Crystal Jet's software includes Fontware for Ventura Publisher. Fontware, from Bitstream, is a sophisticated typographic program that produces precisely fitted fonts in any selected size. Instead of having two or three fonts to cover all sizes and enlarging or reducing them as needed, Fontware designs each font for the exact size needed. The Bitstream Charter font is standard with the printer, and a library of other fonts is available.

Photo 1: *The PS2.0 printer/scanner controller board. It is composed of two boards connected together to occupy one slot.*

Fontware requires an AT, and the manual recommends adding a math coprocessor and an Intel Above Board (or a similar product) to increase memory to at least 640K bytes before using Fontware. Since our test systems were PCs, we did not try to test the Fontware package.

CrystalControl printer emulations include the HP LaserJet (the default) and LaserJet Plus, NEC 3350 and 5510, Qume Sprint 5, Diablo 630, Epson MX/FX, and the IBM Graphics Printer. The Crystal Jet does a solid job of emulating the LaserJet and the Epson MX; it ran the Ventura Publisher sample pages in Epson emulation mode without a hitch.

Because the printer emulations, fonts, and configuration controls are in software, and because of the way the printer uses the host computer's CPU, the Crystal Jet is an extremely flexible printer. You can configure the printer the way you want without having to set switches or install cartridges; your hands needn't leave the keyboard. At the cost of some complication in setup, you have much more control over the printer. In fact, flexibility is probably the Crystal Jet's most outstanding feature.

Installing the Crystal Jet's separate drum and toner cartridges is slightly less convenient than using the Canon all-in-one cartridge on the LaserJet; on the other hand, you don't have to discard a drum with life left in it because you are out of toner. Replacement drums cost $75, and toner cartridges are $60. Installation is very easy: With the printer open, simply slide the drum and the toner cartridge into place and lock with the flick of a lever.

According to Taxan, the drum lasts for 10,000 pages, and the toner cartridges are good for 5000 pages. The life of the print engine is given as 300,000 copies, which is about the life of a LaserJet. The duty cycle is given as 800 pages per day.

The Crystal Jet comes with a one-year warranty. Taxan says it will provide servicing through its offices.

Table 1: *The benchmark results show that the CrystalPrint VIII was the fastest in all tests except for the mixed text and graphics 30-page example file. The Crystal Jet was limited in speed because it depends on the host computer's CPU. All times are in hours:minutes:seconds.*

	CrystalPrint	Crystal Jet	HP (8-MHz AT)
30-page text file			
4.7 MHz	0:03:44	0:13:12	0:04:04
7.1 MHz	0:03:46	0:09:23	
One page of text			
4.7 MHz	0:00:18	0:00:34	0:00:29
7.1 MHz	0:00:18	0:00:27	
30 copies of a single page of text			
4.7 MHz	0:03:42	0:04:22	0:03:58
7.1 MHz	0:03:46	0:04:14	
Mixed text and graphics: Ventura Publisher SCOOP file			
4.7 MHz	0:02:01	0:08.38	0:08:40
7.1 MHz	0:02:01	0:05.24	
Mixed text and graphics: 30-page Ventura Publisher example file			
4.7 MHz	0:40:08	1:26:33	0:32:31
7.1 MHz	0.38:39	0:55:46	
Warm-up time (ready to print)	0:01:25	0:01:12	0:01:18

Substantial Documentation

The documentation consists of four manuals: an installation manual, misleadingly labeled Instruction Manual; the Crystal System manual, which covers installing the interface board and setting up various software packages for use with the printer; the CrystalControl User's Guide, which covers the control program for the printer; and the Fontware Installation Kit for Ventura Publisher User's Guide.

The documentation ranges from excellent to adequate. The only really annoying point was a lack of information on the printer's error codes. Although the common ones, such as `shell open` or `paper empty`, are explained in the manuals, some error codes merely indicate the need for periodic maintenance or a fault with the internal printer circuitry. The manual gives no information at all on these codes; it only instructs you to call a service technician.

Data Technology CrystalPrint VIII

Unlike the Crystal Jet, the $2495 CrystalPrint VIII has its controller, 1.5 megabytes of nonexpandable RAM, and LaserJet Plus emulation built into the printer. It can handle full-page 300-dpi text and graphics, and it comes with four built-in fonts. The front panel is the same as the Crystal Jet's.

The CrystalPrint ran all the LaserJet-compatible software we tested. In fact, the only major difference between this printer and the LaserJet is that the LaserJet stacks its output face down and the CrystalPrint stacks it face up.

continued

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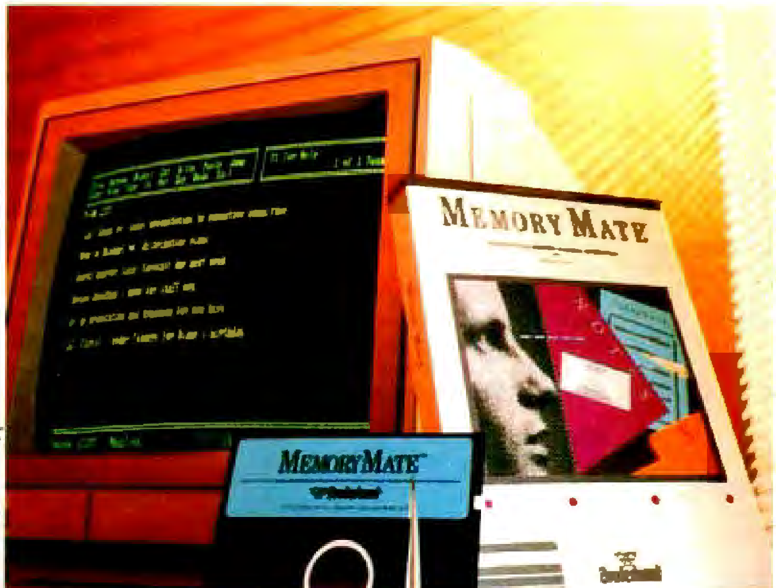

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CrystalPrint VIII

Type
LCS printer

Company
Data Technology Corp.
2551 Walsh Ave.
Santa Clara, CA 95051
(408) 727-8899

Features
Casio print engine, rated at 8 pages per minute; 1.5 megabytes of RAM; 300- by 300-dpi resolution; serial and parallel ports; four resident fonts; also uses font cartridges and accepts any LaserJet-compatible soft font; built-in LaserJet Plus emulation; 250-sheet paper tray

Size
18⅓ by 16½ by 13½ inches; 70½ pounds

Hardware Needed
Any computer with a serial or parallel port

Documentation
112-page Getting Started; 120-page Reference Manual

Options
Paper cassettes: $75
Font cartridges A, C, F, H, Y, and Z: $195 each
Emulation cartridges for Epson FX and Diablo 630 printers: $195 each
250-sheet straight-through automatic feeder: $595

Price
$2495

Inquiry 886.

Crystal Jet

Type
LCS printer

Company
Taxan USA Corp.
18005 Cortney Court
City of Industry, CA 91748
(800) 772-7491
(818) 810-1291

Features
Casio print engine, rated at 8 pages per minute; 300- by 300-dpi resolution; PS2.0 controller/scanner board with 2 megabytes of RAM; four resident fonts; Epson MX/FX, IBM Graphics Printer, Diablo 630, NEC 3550 and 5510, Qume Sprint 5, HP LaserJet and LaserJet Plus emulation; CrystalControl and Fontware software; 250-sheet paper tray

Size
13½ by 18¾ by 16½ inches; 88 pounds

Hardware Needed
IBM PC, AT, or compatible (PC AT recommended)

Documentation
47-page Fontware Installation Kit for Ventura Publisher; 38-page Instruction Manual; 126-page Crystal Control User's Guide; 43-page Crystal System manual

Options
Dual-feed sheet feeder: No price set

Price
$3495 (includes controller board)

Inquiry 885.

Like the LaserJet, the CrystalPrint VIII uses optional font cartridges ($195 each). Although they are not interchangeable with LaserJet cartridges, they follow the same nomenclature and contain the same fonts. The cartridges available are equivalent to LaserJet's A, C, F, H, Y, and Z cartridges. Any LaserJet-compatible soft font will work, too. Emulation cartridges for the Epson FX, the Diablo 630, and the Hewlett-Packard Graphics Language are also available as options.

The printer's two cartridge ports are located beneath the control panel. They are unlabeled, but they are not identical. The emulation cartridge goes on the right, and the font cartridge on the left (as you face the printer). You could easily plug the cartridges into the wrong ports; this would produced an error code 18 on the printer's display. Unfortunately, 18 is not one of the codes on the quick-reference guide on the printer, nor is it immediately obvious in the documentation.

Unlike the Crystal Jet, the CrystalPrint's memory is inside the printer, and the CrystalPrint runs off the computer's standard parallel printer port. There is no special interface card, and the LaserJet emulation is built in; this makes the CrystalPrint easier to set up than the Crystal Jet. You simply install the drum and toner cartridges, connect the cable, and turn the machine on.

On the tests, the CrystalPrint ran neck and neck with the LaserJet and ahead of the Crystal Jet. The LaserJet was slower in some tests because of its 512K bytes of memory, but it was faster in one of the tests because it was connected to an AT. By and large, however, the times are comparable.

Spotty Emulation

In addition to the standard LaserJet emulation, we also tested the optional Epson FX emulation. While the LaserJet emulation worked flawlessly, the Epson emulation didn't.

The CrystalPrint failed when we attempted to print some sample pages from Ventura Publisher configured for an Epson printer. This test is a particularly severe one because Ventura Publisher tells an Epson printer to make three passes per line to get a higher resolution (about 216 dpi). On the CrystalPrint, this produced three superimposed partial copies of each line. However, a WordPerfect test document that puts out the entire character set and samples of the various fonts, pitches, and other printer characteristics worked perfectly in Epson mode.

Technical support for Data Technology said that the company was not aware of a problem, but that it would try to repeat the problem we had.

The CrystalPrint's documentation is adequate. The installation manual, Getting Started, is complete, accurate, and illustrated; the Reference Manual, however, is not as good. The last half of the Reference Manual is a listing of the LaserJet control codes in hexadecimal. This is perhaps useful for programmers, and Data Technology's listing is better formatted than LaserJet's, but it is not something the average user needs. The manuals with the review printer were preliminary versions; final versions are now included with the printer.

Data Technology estimates the life of a toner cartridge at 5000 pages, and the life of the drum at 8000 pages. The duty cycle is 5000 pages per month. The toner cartridges and drum are considerably more expensive than Taxan's—$119 and $159, respectively.

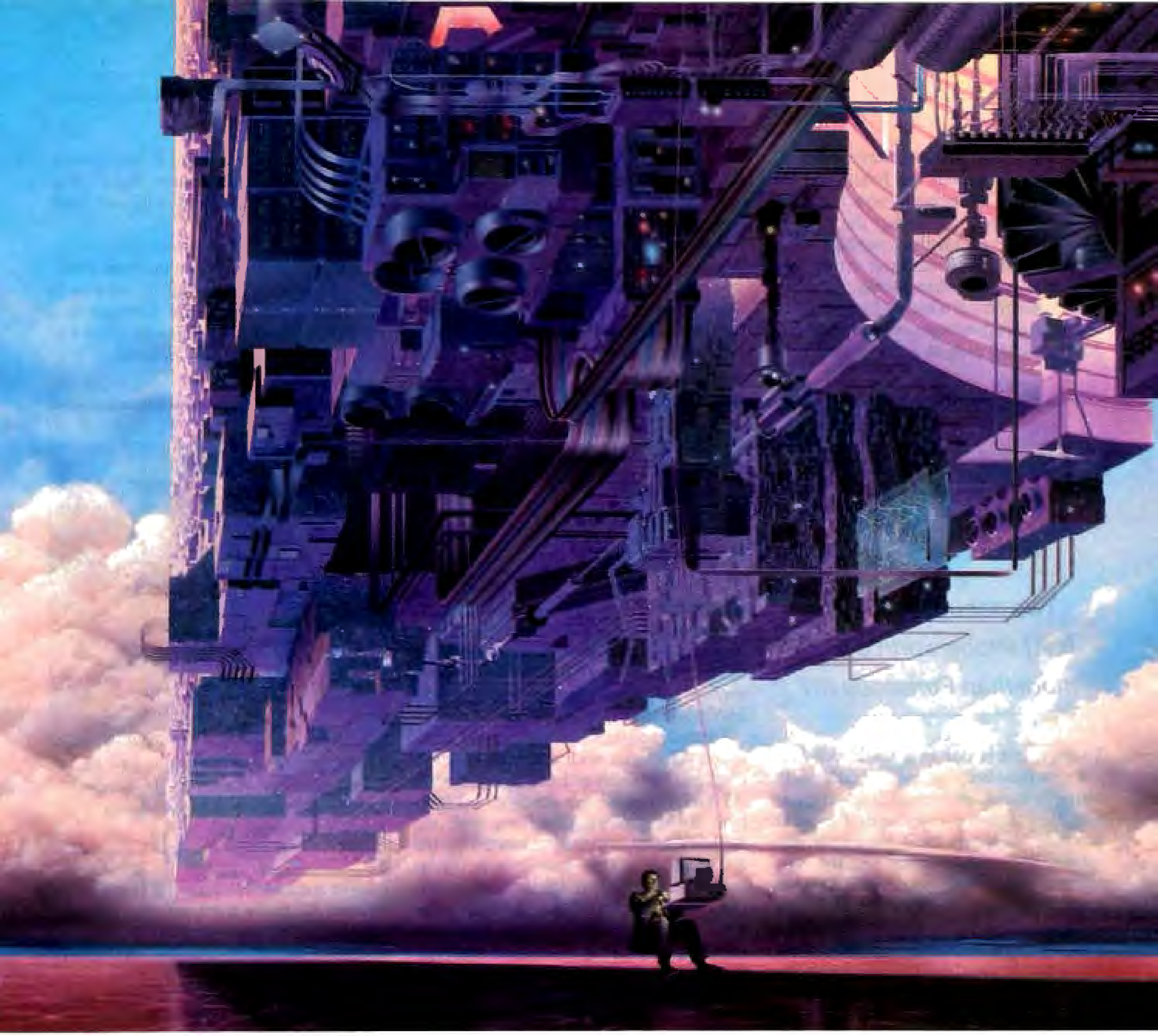
The CrystalPrinter comes with either a one-year warranty with walk-in service or a 90-day warranty with service on-site. Service is provided through Momentum Service Corp., which has 140 offices throughout the U.S. Extended service contracts are available.

No Major Advantages

The Taxan Crystal Jet and the Data Technology CrystalPrint are good, solid page printers. While LCS print engines do not yet offer any major advantages over a laser printer, we found no serious drawbacks either. Taken simply as page printers, they are worthy competitors of the LaserJet. They provide reasonable speed (assuming the Crystal Jet is connected to at least an 8-MHz AT), solid performance, and good, but not great, print quality at decent prices.

Of the two, we consider the Crystal Jet to be the better value. The PS2.0 interface board, the CrystalControl program,

continued



and the Fontware software provide flexibility; and both the board and the software can be replaced with improved versions without scrapping the printer. The CrystalPrint has the advantage of being $1000 cheaper, easier to set up, and somewhat easier to use, thanks to the font and emulation cartridges. Both printers share the disadvantages of producing output that is not quite as good as the LaserJet's and of using supplies that are not as widely available as those for the LaserJet.

Someday, LCS printers may be smaller and cost less; in fact, Data Technology has already announced the CrystalPrint Series II ($1995), which the company says has the smallest footprint of any available xerographic page printer. For the time being, however, the LCS printers aren't any cheaper, faster, or smaller than laser printers. Still, if you need a non-PostScript page printer, the Crystal Jet and the CrystalPrint VIII are both worth a look. ■

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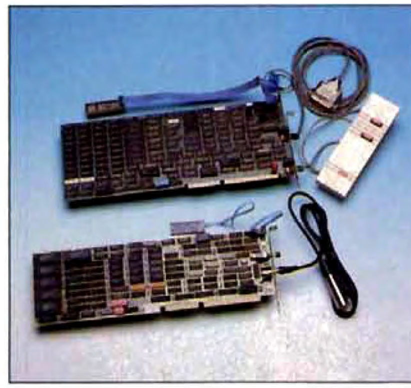
Getting the Bugs Out

Ross M. Greenberg

Two debugging tools: Is AT Probe worth $1500 more than Periscope III?



Hardware-assisted debuggers like AT Probe (top) and Periscope III (bottom) can significantly reduce debugging time—for a price.

Your project is due in a week. All beta test sites have been calling dutifully, indicating no major problems. Suddenly, one site after another calls with the same problem. It seems their hard disk dissolved, and your program was the only one running when it occurred. Time to start debugging.

Either of two hardware-assisted debugging systems, AT Probe ($2495) from Atron and Periscope III ($995) from The Periscope Company, may be able to help. Both provide a means of isolating their respective debugging programs from "normal" code space. They offer some unique features as well, including the ability to stop your code in the middle of *anything*, debug it, and then continue processing; real-time tracing, which only ICEs (in-circuit emulators) could do until now; the ability to breakpoint in real time, based on access to any component within the machine; and displaying and experimenting with the prefetch buffer. (For a discussion of debugging, see "Finding the Culprit" on page 154.)

During the review process, I used the boards to solve a variety of bugs: a write access by a terminate-and-stay-resident (TSR) program outside its data space; problems with the initialization routines in two different device drivers; timing problems between incoming characters in an interrupt-driven TSR concurrent serial-communications program; spelunking through the innards of MS-DOS to determine real-time DOS usage of the PSP (Program Segment Prefix) and FCB (File Control Block) records; and using breakout switches to enter the debugger on an apparent total-system lockup. I might have been able to solve some of these problems without a hardware-assisted debugging board, but it would have taken significantly longer.

I tested the boards on a variety of high-speed AT clones with and without EGA displays. The EGA causes a problem with AT Probe because the debugger's 128K-byte RAM footprint conflicts with the memory space normally allocated for the EGA BIOS. (This problem is documented in the manual.) You can select another area, but the 128K-byte footprint is pretty large. At 64K bytes, Periscope III's DOS footprint is smaller than AT Probe's, so it ran on my EGA system without any modifications.

AT Probe

AT Probe 2.0 is a full-height, full-length, IBM PC AT card with 1 megabyte of write-protected on-board memory and the ability to be used in protected mode. It comes with a cable that plugs into the 80287 socket on the AT motherboard. Your 80287 plugs into the cable's piggyback socket. The debugger has both hardware and software components. Most of the software loads directly into AT Probe's own memory, but 128K bytes of system RAM is also required. Installation is easy; it takes only moments. (An XT version of the board is also available.)

A switchbox comes with AT Probe and is an intrinsic part of the package. It contains a Stop button, which you can use to break out to the debugger, and a Reset button, which you can optionally install to let you reset the computer. To install the Reset button, you crimp a connector (which is provided) to the power-supply reset wire (not available on all AT clones). This is a permanent change, and I'm surprised Atron didn't use a less intrusive method. However, if you need to remove AT Probe from your system, you simply pull its reset wire out of the connector, which then remains attached to the power-supply wire.

Various add-ons to AT Probe are available: AT Source Probe ($395) lets you debug at the source code level in addition to the symbolic level; AT Software Performance and Timing Analyzer ($395) adds timing and performance measurement tools to the debugger; and Winprobe ($495) enables you to debug software designed to run under Microsoft Windows 2.0.

Three options are also available to optimize AT Probe for specific applications. The /ISO option ($395) lets you run the entire debugging process in the 80286's protected mode using no system memory. There are certain relatively obscure disadvantages to running the /ISO version (most having to do with the keyboard), but the beauty of running in protected space, where the debugger is almost invisible to your own code, is worth it.

The /PL option ($125) supports Plink86 Plus, a linker from Phoenix Technologies that resembles the standard Microsoft Linker but lets you use overlays in a more powerful way. The /PL option lets you set breakpoints in overlays

continued

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*SCO VP/ix available as separate product.

**Cost comparisons are based on most recently published U.S. domestic suggested list prices. Cost model: Base machine: IBM PS/2 Model 80, 70Mb disk, 1Mb RAM, IBM 8512 color monitor, 1Mb additional IBM RAM, IBM Proprinter XL.® 1-user DOS system: Base machine, plus DOS 3.3, WordPerfect 4.2, Lotus® 1-2-3,® dBASE III PLUS.® 1-user OS/2 system: 1-user DOS system, substitute OS/2 for DOS. 1-user SCO XENIX system: Base machine, plus SCO XENIX 386 for PS/2, SCO VP/ix, SCO Lyrix® (word processing), SCO FoxBASE+™ (dBASE III PLUS workalike), SCO Professional™ (1-2-3 workalike). 9-user SCO XENIX system: 1-user SCO XENIX system, plus intelligent 8-user multiport card, 8 IBM 3151 ASCII terminals. 33-user SCO XENIX system: 9-user SCO XENIX System, plus 3 more intelligent 8-user multiport cards, 24 more IBM 3151 ASCII terminals, 4 Mb additional RAM, additional 70Mb disk.

AT Probe 2.0

Type
Hardware-assisted debugger

Company
Atron
12950 Saratoga Ave.
Saratoga, CA 95070
(408) 253-5933

Features
2K bus-cycle traceback buffer; 4 hardware breakpoints with 1 megabyte of on-board memory; 660K-byte symbol-table space; multiple software tools; breakout switch Reset button; 12-inch 80287 cable (longer lengths available); 2-foot cable on breakout switch

Size
5 by 13½ inches

Hardware Needed
IBM PC AT or compatible with 8-MHz/10-MHz AT hardware-compatible bus structure (one 16-bit slot required); one wait state required; 128K bytes of available memory

Software Needed
DOS 2.0 or higher; DOS 3.0 or higher recommended

Documentation
220-page AT Probe/AT Source Probe Manual

Options
AT Source Probe: $395
AT Software Performance and Timing Analyzer: $395
Winprobe: $495
/PL (Plink86 Plus) extension: $125
/ISO (protected-mode debugger): $395
/ISO and /PL extension: $495
/PRO (protected-mode operation): $975
/PRO and /PL extension: $1075

Price
$2495
386 Probe: $4195

Inquiry 887.

Periscope III 3.1

Type
Hardware-assisted debugger

Company
The Periscope Company
1197 Peachtree St., Plaza Level
Atlanta, GA 30361
(404) 875-8080
(800) 722-7006

Features
8K bus-event traceback buffer; 64K bytes of on-board memory with 32 hardware breakpoints; ability to use alternate display device; multiple software tools; 15-inch 80x87 cable (longer lengths available on request); 5-foot cable on breakout switch

Size
4⅛ by 13¼ inches

Hardware Needed
IBM PC, XT, AT, or compatible (16-bit bus slot required on AT), operating with one wait state at up to 10 MHz; 64K bytes of available RAM

Software Needed
DOS 2.0 or higher; DOS 3.0 or higher recommended

Documentation
218-page Periscope Manual; Quick Reference card

Price
8-MHz version: $995
10-MHz version: $1095

Inquiry 888.

that you haven't yet loaded from disk. Another option, /PRO ($975), lets you run in protected mode in memory above the first megabyte. Combinations of these options are also available: /ISO with /PL ($495), and /PRO with /PL ($1075). The particular software configuration I tested included the /ISO and /PL options and the AT Source Probe.

Probing for Bugs

Using AT Probe is straightforward. The command structure of the debugger requires a considerable learning curve because it is not similar to DOS DEBUG; however, the on-screen help facility in two command windows makes the process less painful than it would be if you had to turn to the manual all the time. The user interface, however, is simply a command-line interface.

When invoked, AT Probe looks for its configuration file, `PROBE.CFG`, which contains the base address at which to load the software, as well as the cursor- and screen-addressing information required to use a remote serial device as if it were a local console.

When you first load the debugger, it also looks for an `INIT.MAC` file, which can contain user-defined macros concerned with initialization. (An AT Probe macro contains a series of AT Probe commands.) As with any macro library, you eventually end up with your own set of specially designed tools, but AT Probe comes with a good set in `PROBE.MAC` to use for your initial debugging sessions. This set includes such macros as sector read, sector write, display program prefix segment, display registers, and display stack data.

Once within the debugger, you can specify the name of the file you want to debug and its associated symbol tables, as well as any additional macro files you wish to load. You can examine the code in its disassembled state, and symbol names are shown after their actual addresses to aid in your debugging. From past experience, I find that actually replacing the hexadecimal address with the symbol name is a bit more comfortable and closer to the original source code, but that's a matter of personal preference.

Debugging an application without a symbol table is more difficult, but since AT Probe lets you enter symbol names at specific addresses and thereafter displays those symbol names, exploring code fragments (even DOS itself) is easier than before. The board devotes 660K bytes to keeping your symbol table in its write-protected memory so that it won't be overwritten.

The heart of debugging, the setting of breakpoints, is an easy task with AT Probe. You can set them to occur when execution reaches a given location; when a particular range of memory is read, written, or fetched by the CPU; or when a specified I/O port (or a particular value for that port) is read from or written to.

The real power of AT Probe shows in its macros. The macro capability lets you execute an intelligent breakpoint request, such as: "Breakpoint when an area outside of this bounded area is written to, if and only if the code segment is within this range and the data value at this address is greater than a particular value and less than this value." You can make a macro just about any length you like, and it can call other macros (up to a nesting level of 5) with parameter passing.

The macro processing speed isn't as fast as I'd like. An intelligent breakpoint request runs at full speed on AT Probe, but once it reaches a breakpoint and starts executing in the CPU, processing slows down. When you know this, you will find yourself setting breakpoints a bit more sparsely.

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Finding the Culprit

Fixing a bug, once found, usually takes only minutes; finding it, however, can take minutes or weeks. A great number of software-only debuggers are available, all of which let you examine, step-by-step, each instruction the CPU executes, and compare the actual results with the results you expected. But, for a variety of reasons, hardware-assisted debuggers can make the process go much more quickly than software-only debuggers can.

One of the most common software debuggers is DEBUG, included with MS-DOS up to version 3.3. DEBUG is very useful for examining small assembly language programs or for resolving simple problems. However, it's woefully inadequate for any but the most rudimentary debugging. To debug program code easily, you need to be able to examine it with a symbolic listing; for example, `INC [TIMER_TICK]` is inherently clearer than `INC [0DCA]`. The first conveys at least part of the meaning the original programmer intended. To debug easily, you need to see the source code, or at least the symbol map. Many symbolic debuggers contain options to enter these symbols as required.

Other capabilities also affect the debugging process. When single-stepping through your code, for instance, a debugger needs to be able to set the "single-step" bit in the processor flag word. This bit generates an interrupt after each instruction, which the debugging program then processes, and it usually results in a display of the next instruction to execute (or the previous one) and the current setting of each register. If this information is stored in a traceback buffer, then you can see how your code arrived at the current point of execution. The larger the traceback buffer, the more instructions you can see, and the easier debugging becomes.

Determining when to examine that traceback buffer is more of an art than a science; being able to set breakpoints to stop execution of the current program and enter debug mode makes the process easier. The number of breakpoints a particular debugger allows is an important consideration, since the number and different types of breakpoints you use let you execute more of your code and less single-step tracing. The ability to issue breakpoints when your program reads or writes to a particular area of memory, when a register equals a certain value or range of values, or when your program accesses a particular I/O port is an important aid to debugging.

However, if the problem you're trying to find stems from the interaction of various hardware components over which you have no control (such as a timer tick occurring every 1/18 second or a conflict of serial-port interrupts), then even the niceties of Microsoft's CodeView (a full-screen symbolic debugger) may not suffice. It's not that software debuggers don't have the ability—most do; it's simply that tracing or single-stepping through your code can be terribly slow, because the CPU is executing perhaps hundreds of debugger instructions each time it executes one of your program's instructions. Trying to use the same CPU chip to process all these "intelligent" breakpoints, to manage a traceback buffer, and to protect your code and the debugger code from each other is a difficult, if not impossible, task.

Finally, sometimes the software debugger itself has an adverse effect on what you're debugging (since the position of your program in memory may depend on where the debugger is placed). Debugging may even be impossible, since the errant pointer causing your problem may actually modify a portion of the memory space occupied by the debugger—thus causing the debugger to crash mysteriously. In these situations, hardware-assisted debuggers like the ones reviewed here are your only choice.

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ware breakpoints active at any given time. I found that this wasn't sufficient in many cases, especially when I was trying to trace carefully through the many different cases on a C `case/switch` statement. I don't like having to outsmart limitations a debugger places on me.

Fetch and Carry

For the CPU to be as fast as possible, it automatically reads the next few instructions into a small on-board buffer while it executes its current instruction. In most programs, after a given instruction has run, the instruction most likely to run next is the one that follows it; since that instruction is already in the prefetch queue, little access time is needed except to read or write the operands.

Since prefetch is used only for instruction execution, it might be useful to set a breakpoint on prefetch into any area of memory that should never be executed but can be read or written to, such as your data-segment area or your low-memory interrupt table.

AT Probe's traceback buffer is 2K bus cycles, or events, in length. Atron calls this a *dequeued* buffer. You won't see instructions that have been fetched but not executed unless you specifically ask to see them. This is an important consideration when looking at the traceback buffer; it can be confusing to see instructions that were never executed.

A few features of note are AT Probe's ability to debug using Microsoft C's local stack referencing, its complete 80287 support, an on-line editor and notepad (in AT Source Probe), the ability to follow a nested calling convention backward on the stack, and the ability to re-enter data items by data type instead of hexadecimally, byte by byte.

One caveat, however, regarding AT Probe: One of the manual's appendixes contains a note about executing breakpoints while in a non-reentrant BIOS call, such as the keyboard- or monitor-service routines. Atron says that since AT Probe uses these routines, you could crash the system if you breakpoint within them.

Writing a Wrong

I used AT Probe to find a `write` access by a TSR outside of its data and code space. First, I defined a write-to-memory breakpoint for each of two memory-address ranges: one before the initial TSR code segment, and one after the last TSR segment. Both DOS and foreground programs, such as `COMMAND.COM`, normally access these areas of memory. Therefore, the debugger had to filter out all such valid `write` accesses.

Using a macro to set the breakpoints, I checked the code segment after each breakpoint to see if it fell within the TSR range. If it didn't, I resumed program execution; if it did, I knew I had found the culprit and could use the real-time traceback buffer to determine how I had gotten to the instruction causing the problem. Again, the macro didn't execute as fast as I'd like, but with some fine-tuning of its logic, I managed to speed it up.

Periscope III

Periscope III 3.1 is a full-length hardware-assisted debugging card with 64K bytes of write-protected RAM, an 8K-bus-event real-time traceback buffer, 32 hardware breakpoints, and a remote breakout switch. It requires an IBM PC XT, AT, or compatible with 64K bytes of available RAM. (Since the board is not a full-height card, it runs in the XT as well as the AT.) Periscope III comes in two

continued

models: an 8-MHz version ($995) and a 10-MHz version ($1095). It requires DOS 2.0 or higher, but DOS 3.0 or higher is recommended because DOS 2.0 and 2.1 contain some bugs involving improper changes to the stack; The Periscope Company warns that if your breakpoint happens to occur at just the right—or wrong—moment, you may have trouble. Note that this is true for AT Probe, too.

Like AT Probe, Periscope III has a cable that plugs into the 80287 socket on the motherboard, and an existing 80287 plugs into the cable's piggyback socket. A plug socket at the end of the card attaches to a breakout button that immediately enables the debugger.

Once you install the hardware (which takes about 5 minutes), you must install the software—also a rapid and straightforward process. You can run the software portion of the debugger without the hardware. After you install the software, you're ready to run a TSR called `PS.COM`, which takes command-line or indirect file switches. One switch lets you specify which area of memory the board is to use. Other switches let you specify the size of the symbol table, various window sizes, and other setup parameters.

No software extensions are available at this time, including those that allow for protected-mode operation; thus, most of the symbol table is visible in system memory. Although the debugger program itself is write-protected and is therefore safe from typical programming mistakes, the symbol table and other important tables are not protected. And since these tables are stored in system memory, you may not have enough memory to debug a large program with a large symbol table. This was not a problem in my testing, however.

Up Periscope

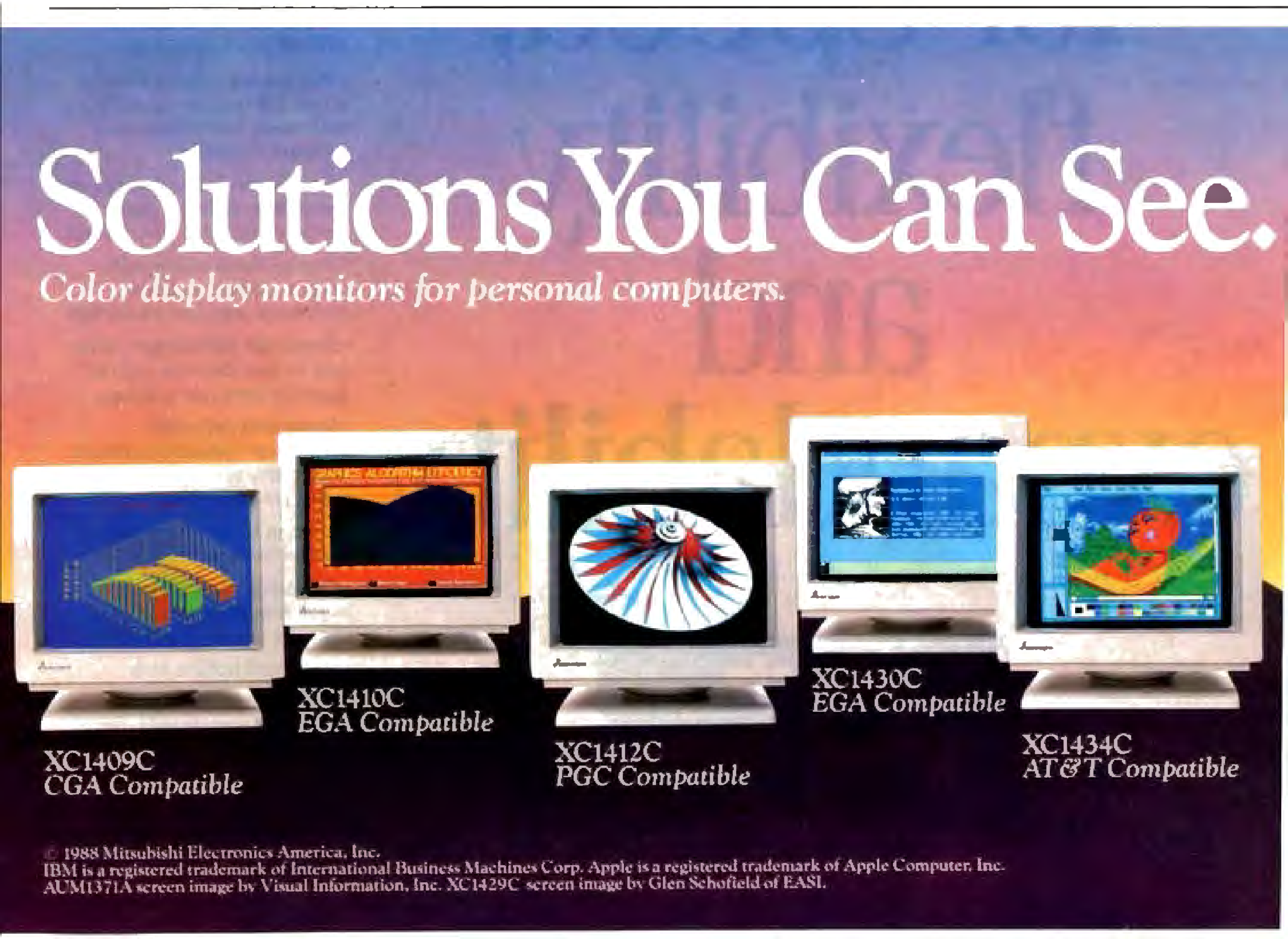
Once you load `PS.COM`, it sits quietly in the background until you call it. You can access it in either of two ways: through the breakout switch, or through `RUN.COM`, which automatically loads your program and its symbol table. Once your program is loaded, you are in the debugger, ready to debug your code.

Part of Periscope III's power is, surprisingly enough, in its user interface. You can choose from a variety of screen windows. I found that having two data windows, one stack window, a register window, and a disassembly window usually sufficed for my needs. Changing window sizes is an easy operation; for example, if you want two data windows with lengths of 4 lines and 6 lines, respectively, you enter `/W D:4 D:6`.

There is a not-so-subtle difference between Periscope III and AT Probe: AT Probe feels as if it were designed for programmers, while Periscope III feels as if it were designed by programmers. This shows through not just in the display of the various windows, but also in the command set and options, designed for programmers who want ultimate control over their debugging environment. For example, to issue a breakpoint when the byte, `COUNT`, equals 08, you would enter `BB COUNT EQ 08`. For AT Probe, the command would be `BP 1=.COUNT W DATA 08`.

Periscope III provides breakpoints on byte, code, interrupt, line, memory, port, register, user test, word, and exit. AT Probe has many of these abilities, but its interface uses a less intuitive format.

The myriad breakpoints that Periscope III allows also reflect this philosophy: You can set up to 16 hardware breakpoints, allowing read, write, execute, and fetch breaks, and including breakpoints above the first megabyte of memory for AT-class machines. You can also set breakpoints when the data on the bus meets a particular value, or when input or



output to a port occurs (you can specify up to 16 different ports). These breakpoints can be set directly on Periscope III's board. Finally, you can set a *pass count*, which breaks out only after the breakpoint has been executed a certain number of times; for example, "break on the fifth write to this screen location."

You can also set software breakpoints. Aside from those breakpoints that are put in Periscope III hardware for speed, you can set additional interrupts when a particular byte, word, or register meets certain tests (less than, equal to, or greater than a specified value), as well as when a particular interrupt executes, when a particular line of source code runs, when returning from the currently executing routine, or when a user-supplied (and previously loaded) assembly language routine returns a certain value.

With Periscope III's "go using monitor" mode (`GM` command), some of these software breakpoints can work in combination with the hardware breakpoints. Thus, the program can run at full speed until it reaches a breakpoint on the board. Control then transfers to the board to determine if the specific condition exists, such as "break on register value" (`BR` breakpoint). If not, the code resumes execution immediately. If the conditions are met, the breakpoint executes, and you can start debugging.

One real disappointment is that "break on register value" allows only one breakpoint test for each register. Thus, testing for a write access to a range of memory with a double range check on the CS register isn't as easy to accomplish on Periscope III as on AT Probe. (AT Probe's macro capability can handle this.)

Periscope III lacks macro capability, but, with its `USEREXIT` capability, you can make tests as arbitrarily complex as you wish. A `USEREXIT` is user-written assembly language code (`USEREXIT.ASM`) with which Periscope III can interface. It is loaded as a memory-resident program, called `USEREXIT.COM`, that uses an available interrupt. Of course, you'll have to debug the assembly language routines that make up the `USEREXIT` routine itself.

Like AT Probe, Periscope III has traceback-buffer capabilities. However, Periscope III's traceback buffer is 8K bus events long (a bus-event record is 48 bits wide), so it can hold substantially more information than AT Probe's 2K-bus-cycle buffer. You can set up the buffer to capture 8K events before the breakpoint, 4K events before and 4K events after the breakpoint, or 8K events after the breakpoint. However, much of Periscope III's traceback information consists of prefetch instructions. As such, except for the obvious ones, like `jmp`, `call`, `ret`, and `int`, the trace buffer contains instructions that may not have been executed but were only in the prefetch buffer. This makes debugging more difficult.

Periscope III comes with a number of auxiliary programs, including one to let you use the map-file output from Plink86 Plus, and another to run through assembly language source code and make each symbol public. Since the more symbols you have, the easier the debugging becomes, the `PUBLIC` program should be a welcome addition to any library.

Driving Devices Crazy

Debugging a device driver can be difficult, especially since the device driver is loaded before you can load your debugger. Periscope III's distribution disk contains a program, `SYSLOAD`, that lets you load the important parts of Periscope III as device drivers so you can debug the device-driver initialization routine. When I combined this with Periscope III's ability to perform a "short boot" (which usually

continued

leaves the interrupt vectors loaded), debugging a device driver became as easy as debugging any other program.

The problem I had was that the serial-communications device driver was crashing the system somewhere in the initialization routine—sometimes. At other times, and at high data transfer rates, characters were being dropped. The worst kind of bug is the kind that isn't always repeatable.

By setting breakpoints on input or output instructions to ranges of ports, I found that the device-driver initialization routine was turning interrupts on too soon. By using Periscope III's user-exit capability, I found that the time used to return after a polling loop and before generating the End-of-Interrupt instruction was sufficient for a character to arrive when receiving at 115K bytes per second. Without a hardware-assisted debugging board, either condition would have been difficult, if not impossible, to discover.

The Competitive Edge

Determining which debugger is better is a difficult task. There is no clear and simple benchmark that you can base a judgment on. Once you find a bug with one debugger, it's gone, and it's impossible to replicate the problem. (But, sadly, another bug always lurks around the corner; there's never a shortage of them.)

If you're developing Microsoft Windows programs; if you're using the overlay capability of Plink86 Plus substantially; if your code is very large (greater than 400K bytes); if you have a huge number of symbols; or if you're writing a protected-mode application (and with OS/2 on the horizon, protected-mode operations are going to become increasingly important), then you need the support offered as options for AT Probe 2.0.

However, the interface on Periscope III is easier to work with than AT Probe 2.0's; the capabilities, such as the number and type of breakpoints, are substantially better; and the command summary is, to my way of thinking, closer to the debugging needs of a programmer. And if you're a small developer with limited funds, Periscope III's lower price becomes paramount.

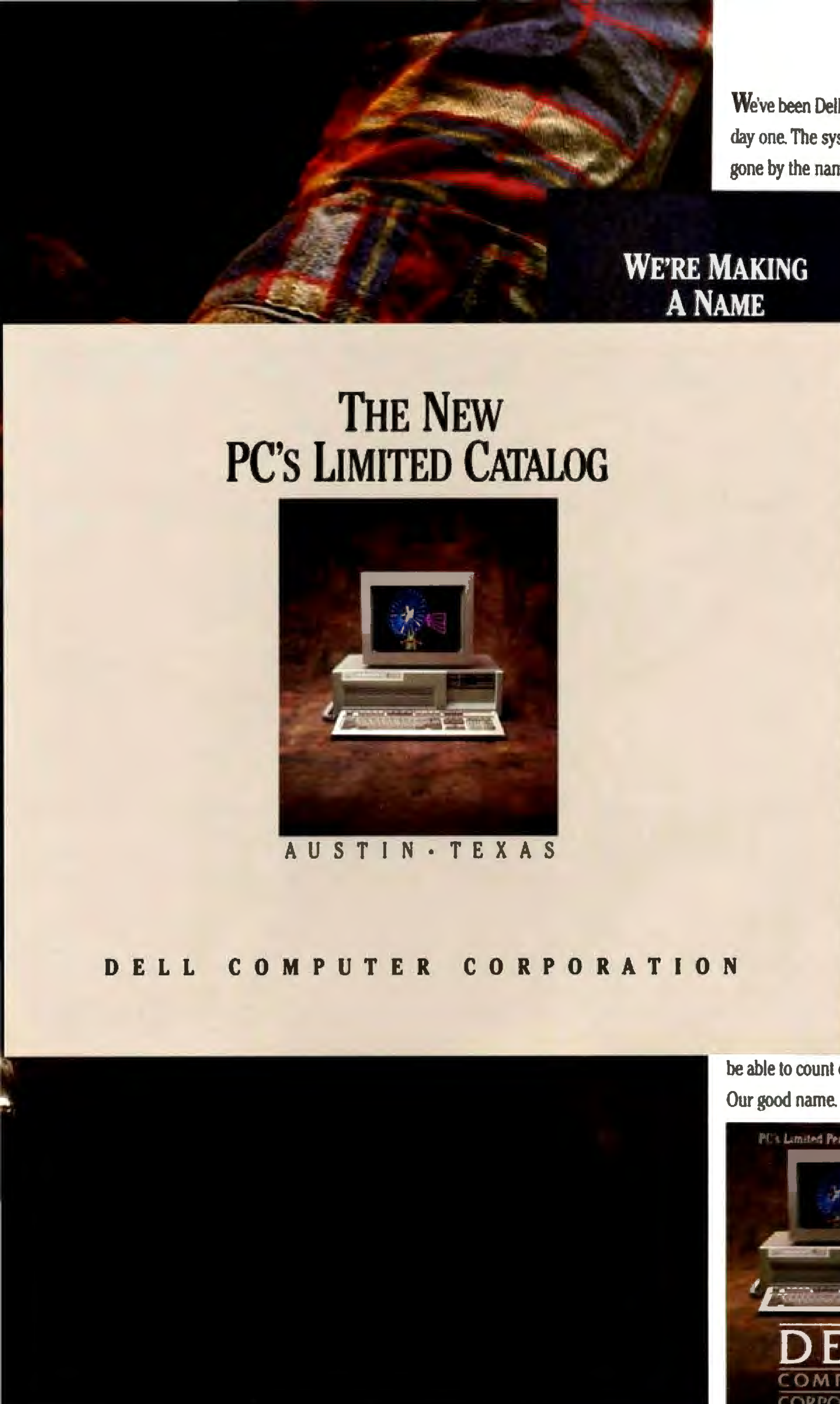
But all this is changing. New releases on both products are forthcoming. The features in the new releases clearly indicate how acutely each company is aware of the competitive edge the other has to offer.

The Periscope Company says that Periscope III 4.0 (due out this month) will support Microsoft Windows, Plink86 Plus's overlays, and Microsoft C's local symbols. Periscope IV, due out this spring, is planned to support the 80386 as well as the 80286. Atron says that the next release of AT Probe, also due out this month, will contain a user interface similar to that of Microsoft CodeView. Atron's 386 Probe for 80386 systems has recently been released. It's an interesting race to watch.

Both AT Probe and Periscope III serve admirably as debuggers. Each does quite a bit more than its advertising represents, and each also has major enhancements in the works. But does AT Probe make up the $1500 difference in price (almost $2000 if you include AT Source Probe) with added programmer productivity?

The answer isn't as clear-cut as I'd wish. If you don't need the special capabilities AT Probe has that Periscope III doesn't have, then, no, AT Probe isn't worth the difference in price. If, however, you do need them, and you need them badly, then the price doesn't matter as much. ■

Ross M. Greenberg, owner and chief executive officer of Software Concepts Design in New York, is a computer consultant and software designer.



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And that's how things are going to stay for some time to come.

Because, in just three years, we've become one of the seven largest personal

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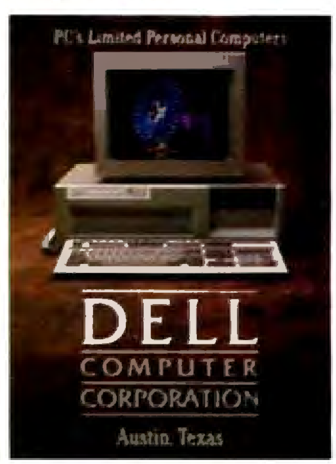

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InfoWorld Magazine called our 386 system the fastest desktop computer they have ever tested. Based on 80386 technology that utilizes 0 wait state Static RAM, the System 300 is highly effective in research and development applications, CAD/CAM, database management and desktop publishing. In addition, it is an ideal entry level, low cost alternative to a minicomputer in multi-user environments using 386 UNIX®/XENIX® operating systems. The PC's Limited System 300 is MS-DOS® and MS® OS/2 compatible.*

PC's LIMITED SYSTEM 300

STANDARD FEATURES

- Intel 80386 running at 16 MHz.
- 1 MB of 0 wait state Static RAM, expandable to 6 MB Static RAM, plus 10 MB Dynamic RAM.
- 1.2 MB 5.25" or 1.44 MB 3.5" diskette drive.
- Dual diskette and hard disk drive controller.
- Enhanced 101-key keyboard.
- 1 parallel and 2 serial ports.
- 200 watt power supply.
- Real-time clock.
- 8 expansion slots (1 32-bit, 5 16-bit, 2 8-bit).
- 12 month, on-site Honeywell Bull service contract. (Available for complete systems.)

SYSTEM 300 Hard Disk Drives	With monitor/adaptor			VGA Color Plus
	Monochrome	EGA	VGA Mono	
40 MB-28 ms	$4,299	$4,799	$4,599	$4,999
70 MB-28 ms	$4,699	$5,199	$4,999	$5,399
150 MB-18ms — ESDI	$5,999	$6,499	$6,299	$6,699

*August 3, 1987 Built in the U.S.A.

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The new PC's Limited System 200 is one of the highest performing 80286-based personal computers you can buy. Its high speed 12.5 MHz operation is ideal for business applications, as well as software development, local area networks, CAD/CAM, and desktop publishing. The System 200 is MS-DOS® and MS® OS/2 compatible.

PC's LIMITED SYSTEM 200

STANDARD FEATURES

- Intel 80286 running at 12.5 MHz, switchable to 6.25
- 640 KB of RAM, expandable to 16 MB.
- 1.2 MB 5.25" or 1.44 MB 3.5" diskette drive.
- Dual diskette and hard disk drive controller.
- Enhanced 101-key keyboard.
- 1 parallel and 2 serial ports.
- 200 watt power supply.
- Real-time clock.
- 6 expansion slots (4 16-bit, 2 8-bit).
- 12 month, on-site Honeywell Bull service contract. (Available for complete systems.)

SYSTEM 200 Hard Disk Drives	With monitor/adaptor			VGA Color Plus
	Monochrome	EGA	VGA Mono	
20 MB	$1,799	$2,299	$2,099	$2,499
40 MB-40 ms	$1,999	$2,499	$2,299	$2,699
40 MB-28 ms	$2,299	$2,799	$2,599	$2,999
70 MB-28 ms	$2,699	$3,199	$2,999	$3,399
150 MB-18 ms—ESDI	$3,999	$4,499	$4,299	$4,699

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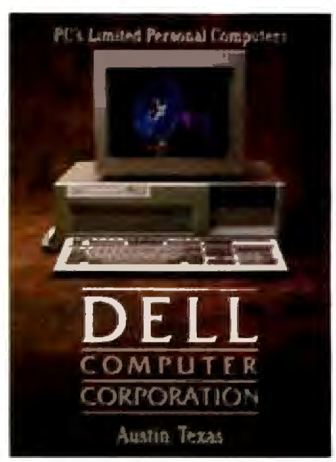

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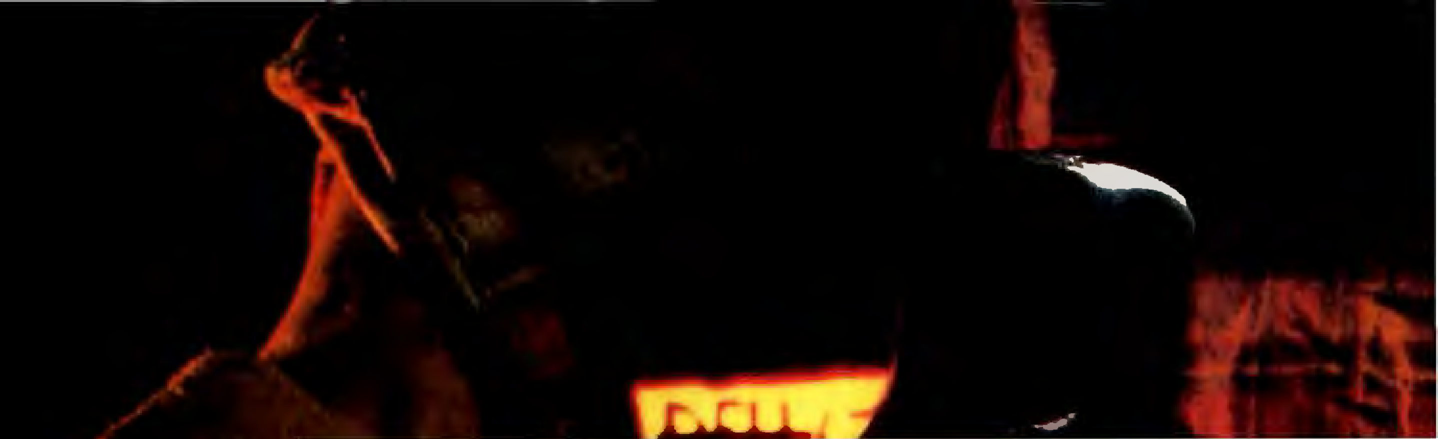

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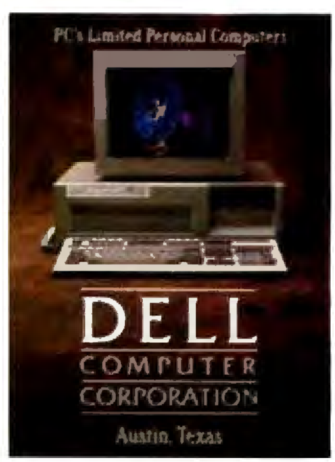
Our Turbo PC is an extremely affordable, entry-level system for business and home use. Word processing, spreadsheets and accounting are only a few of the applications the Turbo PC can run quickly and efficiently. It also can be easily connected into local area networks and can be configured to your exact specifications.

PC's LIMITED TURBO PC

STANDARD FEATURES
Intel 8088-2 running at 8 or 4.77 MHz.
640 KB of RAM.
360 KB diskette drive.
Diskette drive controller.
84-key keyboard.
130 watt power supply.
8 expansion slots.
12 month, on-site Honeywell Bull service contract. (Available for complete systems.)

TURBO PC	With monitor/adaptor	
	Monochrome system	EGA color system
1 360 KB diskette	$799	NA
20 MB hard disk	$1,199	$1,699
40 MB hard disk	$1,399	$1,899



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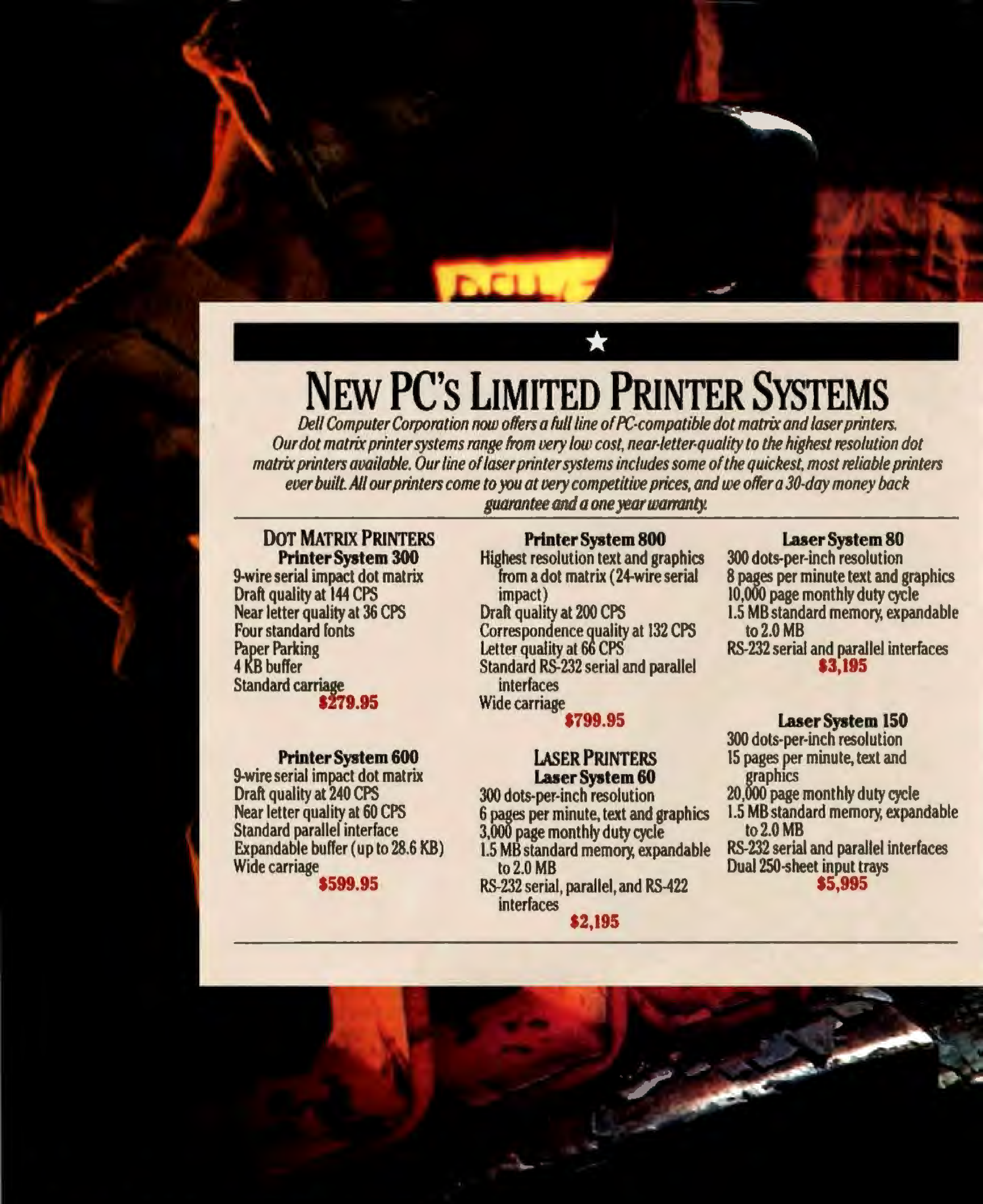

NEW PC'S LIMITED PRINTER SYSTEMS

Dell Computer Corporation now offers a full line of PC-compatible dot matrix and laser printers. Our dot matrix printer systems range from very low cost, near-letter-quality to the highest resolution dot matrix printers available. Our line of laser printer systems includes some of the quickest, most reliable printers ever built. All our printers come to you at very competitive prices, and we offer a 30-day money back guarantee and a one year warranty.

DOT MATRIX PRINTERS

Printer System 300

9-wire serial impact dot matrix
Draft quality at 144 CPS
Near letter quality at 36 CPS
Four standard fonts
Paper Parking
4 KB buffer
Standard carriage
$279.95

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9-wire serial impact dot matrix
Draft quality at 240 CPS
Near letter quality at 60 CPS
Standard parallel interface
Expandable buffer (up to 28.6 KB)
Wide carriage
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Printer System 800

Highest resolution text and graphics from a dot matrix (24-wire serial impact)
Draft quality at 200 CPS
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Laser System 60

300 dots-per-inch resolution
6 pages per minute, text and graphics
3,000 page monthly duty cycle
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300 dots-per-inch resolution
8 pages per minute text and graphics
10,000 page monthly duty cycle
1.5 MB standard memory, expandable to 2.0 MB
RS-232 serial and parallel interfaces
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Laser System 150

300 dots-per-inch resolution
15 pages per minute, text and graphics
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1.5 MB standard memory, expandable to 2.0 MB
RS-232 serial and parallel interfaces
Dual 250-sheet input trays
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System enhancement products are a key component to providing a total solution. And, due to our unique manufacturing capabilities, we can build a system to your exact specifications, integrating enhancement products from a wide selection of peripherals.

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14" VGA monochrome, Paper white phosphor
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14" VGA Color Plus
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GRAPHICS BOARD
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MODEMS
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dBase III Plus™
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Ventura Publisher™
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LIM EMS expanded memory board with 512 KB, expandable to 2 MB
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1 MB High speed Static RAM (for System 300)
$499.95
512 MB RAM upgrade kit (for System 200)
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Intel 80287-6
$249.95
Intel 80287-8
$399.95

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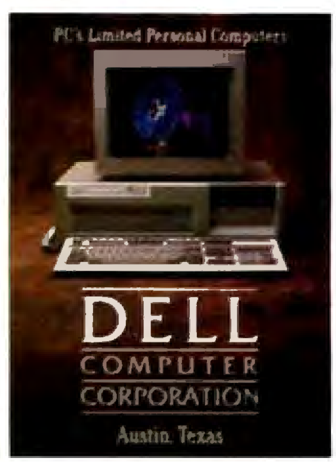
$119.95
MS®-OS/2 (Available in March)
$324.95



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Because, in just three years, we've become one of the seven largest personal computer companies in the US.

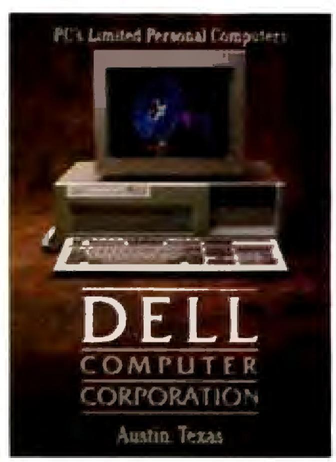
So we're going to keep on designing, developing and building fast, high performance computers right here in Austin, Texas. And we'll keep on selling them directly to users like you. Because the only good way to keep prices down is to cut out the middleman. No computer dealer means no dealer mark up.

And what could be simpler than picking up the phone, placing an order and having PC's Limited MS-DOS® and MS®OS/2 personal computers delivered right to you?

You can also call for our free catalog.

Keep in mind that our low, systems prices include something other manufacturers can't match. A one year, on-site service contract from Honeywell Bull, along with access to our technical support people over toll free phone lines.

And remember too that everything we make goes out the door with something you'll be able to count on for a long time to come. Our good name.



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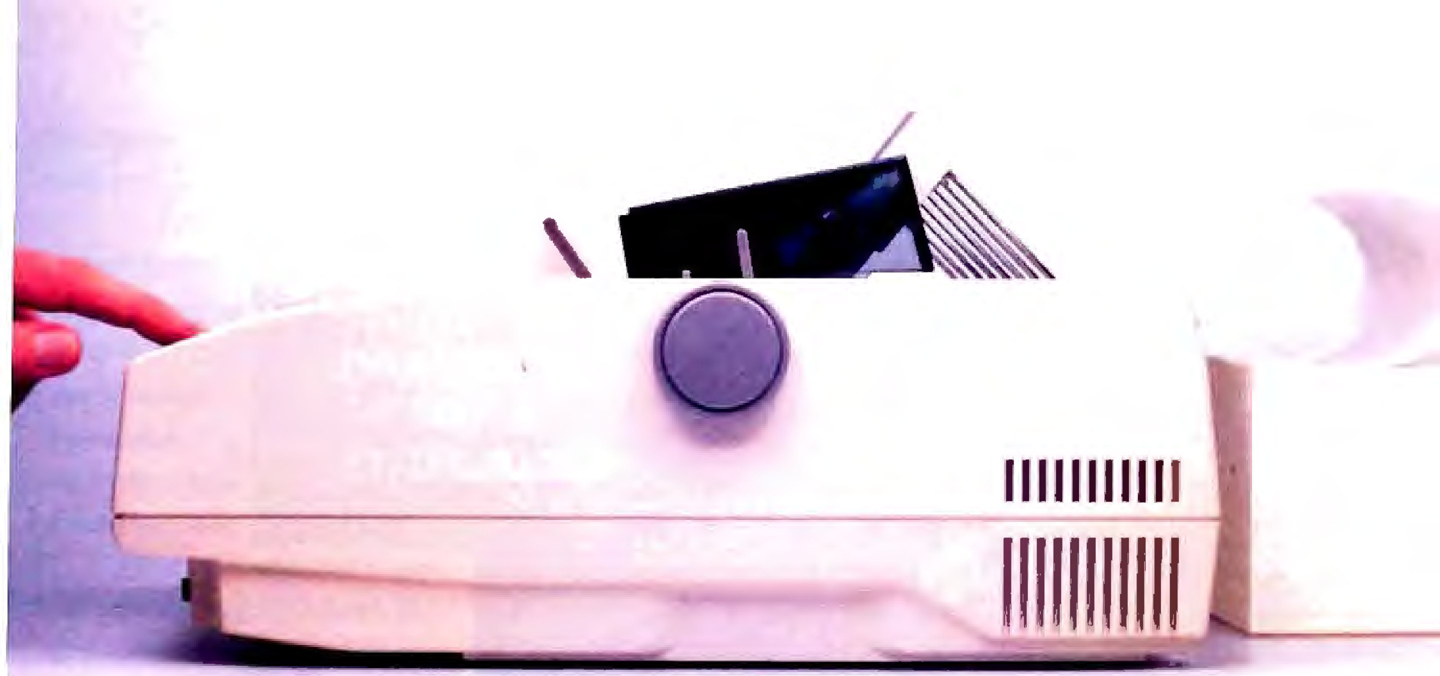

How To Easily Start A Feeding Frenzy.

We realize if you're looking for a fast, letter-quality printer, there's a few out there to choose from. We should know, we've developed some of the very best.

But if you're looking for a printer that's not only fast, but can easily devour any job you throw at it, you'd best look at the new Toshiba P351SX 24-pin dot matrix printer.

Take envelopes, for example. The P351SX comes with an optional automatic envelope feeder. That way your envelope is printed with the same speed and ease as your document.

We even replaced the hassle of dip switches with our new front panel. So you can make all your choices at the touch of a button.

But we wanted to make your printing jobs even easier still, so we added a few more convenient features.

Like the unique ability to print six-part forms with each part as legible as the first. Plus a built-in tractor and tear bar. A fanfold bypass. An autoload lever. A multistrike film ribbon. IBM Proprinter and Graphics Printer,[1] Qume Sprint 11,[2] Toshiba and other popular printer emulations. And a 64K buffer.

But rest assured, none of these features were added at the expense of speed. Because the P351SX zips merrily along at an amazing 360 cps for draft and 120 cps for letter quality.

All of which means the P351SX printer will quickly polish off any printing job. From letters and envelopes to graphics and full-sized spreadsheets.

And that's an appetizing thought for any busy office.

For the name of your nearest Toshiba printer and computer dealer, call 1-800-457-7777.

[1]IBM and Proprinter are registered trademarks of International Business Machines Corporation. [2]Qume Sprint 11 is a registered trademark of Qume Corp.

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Toshiba America, Inc., Information Systems Division

Circle 307 on Reader Service Card (DEALERS: 308)

Two Fast C Compilers for PCs

Namir Clement Shammas

Microsoft introduces an improved version of its C compiler and QuickC, a front-end development tool

First, Microsoft improved its C compiler, MS-C version 5.0, by adding powerful optimizing capabilities and support for the ANSI C standard. Then, it threw in an integrated package for C language development called QuickC. In a nutshell, QuickC is to traditional C compilers what Borland's Turbo Pascal is to Pascal implementations: a convenient, integrated environment for rapid software development. Now C programmers can buy one package that provides a friendly environment for front-end prototyping and professional workhorse language tools.

Microsoft sells the MS-C compiler bundled with QuickC 1.0 for $450. It also sells QuickC separately for $99. Both compilers run on an IBM PC or compatible with 448K bytes of RAM. QuickC requires a system with two floppy disk drives or a 5¼-inch floppy disk drive and a hard disk drive. MS-C 5.0 requires a hard disk drive.

You install both MS-C and QuickC using the `SETUP.EXE` utility. It automates the installation process and lets you customize the configuration of both compilers. It does this by prompting you to insert various disks from the package into drive A and copying only the files required for your particular installation. Moreover, `SETUP.EXE` uses the librarian utility, `LIB.EXE`, to combine one or more of these files into libraries built to fit the various configurations you request. This operation reduces the amount of disk space required and speeds the linking process.

The configuration options include the destination drive, the names of the QuickC subdirectory and auxiliary subdirectories, the memory model, the type of floating-point math support, and the graphics library support.

QuickC 1.0

QuickC parallels the QuickBASIC environment and includes an editor, filing system, compiler, linker, and debugger. You can invoke the QuickC environment by typing `qc`, and you can specify options related to the type of video card (e.g., CGA, EGA, and MA) in the system and the presence of a color monitor. The environment displays the main pull-down menu bar, the editor window, the error window, and the program-status line. Vertical and horizontal scroll bars are visible at the right and bottom edges of the editor window. QuickC lets you enter commands by pressing keys or by using an optional mouse.

You invoke the pull-down menus in the main menu bars by using the Alt key with other key combinations or by clicking on a choice with a mouse. You can select items in a pull-down menu in several ways. First, you can use the cursor-control keys to highlight a choice and then press Return. Second, you can press the key that corresponds to highlighted characters in the menu. Finally, you can point to and click on an item with the mouse. These various selection methods allow you to pick the style you're most comfortable with.

QuickC has two types of on-line help, and both are available by pressing the F1 key. The first is a series of eight help screens that present information on editing commands, characters in a regular (string-based) expression pattern search, C operator precedence, standard ASCII table, extended ASCII table, escape sequences, `printf` formatting, and C data types (with value ranges).

The second type of help documents the C keywords and various library functions. In this case, a window displays the different topics, and you make a selection by using the cursor-control keys or by typing the first letter in an option and then pressing Return. Once you've made a selection, the Topics window displays the names of the functions in the chosen category. You select functions in this window the same way you select topics. QuickC redisplays the editor window, with a brief description of the chosen function above it.

The QuickC editor is similar to WordStar in nondocument mode, except in how you select and manipulate a block of text. The commands are easy to learn and lend themselves more naturally to the use of a mouse. The editor uses a clipboard to save deleted text that you can paste back into the source code. The editor also has an interesting feature that lets you put it in read-only mode, protecting source code files from accidental changes during browsing.

While the QuickC editor supports the Find and Replace features present in any text editor, it also supports a Regular Expression option. This enables you to seek more complex and flexible text patterns. The Regular Expression feature is a subset of the Unix `grep` (global regular expression processing).

The QuickC editor does not handle multiple files. Professional programmers will still use their sophisticated multifile text editors to write the source code and resort to the editor in QuickC for fast corrections.

The QuickC environment incorporates a filer that is responsible for various tasks related to source code file management. Among these tasks is a reminder for you to save the currently edited file when you exit or load another. The filer permits you to load an entire file and merge an include file with the currently edited file. The filer also offers you two mechanisms to select a source code file. The first involves picking a file at large from a directory display; you can specify the subdirectory path and wild cards used to display the filenames. The second method is to select a `.MAK` file from a program list. A program list groups a related set of source

continued

QuickC 1.0	MS-C 5.0 (including QuickC 1.0)
Type C compiler	**Type** C compiler
Company Microsoft Corp. 16011 Northeast 36th Way P.O. Box 97017 Redmond, WA 98073 (206) 882-8080	**Company** Microsoft Corp. 16011 Northeast 36th Way P.O. Box 97017 Redmond, WA 98073 (206) 882-8080
Format One double-sided, double-density 5¼-inch floppy disk	**Format** Eight double-sided, double-density 5¼-inch floppy disks
Language Machine language	**Language** Machine language
Hardware Needed IBM PC or compatible with 448K bytes of RAM and two floppy disk drives, or one 5¼-inch floppy disk drive and a hard disk drive	**Hardware Needed** IBM PC or compatible with 448K bytes of RAM and a hard disk drive
Software Needed MS-/PC-DOS 2.1 or higher	**Software Needed** MS-/PC-DOS 2.1 or higher
Documentation 417-page Programmer's Manual; on-line help; Quick Reference card	**Documentation** Three manuals and a spiral-bound Quick Reference Guide
Price $99	**Price** $450
Inquiry 902.	**Inquiry 903.**

files for a software project and is similar to a make facility.

Compiling with QuickC invokes a special dialog box that permits you to select various compilation options, such as warning levels, output objects (e.g., object files, stand-alone executable files, or an in-memory executable image), Microsoft language extensions, speed optimizations, stack checking, pointer checking, and debugging. Other options let you control the extent of compilation: a single file, altered files, or all project files. The QuickC environment allows only the medium memory model, which imposes restrictions on the amount of data a program can handle. Its run-time library incorporates code that supports the automatic use of the 8087 and 80287 chips. QuickC contains its own debugger in its environment and cannot use the CodeView debugger.

The QuickC package also includes a command-line version of the QuickC compiler, `QCL.EXE`. This program lets you compile and link in one step, or compile your source code into object files that you link later. The `QCL` compiler employs many switches that parallel the menu options of the QuickC environment. Its advantage over the QuickC environment is its ability to generate code for different memory models: It supports the small, medium, compact, and large models. (If you use the code within the QuickC environment, you can use only the medium memory model.) Since `QCL`'s options resemble those of the full-fledged MS-C compiler, I will concentrate on the latter in this review.

Microsoft C 5.0

Unlike QuickC, the MS-C 5.0 compiler is strictly command line-oriented. However, its operation closely resembles `QCL` in that it quickly compiles source code and automatically links the object code files. MS-C 5.0 comes with several enhancements and changes from its predecessor, version 4.0. Two of the most significant changes are its improved code optimization and support of the ANSI C standard. Although it was not available for this review, Microsoft's newly released MS-C version 5.10 adds OS/2 support.

ANSI-standard support includes function prototyping and the implementation of the `const` and `volatile` types. MS-C 5.0 also lets you use enumerated types, treating them as integer values. The compiler no longer supports the `long float` type (its replacement is the type `double`). MS-C 5.0 now supports the `long double` type to provide enhanced data precision. You can use the `signed` keyword to explicitly indicate signed data.

The MS-C compiler is rich with numerous directives that let you fine-tune the resulting output code. These switches fall into a number of categories, such as memory-model selection, type of processor instructions, type of floating-point support, types of code optimization, and object-code generation for a debugger, to name a few.

The MS-C compiler supports five memory models: small, medium, compact, large, and huge. The floating-point switches enable you to generate code for the 80x87 coprocessor and use emulation routines, generate in-line code, or call for an alternate floating-point math package. You can also instruct the compiler to generate instructions for the 8088/8086, the 80186/80188, or the 80286 processors, but MS-C 5.0 does not generate native code for the 80386.

MS-C 5.0 can optimize programs for execution speed, code size, and loop execution. Other directives let you perform a wide variety of tasks, such as control checking for null and out-of-range far pointers, enforcing ANSI standards, specifying output filenames for `.OBJ`, `.EXE`, `.LST`, `.ASM`, and `.MAP` files, and generating code for Windows applications. You can also specify the generation of an object file for use with either CodeView or SYMDEB debuggers.

MS-C comes with many function libraries that let you perform a wide variety of tasks. The low-level libraries provide routines for buffer manipulation, memory allocation, process control, time management, and routines to access the BIOS and MS-DOS interface. The common C function libraries provide support for character classification, data conversion, searching, sorting, and string manipulation.

The file manipulation and I/O libraries provide directory control, file handling, stream I/O, low-level I/O, console I/O, and port I/O. The math function libraries encompass logarithmic, trigonometric, hyperbolic, power, and other transcendental functions. Finally, the graphics library contains routines to select the proper display mode, set coordinates, set the palette, set display attributes, output images and text, and transfer images. The graphics library supports EGA, CGA, MA, 2- and 16-color high-resolution VGA, and 256-color medium-resolution VGA modes.

Included in the package are the linker (`LINK.EXE`) file utilities and the Code-

continued

Some of the world's biggest problems are being solved with a touch of Smalltalk.

The French Ministry of Foreign Affairs is responsible for keeping **Abroad and involved in foreign affairs.** *track of every French citizen living abroad and every foreigner living in France. Each day, they process thousands of requests for documents or information, each one of which takes at least fifteen minutes. Arthur Andersen, the world's largest accounting firm, has developed a natural language processing application with Smalltalk/V that enables clerks without computer training to extract the necessary data much faster. Thanks to Smalltalk and system developers Bart Schutte and Pascal Wattiaux, what once took fifteen minutes now takes 30 seconds. Vive la Smalltalk!*

On the ground floor of high-tech environmental control. *Climate, energy, fire and security are all critical aspects of environmental control in large office buildings. The challenge for Johnson Controls, a leader in this industry, is to provide a control system that is both technologically advanced and simple to operate. Using Smalltalk/V, Research Scientists Gene Korienek and Tom Wrensch have created a workspace environment that allows rapid prototyping and modeling of future systems. At Johnson Controls this system is used to explore relationships between cognitive models of building operators and corresponding iconic representations of building components. Each system can then be tested by simply clicking a mouse and viewing the results in sophisticated color graphics on a PC.*

The world is made of objects. So naturally, the world is turning to Object-Oriented Programming (OOPS). And the fastest, easiest OOPS language and environment is Smalltalk/V.

With OOPS you program by defining objects, their interrelationships and their behavior. Objects can represent both real-world entities—people, places, things—as well as useful abstractions such as stacks, sets and rectangles. Smalltalk/V provides everything you need to solve problems big and small, including a comprehensive tutorial to get you started.

Who needs Smalltalk?

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Table 1: *MS-C 4.0, 5.0, and QuickC 1.0, compared using the BYTE benchmark programs. The compilers were directed to generate code that would resemble QuickC's code as closely as possible. You can see that optimized MS-C 5.0 code is faster than either MS-C 4.0 or QuickC code and that QuickC is faster than MS-C 4.0.*

Test	Sieve	Sort	Float coprocessor	Float emulation	Dhrystone
Compile/link					
QuickC 1.0	00:10	00:13	00:12	[1]	00:17
MS-C 5.0[2]	00:12	00:13	00:12	[1]	00:18
MS-C 5.0[3]	00:11	00:12	00:12	[1]	00:15
MS-C 4.0[2]	00:16	00:18	00:19	[1]	00:24
MS-C 4.0[3]	00:15	00:18	00:19	[1]	00:23
Execution					
QuickC 1.0	00:08	00:24	00:13	6:37	2382*
MS-C 5.0[2]	00:07	00:23	00:10	3:35	2777*
MS-C 5.0[3]	00:16	00:30	N/A	N/A	2173*
MS-C 4.0[2]	00:13	00:27	00:10	3:52	2272*
MS-C 4.0[3]	00:18	00:31	N/A	N/A	2000*

* Higher numbers indicate better performance.

[1] Benchmark compiled once using the /FP1 directive.
[2] Optimized code.
[3] Unoptimized code.

Note: The QuickC environment supports only the medium memory model. I set QuickC to disable stack checking and to generate 80286-specific code. Since MS-C 5.0 loop optimization produced invalid times, I disabled this feature for the Float benchmark. Also for the Float benchmark, I used the /FP1 option to allow the program to run with or without a coprocessor present. Compile/link and execution times are in minutes:seconds; Dhrystone execution is in Dhrystones per second. The Dhrystone version is 1.1, using no registers and performing 50,000 iterations.

View debugger. LINK is a command line-oriented linker that complements the features of the compiler with many directives to tailor the final properties of the executable file. Among these directives are ones to create special-format .EXE files for use with the CodeView debugger, pack adjacent code into one 64K-byte segment, and create libraries for use with QuickC.

You use a librarian utility (LIB.EXE) to manage object code libraries by adding, deleting, replacing, copying, and extracting sublibraries from larger ones. You use the MAKE.EXE utility to maintain or automate software projects. It works by checking the dates of a program's source files. If some of the dates have changed, MAKE invokes the compiler or linker to bring all the program's components up to date.

The CodeView debugger is perhaps the most important programming tool accompanying the MS-C compiler. This sophisticated and versatile debugger comes with its own environment. It lets you view the C source code along with the compiled machine code, single-step through the code, display registers, and set breakpoints.

See How They Run

I compiled and ran four benchmark programs: BYTE's Float, Sieve, and Sort benchmarks and the Dhrystone. I used an 8-MHz IBM AT equipped with Intel's Inboard AT/386 that had an 80386 CPU and an 80387 coprocessor running at 16 MHz, 640K bytes of base memory, 2 megabytes of extended memory (used for a RAM disk), a 20-megabyte hard disk drive, and a 30-megabyte HardCard. The system ran under PC-DOS 3.1.

I installed the C compilers on the HardCard. I then used the QuickC compiler to compile the benchmark programs into stand-alone executable files, which I ran from DOS. I set the compile options for speed optimization; this setting generates 80286-specific code and disables stack-checking. I ran the Float benchmark twice, once to utilize the math coprocessor and once with the coprocessor disabled to evaluate the speed of the emulation libraries. I suppressed the 80387 chip by setting the NO87 environment using the command SET NO87=true.

I also compiled these programs using MS-C 4.0 and 5.0. To get a reliable idea of how QuickC's results compared to MS-C's, I set the compiler switches to match QuickC's optimizations as much as possible. To do this, I used the medium memory model, disabled stack-checking, and requested 80286-specific code. I invoked the /FP1 directive when I compiled the floating-point test program, allowing it to run with or without the coprocessor chip.

With the exception of the Float test, I compiled the programs twice: once with maximum code optimization, and once with optimizations disabled. MS-C 5.0's loop optimization capability eliminated the for loop within this program entirely, yielding an elapsed time of 0. Therefore, I used a combination of compiler directives that matched all but loop optimizations when compiling the Float program.

The benchmark results, shown in table 1, favor the MS-C compiler over QuickC. The executable files emitted by MS-C 5.0 have faster run times than those produced by QuickC or MS-C 4.0. The speed optimization made a significant impact on the Sieve benchmark, nearly doubling the speed of the program. You can see improvements of roughly 20 to 50 percent in execution speed between the optimized executables of MS-C 5.0 versus MS-C 4.0. The compilation and linking speeds for both MS-C 5.0 and QuickC are better than those for MS-C 4.0 and are indicative of their good overall speed. (Keep in mind that I used a 386 system running IBM PC AT hard disks.)

Two Good Choices

QuickC offers the novice C programmer a comfortable environment in which to learn C. The WordStar-like editor, flexible filer system, rich on-line help, in-memory compilation feature, and fast, convenient compilation are factors that appeal to the student of C language or to the software designer who wants to prototype code rapidly. The optimized code is faster than MS-C 4.0's and comes close to the speeds of optimized MS-C 5.0 code. However, the QuickC environment supports only the medium memory model, which limits its usefulness in developing large programs and even its use as a front-end development tool.

The Microsoft C 5.0 compiler is a workhorse language tool. It incorporates many optimization features, supports the new ANSI standard, and automates the linking process. The extensive compiler and linker directives, the librarian, and the CodeView debugger provide you with a robust development package. ■

Namir Clement Shammas, of Glen Allen, Virginia, is a freelance writer and a columnist for several microcomputing magazines.

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New Power for FORTRAN

Carl Byington

Two new compilers take advantage of the 80386 and its coprocessors

FORTRAN has been around for over 30 years, but when it comes to number crunching, FORTRAN is still the best tool. Now, it is even better. Two new compilers use the 32-bit registers of the Intel 80386 to allow more efficient code when accessing arrays larger than 64K bytes and when using 32-bit integers. Both SVS FORTRAN 386 version 2.7 ($895) from Science Applications International Corp. (SAIC) and NDP FORTRAN 386 version 1.3a ($595) from MicroWay generate code for the 80386 32-bit native mode and support the 80287, 80387, and Weitek 1167 floating-point coprocessors.

These compilers require more than minimum hardware configurations. NDP FORTRAN 386 requires an 80386-based computer with a 1.2-megabyte floppy disk drive, a hard disk drive with at least 2 megabytes free, at least 640K bytes on the motherboard, and 2 megabytes of extended memory. It also requires that you have MS-DOS 3.2 (or higher) and Phar Lap's 386|ASM, 386|LINK, and RUN386. The Phar Lap programs are available in the 386|ASM/LINK package for $495. SVS FORTRAN 386 requires an 80386-based computer with a 1.2-megabyte floppy disk drive and a hard disk drive with 2 megabytes free. SVS FORTRAN needs 640K bytes, but does not require extended memory to run. You will need MS-DOS version 2.0 or higher and Phar Lap 386|LINK. Both compilers produce executable code that requires a floating-point coprocessor, but only the SVS compiler requires a floating-point coprocessor for the compiler itself.

Power at a Price

Both compilers depend on a DOS-extension package that interfaces their 32-bit code to the IBM PC's 16-bit operating system. The SVS FORTRAN system uses a modified version of the X-AM package from Intelligent Graphics Corp. NDP FORTRAN uses Phar Lap's RUN386 version 1.1v or higher. In a normal 16-bit compiler, there are three components that may contain bugs (the compiler, the run-time libraries, and the operating system). With these 32-bit compilers, you also have to worry about the DOS-extension package.

Both compilers generate object modules that you must link with the run-time libraries to create an almost executable module. To run that module, you must first invoke the DOS-extension package. Neither the compilers nor their generated object programs will run if the 80386 processor is in the virtual 86 mode. The run-time libraries do not include any routines for screen I/O, cursor control, color control, graphics, or database management.

Both compilers, their generated object programs, and the Phar Lap tools all work correctly with Personal REXX from Mansfield Software Group. Personal REXX is a powerful command processor to which I am addicted.

SVS FORTRAN 2.7

When you purchase the SVS system, you receive the compiler and the run-time libraries. Also included is a copy of the required DOS-extension package, but you must purchase the required linker separately from Phar Lap. The software is on two 1.2-megabyte floppy disks: one for use on 80287/80387 systems and the other for use on Weitek 1167 systems. SAIC supplies a user's guide, a FORTRAN reference manual, and a debugger reference manual. None of the manuals include an index. The license for the compiler provides an unlimited license to distribute the DOS-extension package with your linked modules to your clients.

The SVS compiler runs on Motorola 68000 and National Semiconductor 32000 Unix environments, in addition to MS-DOS on an 80386-based system. The manual covers all systems generically, with an appendix giving the specific details for each system.

The SVS FORTRAN compiler requires a floating-point coprocessor. You must choose a numeric processor (e.g., 80287, 80387, or Weitek 1167) when you install the compiler. If you want to compile a program on a machine with one numeric processor and execute that program on a machine with a different numeric processor, you must modify the compile-and-link batch files. You need to copy the target coprocessor support library to the proper subdirectory on your hard disk and change the numeric coprocessor switch in the compiler command line before you can begin cross development. The documentation for this process is sketchy.

The compiler recognizes over 20 switches to control the input and output files, debug status, FORTRAN-66 compatibility, numeric processor selection, and parameter passing model. You can also specify most of these as metacommands of the form $xxx in the source file.

A Complex Path to Execution

The SVS FORTRAN compiler is really three separate programs (FORTRAN, TCODE, and JLINKER) that you must run with different parameters. These three programs read your FORTRAN program and produce a linkable object module. There is no option to generate an assembly language source or listing file.

SAIC supplies a small batch file to compile and link a single FORTRAN program. Compiling `FOO.FOR` will produce `FOO.OBJ`, `FOO.REX`, and `FOO.EXE`. The `.OBJ` file is the linkable object module. The linker produces the relocatable executable file called the `.REX` file. The `.EXE` file is a copy of XAMENV, the X-AM equivalent of Phar Lap's RUN386. When you run `FOO` from the DOS command line, you are really running a copy of XAMENV with a different name. That program determines the name (`FOO`) from DOS and loads `FOO.REX` as a protected native-mode 80386 program.

You can modify two pieces of information in the `FOO.EXE` file. The STACKSZ utility can modify the stack size value in the `FOO.EXE` file. If you are running under DOS 2.x, the program name (`FOO`) is not available for execution. The SVSNAME utility can modify the program name value inside the `FOO.EXE` file so that it can locate `FOO.REX` even under DOS 2.x.

Every FORTRAN object program creates another copy of XAMENV on your disk. All these copies differ only in name, in the few bytes that store the FORTRAN object program name (you cannot even reference that field unless you run it under DOS 2.x), and in the stack size for the program. The problem is that each FORTRAN program on your disk uses 116K bytes of disk space to store just 20 bytes of information. The alternative is to create a batch file that runs your programs and makes a temporary copy of

continued

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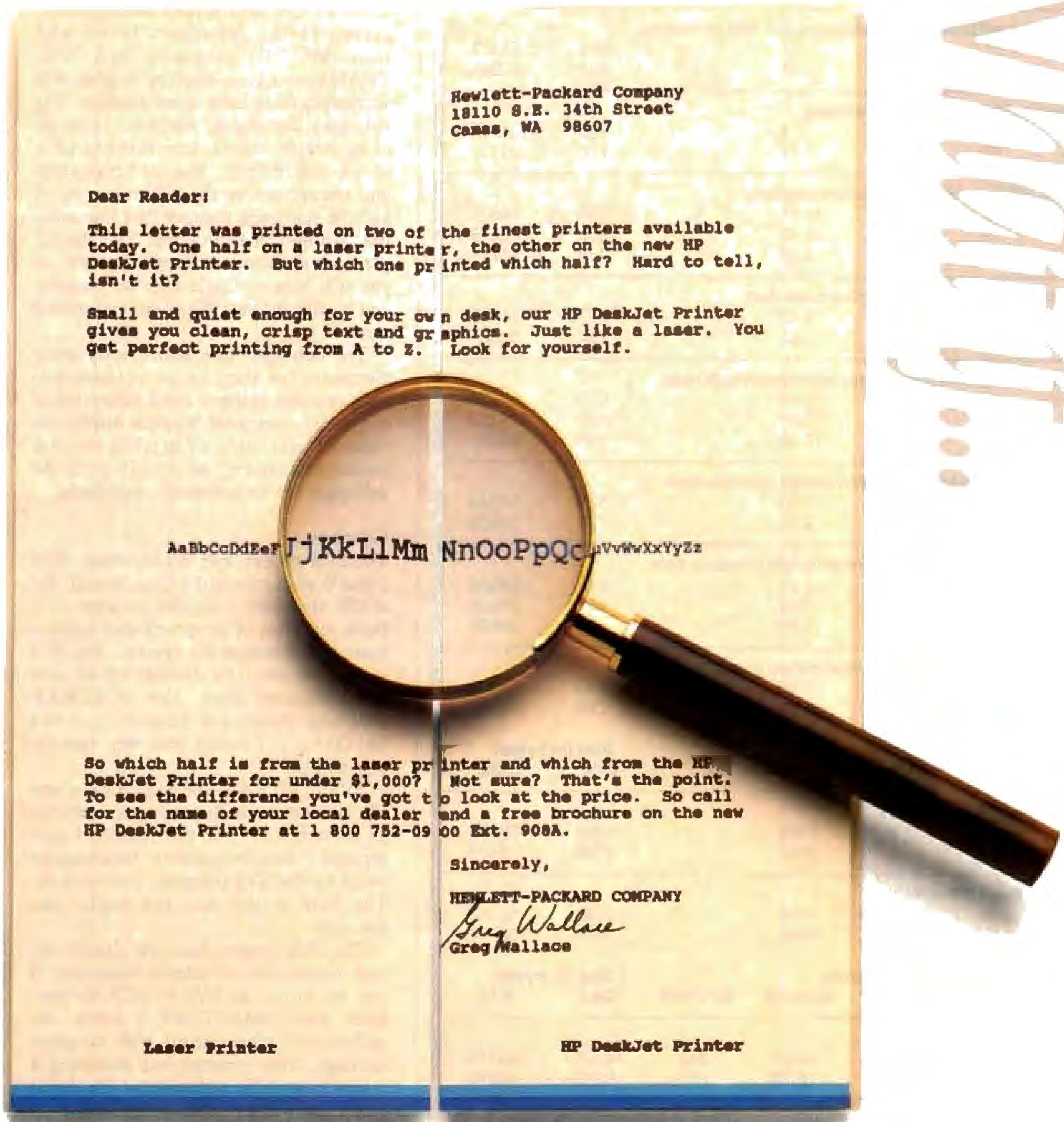
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Table 1: *Results of FORTRAN benchmarks show that SVS FORTRAN produces considerably smaller executable code than that produced by NDP FORTRAN.*

	Time (in seconds) Compile	Link	Execute		Size (in bytes) .OBJ	.EXE
Floating-point arithmetic (calculations) (10,000 iterations)						
NDP	11	8	.32		923	54332
SVS	18	7	.25		687	20084
Eratosthenes Sieve (15,000 iterations)						
NDP	11	9	.11		888	84312
SVS	18	7	.11		730	20160
Write 1024 128-byte records of character data						
NDP	10	8	4.97		1034	54508
SVS[1]	18	8	5.49		939	30248
SVS[2]	18	8	8.94		939	30248
Read 1024 128-byte records of character data						
NDP	10	9	8.42		812	54328
SVS	18	8	8.68		784	30368
Write 1024 126-byte records of formatted numeric data						
NDP	10	8	9.06		850	54236
SVS[1]	19	8	7.07		830	28252
SVS[2]	19	8	12.89		830	28252
Read 1024 126-byte records of formatted numeric data						
NDP	11	8	9.03		821	54244
SVS	20	8	9.01		773	31628
Write 1024 36-byte records of unformatted numeric data						
NDP	11	9	1.81		846	54928
SVS[1]	19	8	1.69		825	24824
SVS[2]	19	8	2.60		825	24824
Read 1024 36-byte records of unformatted numeric data						
NDP	11	9	1.65		813	54932
SVS	20	7	1.43		764	24800
	Time (in seconds) Compile	**Link**	**Whetstones**		**Size (in bytes) .OBJ**	**.EXE**
Single-precision Whetstones						
NDP	23	8	1923		5209	56972
SVS	21	7	2000		3285	28488
Double-precision Whetstones						
NDP	24	8	1666		5698	57252
SVS	22	8	1666		3629	28740
	Time (in seconds) Compile	**Link**	**Execute**	**MFLOPS**	**Size (in bytes) .OBJ**	**.EXE**
Single-precision LINPACK						
NDP	55	12	83.87	.242	14935	388776
SVS	25	9	76.73	.265	9138	40972
Double-precision LINPACK						
NDP	57	16	102.38	.195	15344	711720
SVS	26	9	97.93	.204	9543	44200

[1]Create new file.
[2]Overwrite old file.

Note: Timings for the Whetstone benchmarks are given in thousands of Whetstones per second. Timings for the LINPACK benchmarks are given in both seconds and MFLOPS (millions of floating-point operations per second). The object-file sizes are given for the EXP form for the NDP system, and the .REX form for the SVS system.

XAMENV, sets its stack size to the current program's required size, runs it, and then deletes it.

Tools for Debugging

The SVS debugger is a symbolic debugger that uses a line-oriented display. Instead of the multiple-window, user-screen-saving debuggers found with many MS-DOS packages, SVS FORTRAN uses a glass-teletype display with simple scrolling lines of information. The debugger can display variables by name or by specific value as long as the variable is not in a register. You set breakpoints and tracepoints by the subroutine name and the statement number (not line number) within that subroutine. This debugger does not know about watchpoints, so you will have to single-step the program and display the variable of interest at each step.

The debugger can also display array elements, but there is no command to display every element (or a collection of elements) of an array. You can display the value of $x(1)$, $x(i)$, or $x(x(1))$, but you cannot display $i+j$ or $x(i+1)$ since the debugger has no arithmetic operations.

Gotchas

The SVS system does not associate units 5 and 6 with standard I/O. Although the ANSI standard does not require this, there are a lot of programs that assume these unit numbers are special. The SVS system uses unit 0 for standard I/O and unit 1 for standard error. New FORTRAN programs should use `READ(*,...)` and `WRITE(*,...)` rather than any specific unit number.

SVS FORTRAN 386 can create a new file about twice as fast as it can overwrite an existing file. For this reason, I performed file-manipulation benchmarks twice for the SVS compiler (see table 1). The NDP system does not display this anomaly.

The SVS system does not tolerate device drivers that use extended memory. If you try to run an SVS FORTRAN program while SMARTDRV is active, the system will reboot itself with no error message. Your program will also hang if it tries to write an unformatted file that is larger than the available disk space. If that happens, you just press Control-C to terminate the program without rebooting the machine. Finally, the DOS-extension package takes over interrupt vectors 78 to 7F and does not restore them when the FORTRAN program terminates.

SVS Code Generation

The SVS compiler generates code that contains some interesting features. The

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SVS FORTRAN 386 2.7	NDP FORTRAN 386 1.3a
Type 80386 native-mode FORTRAN compiler	**Type** 80386 native-mode FORTRAN compiler
Company Science Applications International Corp. 5150 El Camino Real Suite C-31 Los Altos, CA 94022 (415) 960-3322	**Company** MicroWay P.O. Box 79 Kingston, MA 02364 (617) 746-7341
Format Two 1.2-megabyte 5¼-inch floppy disks (one for 80287/80387 systems and one for Weitek 1167 systems); one 3½-inch floppy disk for PS/2 Model 80	**Format** One 1.2-megabyte 5¼-inch floppy disk
Language Pascal	**Language** FORTRAN
Hardware Needed 80386-based system with one 1.2-megabyte 5¼-inch floppy disk drive; 640K bytes of RAM; hard disk drive with at least 2 megabytes free; 80287, 80387, or Weitek 1167 floating-point coprocessor	**Hardware Needed** 80386-based system with one 1.2-megabyte 5¼-inch floppy disk drive; 640K bytes of RAM; hard disk drive with at least 2 megabytes free; 2 megabytes of extended memory; 80287, 80387, or Weitek 1167 floating-point coprocessor
Software Needed Phar Lap 386|ASM/LINK: $495	**Software Needed** Phar Lap RUN386 and 386|ASM/LINK: $495 (needed only if running under DOS)
Documentation 45-page user's guide; 200-page FORTRAN reference manual; 55-page debugger reference manual	**Documentation** 90-page user's manual; 100-page reference manual
Price $895	**Price** $595
Inquiry 904.	**Inquiry 905.**

compiler aligns the code for a loop on a 4-byte boundary. When the jump transfers control from the bottom of the loop back to the top, the 80386 processor needs to access memory to fill the prefetch queue with the first instruction. This alignment ensures that all the bytes fetched with that first instruction are part of the current loop.

The compiler typically optimizes for execution speed, generating the three-instruction sequence

```
mov   eax,temp20
lea   ecx,[eax+eax*8]
lea   eax,[ecx+eax*2]
```

rather than the much shorter single instruction

```
imul  eax,temp20,11
```

because the three-instruction sequence actually executes about 12 percent faster.

You should not consider the SVS compiler as a perfect optimizing compiler, however. A peephole optimizer would clean up these instruction pairs that the SVS compiler generated in some of my test cases.

```
mov  temp10,eax
mov  eax,temp10   ; remove

mov  temp10,eax
mov  ecx,temp10   ; replace with
      mov ecx,eax

mov  edi,temp10   ; remove
mov  edi,1
```

For a DO loop of the form "DO 10 I = 1,N", SVS generates the following loop-control instructions at the bottom of the loop:

```
inc temp10
mov esi,temp10
cmp esi,temp14
jle top
```

If you use the index variable inside the loop only as an array subscript, SVS could improve this code by changing to the loop style that NDP FORTRAN uses.

NDP FORTRAN 1.3a

When you purchase the NDP system, you receive the compiler and the run-time libraries. You must still purchase the required assembler, linker, and DOS-extension package separately from either Phar Lap or MicroWay. You can sell your linked modules to your clients, but the modules will be of no value to them unless you also buy an unlimited license to distribute the DOS-extension package, your client buys a copy of the DOS-extension package for each machine that will run your application, or your client runs Unix.

This compiler is available only for the 80386 under either Microport's Unix or MS-DOS with Phar Lap's 386|DOS-Extender (see table 2). The package includes the NDP FORTRAN compiler, a compiler driver (f77), a make utility (mm), and the run-time libraries. The run-time libraries do not include any procedures for screen I/O—for example, cursor control, color control, windows, or graphics.

NDP FORTRAN comes on a single 1.2-megabyte floppy disk. To install NDP FORTRAN, you simply copy the entire contents of the floppy disk to any subdirectory listed in your `PATH` command. You must also add `SET NDP=path` to your `AUTOEXEC.BAT` file to tell the compiler its location. If the Phar Lap tools are not in the NDP directory, you need to add `SET TOOLS=path` to your `AUTOEXEC.BAT` file.

MicroWay supplies a user's manual and a reference manual. Both manuals include an index.

The NDP FORTRAN compiler does not require any numeric processor. The object programs that it generates require a numeric processor (e.g., 80287, 80387, or Weitek 1167) based on the switches that you specify when the program compiles.

There are three ways to run this compiler. You can run the compiler driver (f77) with a variety of switches. The driver will then run the compiler, assembler, and linker with the appropriate switches. You can run the minimake program (mm), and it will build your program according to the values that it has saved in a small database, or you can directly run the compiler, assembler, and linker yourself (from a batch file) with the correct switches. This last approach is the only way to get the assembler to produce the assembly language listing file that you will need to use the debug-

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Table 2: *A comparison of features.*

Basic facilities		
Product version	SVS FORTRAN 386 version 2.7	NDP FORTRAN 386 version 1.3a
Hardware support	80386, 68000, 32000, 80287, 80387, Weitek 1167	80386, 80287, 80387, Weitek 1167
Operating system	Unix (68000 and 32000); MS-DOS (80386)	Microport Unix V.3; MS-DOS
MS-DOS extension	X-AM from IGC	Phar Lap RUN386
Copy-protected	No	No
Memory required	2 megabytes	2 megabytes
Disk space required	2 megabytes	2 megabytes
Assembler required	None	Phar Lap 386|ASM 1.1v
Linker required	Phar Lap 386|LINK	Phar Lap 386|LINK 1.1v
Development		
Debugger	Symbolic	DOS-type Debug supplied with Phar Lap software
Generates symbolic assembly code	No	Yes
Data Types		
Logical	*1, *2, *4	*1, *2, *4
Integer	*1, *2, *4	*1, *2, *4
Real	*4, *8	*4, *8
Complex	*8	*8, *16
File I/O		
Unit 5 or 6 for standard I/O	No	Yes
Interfaces		
Call other languages	Pascal, C	Pascal, C
DOS I/O	No	No
Compatibility		
VDISK	No	Yes
SMARTDRV	No	Yes
REXX	Yes	Yes

ger. The compiler recognizes over 50 switches to control the optimization level, I/O file directories, FORTRAN-66 compatibility, and numeric-processor selection. Although the FORTRAN language is not case-sensitive, these compiler switches are.

Limited Debugging Capabilities

The NDP FORTRAN system does not include a debugger, but the Phar Lap tools include two debuggers. The MINIBUG debugger is very similar to the DOS Debug. The 386DEBUG is something of a symbolic debugger, which probably works nicely for assembly language programmers, but has serious limitations for FORTRAN programmers. The only symbols that this debugger knows are global (external) symbols, and NDP FORTRAN generates global symbols only for named common blocks and subroutines. This means that you can dump the contents of a named common block, or set a breakpoint at the entry to a subroutine, without the listing files. If you want to do anything else, you still need the listing files and the ability to read 80386 code.

Like MINIBUG, 386DEBUG cannot display any file on the screen, so you still need hard copy listings. 386DEBUG can use a second ASCII terminal connected to COM1 or COM2 for debugging. In this mode, the debug commands do not overwrite your FORTRAN program output on the main monitor, but you need a second monitor and keyboard on your desk.

Into Extended Memory

Both the compiler and the object programs that the compiler generates recognize the existence of the VDISK and SMARTDRV device drivers. You could place your source code and the run-time libraries on a large VDISK, letting you compile, link, and execute programs without touching the hard disk. If you gave that same memory to SMARTDRV, you would achieve almost the same performance level, but the hard disk would always have a current copy of your code.

Gotchas

The NDP system has problems detecting the end of available disk space. If your program tries to write a file (formatted or unformatted) that is larger than the available disk space, it will not receive any error indication. The write statement will complete, and control will pass to the next statement, even though the data was not actually written.

Data size has a dramatic effect on program size in the NDP environment. Consider a program that declares a 4-megabyte array. The object program that the NDP compiler generates is much smaller than 4 megabytes, but the executable program that the Phar Lap linker generates is larger than 4 megabytes. The executable file contains an image of the array, even if the array is not initialized. If you locate the array in a common block, this problem does not occur.

The -n2 compiler switch for 80387 code works correctly, but the compiler driver still asks for the 80287 library during the link phase.

NDP Code Generation

The main weakness of the NDP compiler's code generator is in the array-addressing computations in DO loops. The compiler generated a total of 68 instructions for a simple array multiply routine. Of these, the compiler could remove 15 (22 percent) without changing any of the other instructions.

Another weak spot is the code generated for real-to-integer conversions. This compiler generates the following code for the statement i=x:

```
fnstcw   word ptr temp16
mov      ax,temp16
or       ax,3072
mov      temp14,ax
fldcw    word ptr temp14
fld      dword ptr x
fistp    dword ptr i
fldcw    word ptr temp16
```

continued

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This compiler needs only two control words to run the 80387 for most operations. One control word specifies round nearest (used for normal operations) and the other specifies chop (for real-to-integer conversions). In the above example, the first four instructions store the normal control word and convert it to the conversion control word. The compiler could remove those instructions if it generated two constants for the appropriate control words and loaded them as necessary.

A peephole optimizer should be added to clean up these instruction pairs that were generated in some of my test cases:

```
mov   ecx,1         ; remove
imul  ecx,ecx,10    ; replace with
                    ; mov ecx,10

mov   temp24,edx
cmp   temp24,0      ; replace with
                    ; or
                    ; edx,edx
jle   label

lea   ecx,[edx]     ; replace with
                    ; mov ecx,edx

fst   [ebx]         ; replace with
                    ; fstp [ebx]
fstp st(0)          ; remove
```

For a DO loop of the form "DO 10 I = 1,N", this compiler generates the following loop-control instructions at the bottom of the loop:

```
dec temp10
jne top
```

Note that this code is much faster than the code that the SVS compiler generates.

Trade-offs of Speed and Convenience

I tested both compilers on a Compaq 386/20 with an 80387, 6 megabytes of Compaq 32-bit memory, and a 60-megabyte hard disk drive.

The SVS system creates executable files about 25K bytes smaller than those that the NDP system produces. This mainly reflects the size of the base set of run-time routines that link into any FORTRAN program. The NDP compiler generates object code sequences that are about 25 percent larger (in terms of object code bytes) than those that the SVS compiler generates, but the code executes only about 5 percent slower.

The SVS compiler takes almost 50 percent longer than the NDP compiler on small test cases like the Sieve and File I/O benchmarks, but it becomes almost twice as fast as the NDP compiler on large or complicated programs such as the LINPACK.

The SVS system comes complete with almost everything you need to write, debug, and sell your FORTRAN application object module. The only other equipment you need is the Phar Lap linker. The NDP system does not include a debugger, although it does include one with the required package from Phar Lap.

While the SVS compiler has much better debugging facilities than NDP, with SVS you'll have multiple copies of XAMENV.EXE taking up hard disk space.

If you need a compiler that is compatible with extended-memory utilities, such as VDISK and SMARTDRV, NDP FORTRAN is the only choice.

In short, while both compilers are powerful, neither is perfect. Indeed, the major disadvantages of both compilers are that they are neither as mature nor as stable as the 16-bit compilers from Ryan-McFarland or Microsoft. ■

Carl Byington is the founder of 510 Software Group, Rancho Palos Verdes, California. The company specializes in language, run-time support systems and database applications.

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Interleaf Publisher for the Macintosh II

Paul Kahn

Combined features from both the personal-computer and workstation worlds yield mixed results

As Interleaf moves its publishing software downstream from the engineering workstation world of Sun and Apollo into the desktop-publishing world of the Macintosh II, it becomes clear that both worlds have a lot to learn from each other. Interleaf Publisher is a heavy-duty publishing system that includes good and bad features from its original workstation implementation and the popular Macintosh user interface.

Interleaf Publisher 3.00 is a complete translation of Interleaf's Technical Publishing System 3.0. No part of the basic system has been left out, but the equation editor, an added cost option on the other implementations, is not available for the Mac II. Interleaf has adapted its product from previous multitasking, multiuser, virtual-memory-using versions to the single-tasking, single-user, no-virtual-memory Macintosh operating system. Currently, Interleaf does not work under MultiFinder. It costs $2495 and requires a Mac II with 5 megabytes of memory and at least 14 megabytes of hard disk storage.

To fit it into the Macintosh user interface, Interleaf has made some modifications to its user interface but has retained some non-Macintosh ways of doing things. Veteran Interleaf users will still find the desktop/pop-up menu/window system they have used before, but for the Macintosh version they will also find a pull-down menu bar, windows with a close box, scrolling bars, and resizing boxes, all controlled from a one-button mouse (previous implementations used two- or three-button mice). Veteran Macintosh users will find a desktop that resembles the Finder desktop in some ways, but that requires them to access menus and manipulate icons in ways that are unique to the Interleaf product.

The overall result is mixed. On the up side, Interleaf Publisher sets new standards for many things: editing tools for structured documents; production control for large publications; integration of text, vector graphics, and image editing within one application; and portability of document results across multiple implementations on different machines. On the down side, when you look at Interleaf Publisher next to the current crop of Macintosh desktop-publishing applications, you can see that it has user-interface conventions that differ radically from other Macintosh applications; it is expensive both in price and configuration requirements; it is not well suited for publications with more than one story per page; and it does not provide a high level of typographic controls (e.g., no kerning).

Considerable Features

Interleaf Publisher's major features set it apart from other document preparation systems on any machine:

Document, component, and frame property sheets. An Interleaf document consists of things that have properties. The notion that you could describe the formatting of text in terms of property sheets first appeared on the Xerox Star. The concept has been notably absent from the world of Macintosh text processing until quite recently, when it appeared as "style sheets" in Microsoft Word 3.0.

In Interleaf, a document's page format is described in a *document* property sheet. The text is structured in components (e.g., a paragraph, a title, and a subhead), and each component has a name and a set of *component* property sheets that describe it. Frames that contain any mixture of text and graphics have a *frame* property sheet.

Hyphenation control and spelling checker. Interleaf uses the same Houghton Mifflin hyphenation dictionary (an 80,000-word dictionary that has up to 4000 user-defined words) that is familiar to Macintosh users of Aldus PageMaker and Microsoft Word.

Auto-number streams and auto-reference marks. Interleaf lets you automatically generate tokens, called auto-number streams, to produce numbers for such purposes as outline headings, paragraph numbers, and table or figure captions. From this, you can produce auto-reference marks that the program automatically updates as needed.

Index and table of contents. At any time, you can mark words or passages to be collected in an index, or headings to be included in a table of contents; both are created after editing rather than interactively.

Multiple columns. Interleaf handles multiple columns on a document rather than a page level. Sophisticated vertical balancing controls allow the document property sheet to distribute white space between letters, words, and components to balance out columns on a page.

Book directory. Interleaf provides a special directory, called a book, for organizing documents within a single publication. Page numbers, auto-number streams, auto-references, and even word searching and page scrolling for all documents placed in a book directory are linked together.

Graphics frames and micro-documents. You can create one or more frames in any component. A frame, which can contain graphics or text, can be as small as a single period or as large as the current page. Frames are anchored to some point in the component and move from page to page as needed. Interleaf provides a diagramming editor for creating graphics in these frames.

Text typed into a frame from the keyboard is organized in "micro-documents." You can cut, copy, paste, or edit the micro-documents just like any other text. You can resize the rectangle in which they appear or break it up into

continued

Interleaf Publisher 3.00

Type
Document preparation and management/desktop-publishing software

Company
Interleaf Inc.
Ten Canal Park
Cambridge, MA 02141
(617) 577-9800

Format
16 800K-byte 3½-inch floppy disks

Hardware Needed
Mac II with 5 megabytes of RAM and 14 megabytes of available hard disk space

Software Needed
System 4.2; Finder 6.0 or higher (does not work under MultiFinder)

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Price
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Diagramming editor. The full-featured vector graphics editor provides tools for creating lines, circles, ovals, rectangles, polygons, and splines. You can fill any closed object with a pattern; group, lock, or arrange objects in layers; and move, size, or rotate objects by moving the mouse in relation to the size of the frame or by numeric increments.

Data-driven charts. The system provides a range of common chart formats (including a bar, pie, or line chart and a scatter plot) that you can paste into any frame. Data entered into a property sheet generates the chart. These charts are well suited for business graphics but do not support the number of data points needed for scientific work.

Image editing. You can copy and paste raster files created by scanners or paint programs into graphics frames, which the Interleaf image editor can manipulate.

Portability. All versions of Interleaf's publishing software can save a document as a simple ASCII text file. Interleaf uses a markup scheme for describing both text and graphics that looks like a cross between a Pascal program and SGML (Standard Generalized Markup Language, a proposed ISO standard for completely describing a document). Such files are upwardly compatible (i.e., later versions of Interleaf can read files saved by simpler or older versions on any machine). This means that any group using a mixture of Suns, Apollos, VAXes, IBM RT PCs, and Mac IIs can run Interleaf software and share documents.

These features have proven to suit applications where people produce large publications (20 to 200 pages, though the software does not limit the size of the document) that require some mix of text and graphics and benefit from writers and editors sharing documents on a network. The primary application that fits this description is technical publishing: documentation and technical reports that are long, complex, and include a mix of text and graphics on the page.

Grafting Interleaf onto the Mac II

Although any innovative Macintosh application will bring *some* new conventions that you must learn, Interleaf brings to the Mac II implementation some workstation-based features that run contrary to what you would normally expect to find.

The Interleaf desktop. Interleaf publishing software first appeared on Apollo and Sun workstations in 1983, before either had a sufficiently powerful window environment to support Interleaf's software. So Interleaf developed its own graphic interface (operated by a three-button mouse) as part of the publishing program itself. The idea of providing a graphic desktop interface to shield the user from the command shell made a great deal of sense in a Unix environment. However, what was a great idea in 1983 now seems to be a bad habit that the company can't do without.

To start Interleaf Publisher, you must choose a workspace, called a "desktop," where Interleaf keeps all working documents. Interleaf can maintain as many of these desktops as disk space will allow. You can use desktops to separate projects or users, but there is no password protection (because the Mac is a single-user system), and you can actually get to anyone else's desktop by simply opening a series of folders from the Macintosh Finder.

Links. To provide a functional bridge between your (Interleaf) desktop and the documents on the Macintosh desktop, Interleaf lets you create links between icons on your desktop and icons elsewhere in the Macintosh file system. The icon representing a link simply contains the path down which Interleaf expects to locate the original document or directory. The original document reflects changes made to this link copy and vice versa. This provides an interesting way to distribute the parts of a publication across various writers' desktops, while an editor maintains linked copies organized in a single book directory.

Special icons. Interleaf also maintains its own set of icons. Just as the Finder manages icon shape, view, and location without making you see all the resources it needs to maintain this graphic information, Interleaf similarly shows you its interpretation of what is actually on a disk.

When viewed from the Finder, Interleaf folders are filled with documents having names ending in three-character dot extensions (e.g., `.doc`, `.boo`, and `.fdr`), along with backup and auto-save versions with added numerical extensions (`.doc,1`, or `.doc,9`). *Attribute files* are control files that store icon location and window-size information. These files have the same name as the document or folder but begin with a special prefix (e.g., `.@report.doc`). Obviously, if you move or rename these files from the Macintosh Finder, Interleaf will not find the files and will not work properly.

Jumbled User Interface

Those who know Interleaf Publisher and the Macintosh have been gritting their teeth about the mix of user-interface conventions that this program contains. The designers of Interleaf Publisher have added some Macintosh features (a close box, elevator scroll bars, and a resizing box, for example) as optional controls to their "native" windowing system. They have added a minimal Macintosh pull-down menu bar at the top of the screen to provide access to desk accessories from the Apple menu, and they have adapted their software to work with a one-button mouse. But they also expect you to adapt to all the other non-Macintosh things that the program does.

Interleaf Publisher relies on pop-up, rather than pull-down, menus. The Interleaf pop-up menu is context- and state-sensitive so that different menus appear depending on what you select and on the cursor position. The menus can have slide-off extensions (secondary menu choices that appear to the right of a menu item), a feature appearing in some new Macintosh applications. Once you get the hang of using pop-up menus and slide-off extensions, you can see all your choices more easily and avoid many dialog boxes (for making secondary choices) that would otherwise be necessary.

Interleaf is very awkward to use with a one-button mouse. The Sun workstation, where Interleaf was born, has a three-

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button mouse. The left button selects, the middle button pops up the menu, and the right button extends the selection. On the Macintosh version, you click the mouse to select, command-click to pop the menu, and shift-click to extend the selection. You use pop-up menus for *everything*, so the hand not on the mouse more or less devotes itself to the command key, which makes the program more awkward to use on the Mac II than on any other workstation.

While Interleaf did not choose the one-button mouse, it did choose to retain other features of its user interface that could have been left behind. The company could have chosen to do something about a few of these differences.

On the Macintosh desktop, you can select an object by pointing and clicking, then you can manipulate it by dragging it with the mouse or by pulling a command down from a menu bar. On the Interleaf desktop, you still must select an icon by clicking on it, but before you can manipulate it, you must choose an action (e.g., move, cut, copy, or open) from a pop-up menu.

The ability to interchange data among Macintosh applications is based on their shared use of the Macintosh Clipboard. Interleaf has its own clipboard, of incompatible format, that serves the function of both the Macintosh Clipboard and Trash-can, without the simple elegance of either. When you cut or copy an icon (a whole document) in Interleaf, it stays on the clipboard until you select and paste it somewhere else, or until you delete it. The clipboard can also contain a maximum of one text selection and one graphics selection from each document. Pasting actually moves the text or graphics out of the clipboard into a document. This means that to copy an item several times, you must copy, paste, and recopy it. Any number of pieces of text, graphics, or documents can be on this clipboard. To paste anything but the most recent item, you must open the clipboard, select the desired item, and then do the paste operation.

Interleaf handles the replacement of highlighted text differently from other Macintosh applications: You must explicitly cut or delete highlighted text, whereas if you type from the keyboard, you will add new text to the old text instead of replace it.

Fonts and Formats

With regard to fonts and formats, historical precedents are, again, very influential. Interleaf continues to use its own hand-tuned screen fonts, which take up over 6 megabytes of hard disk storage. The product supplies 9 of the 11 Adobe PostScript fonts used on Apple's LaserWriter Plus—all but Adobe Symbol and Zapf Dingbats (it provides its own math and Greek symbols fonts, which contain similar characters). It also supplies its own screen bit maps for 13 major sizes, from 6 to 72 points. Those are the only sizes available for use—it cannot generate intermediate point sizes or use any other PostScript fonts downloaded into the LaserWriter.

Interleaf's implementation of the nine Adobe fonts does not include support for the Macintosh keyboard layout or for the entire character set, however. All the European accented vowels and dead-key support for accents are gone (a feature that has been available since the original 128K-byte Macintosh).

All this special font handling maintains Interleaf's speed and compatibility with versions on other machines. In general, the screen fonts are clearer than their scaled approximations as displayed by many other Macintosh applications—except when used to display 6-, 8-, and

continued

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9-point fonts, which are innately hard to read. Unfortunately, in contrast to some other desktop-publishing packages, the program has no zoom option to help ease the precise placement of small text characters (but it does allow zooming in graphics frames).

Interleaf Publisher can read five file formats: bit-mapped images saved in MacPaint or TIFF (Tag Image File Format) files, vector graphics saved as PICT files, graphics saved in EPSF (encapsulated PostScript format) files, text saved in Microsoft's RTF (rich text format) files, and simple ASCII text files.

Interleaf retains some or all of the formatting information created by the source applications, though certain kinds of graphics or text do not translate well. You can import, but you cannot view or edit EPSF format, which Adobe Illustrator uses to export drawings to other desktop-publishing applications.

Mixed Results

When you compare Interleaf Publisher to current Macintosh desktop-publishing leaders like Aldus PageMaker and Quark XPress, you'll find mixed results: In some cases, Interleaf does bring some new capabilities to the Macintosh world, but it also falls short of doing many of the things these smaller, less expensive programs do well.

Interleaf does provide a unified application for creating, editing, and paginating a rich mixture of text and graphics. The Interleaf text editor is full-functioned and fast, as good for writing as it is for complex formatting. This is in contrast to the modular approach taken by PageMaker or XPress, where the system assumes that other programs will edit and revise text and graphics.

But in page layout, Interleaf is more like a word processor than a desktop-publishing program. It basically understands one story per document. It does not provide good tools for mixing several stories across multiple pages, nor does it provide for complex page layout and the fluid combination of text and graphics, things that both PageMaker and XPress do easily. The drawing editor doesn't provide a ruler, a basic tool in any Macintosh graphics application. It is not as simple to use as MacDraw, nor as sophisticated as Adobe Illustrator.

While Interleaf produces good-looking documents, it does not provide the kind of typographic controls found in other desktop-publishing applications. There is no kerning or other controls for tightening or loosening intercharacter spacing. For flexible and full typographic support, PageMaker and XPress win hands down.

By the previous standard of the Macintosh world, the configuration requirements and cost of Interleaf Publisher for the Mac II are both expensive. The program needs 5 times the memory and 10 times the hard disk space of any of the competition; it costs several times as much, and it really needs a full-page monitor since it cannot scale a page to fit a small screen. However, it is by far the least expensive version of the full Interleaf product ever offered, and that's not bad. Interleaf has shown a remarkable ability to improve its product. I hope that future Macintosh versions will include full support for Macintosh fonts and closer adherence to the Macintosh interface. Meanwhile, for creating long, single-story documents, Interleaf Publisher for the Mac II is tough to beat. ■

Paul Kahn is the project coordinator for the Institute for Research in Information and Scholarship at Brown University, Providence, Rhode Island. He has used the Sun and IBM RT PC implementations of the Interleaf Technical Publishing System for over 2 years.

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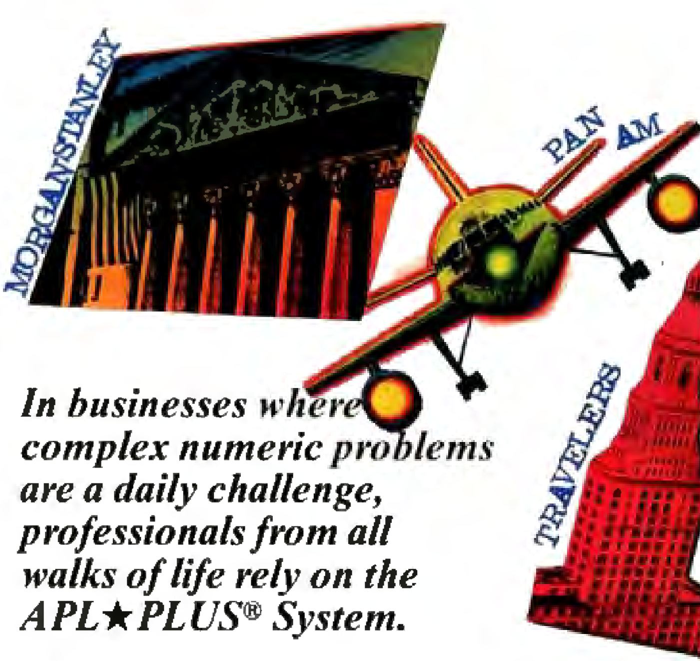

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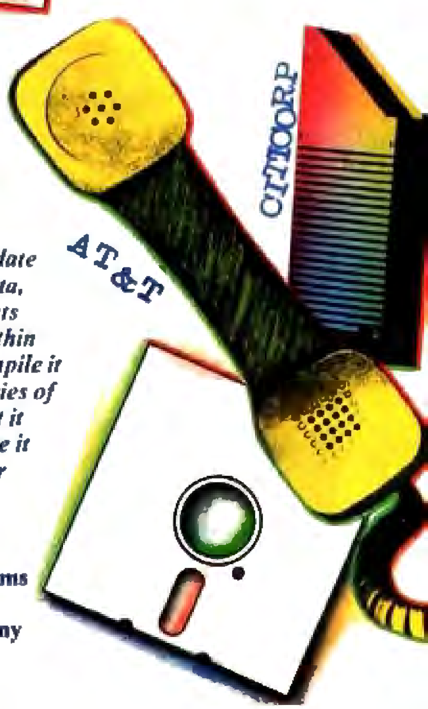

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Circle 265 on Reader Service Card

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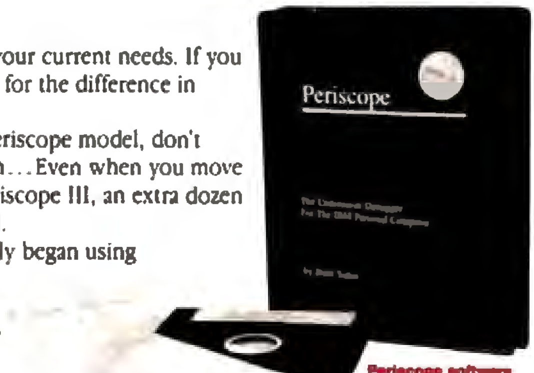

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A Periscope I user who recently began using Periscope III writes, *"I like the fact that within the first half hour of use I was debugging my program instead of learning to use the debugger."*

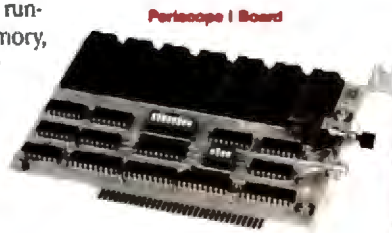
■ **Periscope's software is solid, comprehensive, and flexible.** It helps you debug just about any kind of program you can write... thoroughly and efficiently.

Periscope's the answer for debugging device-drivers, memory-resident, non-DOS, and interrupt-driven programs. Periscope works with any language, and provides source and/or symbol support for programs written in high-level languages and assembler.

■ **Periscope's hardware adds the power to solve the really tough debugging problems.** The break-out switch lets you break into the system any time. You can track down a bug instantly, or just check what's going on, without having to reboot or power down and back up. That's really useful when your system hangs! The switch is included with Periscope I, Periscope II, and Periscope III.

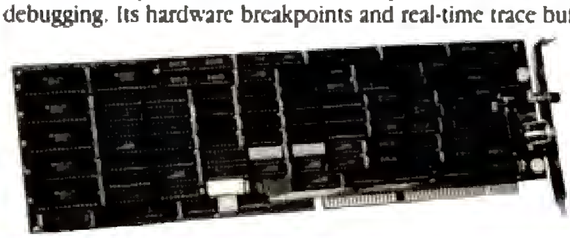

Periscope Break-Out Switch

Periscope I has a board with 56K of write-protected RAM. The Periscope software resides in this memory, safe from run-away programs. DOS memory, where debugger software would normally reside, is thus freed up for your program.


Periscope I Board

Periscope III has a board with 64K of write-protected RAM, which performs the same function as the Periscope I protected memory, AND...

The Periscope III board adds another powerful dimension to your debugging. Its hardware breakpoints and real-time trace buffer let you track down bugs that a software-oriented debugger would take too long to find, or can't find at all!


Periscope III Board

What Periscope Users Like Best:

"I like the clean, solid design and the crash recovery."
Periscope I user

"I like the ability to break out of (a) locked up system!"
Periscope II user

"I am very impressed with Periscope II-X it has become my 'heavy duty' debugger of choice, especially if I need to work on a memory resident utility or a device driver."
Periscope II-X user

" Periscope III is the perfect answer to the debugging needs of anyone involved in real-time programming for the PC . The real time trace feature has saved me many hours of heartache already."
Periscope III user

- **Periscope I** includes a half-length board with 56K of write-protected RAM, break-out switch; software and manual for $345
- **Periscope II** includes break-out switch; software and manual for $175
- **Periscope II-X** includes software and manual (no hardware) for $145
- **Periscope III** includes a full-length board with 64K of write-protected RAM, hardware breakpoints and real-time trace buffer, break-out switch; software and manual. Periscope III for machines running up to 8 MHz is $995; for machines running up to 10 MHz, $1095.

REQUIREMENTS: IBM PC, XT, AT, or close compatible (Periscope III requires hardware as well as software compatibility); DOS 2.0 or later; 64K available memory; one disk drive; an 80-column monitor

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Datavue's Snap Gets a Hard Disk

When Alex Lane reviewed the Datavue Snap 1+1 (February BYTE), he came to the conclusion that the machine was based on good ideas that were poorly executed. After spending some time working with the new hard disk version of the Snap 1+1, I'm amazed at what a hard disk drive can do for the perceived value of a computer.

In addition to the 20-megabyte hard disk drive, there's a 9.54-MHz V20 processor, a very readable fluorescent backlit LCD screen, a keyboard with superb tactile response, and a 720K-byte 3½-inch floppy disk drive. All told, it's a package that has considerably more potential than its dual-floppy disk drive relative, Spark.

Unfortunately, adding a hard disk drive does not eliminate all the problems with the basic Snap 1+1 design. The system has an internal nickel-cadmium battery that promises to allow operation free from the restraint of an AC power cord. I like the freedom of computing without being plugged in, so I eagerly charged the battery, unplugged the cord, and flipped on the power. Nothing happened.

I looked in the manual, and, sure enough, the battery will not power the unit with the hard disk drive installed. I disabled the hard disk drive through the power-on setup program, but the machine still refused to work from the battery. If you get the hard disk drive, the battery becomes just so much dead weight. Of course, you can ditch the extra weight by "snapping" the machine into two parts and using the front half as a RAM disk-based laptop, but then you give up the hard disk drive, too.

If you're looking for a very portable computer with a hard disk drive, the Snap 1+1 ($3695) stacks up pretty well against the competition. It's about the same size as the NEC MultiSpeed HD and the Zenith Z-183: 13½ by 12¾ by 3½ inches. Running at 9.54 MHz, it's faster than the Z-183 in both processing and disk access benchmarks, and it's slower than the MultiSpeed in processing. For example, BYTE's BASIC File Write benchmark took 15 seconds on the Snap 1+1 versus 43 seconds on the Z-183. The Sieve benchmark took 138 seconds on the Z-183, 90 seconds on the Snap 1+1, and 68 seconds on the MultiSpeed.

I still think that the Snap 1+1 falls short of the potential of its design. In spite of that, adding a hard disk drive brings the machine into the middle of a pack of computers offering fully functional computing on the go.

—Curt Franklin

GCC Beefs Up Its Mac Laser Printer Line

In his review of General Computer Corp.'s Personal Laserprinter (PLP) for the Macintosh (January BYTE), Donald Evan Crabb commended the printer for its affordable price but faulted it on several points: its slow speed, its lack of AppleTalk support, and its lack of PostScript support. The company has since taken steps to address all these gripes.

A new version (2.0) of the software, GCC says, offers up to 50 percent faster performance and better compatibility with Macintosh applications. Also new is PLP Share, a $499 network adapter slated to ship this month. The adapter connects to AppleTalk and the PLP, letting multiple users access the printer. GCC also dropped the price of the Personal Laserprinter from $2599 to $1999, which means that you can get the printer-network combo for less than $2500—a very competitive price.

If you really want PostScript support for the printer, you can get that, too. The company now sells an upgrade board, priced at $1999, that authorized dealers can install in the PLP. This board gives the PLP all the features of the company's new printer, the Business Personal Laserprinter Plus. Besides PostScript, the Business Personal Laserprinter Plus has a 12.5-MHz 68000 processor, 2 megabytes of RAM (expandable to 3 megabytes), an AppleTalk interface, and serial and parallel ports for connecting IBM PC compatibles. The printer's font library includes the 35 resident fonts in Apple's standard LaserWriter Plus. At this writing, the Business Personal Laserprinter Plus was scheduled to ship in March for $3999.

—Cathryn Baskin

And Miscellany . . .

. . . Claiming that it's the first company to do so, Zenith has started shipping its version of Microsoft OS/2 for the Zenith Z-386 (March BYTE). The company has also bumped the standard 1 megabyte of 32-bit RAM in the system to 2 megabytes to provide plenty of memory for OS/2. The system with the extra RAM will sell for the same price as the original machine. Zenith's MS OS/2 sells for $299.

. . . Compaq is second out of the gate with OS/2. Compaq's MS OS/2 Standard Version 1.0 for the Deskpro 286 and 386 lines sells for $325.

. . . Our February review of WORM drives by Wayne Rash Jr. included Optotech's 5984 drive and Maximum Storage's APX-3200. Maximum Storage tells us that it—not Information Storage Inc.—designs and manufactures the APX-3200 drives. Also, Optotech informs us that in February it released a single-board controller for the 5984 drive that avoids the problems caused by the bulkiness of the drive's former dual-board controller. The company says that the new controller improves performance by 50 percent, and new software accompanying the controller can now make use of Expanded Memory Specification memory.

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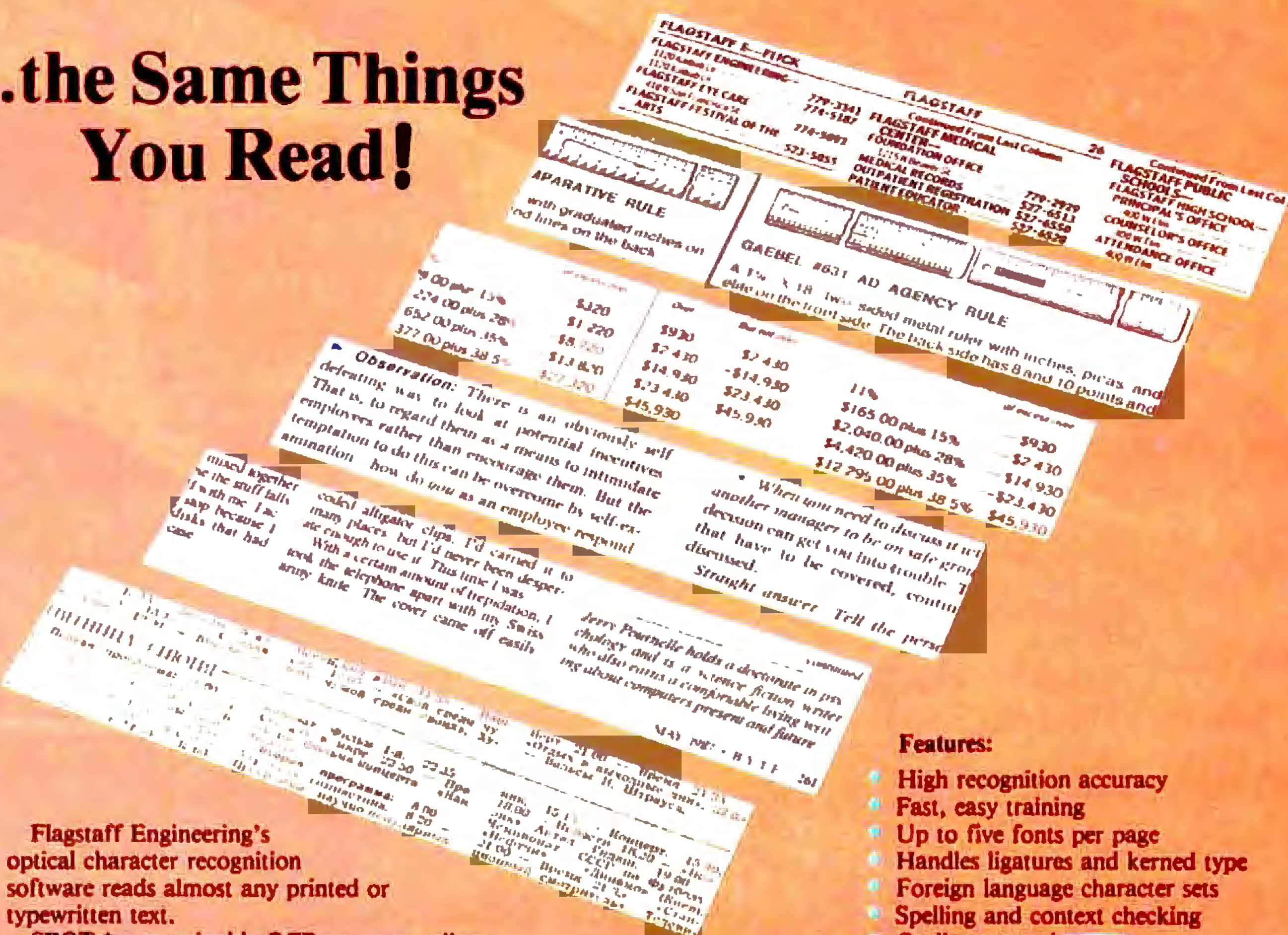

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Memories, Memories

Jerry Pournelle

New ways to speed up, clean up, beef up, and back up all kinds of memory

This column is late, mostly because there's so much good stuff here that I don't know where to begin. Every time I sit down to work, something new comes that I just have to play with. This has happened before, but I don't think things have ever been this bad; only of course I don't really mean "bad," since I'd be in a much worse pickle if I had nothing to write about.

The upshot, though, is that some items are going to get fairly short shrift even though they deserve better.

Fastback Plus

I became a Fastback fan one day at an Atlanta COMDEX when I saw one of its developers back up a hard disk, put a staple through one of the floppies, remove the staple, and restore the files. That was impressive.

I've been using Fastback ever since, and while I've heard rumors of problems with very long files, I've got some very long files indeed and have never had the smallest difficulty. Fastback is fast and reliable; and because it's so fast, it gets *used*, something I can't say for a lot of other backup programs.

Well, Fifth Generation went and improved it with Fastback Plus. I'd complained about the documents. They not only fixed them, they put in help files that make the documents nearly superfluous. They added data compression to save disk space. They added a utility that estimates how many floppies the job will take—it always overestimates for me—and how long it will take (generally an underestimate, but I'm slow and careful about not putting in a new disk until I have labeled the one I took out).

I'm about to change over from the Kaypro 386 to a new Zenith Z-386, so this afternoon I copied 38 megabytes of data from the Kaypro; it took 28 minutes. It required 27 high-density floppies to accomplish the job; and beyond reading the section on installation (Fastback Plus isn't copy-protected, but Fifth Generation likes to handle things with their install batch file), I never opened the manual until the job was done. I then took those files and put them into the Z-386 in considerably less time than it took to copy them.

Fastback Plus is a genuine improvement (in ease of use and user options) over the old Fastback. It will also read backup disks made with older versions, using an option that is called Old Restore Program.

If you have a hard disk drive, you need this program. Highly recommended.

The Golden Bow

If I ever run out of things to write about, I can rate my Christmas presents. (After all, one of my colleagues used to rate the parties at COMDEX.) I won't do that here, but I should mention that Golden Bow sent me a very nice gift: two coffee mugs of a shape I like a lot (straight sides, large handle, and fairly thin china), both marked in gold with the Golden Bow logo plus my name on one and Roberta's on the other.

Packed in the box was a pound of Jamaica Blue Mountain coffee beans, and each mug had liqueur-filled chocolates in it. Since I'm not about to send those mugs back—and I've already consumed the comestibles—I figure I better warn you I've been bribed.

When you use Fastback Plus to back up your files, the program shows you which directory it's working on and flashes the filenames as it copies them; it goes almost too fast to read them, but if you're like me you'll see all kinds of stuff you didn't really want to keep. So, one invariable result of a backup is that I invoke PC Sweep and roam about erasing files I no longer want.

PC Sweep is a shareware program available from Sandi and Shane Strump (P.O. Box 13719, College Station, TX 77841) for $30. Commercial versions are also available, but the original PC Sweep is at least as good as any of those. You can also get a copy, registration paid, from Workman and Associates.

Once you've erased a bunch of files, you'll have empty spaces scattered all over your hard disk. That fragmentation can slow things down, from a little to quite a lot (I've noticed up to a 25 percent increase in the time it takes to copy a large file). The remedy for that is Golden Bow's Vopt, which repacks the disk by moving the files into compact and continuous blocks. There's a new version that shows, in animation, just what it's doing; very pretty, very fast, and quite effective.

I've been using Vopt for nearly a year now, and I've never had the slightest problem with it. In fact, it was Vopt that told me I'd somehow managed to get one of those horrible unmovable Prolock copy-protected programs onto my hard disk; I think one of the kids put in a game when I wasn't here. I got rid of it, of course. But if it weren't for Vopt, I wouldn't have known it was there.

Most books will tell you that disk read/write operations are often the limiting factor in systems operations throughput, which is a fancy way of saying that most disk systems are too slow. This is especially true if you have only floppies.

Repacking the disk with Vopt will help, but the best remedy for slow disk operations is a caching system: a way to put and keep the frequently used disk stuff into memory. Golden Bow's Vcache does that quite nicely. The neat part is that it can make use of either the Lotus/Intel/Microsoft Expanded Memory Specification (LIM/EMS) or the extended memory that works on the IBM PC AT and compatibles. It has been my experience that extended memory isn't

continued

very useful except as a means to heat your house; but used with Vcache, it can speed up some operations (ones that have to go to the disk a lot) something wonderful.

There are limits to what cache systems can do, and if you have a hard disk and use DESQview, they can be more trouble than they're worth; but if you use floppies, you need it bad. If you've got an IBM PC or XT that has an expanded-memory board (like an AST RAMpage), or an AT with extended memory, and don't use DESQview, caching is a simple and effective way to make things go faster. Note too that some copy-protection schemes require you to use floppy disks; caching can help there, too.

Golden Bow's final product, Vfeature Deluxe, competes with SpeedStor, which I've written about in previous columns. Vfeature Deluxe lets you partition your hard disk so that instead of chopping it up into several "logical drives" of 32 megabytes or less, you get one humongous drive of 80, 100, or 300 megabytes—or whatever you have. You can also use Vfeature Deluxe to partition the hard disk into smaller chunks and write-protect any one. You can also password-protect selected volumes.

We got SpeedStor early on, and on the "it ain't broke" theory, I haven't tried Vfeature Deluxe. I make no doubt that it works.

In fact, though, I've little desire to have an enormous hard disk partition. Partly that's superstition, I guess, but there's this as well: if you have a partition larger than 32 megabytes, you *must* boot up the system either from the hard disk or from a specially ginned-up working boot floppy; if you use the original DOS disk to boot up, you can lose some of the data on the hard disk.

I've more than once had some kind of problem that required me to boot up with the original DOS disk; and since that usually happens when we're desperately trying to meet deadlines—and I have a lousy memory as well—I'm a bit afraid to add that kind of complication. You probably don't have that kind of problem.

I've just been told that Priam is sending me one of their 330-megabyte internal hard disks. When it comes, I'll use Vfeature Deluxe to manage it. More on that another time. Meanwhile, Golden Bow makes good stuff.

Memories

I'd guess from my mail that more people are confused about extended and expanded memory than anything else in the microcomputer world. I know I am: every time I write on the subject, I get a flood of mail telling me I got it wrong again.

This time for sure.

I got interested in this when the Z-386 arrived. It came with a 70-megabyte hard disk drive, a Z-449 card to drive the Zenith Flat Technology Monitor (FTM), and 640K bytes of memory on the motherboard. The Z-386 is, hands down, the fastest machine I have; my benchmarks put it as just faster than the 16-MHz Compaq Deskpro 386.

Pure speed isn't everything; in fact, it's not even the main thing. Neither is disk size. What I want is speed in changing from one program to another. Here's an example. Just now the phone rang, and it was Microsoft inviting me to a conference about OS/2. I needed to get at my calendar and my notebook, then send a message to my assistant, all without dumping this article, which I'm writing with Q&A Write. In theory, I can do that with SideKick, DeskLink, and a few other terminate-and-stay-resident (TSR or memory-resident) programs, but in fact the TSRs eat up so much memory

continued

there's not enough room for Q&A Write.

In fact it's worse than that, since I'm also addicted to Microsoft Bookshelf, the CD-ROM I read with the Amdek Laser-drive; that also has a memory-resident component. So do the Mace Utilities, which let you recover data in the event of a crash. There's the mouse driver, and the networking software, and...

The result is that my system is always full up, and the only way I can operate is with DESQview, which lets me switch among all those programs.

You don't *have* to have extra memory to use DESQview; in theory it will swap your programs out to your hard disk, or even to floppies; but in practice that will drive you nuts. You really need extra memory to use it properly.

Extended or Expanded?

OK; we all want extra memory. Now the question is, what kind?

If you have an older system built around an 8086 or 8088 chip, you don't have any choice: if you want more than 640K bytes of memory in your system, you have to install *expanded* memory. This stuff is known variously as the LIM/EMS mentioned earlier and AST enhanced EMS (EEMS); several versions are available. Older LIM/EMS isn't a lot better than *extended* memory (which I'll discuss later); but the AST EEMS boards could do lots of things no other boards could do.

The result was LIM/EMS 4.0, a new memory specification still officially designated Lotus/Intel/Microsoft, but which is really nothing more than AST Research's EEMS with some doodads. The upshot is that if you have AST EEMS memory-expansion boards, all you need is a software driver to make them LIM/EMS 4.0–compatible; but if you have any other company's older memory-expansion boards, you need hardware updates.

Expanded memory works with both the IBM PC and AT (and compatibles). With the old LIM/EMS, you can swap programs into the higher memory. They won't *run* there, but you can swap them into it. With AST EEMS and LIM/EMS 4.0, you *can* run programs in high memory (i.e., above the 1-megabyte address area) with DESQview or Microsoft Windows, meaning that not only can you jump around among programs, but you can actually run several at once. I haven't found that particularly useful, except for communications, but people with enormous spreadsheets to recalculate like the feature. It's vital for communications programs, of course.

In summary, expanded memory is a sort of conjurer's trick; it uses hardware to fool the computer (which doesn't know the memory is there) into looking at a particular area of expanded memory when it thinks it's looking at a chunk of its own main memory. If that's confusing, don't worry about it; the upshot is that it works.

That's expanded memory. Extended memory is quite different.

Since extended memory works only with AT-type machines, it took me considerable time to get it through my head that extended memory is *not* more useful than expanded memory; indeed, it's not really very useful at all.

As a practical matter, the only useful things you can do with extended memory are caching and making RAM disks. Now, true, that's better than nothing, since you can use a RAM disk as a swapping area for DESQview to stash your programs while you run others.

You can't *run* programs swapped into an extended-memory RAM disk; but the swapping operation is a great deal faster

continued

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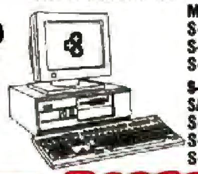

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than it would be to a hard disk. In addition, DESQview has a trick whereby it can get 64K bytes of itself into extended memory. Running DESQview with extended memory is a heck of a lot better than running without it; but extended memory is still less useful than EEMS (or LIM/EMS 4.0).

To further confuse the issue, programs like Above Disc try to use software methods to fool your machine into thinking that extended memory is really expanded memory. None of these programs can do more than turn a block of extended memory into the early version of LIM/EMS; making the machine think extended memory is EEMS is impossible. To get EEMS capability, you have to use some hardware.

These programs don't always work; indeed, those that do work don't work all the time. As an example, I used Above Disc for a while before I converted to DESQview.

One program that is supposed to know how to use the early version of LIM/EMS (as well as EEMS) is Living Videotext's Ready!; about half the time, though, Ready! would load itself into the extended memory that Above Disc was trying to turn into LIM/EMS—and about half the time it wouldn't. I never could see any reason for this; maybe I didn't hold my mouth right. Eventually I gave up on Above Disc.

The LIM/EMS 4.0 standard explicitly states that it cannot be emulated in software. That doesn't mean some hacker out there won't be able to do it. It does mean the big boys won't support it. If you want to expand your system's memory, you need LIM/EMS 4.0 boards. AST boards work fine.

Enter the 386

All the above applies only to PC, XT, and AT machines. It's all different if you have a 386. The 386 machines have memory management and know how to address a lot more than the simple 640K bytes that the PC, XT, and AT can find.

In practice this means that if you have a 386 machine, there doesn't have to be any practical difference between extended memory and expanded memory; the 386 is perfectly capable of operating with either, or both. DESQview on the 386, for instance, can not only swap programs into extended memory, but can also run them from there. (You'll need a 386 memory management program such as Quarterdeck's Expanded Memory Manager 386 [QEMM], but that's a detail.)

Unfortunately, this isn't quite the whole story. The 386 is a 32-bit machine that can also do 16-bit operations; and it has both a 16-bit bus and a 32-bit bus. So far as I know, everyone who makes 386 computers makes the 16-bit bus conform to the IBM PC AT bus standard (except, of course, machines that use the new IBM Micro Channel bus; but let's confine ourselves only to AT compatibles for the moment).

On the other hand, no two manufacturers seem to use the same 32-bit bus structure. We have one bus by Compaq, another by Cheetah, a third by Zenith, yet another by Intel, still another by AST, and there are probably more.

The result is that if you want to add 32-bit memory to your 386, you will probably have to buy it from the company that made your computer. There are exceptions; some machines can use two Cheetah 16-bit memory boards chained to make them 32-bit. Certainly the new Cheetah 386 motherboard can do that. In general, though, to get 32-bit memory you should go to the manufacturer of your 386.

The good news is that you don't really *have* to use 32-bit memory. The 386 chip is smart enough to know what kind of

continued

memory it's dealing with, and when it needs 32 bits of data from a 16-bit memory board, it automatically does two reads. Of course, that takes longer, so it's much better to have 32-bit memory, especially if you happen to be doing computation-intensive work like CAD.

You can also mix both 32-bit and 16-bit memory; I have 2 megabytes of Kaypro 32-bit memory in my Kaypro 386 and another 2 megabytes of Cheetah 16-bit memory addressed above that. I don't often fill the machine with enough programs that it needs that extra memory, but once or twice I have; and while the speed difference was noticeable, there weren't any glitches.

What I was doing at the time was using Crosstalk (under DESQview) to communicate on BIX; keeping SideKick in its own DESQview window; reading a Q&A database in another window; and doing some writing with Q&A Write in yet one more window. Then I got a sudden urge to look in on a game I'd been playing. If I hadn't had those extra 2 megabytes, I wouldn't have been able to do that.

Generally, though, the Kaypro 386 with 2 megabytes of 32-bit extended memory is more than good enough to let me communicate, write, keep my calendar, get at my memory-resident unit-conversion programs, and do my writing. What I've been using to manage this is the combination of DESQview and QEMM. Doubtless other combinations would work, but I don't guarantee them.

For instance, I've had Microsoft Windows/386 for a couple of weeks now, and I understand it's pretty good; but DESQview certainly ain't broke, better is the enemy of good enough, and I don't have any real reason to expect Windows/386 is all that much better than DESQview anyway. I'll get to Windows/386 when I get a chance, but I'm in no great hurry.

Logitech Does It Again

I like mice. As is the case with most touch-typists, I don't like them for writing, but when it comes to editing they're very handy. I've also got accustomed to using the mouse to control Microsoft QuickBASIC 4.0 and in a number of other contexts, including DESQview, which adapts very nicely to a mouse.

I've always preferred the Logitech three-button LogiMouse. I suppose that's because my first exposure to computer rodentia was on Niklaus Wirth's Lilith (I miss that machine a lot). In the Lilith scheme, the middle button of the mouse calls a menu, the left button does some kind of action, and the right button generally cancels the action or changes modes. This seems intuitive to me.

Of course, you can get the effect of three buttons on the Microsoft two-button mouse (i.e., by pushing both buttons at once), and a lot of people prefer the shape, heft, and feel of the Microsoft Mouse to Logitech's. There are even some people who like the Macintosh scheme of using a one-button mouse with double clicks, shift clicks, splat-key double clicks, and so forth. I suppose it's all a matter of preference. In any event, I've always been fond of the LogiMouse.

Lately, though, I've had better reasons than mere preference.

First, there's Logitech's Point editor, which is a terrific utility. For people who just need an editor to manage their system—to change AUTOEXEC.BAT and CONFIG.SYS, make batch files, and suchlike—it's a near-perfect replacement for EDLIN, because it's full-screen, very intuitive, and also has an extensive help menu.

The only nonintuitive feature of Point is that Replace is found under the Edit menu, rather than Search. Most U.S. edi-

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tor programs make Search and Replace part of the same operation, but since Replace changes text, while Search doesn't, you can also argue for the Point organization. Besides, if you remember that anomaly, you'll probably never need to use the Point manual.

Point doesn't have all the features of VEdit or Brief, but it has most of them; and since I never remember how to use all the features of those other (excellent) editors, it hardly matters. People who do a lot of programming might want to look further, but Logitech's Point is darned near perfect for the rest of us, and I know some very experienced programmers who prefer it to any of the others. Point is a great bargain, since it comes as a bonus in the Logitech Mouse with Plus Software package.

I'm also fond of Logitech's Publisher Mouse package; it's still the easiest introduction to desktop publishing I've seen.

Now Logitech has taken the next step: they make a half-slot board that supports both EGA and their mouse. It's called, unsurprisingly, the EGA&Mouse board, and it also has a light-pen connector. The package comes with the Plus Software (including Point); EGA support software, including a program that determines the date of your system's BIOS ROM (any ROM manufactured before October 27, 1982, can't support EGA, and you'll need new ROMs to use theirs or any other EGA board); and the PaintShow program.

PaintShow is an EGA color paint program with several fonts, including math and engineering symbols. I haven't had a chance to compare it with, say, EGA-Paint 2005 from RIX SoftWorks; but certainly PaintShow is capable of some really nice graphics. I'm very fond of the RIX paint programs, but, realistically, PaintShow is good enough for any color graphics I'm ever likely to do. The code isn't provided, but there are ways to glue PaintShow pictures into Modula-2 programs. Printer support is provided.

To top it all off, Logitech offers the Autosync Monitor, which can switch between TTL and analog inputs. In EGA mode it has sharp resolution and a nice crisp picture. There are full controls—horizontal and vertical position, and hold, brightness, and contrast—and they're set at the right side of the monitor, where it's easy to get at them while looking at the screen. Alas, many monitors have those controls at the back where you can't reach them, or on top where they neatly put your arm in the way of your vision when you try to make adjustments.

It's a bit hard to "rate" monitors; at least it is for me, since I don't know much about them. All I can say is that this Logitech monitor is as good as any I've seen in its size. It's a bit small for me, given my eye problems; I still prefer my 19-inch Electrohome and Intecolor monitors. The fact is, though, I could live with the Logitech monitor, and I suspect most people won't ever need anything much better. The only odd thing about the monitor is that it looks rectangular.

Now, all EGA monitors *are* rectangular; at least all of them in this house are. I confess that I hadn't noticed that before; but when I uncrated the Logitech monitor, it was so visibly wider than it was tall that I measured it: 8½ inches tall by 11 inches wide. Then I measured the others. The NEC MultiSync and the Zenith EGA are both 8¼ by 10¾ inches, while the Zenith FTM monitor is 8 by 10¾ inches. My Electrohome 19-inch monitor is actually 11½ inches high by 15 inches wide.

Of the smaller monitors, the Zenith FTM has by far the crispest images, and

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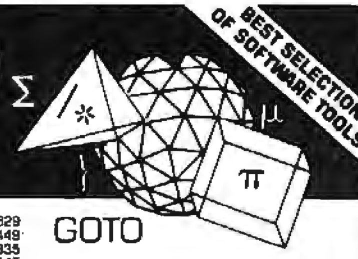

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text on that monitor looks larger than on the others, although I think that must be an illusion; but the Logitech monitor certainly more than holds its own against the others in its class.

Naturally, the monitor works very well with the EGA&Mouse board; and it had no trouble with the output from Orchid, Zenith, or Kaypro EGA boards, or with the Paradise CGA board.

If you're looking to upgrade your system, you really ought to look into the EGA&Mouse package. I doubt you can get a first-class mouse, monitor, EGA board, utility editor, and paint program for anything like the price. This is recommended.

Modula-2 vs. QuickBASIC 4.0

The other day I told some friends I was doing a new programming project. Given my support for Modula-2, they all assumed I'd use that, and a couple of them were shocked when I admitted that I was using Microsoft QuickBASIC 4.0.

There are several reasons. The main one is that I'm working on Roberta's reading program, and the original was written in Microsoft BASIC; it would take me at least a week I don't have to sit down and translate the whole program into Modula-2.

Now, true: over the long haul I'd still in theory save time, since Modula-2 programs are just so much easier to add to and maintain than ever was any BASIC program; but the practical bottom line is that I'm doing Roberta's job in conjunction with a dozen other projects, and translating from BASIC to Modula-2 would require me to sit down and work steadily rather than adding lines by bits and snatches the way I do now.

It did get me to thinking, though.

The real problem with Modula-2 is not understanding the language and learning its syntax. Modula-2 really is a great deal easier to learn than BASIC once you set your mind to it. No: the problem with Modula-2 is that it doesn't have all the neat little built-in string-handling functions that BASIC has evolved over the years.

As an example, the other night I asked Dave Moore, the author of Workman's FTL Modula-2, how I would position the cursor on the screen so that I could print some words at a particular location. Dave took the FTL Modula-2 manual and began looking things up. I knew that he wouldn't find it in either the index or the table of contents, because I'd already looked.

After a while I said, "You can do that, of course?"

"Of course," Dave said. "I know how to do it, I'm just trying to see how anyone would find out if they didn't already know it's a routine in the `ScreenIO` module, or that the command is `GoToXY`."

I don't think he ever did find an answer.

A couple of days later I was talking to Pierluigi Zappacosta, president of Logitech. Logitech makes mice, of course, but they're also known for their Modula-2 compiler, which has the best debugging tools of any language I know. If you're designing a language implementation and want to see a good debugger in action, get Logitech Modula-2; you'll learn something.

"The problem with Modula-2," I said, "is that it's missing all the odd little string routines that BASIC is so rich in. Things like `LEFT$` and `RIGHT$`, and `LTRIM$` and `RTRIM$`. `MID$`. None of these is particularly difficult to write in Modula-2 (or in Turbo Pascal for that matter); but at least in Modula-2 it hasn't been done, and it's not always so simple to figure out a good way to accomplish them."

That got me to thinking. What Modula-2 needs is a book oriented toward BASIC programmers. There are a lot of BASIC programmers out there, and many have learned the evils of `GOTO`, undeclared variables, and side effects. Many are ready to switch, providing that switching won't be too difficult. I suspect I'd have translated Roberta's program from BASIC to Modula-2 a long time ago if Modula-2 had the string-handling tools BASIC programmers take for granted. I sure wish someone would write up a library of such tools.

Maybe one day I'll do it.

Until then, though, I continue to use QuickBASIC 4.0 for most of the quick-and-dirty run-once programs like text filters; and I continue to wish I'd done them in Modula-2 after I write them. Sigh.

It's Gorgeous

CD-ROM technology is here, and it works. Microsoft Bookshelf running on my Amdek Laserdrive has already proved invaluable; as I predicted, I now tend to *use* some of the reference books I've had all these years. It's very convenient just to pop things up on the screen.

The reason the CD-ROM hasn't really taken off is the usual chicken-and-egg problem: there aren't enough readers because there isn't enough software, and people aren't developing the software because there aren't enough CD-ROM drives out there to make the market big enough to justify the investment. Time will change all that; I confess it's going slower than I thought it would.

NASA's Jet Propulsion Laboratory (JPL) may help speed the process. I

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haven't been much of a fan of NASA since Apollo days—how can it take longer to design an O-ring than it did to design and build fleets of bombers in World War II?—but JPL has always been the exception, the showpiece shop NASA points to when they want to look superb.

I never miss a chance to get to a JPL spacecraft encounter, and I've always wanted a way to get at the planetary data they've gathered. Now I have one: they're putting it on CD-ROMs. So far there are two CD-ROM disks in the Planetary Data System Space Science Sampler series. Both play fine on the Amdek Laserdrive; and they're gorgeous.

One contains images of *Voyager 2*'s encounter with Uranus: on an EGA system, they're terrific; on a full PGA system (Orchid's TurboPGA board and Electrohome's 19-inch multisync color monitor), they're nothing short of glorious. They ain't too shabby with plain old CGA, either.

The other disk is a collection of data files from all over the solar system: images of Los Angeles from space; a weather movie of Jupiter; Callisto and Io; Mars maps; Saturn's rings; Titan and Tethys; and just a lot more.

The whole thing is incredible. If you weren't planning on buying a CD-ROM reader for Microsoft Bookshelf or the Micro Medex medical library, get one just to look at these. Check with Tom Renfrow at JPL on availability; JPL's address is in the Items Discussed box on page 208.

Short Shrift

This is embarrassing: I have all these tons of things to write about, and I can't even get started.

Example: the Atari Mega ST, with hard disk drive and Antic's Spectrum and CAD three-dimensional software. This package is nothing short of amazing, and half the ad agencies in Hollywood are using Atari Mega STs as visual workstations to block out their ad campaigns.

The problem is, the package is so good it deserves a whole column. There's absolutely no way I can cover all that in the space I have left.

Then there's DeskLink from Traveling Software. They've taken LapLink to its logical conclusion and have come up with a 1-to-1 computer-linkage system that uses normal 4-wire telephone cord to connect the machines, works like a dream with totally intuitive menus, and even has a "talk" feature that lets, for instance, a secretary send an unobtrusive on-screen note to the boss, or vice versa.

I can use this to link machines that are themselves linked into the CompuPro ARCNET PC network, thus completing the integration of Chaos Manor. I've yet to see a Traveling Software product I didn't like, and this is certainly no exception; more next month.

There's the new edition of the Mace Utilities, which do an amazing job of resurrecting data from dead hard disks. If one day your hard disk reports `Invalid Drive Specification` or `General Failure Reading Drive C:`, my advice is, don't touch it. Leave the machine running, pick up the phone, and call Mace. If you don't have their utilities, buy them; your chances are much better if you have them installed before things crash.

Since crashes are inevitable, you have to be braver than I am to be without the Mace Utilities.

Mace also makes programs that fix problems with dBASE files; once again, if you find you've lost valuable dBASE data, *don't do anything* until you've called Mace.

Incidentally, if you're scared to try recovering data yourself, Workman and Associates have made quite a reputation by getting data off supposedly dead hard disks. My son Alex has become a Mace fan. He also has other tricks he won't tell me about. They sure can find data everyone thought was lost.

TurboTax

This column will be out just when everyone has to face their taxes.

My bookkeeping system runs under Concurrent 286 on the Golem, my big CompuPro machine. I wrote the software a long time ago to conform to what I learned from Accounting 101 textbooks; it seems to be flexible enough to take care of my *business* tax accounting.

Filling out the personal tax forms is something else again.

In years past I've relied on MacInTax, partly because that program will print everything, forms and all. ChipSoft's TurboTax, on the other hand, required you to use a normal IRS Form 1040 in your printer, and I have *never* had much luck at getting any printer in the world lined up well enough to put its output into little boxes and squared; certainly, I don't think I can do it with a 1040.

This year, TurboTax will print the 1040, provided you have an Epson- or IBM Graphics-compatible dot-matrix printer. I don't have one of those, but they aren't hard to come by for a few hours, and that's greatly preferable to trying to get things properly aligned.

I haven't used TurboTax before, but I've heard good things about it. The manual looks complete and, given the subject matter, relatively easy to use—although, face it, even with a computer things are going to be *complicated* this year. It's also available as I write this, which MacInTax is not.

I can't strongly recommend a program I haven't actually used, but TurboTax looks like the one I *will* use.

Winding Down

I'm completely out of space, and I still haven't touched all the good stuff.

continued

Items Discussed

Amdek Laserdrive $995
Amdek Corp.
1901 Zanker Rd.
San Jose, CA 95112
(408) 436-8570
Inquiry 934.

DeskLink $169.95
Traveling Software
19310 North Creek Parkway
Bothell, WA 98011
(206) 483-8088
Inquiry 935.

DESQview 2.0 .... $129.95
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica, CA 90405
(213) 392-9851
Inquiry 936.

Empire $49.95
Interstel
P.O. Box 57825
Webster, TX 77598
(713) 486-4163
Inquiry 937.

Fastback Plus $189
Fifth Generation Systems Inc.
1322 Bell Ave.
Suite 1A
Tustin, CA 92680
(800) 225-2775
Inquiry 938.

Mace Utilities 4.10 .... $99
Paul Mace Software
400 Williamson Way
Ashland, OR 97520
(503) 488-0224
Inquiry 939.

Microsoft Bookshelf $295
Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073
(203) 882-8080
(800) 426-9400
Inquiry 940.

PaintShow $79
Plus Software $29
EGA&Mouse $399
Autosync Monitor $699
Logitech Inc.
6505 Kaiser Dr.
Fremont, CA 94555
(415) 795-8500
Inquiry 941.

PC Sweep $5
Workman and Associates
1925 East Mountain
Pasadena, CA 91104
(818) 791-7979
Inquiry 942.

Planetary Data System Space Science Sampler
NASA JPL
4800 Oak Grove Dr.
Pasadena, CA 91109
(818) 354-6347
Inquiry 943.

RAMpage/2 .... $345
RAMpage/286 .... $545
AST Research Inc.
2121 Alton Ave.
Irvine, CA 92714
(714) 756-4942
Inquiry 944.

Reach for the Stars $40
Strategic Studies Group
1747 Orleans Ct.
Walnut Creek, CA 94598
(415) 932-3019
Inquiry 945.

TurboTax $75
ChipSoft
5045 Shoreham Place, #100
San Diego, CA 92122
(619) 453-8722
Inquiry 946.

Vopt $49.95
Vcache $49.95
Vfeature Deluxe $120
Golden Bow Systems
2870 Fifth Ave.
Suite 201
San Diego, CA 92103
(619) 298-9349
Inquiry 947.

Zenith Z-386
Model 40 .... $6499
Model 80 .... $7499
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 391-7000
Inquiry 948.

There's the Complete PC Answering Machine, which is so good it might be worth buying a Blue Chip XT clone just to dedicate for use as a telephone device. There's Borland's Quattro, which in my judgment is the spreadsheet for the rest of us: not copy-protected, plenty of features, and the simplest installation and tutorial I've ever seen for a spreadsheet. There's Concurrent DOS 386. Here's AutoDimensioning for Generic Software's CADD 3.0 (PC). TK!Solver. MathCAD. The list goes on, and what am I supposed to do?

The book of the month is *David's Sling* by Marc Steigler (Baen Books, 1988), a novel of how information-age technology might be used to defeat bureaucracy; a really good read. While you're in the bookstore, you might pick up *Imperial Stars, Volume Two: Republic and Empire*, edited by J. E. Pournelle, also from Baen Books.

The computer books of the month are Timothy Budd's *A Little Smalltalk* (Addison-Wesley, 1986) and Chris DeVoney's newest edition of *Using PC DOS* (Que Corp., 1986). One's a great intro, the other's the best DOS handbook I have.

The games of the month are Reach for the Stars (Macintosh only) and Empire (Atari ST; PC version upcoming). Both are revisions of classics. Reach for the Stars is a computerized version of the old board game Stellar Conquest, with new features added. It's totally strategic level; combat is automatic and is based on the Lanchester equations in which the squares of the forces involved are the key numbers. You control economics as well as military production, and the darned game is fascinating, as well as a good example of using the Mac interface to control something really complex.

Empire is a microcomputer version of a classic originally written for a VAX. It has some bugs, which the designer promises to take care of in a revision; but bugs and all, the darned thing turns out to be fascinating enough that the other night I sat down at 9:30 and didn't look up until 4:30 the next morning.

Maybe next month things will slow down, but I doubt it. ■

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. Jerry welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

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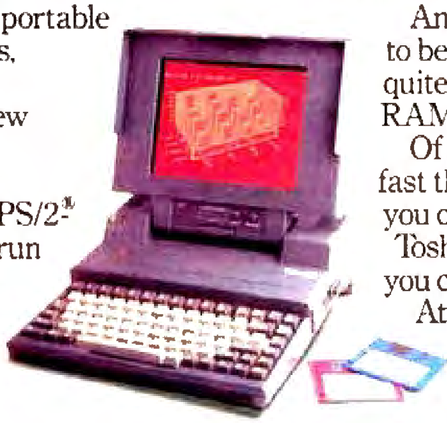

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Circle 316 on Reader Service Card

Two Big Winners

Ezra Shapiro

Decision Pad helps clarify tough choices; QuicKeys enhances a Mac keyboard

It's April, time for pranks and all sorts of tomfoolery. Unfortunately, I received my April Fools' surprise early, courtesy of Jasmine Technologies, manufacturer of hard disk drives for the Macintosh. I've had a Jasmine Direct Drive 160 for about 3 weeks now, and it has performed splendidly; that's not the problem. Jasmine sells its drives loaded with roughly 10 megabytes of shareware and public domain software. On the surface, it's a nice idea; sure beats collecting the stuff on your own.

However, not all of this assortment has been tested by Jasmine. A number of the programs can bring your Mac to a grinding, ugly halt, and some can even do serious damage to your system files. Many programs are experimental versions, and a few date back as far as 1984. Some are grossly incompatible with current system software, and some never worked well even when they were new.

It took me about 3 days to plow through the disk. It's not all bad—you get the latest version of ResEdit, a couple of interesting utilities, some fonts, and suchlike. Only a small percentage of the programs are seriously problematic, but weeding them out requires painstaking effort.

What's particularly irritating is that Jasmine is in a position to perform a real service to customers and starving shareware authors by providing a selection of tested software. But instead of checking the programs, Jasmine posted a message disclaiming any responsibility for mishaps arising from use of these programs. If I read my dictionary right, the opposite of "responsible" is "irresponsible." And Jasmine's policy is certainly irresponsible.

This is no public service; it's a menace. Be warned. A loud boo to Jasmine for this one.

Almost Artificial Intelligence

Decision Pad (Apian Software, $195) is an MS-DOS package that falls into the nebulous category of "decision support software." I've always hated that label; it's an imprecise term, and I'm never sure what the companies that use it want it to mean. Many of the programs I've seen billed as such are mostly hot air.

But Decision Pad is a top-notch piece of software, and it has been growing on me in the 5 weeks I've been working with it. The program is a useful tool for examining the strengths and weaknesses of alternative solutions to any given problem, from choosing the right restaurant for a business lunch to selecting the best candidate for a job opening. Essentially, Decision Pad uses simple quantitative techniques to provide qualitative analyses of your data.

The metaphor is much like that of a spreadsheet or a database table. Each row shows one alternative; columns are used to break that alternative into its component parts. Using the lunch example, the rows would be individual restaurants, and the columns would be attributes like price, speed, quality, and atmosphere.

Decision Pad lets you develop a ranking scale for each attribute in verbal units that seem to be appropriate, like "excellent/good/average/fair/poor" for quality or "expensive/reasonable/bargain" for price. You then assign number values to these ranking scales. Finally, you give weight to the different attributes; let's say price is twice as important to you as atmosphere. Decision Pad then computes the results and tells you which restaurant would be your best bet.

Unfortunately, examples like this tend to trivialize the utility of the program. I wouldn't recommend using Decision Pad to choose a restaurant any more than I'd suggest that you need an expert system to tell you when your car is out of gas. Decision Pad is much more appropriate for issues that require selecting from among a quantity of very similar alternatives.

Ten years ago, I ran a want ad in the *New York Times* for an assistant and received over 200 resumes; almost all of them were in line with the basic requirements. It took me weeks to whittle down the list to a manageable group of applicants. Decision Pad would have been extremely helpful.

Other examples leap to mind: Which combination of nutrients grows the healthiest culture in a petri dish? What midsize car, from which rental agency, should you try to get for freeway driving in Los Angeles? Where should you build a new manufacturing facility, from among a selection of 200 suburban sites in six states? Decision Pad looks better and better as the quantity of data grows and the differentiating characteristics get less and less obvious.

The program is easy to learn, and it comes with examples at different levels of complexity. The basic interface is rather a cross between a spreadsheet and a utility program like SideKick; you can enter commands as Alt-key mnemonics, use a mouse or cursor keys to select from a menu, or enter the traditional slash followed by a letter à la Lotus 1-2-3 or SuperCalc.

The documentation is clear, if a little overladen with hyperbole. It's missing a decent spec sheet, but it does give you a thorough tutorial. I had no trouble getting going. Once you've grasped the basic principles of Decision Pad (in an hour or less), you should be able to start using it immediately.

The worksheet holds a maximum of 150 alternatives (rows) and 60 attributes (columns). Decision Pad has no internal computational ability except what I've described; that is, you cannot modify numerical data or make comparisons employing any method other than the ranking system. However, the program can

continued

import and export files in Lotus .WKS format, so if you need heavy-duty number crunching, you can pop your file into (or out of) your favorite spreadsheet or analytical database. Reports can be generated as standard text documents, or you can see them depicted as bar graphs.

Perhaps the nicest feature lets several users get at the same data and develop their own ratings. Decision Pad will track the variations in the standings and report on how each member of the group has evaluated the data.

You can play "what if" to your heart's content, changing the data or reworking the scales. It's possible, of course, to alter the weights so that the results turn out exactly the way you want them; using this program effectively requires self-discipline. Even if you cheat, though, my hunch is that the process of preparing your information for Decision Pad will focus your attention on meaningful details you might otherwise overlook. At the very least, a session with this program will give you insight into the criteria you're applying to a decision.

At the start of my testing, I was prepared to dislike Decision Pad. I thought it was going to be a way to use a computer to perform tasks better handled by scrawling notes on a legal pad. Instead, I was delightfully surprised. Even if you get nothing from Decision Pad but a better understanding of your decision-making strategy, it's worth the price.

Highly recommended.

Items Discussed

Decision Pad $195
Apian Software
P.O. Box 1224
Menlo Park, CA 94026
(415) 851-8496
Inquiry 949.

QuicKeys $99.95
CE Software
801 73rd St.
Des Moines, IA 50312
(515) 224-1995
Inquiry 950.

The Jury's in on QuicKeys

Last month, I mentioned that I hadn't had enough time to decide whether I liked QuicKeys (CE Software, $99.95), a keyboard programming utility for the Macintosh. The jury is now in, and the verdict is favorable. QuicKeys is right up there with sliced bread, the Great Pyramid of Cheops, and other wonders.

It's what is known as a keyboard enhancer; you use it to assign commands, mouse operations, and text strings to keys of your choosing. Anyone coming in from another operating system (MS-DOS or CP/M, say) already understands the concept; I'm amazed that it has taken this long for a good product like this to appear on the Mac. Nevertheless, here it is, and it's as invaluable as products like SmartKey, ProKey, and SuperKey are in the IBM PC universe.

Running the program is no big deal. You can define keyboard substitutes either by using a stand-alone application or by calling up a device-configuration screen from the Mac's Control Panel. QuicKeys can also be brought to life by hitting a hot key that avoids the Control Panel step. Once you're looking at the QuicKeys panel, you select the type of operation (e.g., choosing a menu item, inserting text, defining a command alias, and clicking and dragging the mouse), then press the key or key combination that will ever after invoke your definition. Every type of Mac action has a QuicKeys equivalent.

Sets of QuicKeys can be saved to or loaded from disk at any time. This is a very smart program; it has both a universal set of keys available wherever you are and the intelligence to let you create sets specific to the application you're running at the moment. To my delight, I discovered that the application-oriented stuff is not sacrificed under MultiFinder. Since QuicKeys intercepts your keystrokes before passing them along to the operating system, your new keyboard shortcuts supersede the command-key equivalents on the Mac menus so you can effectively redefine anything to suit your taste.

This override process caused the only problem I had while getting adjusted to QuicKeys. The universal key set that comes with the program defines Command-Q as an automatic, absolute "quit." While using MicroPhone, a telecommunications program that uses Command-Q as an alias for Control-Q, I found myself aborting the program every time I tried to stop screen scrolling. This was easily fixed by redefining the quit maneuver to Option-Command-Q.

Bear in mind that QuicKeys is not a macro recording program like Tempo; the product is a bit of a pain if you need to build complex macros. You're allowed to assign only one action to any particular key, so you can't simply log a series of operations and attach it to a single keystroke. To work around this, QuicKeys does let you chain reassigned keystrokes into sequences, so you can build macros step by step. Think of each key as a variable and its related operation as a value, and you've got the basic idea.

There are certainly enough key combinations to go around. QuicKeys recognizes the Shift, command, and option keys as unique modifiers, so every key represents eight different characters. On keyboards for the Mac SE and II, which have a separate Control key, the total jumps to 16.

On an extended keyboard, you'd theoretically have 1488 combinations to work with. To get some of the more obscure possibilities on my new DataDesk keyboard, I figure I'd need both hands and my nose to hold down the correct keys at the same time.

The number of keys on these extended keyboards does legislate a healthy amount of organization. As I get deeper into the product, I find myself regularly rethinking which keys do what. I certainly don't have the mental fortitude to master function keys mapped to a depth of 16 levels. My personal maximum is about three per key.

Also, it would be a big help to have similar actions located in the same region of the keyboard no matter what program I'm using.

I'm also a little concerned that as I become addicted to QuicKeys, I'm losing touch with the Mac as a lowest-common-denominator machine. To explain: I've known many MS-DOS users who have become so dependent on a selection of utilities and keyboard enhancements that they become paralyzed when they're forced to work on other people's computers. Will my customization of the Mac interface with QuicKeys ruin me for other Macs?

But philosophical mutterings aside, QuicKeys is first-class software. It's never crashed on me, no matter how hard I've pounded on it. The documentation is excellent. QuicKeys is an absolute requirement if you have an extended keyboard (particularly since no Mac programs understand or use the function keys yet); if you're stuck with a standard keyboard, it's merely wonderful.

There's an implicit irony in all this. Back in 1984, I heard an awful lot of sneering from rabid Macaholics who couldn't understand why anyone would want to use a keyboard instead of a mouse. Function keys and Control-key sequences? Phooey!

My, how times have changed! ■

Ezra Shapiro is a consulting editor for BYTE. Contact him c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

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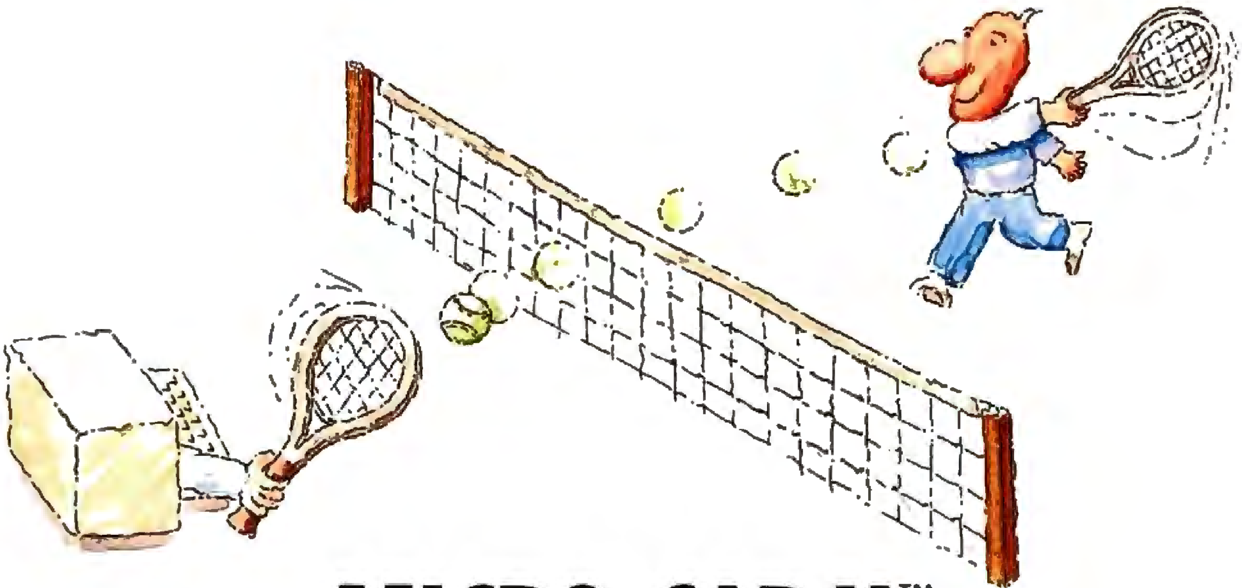

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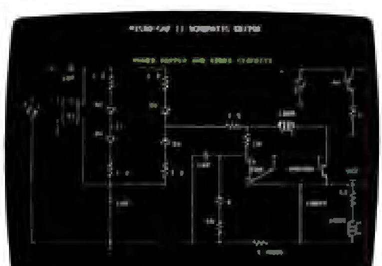

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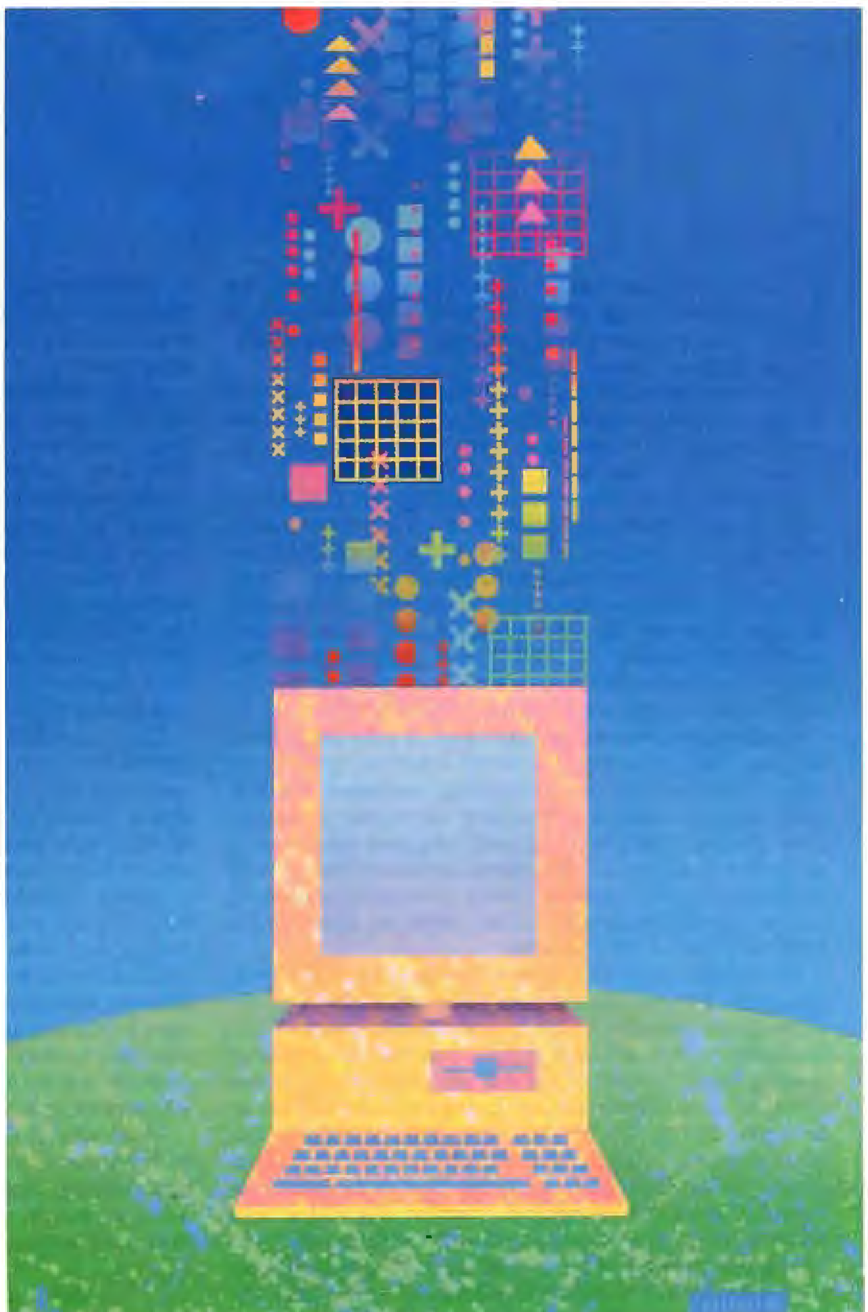
Memory Management



Introduction

Memory Management

Life with computers has evolved in funny ways. First, we learned to manage stacks of punch cards, then piles of floppy disks, then our virtual desktops. Next, they'll be asking us to learn to manage memory.

Maybe not. Some things are still best left to the machines themselves, and managing memory may be one of them. But understanding the dynamics of memory management helps us choose the right technology for a given task.

The trend in microcomputer technology has always been toward more powerful hardware. Today, it is not uncommon to find personal computers with a megabyte or more of memory and the capability to expand to 8 or 16 megabytes. Many microcomputers now come with sophisticated 32-bit processors that either provide hardware support for memory management on-chip (e.g., the CPU in a Compaq Deskpro 386) or have a socket for adding a memory management unit (the Mac II, with a socket for Motorola's 68851 MMU).

As usual, hardware technology outpaces software technology, and today's currently available operating systems use only a fraction of the potential of these machines. For MS-DOS, interim available solutions to the memory management problem include bank switching and multitasking shells that sit on top of DOS. Apple introduced MultiFinder in October 1987 to provide limited concurrent processing and background printing capability. However, these options are clearly short-term solutions.

Meanwhile, software engineers are devising new operating-system designs that can take advantage of the large address spaces provided by these sophisticated CPUs. These operating systems will be complex. They will be capable of running multiple applications that are protected from each other, yet allow these same applications to communicate information among one another. The same complexity that gives these multitasking systems such power also requires much training and experience to tap their full capabilities. After the initial time investment, however, they will be safer and more interesting environments under which to program.

This month, we chose to look at techniques that these operating systems use to manage the computer's main memory. In addition to a general introduction to the subject, we present three examples of how these techniques are applied in three operating systems: OS/2, Unix, and the Macintosh operating system.

In his "Overview of Memory Management," Randall L. Hyde discusses memory management techniques for personal computers—past, present, and future. He covers the wide array of memory management techniques, from those implemented only in software to those that require hardware support for their proper operation. He discusses the relative merits of segmented and paged virtual memory.

Vic Heller gives us an inside look at how OS/2 uses the 80286 to implement segmented virtual memory. In his article "OS/2 Virtual Memory Management," we see how OS/2's software data structures work with the 80286's hardware data structures to provide not only virtual memory but also dynamic linking and sharing of code segments.

Unix is an alternative to OS/2. Unix has been running on 680x0s for many years due to that processor's flat address space, but as Carl Hensler and Ken Sarno explain in their article "Marrying Unix and the 80386," porting Unix to the 80386 is quite easy. In addition, the 80386 offers modes that make it easy to run existing DOS applications.

Finally, Alan Anderson, in "Macintosh Memory Management," gives us a look at the Mac's memory management system, which was present in the first 128K-byte RAM Macs and is still with us today in the Mac II. He explains how this memory management software works, along with its advantages for the end user and its pitfalls for the unwary programmer. He concludes with a look at MultiFinder and how it was carefully crafted to provide compatibility with existing Mac software and concurrency among several applications.

These articles show that microcomputer environments are evolving toward solutions that will allow us to harness the true potential locked within the new generation of 32-bit microcomputers, without jeopardizing our huge investment in existing software.

—Eva White, Technical Editor
Tom Thompson, Senior Technical Editor at Large

Overview of Memory Management

Powerful hardware and plentiful memory make techniques for managing microcomputer memory more interesting—and necessary

Randall L. Hyde

UNTIL RECENTLY, it has been too expensive to provide hardware support for memory management on microcomputers, or even enough memory to make it worthwhile to manage. But with the advent of microprocessors with on-chip memory management and cheap memory, many of the memory management techniques for mainframes are migrating to the world of microcomputers.

More sophisticated memory management means faster and more reliable multitasking. With the emergence of multitasking systems on microcomputers, it's time to dust off those college textbooks and look at some of the classic issues in memory management. I'll discuss the memory management techniques that have become prevalent on microcomputers and look at some others migrating to this realm—techniques such as paging, segmentation, or a combination of both. Other articles in this issue will look at specific examples of these techniques.

A memory manager is a process, typically within an operating system, that provides memory-related services to other processes. Its job is to allocate and deallocate memory, swap code and data between main memory and secondary memory, protect one process from another, and coordinate access to shared data between processes.

Although many of the memory manager's tasks are easily done in software, performance considerations often dictate the use of special memory management hardware. Some functions (like protection) require assistance from a hardware memory management unit (MMU).

Because of the high costs of hardware support and memory, memory management on personal computers has typically been done in software. When memory prices fell, bank-switching techniques were developed to extend the addressing range of machines while allowing people to use existing hardware and software. But bank switching is only an interim measure. Tomorrow's applications will run on new, sophisticated hardware that will let operating system designers make memory management practically transparent to the application developer and user alike.

Software Memory Management

Software-based memory managers provide at least two functions: memory allocation and deallocation. To allocate memory, the requesting process specifies a block size. The memory manager returns the address of the block allocated to the process. When deallocating memory, the process provides the block address (and sometimes the length of the block as well), and the memory manager returns the memory to the free memory pool.

After several allocation and deallocation requests, free memory can divide into many small pieces spread throughout the address space. This memory fragmentation reduces the largest block of memory available to a requesting process. If there isn't a block big enough to handle the request, the memory manager may attempt to rearrange the blocks in memory so that the free blocks are joined together in a single, large free block of memory. This technique, called garbage collection, is a convenient way to maximize memory use. However, there are three problems with garbage collection: performance, contents, and pointers.

The performance issue stems from the fact that to build a large free block of memory, large blocks of (currently used) memory might be moved (which takes a considerable amount of time). The performance problem, however burdensome, pales in comparison to the content and pointer problems. The content problem arises if the memory manager moves a block of memory containing machine instructions that are referenced by other code (via calls and jumps). Those instructions using this code will fail unless the garbage collector fixes the references.

Whenever the memory manager allocates a block of memory to a process, it gives the process a pointer to the allocated block. Then the process uses that pointer to access the block of memory. But if the memory manager moves that block of memory via a garbage collection operation, that pointer will no longer point to its original data.

A simple way to solve the pointer problem is to make the memory manager aware of pointers that point into movable data blocks. Whenever the memory manager needs to move the block, it simply adjusts all pointers that point to the block so that they point into the block at its new location. The only problem with this approach is that the user process might make several copies of the pointer, all of which the memory manager must know and adjust when it moves the block. The

continued

overhead for such a situation can quickly overwhelm the system.

A memory manager can use *handles* to overcome the problem of keeping track of multiple pointers. A handle is a double indirect pointer—that is, a pointer to a pointer to the data. To access a data block, a process loads a temporary pointer variable with the value to which the handle points. The process then uses this temporary pointer to access the desired data. Now when the memory manager wants to move a block of data around, it changes only the master pointer to the data. The handle that points to the pointer is still valid, as are any copies of the handle (see figure 1). (For a discussion of the Macintosh's handle-based memory manager, see "Macintosh Memory Management" by Alan Anderson on page 249.)

However, handles are not without their own problems. They aren't particularly efficient. After all, it takes much more time to access a block of data using a handle than it does using a straight pointer. Furthermore, address arithmetic isn't as convenient when using handles as it is when using straight pointers. You can't (safely) copy the pointer into a register and continually increment that pointer to access successive items in an array. A system call may result in a garbage collection operation that may cause the mas-

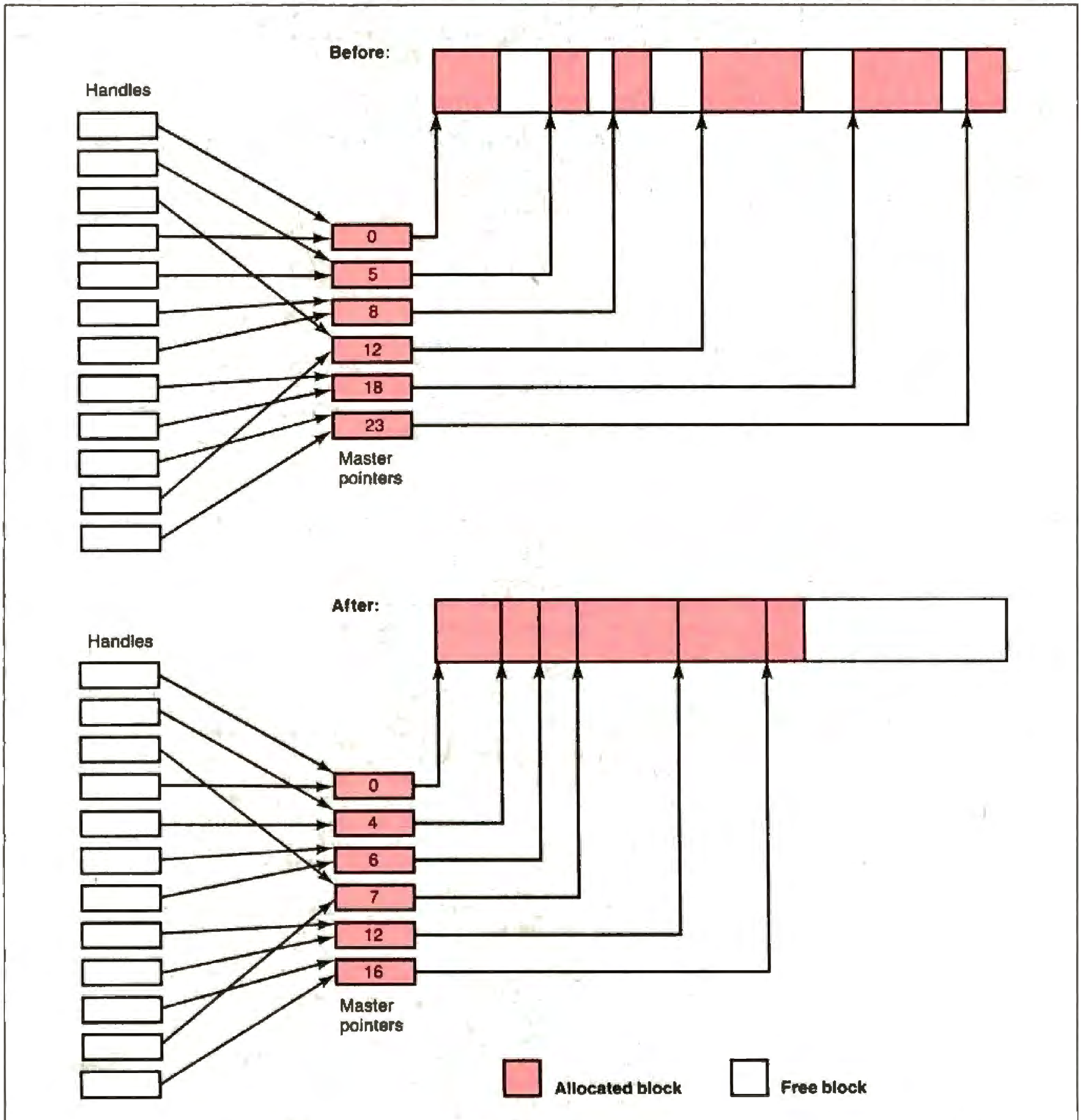


Figure 1: *Handles can ease the memory manager's job of moving blocks to free space for allocation requests. The system can change the value of the master pointers without having to change the value of the handle embedded in the user programs.*

ter pointer (but not your register) to point to a different location. Continuing to use the now invalid register value to access the array may produce unexpected results.

Another disadvantage of handle-based memory managers is their complexity. There's a lot more work involved in using handles than making calls to ALLOC and FREE. On systems like the Atari, Amiga, and IBM PC (under DOS), the memory manager routines may not provide sophisticated garbage collection routines and other amenities, but these systems are easy to use. In fact, most of the memory management routines provided on these systems correspond to those routines provided by high-level languages like C or Pascal.

Finally, it is very difficult to safely implement handles in a true multitasking environment. One process might dereference a handle, but before accessing the specified memory location, a timer interrupt could come along and transfer control to another process. That process might ask for some additional RAM that could force a garbage collection operation. The garbage collection operation could move the data pointed to by the dereferenced handle, rendering the dereferenced handle invalid. When control is returned to the original process, it will reference the incorrect memory location.

The benefits gained by a handle-based system's complexity are easily lost as more and more memory is added to the system. Whereas garbage collection can be quite useful on a system with 1 megabyte or less, as you approach 4, 8, or 16 megabytes of system memory its usefulness declines. With 8 megabytes of system RAM, most processes will be able to allocate all the memory they need. An incredible amount of activity, or a large number of concurrent processes, would be necessary before memory fragmentation would cause a problem.

Bank Switching: A Stopgap Measure

Bank switching is an all-but-obsolete memory management technique used mainly to expand the capabilities of a machine with a limited address space. It is present in systems like the Apple IIe and the IBM PC (via LIM/EMS systems). Bank switching extends the memory space of a processor by assigning several blocks of memory to the same memory address in the processor's address space. Whenever an access to the address range containing these blocks of memory is performed, only one of the blocks responds. The choice of which block responds to the access request is controlled by a bank selection register. By changing this register's content, a program can access different banks of RAM, thereby providing access to more memory than the processor can directly address.

Bank switching suffers from two major drawbacks. First, controlling the bank selection register(s) is an exercise left to the application programmer. This complicates the program's design and introduces several problems related to program maintenance. Second, accessing the bank registers requires a certain amount of time—time taken away from the program. This results in a performance penalty for programs using bank switching techniques. The penalty can range from mild, for programs that rarely switch banks of memory, to extreme, for those that may have to switch banks between each data access.

Of course, bank switching is preferable to its alternatives: either living with the address space limitations of the processor (impractical for today's high-powered applications) or swapping the data to and from the disk drive (as cumbersome as bank switching and far slower).

Virtual Memory

The best solution in a multiprogramming/multitasking environment is a virtual memory manager. With a virtual memory manager, the process can assume that the entire logical address space is available; the process need not make explicit memory manager calls.

Paging and *segmentation* are the two main virtual memory techniques in use. Paging uses a fixed-size allocation scheme; segmentation uses variable-size blocks. In paging systems, the entire address space is partitioned into equal-size blocks, which are given to a process upon request. Internal fragmentation results when the process does not use the entire block. With segmentation systems, because the programmer can specify the size of the block, there is little waste due to internal fragmentation; but external fragmentation occurs when blocks of available memory, scattered throughout memory, accumulate because they are too small to fill an allocation request.

Whenever the process accesses a memory location not currently in memory, the hardware signals that a fault has occurred, and the memory manager maps in a free page (or segment) for use by the process and returns control. If there aren't any free pages or segments of memory available, the memory manager attempts to free up some memory by writing used blocks of data to disk and allocating that memory to the process. It then swaps these blocks back in if the process that owns them needs to access them.

Generally, the programmer need not be concerned with the details of memory

continued

management; there are, however, certain data structure considerations that will affect performance in paging systems. For example, languages such as Pascal and C store elements of an array in row major order. Other languages, such as FORTRAN and certain dialects of BASIC, store array elements in column major order. By knowing the orientation, the programmer can reduce page faults tremendously by using array indexes that follow the storage order.

A simple paged memory management system is easy to implement in hardware. A set of page registers intercepts certain address bits from the CPU and translates these bits to a different value via a lookup table. This lets the system remap memory as desired. Figure 2 illustrates this remapping function. In this example, the CPU supports 16 address lines. The lower 13 address lines are passed, unchanged, to the memory modules. The upper 3 bits are used as an index to select the appropriate page register. The 13 address lines, passed directly to the memory module, determine the page size—in this case, 8K bytes.

Operating systems can use paging schemes to extend the addressing range of a CPU in addition to remapping the address space. A CPU with a 16-bit address bus can be expanded to a 24-bit address bus with 256 16-bit page registers. The upper 8 bits of the logical address are fed into the page register array. Each page register is 16 bits long, and the 16-bit output is combined with the 8-bit offset (the lower 8 bits of the logical address) to yield a 24-bit physical address. This scheme uses a page size of 256 bytes. The page size is determined by the number of bits passed directly from the CPU to the memory module.

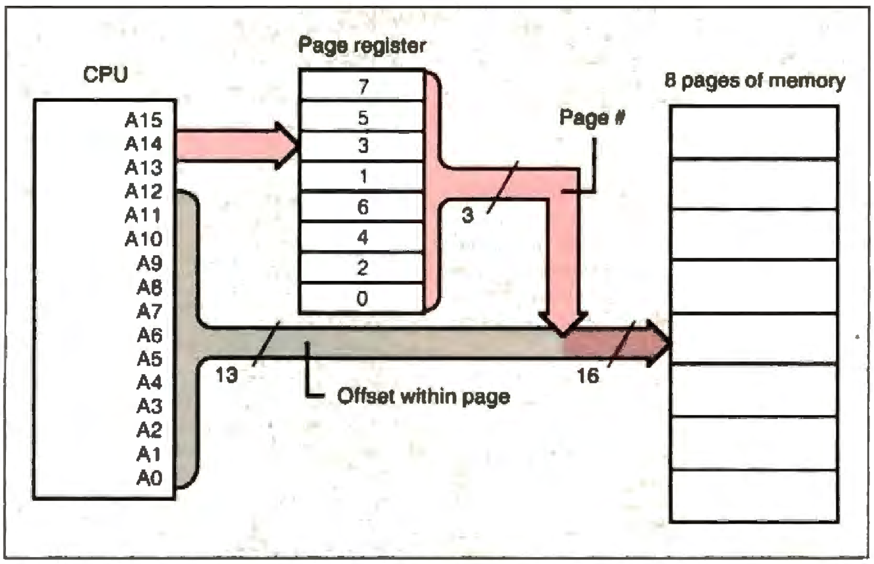


Figure 2: *Example of a paging system that uses 3 bits of the CPU's 16 address lines as an index into the eight 8K-byte memory pages.*

Paging systems, however, suffer from a few drawbacks. Manipulating page registers can be time consuming. The examples presented thus far use a 16-bit logical address. To use a 24-bit address bus with a 256-byte page size, the page registers will consume 128K bytes. Since the operating system must save and reload the page register values every time it transfers CPU control to a different process, a considerable amount of time will be required just to save and load the page registers. Furthermore, those 128K bytes have to be fast, and that means expensive.

For larger systems, most paging schemes use page table pointers, which point to page register values in main memory. These pointers usually take the form of a small associative cache memory that keeps the most recently used page register values. Main memory access to the page table adds 5 percent to 10 percent overhead, depending on the size of the page register's on-board cache. For example, the National Semiconductor 32082 MMU maintains a 32-entry associative cache on-board and refers to main memory when a memory access cannot be translated with on-chip data. The 32532 CPU with MMU provides a 64-entry cache. The Motorola 68851 operates similarly, providing 64 entries in the associative cache.

To reduce the amount of fast storage required for page tables, the operating system can use larger page sizes. For a 64K-byte page size, for example, it would need only 256 page registers to remap up to 16 megabytes of memory. Unfortunately, memory must be allocated in integral page sizes. A process requesting 32

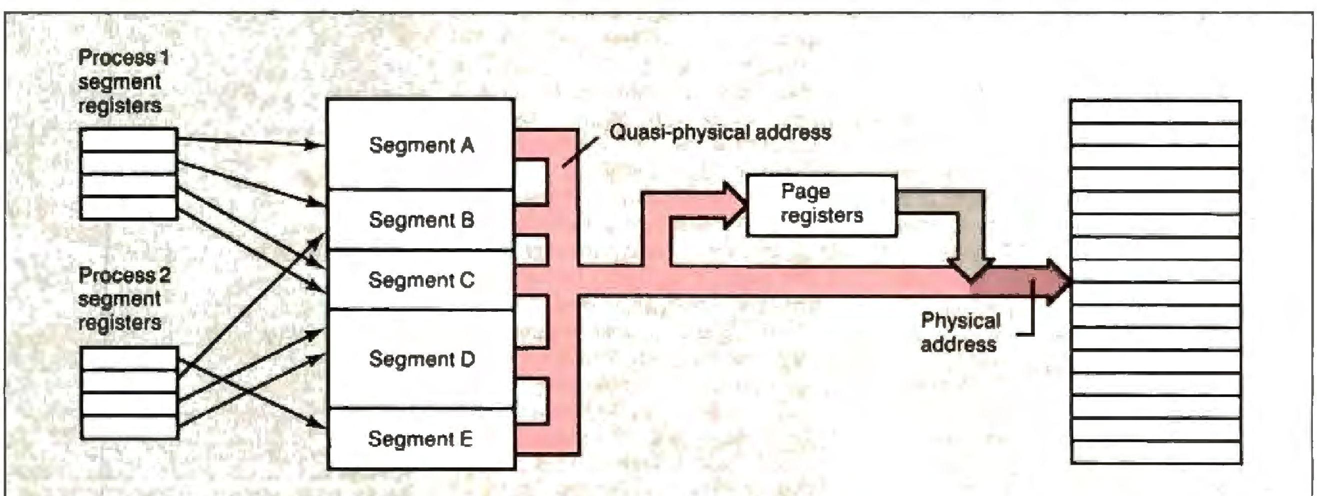


Figure 3: *A hybrid segmentation/paging system tends to reduce both internal and external fragmentation.*

additional bytes would be allocated a 64K-byte page. Increasing the page size decreases the number of page registers required; however, it also increases the amount of waste due to internal fragmentation.

The National Semiconductor 32082 MMU chip allocates memory in 512-byte pages. The National 32532 CPU chip, which includes an on-chip MMU, uses 4K-byte pages. The Motorola 68851 chip lets the system designer select from various page sizes (e.g., 512, 1024, 2048, on up to 32K-byte), although you can employ only one page size at any given time. This lets you decide about compromises between internal fragmentation problems and large page table sizes.

Segmentation

Segmentation eliminates the need for an expensive bank of page registers. Intel's 80x86 and Zilog's Z8000 families use segmentation techniques. Segmentation is unique in the sense that its effects are visible in both the logical and physical address spaces. Segmented addresses consist of a segment component and an offset component, usually specified by `segment:address`. "Segment" represents the name of some block of storage, and "address" specifies an offset into that block. (For a discussion of a segmented memory manager, see "OS/2 Virtual Memory Management" by Vic Heller on page 227.)

The advantage of segmentation over paging lies in the way programs are organized. Most programs deal with only two distinct items: code and data. Data can be further divided into categories (e.g., static data, dynamic data, stack data, shared data, and constants). Segmentation works on the principle that a program will need to access only a limited number of items at one time. Even in the extreme example above, only six different items (the code segment and the five data segments) need be accessed at once.

In a segmentation system, you need a segment register for each concurrently referenced data segment. For the six items listed above, only six segment registers are required to provide complete access. Compare this to the 65,536 page registers required in a system with a 24-bit logical address and a 256-byte page size. Segmentation, therefore, is not only more sophisticated than paging mechanisms (by adding two component logical addresses), but more economical as well.

Segmentation is actually a powerful concept that has been given a bad name by Intel's earlier processors (pre-80386). Due to Intel's implementations, most people associate segmentation with a 64K-byte addressing limit. This is a limitation of certain Intel processors because they allow only a 16-bit offset as part of the segmented address. The 80386 corrects this problem by allowing a 32-bit offset associated with each segment value. (For an example of an operating system that uses the memory management facilities of the 80386, see "Marrying Unix and the 80386" by Carl Hensler and Ken Sarno on page 237.)

Sharing Memory

Besides supplying all the memory a process requests, memory management coordinates access to shared data between two or more processes. This could be something as simple as two users sharing the same copy of a compiler or editor in memory, or as complex as shared data structures for communication between multiple processes (e.g., cutting and pasting between two applications). Data sharing presents many challenges to the memory manager designer, as well as to the application designers exploiting these features.

In a paging system, if two processes need to share a page of memory, a page register for each process points to the page they need to share. The major problem with data sharing in paged-memory systems concerns the use of pointers. A pointer stored in a shared data structure may not point to the same item in the address spaces of both processes sharing that pointer. The only solution is to ensure that the data which a shared pointer references is also shared and lies at the same logical address in both processes.

Segmented systems don't have a problem with pointers. Since a segmented address consists of two components, a segment and an offset within that segment, a pointer containing these two elements provides all the information needed to access data anywhere in memory.

Paging schemes have two major drawbacks: the large size of the page table required for each process (which must be stored in main memory, further degrading performance) and the problem with shared data structures. Segmentation systems suffer from external fragmentation. Using a hybrid segmentation/paging scheme can solve these three problems.

This system appears as a segmented system to the software. Once the segmentation hardware generates a "quasi-physical" address, it then passes this address through a set of page registers to produce the true physical address (see figure 3). To the software, this system looks like a pure segmentation system, so all the advantages of segmentation apply. The paging hardware eliminates segmentation's big problem: external fragmentation. The

continued

paging hardware remaps unused segments to a contiguous memory pool for use by other processes. Even though paging is used, there aren't any problems with data sharing since pointer addresses refer to the segmented addresses rather than physical addresses.

Placement and Replacement

Regardless of how a process requests memory, the virtual memory manager's job is to provide the memory. The memory manager usually keeps track of free memory with a bit map or a linked list. With the fixed-size allocation blocks of a paged system, placement and replacement algorithms are very easy. Any block in memory can be remapped to any address. However, for segmentation and software-only schemes, the requested block of memory can be placed only in an area of memory currently unoccupied. If two or more such areas are free, then the memory manager must choose (using some algorithm) which free block to allocate for the request.

A placement algorithm selects a free block in memory for a given request. Some well-known placement algorithms are first-fit, best-fit, and next-fit. First-fit allocates the first available block large enough to satisfy the request, best-fit allocates the block closest in size to the request, and next-fit allocates the next available block large enough to satisfy the request.

The diagram in figure 4 shows a list of free and allocated memory blocks. The last block allocated was 14K bytes from a 22K-byte block, which left an 8K-byte fragment. If a process needs to allocate a 16K-byte block, then the first-fit algorithm selects the first available block that satisfies the request, starting at the beginning of the memory pool. The best-fit algorithm also starts its search at the beginning of the list and selects the block closest in size to 16K bytes. The next-fit, however, will start its search at the point where the last block was allocated and select the next available block of sufficient size.

As it turns out, the first-fit algorithm is not only the simplest but usually the best and fastest as well. The next-fit algorithm produces slightly worse results than the first-fit. The next-fit algorithm produces more external fragmentation than the first-fit because it always starts at the last block allocated and seeks the first available block (of sufficient size) beyond that point. The result is that the largest block of free memory, which usually appears at the end of the memory space, is quickly broken up into small fragments.

The best-fit algorithm produces results inferior to the next-fit. Because the best-fit always searches for the smallest possible block to satisfy the current request, this algorithm also guarantees that the amount of memory left over after the allocation occurs is as small as possible. Each memory request always wastes the smallest amount of memory; main memory is quickly littered by blocks too small to satisfy memory allocation requests.

In a virtual memory system, the memory manager often encounters a situation where one process is requesting a block too large to fit into memory. Since there is insufficient storage for the request, the memory manager must make room for the request by writing certain blocks of data to disk, thereby freeing those blocks to satisfy the current request. Replacement algorithms decide which blocks of memory can be swapped out.

A poor choice for the replacement algorithm may cause *thrashing*, a situation where the system may spend more time swapping blocks in and out of memory instead of operating on the data therein. To reduce this possibility, the replacement algorithm should select a block that won't be accessed for a considerable amount of time. The optimal-replacement algorithm holds that the best block to choose is the one that will be accessed the farthest in the future. Unfortunately, in most systems the order in which the blocks will be allocated is not known.

The least recently used (LRU) algorithm is a good approximation of optimal replacement. It is based on the assumption that the likelihood that a process will access a block is usually inversely proportional to the amount of time that has passed since the last access. Temporal locality is where blocks (or groups of blocks) tend to be accessed in widely spaced bursts rather than in evenly spaced intervals. Therefore, if a block hasn't been accessed in a while, it is a good tip-off that it won't be used for quite some time.

Unfortunately, the LRU is too expensive to implement (in hardware or software) because each memory access requires a "time tag" to be written to a descriptor for that block. Whenever a block must be replaced in memory, the system must locate the oldest time tag and replace that block. Such operations involve considerable hardware and software overhead, so the LRU replacement algorithm is rarely used.

A slight modification of LRU is the not recently used (NRU) replacement algorithm. This algorithm classifies blocks into four categories based on memory references (R) and modifications (M). A memory reference is any access (read or write) to a memory location. A memory modification occurs when that location is written to. Based on these two operations, the following table rates them according to their "replaceability":

0: not referenced, not modified	(____)
1: not referenced, modified	(__M)
2: referenced, not modified	(R__)
3: referenced, modified	(RM)

(Class 1 occurs when a time-out operation resets the referenced bit).

The NRU algorithm picks a block of memory, at random, from the lowest-

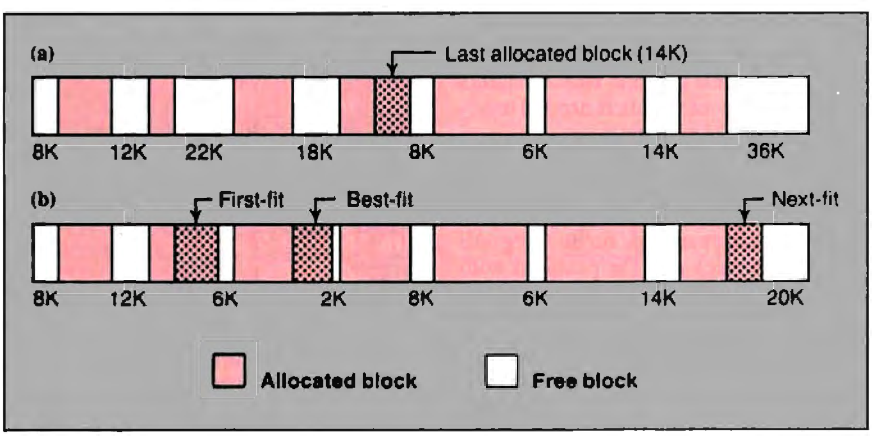


Figure 4: (a) *A typical memory configuration after several allocation and deallocation operations. The last allocated block was a 14K-byte block from a 22K-byte free block.* **(b)** *The difference between the first-, best-, and next-fit placement algorithms in satisfying a 16K-byte allocation request. First-fit will allocate 16K bytes from the 22K-byte block, leaving a 6K-byte block free. The best-fit will search the entire list looking for the closest fit; it will leave a 2K-byte block free, which is too small for most processes to use. The next-fit will start looking from the last allocated block. Often, it will break up the large blocks of memory that tend to be found at the end of memory.*

numbered class and swaps that block to disk. The algorithm offers reasonable performance with very little hardware overhead. It is best if hardware maintains the M and R bits; otherwise, the memory manager would have to execute many instructions for each user instruction that accessed memory. The National Semiconductor MMU chips, for example, provide hardware to support the NRU algorithm. The NRU algorithm is relatively easy to implement in hardware (it need handle only two additional bits) and doesn't place as much of a demand on the software as the LRU algorithm.

Other popular replacement algorithms include FIFO and first-in/not-used/first-out (FINUFO). The FIFO algorithm keeps all the blocks in the system in a queue. Whenever a block must be replaced, the FIFO algorithm replaces the block at the front of the queue and then moves that block to the tail of the queue. The FINUFO algorithm is similar, except that every time a block is accessed, it is moved to the end of the queue. Replacement blocks are still taken from the front of the list and added to the end once they are swapped. The FINUFO algorithm tends to congregate often-accessed blocks at the end of the queue so that they are rarely swapped out of memory.

In the simplest virtual memory system that uses paging, a process begins without any of its pages in memory. As soon as the CPU attempts to execute the first instruction, it will access a memory location not present in real (as opposed to virtual) memory. This will cause a page fault, requiring the memory manager to load the page containing the first page of the program. With each memory access outside this first page, or when the program "falls" into the next page, the memory manager loads the appropriate page of memory. This is called "demand paging" because pages are swapped in and out on demand.

Demand Paging

Usually, processes do not access many different pages in memory. Rather, most programs exhibit a locality of reference. During any point in the execution of the program, it will access only a small number of pages. The set of pages in use by a program at any given time is called its *working set*. In a demand-paged model, it may take 20 or more page faults before a process's working set is present in memory. Since the overhead associated with a page fault is rather high, the performance of the entire system is degraded. Many high-performance memory managers attempt to keep track of a process's working set. Whenever a process is swapped into memory, the memory manager attempts to load the entire working set. This working set model (also called prepaging) reduces the system overhead considerably.

In a virtual memory system employing segmentation, entire segments (rather than pages) are usually swapped in and out of memory. The principle of locality applies to segments as well. At any time, a process will access only a couple of segments. Since a code segment typically contains many more instructions than a page, and a data segment usually contains much more data than a page, thrashing is not as much of a problem with segmentation. In fact, swapping in an entire segment is a form of prepaging.

Nevertheless, the working set model applies to segmentation systems as well as to paging systems. At any given time, the process accesses a certain set of segments. These segments form the working set for that process at that particular time. The virtual memory manager, to ensure the highest performance, should attempt to load the working set of segments for a process when it is being swapped into memory. Segmentation's benefits work against it as well. Although loading a segment is a form of prepaging, segmentation suffers from the fact that segments are usually much larger than pages and hence take more time to swap to and from the disk.

Trend Toward Virtual Memory

Most microcomputer systems rely on software solutions to the memory management problem. They coordinate the use of allocated and deallocated blocks of memory, but most leave protection constraints to the individual programs.

Within 5 years, most (new) computer systems will routinely incorporate memory management hardware. Operating system designers will be able to provide virtual memory easily. The choice will be between segmentation, paging, or a hybrid segmentation scheme.

The trend in hardware is toward powerful on-chip hardware MMUs. Currently the 80386, 32532, Fairchild Clipper, and 68030 CPUs all provide sophisticated hardware memory management. In a few years, most personal computers (since they will be using chips such as these) will support hardware memory management and virtual memory. Today's complex software memory allocation and deallocation schemes will give way to systems in which memory management is totally transparent to the programmer. ■

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OS/2 Virtual Memory Management

How OS/2's hardware and software data structures work together to provide virtual memory, dynamic linking, and sharing of code

Vic Heller

MICROSOFT OS/2 MEMORY management takes advantage of the 80286's fault-handling capability to support segment-based virtual memory. Programs link dynamically at load time or run time or both to library modules for system services; independent software packages can use dynamic-link library (DLL) modules to share code and data used by multiple related applications. I'll give an inside look at the design of OS/2's memory manager version 1.1 as an example of segmented virtual memory management.

Providing the virtual memory, as well as the dynamic linking and sharing of code between tasks, requires some carefully thought out data structures. The 80286 supplies hardware support for protecting tasks from each other, but we also need to keep track of allocated and unallocated memory and the status of a task's segments (e.g., present, swapped, discarded, or allocate on demand (AOD)). We need to be able to find a segment that is not present. If there isn't enough physical memory for an allocation request, the memory compactor must be able to determine whether it can move segments around to make room, or if it will have to discard or swap some segments out of memory. Providing the ability to share data among tasks adds another dimension to the complexity of the system. I'll look at the data structures OS/2 uses and explain how they work together.

Figure 1 shows OS/2's hardware and software data structures. Each task has a per task data area (PTDA) created by OS/2. Every executable or DLL file has a module table entry (MTE) as part of its header. The operating system reads the MTE into memory when it loads a program or library module. The PTDA contains data global to the task (local descriptor table (LDT) information, thread count, and so on) and some data specific to each thread of execution within the task (current register contents and so forth); the MTE contains each segment's size, location in the file, and other type information. The system uses the PTDA to locate a single descriptor that maps a segment so it can be edited when the state changes. The system uses the MTE to find the executable or DLL file information so it can find and read the segment contents into memory.

The 80286 hardware provides each task with an array of segment "descriptor" structures (LDT) to restrict each task's access to those segments the operating system allows. A valid descriptor entry contains a user segment's physical address, size, and access rights (read/write/execute). The operation of placing a selector into a segment register causes the 80286 hardware to use the selector to index the LDT, fetch the corresponding LDT descriptor, and allow access and limit checking during each subsequent memory reference. Figure 2 shows an LDT entry (descriptor), along with the format for a selector and the segment registers with their hidden descriptor cache.

The LDT descriptors work closely with two software data structures: the physical arena and the handle table. In fact, starting with any one of these structures, the system can find either one of the others.

The physical arena is a list of headers that keeps track of all available physical memory by linking free and allocated blocks of memory. A header holds a segment's handle, owner, and last detected access time (time stamp). The handle table holds more permanent information that the system must have when a segment is not present in the physical arena—information such as the segment's selector, owner, swap ID, and state.

The 80286 provides an accessed bit in each descriptor that assists the operating system in choosing which segments can be swapped out or discarded. The hardware sets this bit whenever it accesses the corresponding segment. On the order of once per second, OS/2 examines and clears these bits, and updates the physical arena time stamps for each accessed segment. When physical memory becomes scarce, OS/2 builds a simple ordered list of the segments, with the oldest time stamps first. This list is rebuilt when it is exhausted (all its entries are discarded or swapped) or when significant physical arena changes take place.

The compactor uses the handle table and owner to modify the descriptor and handle states of segments that it moves, swaps, or discards. When a segment is not present, the handle state tells whether the segment is swapped, discarded, AOD, or in transition (being swapped or moved), and part of the handle table's address field is used to identify the owner. If the segment is swapped out, the address field also contains the swap ID. A swap ID indexes the swap control table

continued

(SCT), which tells where the segment is located in the swap file. When the state of a segment is discarded or AOD, the system uses the owner ID to locate the MTE, which contains information about where to find the segment contents.

When the system swaps out or discards a segment, it moves the segment's owner into the handle table, and the handle is stored in the LDT descriptor's address field. If a descriptor's access is marked "not present," the hardware does not depend on the contents of the address field, which lets OS/2 overlay the address field with the segment's handle.

Dynamic Linking and Sharing

Executable and DLL files have relocation records that encode internal and external references that OS/2 must resolve when it loads the files. Because the system allocates selectors for each segment defined by an executable or library module when a module is loaded, internal segment or far pointer references are not resolved at link time; they must be resolved at load time. Because DLL modules can be individually replaced, all external references to library modules must also be resolved at load time.

Segments can share their virtual addresses, their contents, or both. Each LDT has separate shared and private selector regions. Selectors that map to descriptors in the private region are called private selectors; those that map to descriptors in the shared region are called shared selectors. Figure 3 graphically depicts the difference between the two.

Private and shared selectors are interleaved to allow for the smallest possible LDT size (see figure 1). The selector type is independent of whether the segment contents are shared; table 1 shows the four possible combinations of shared and private selectors and shared and private memory.

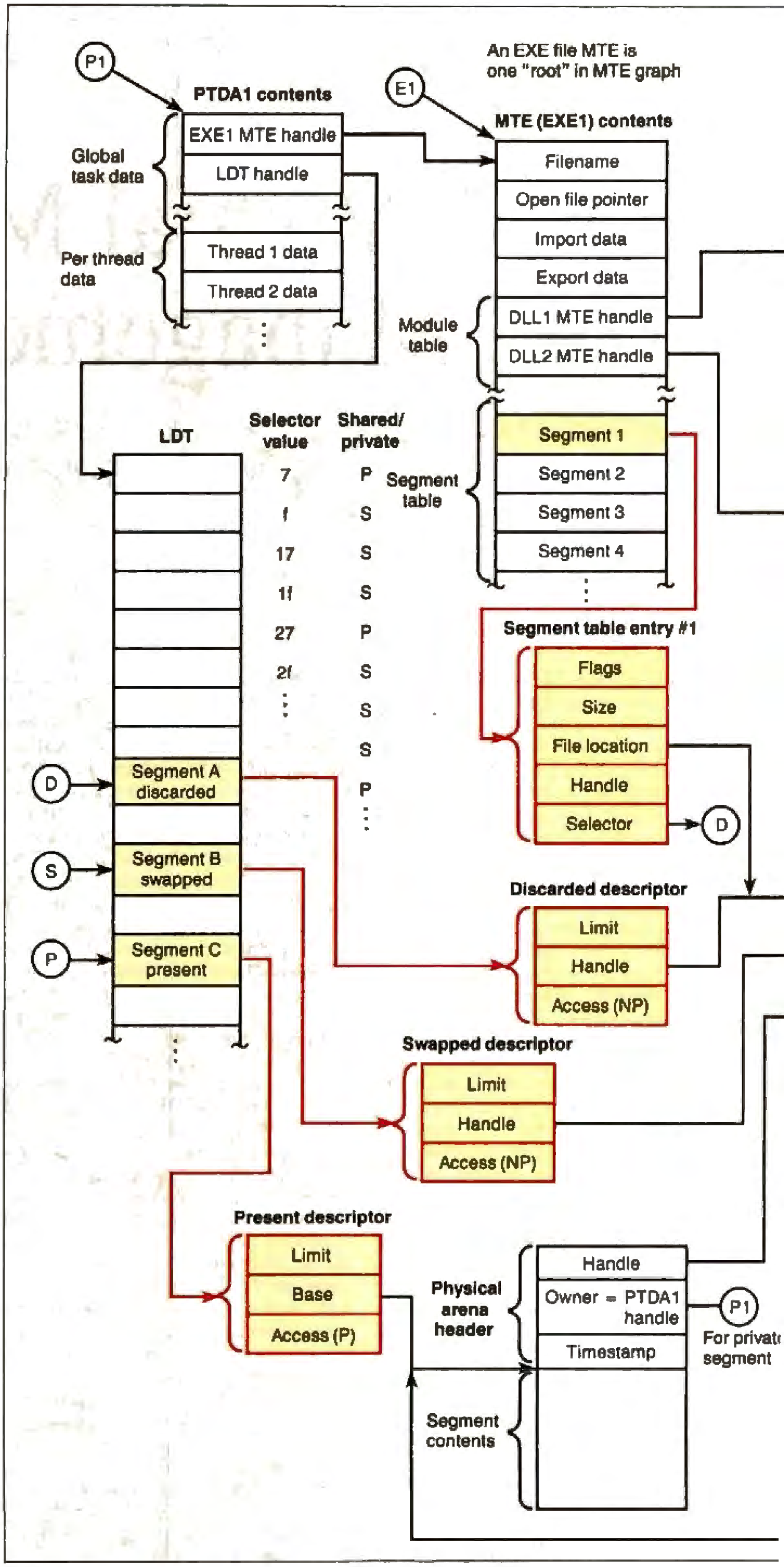
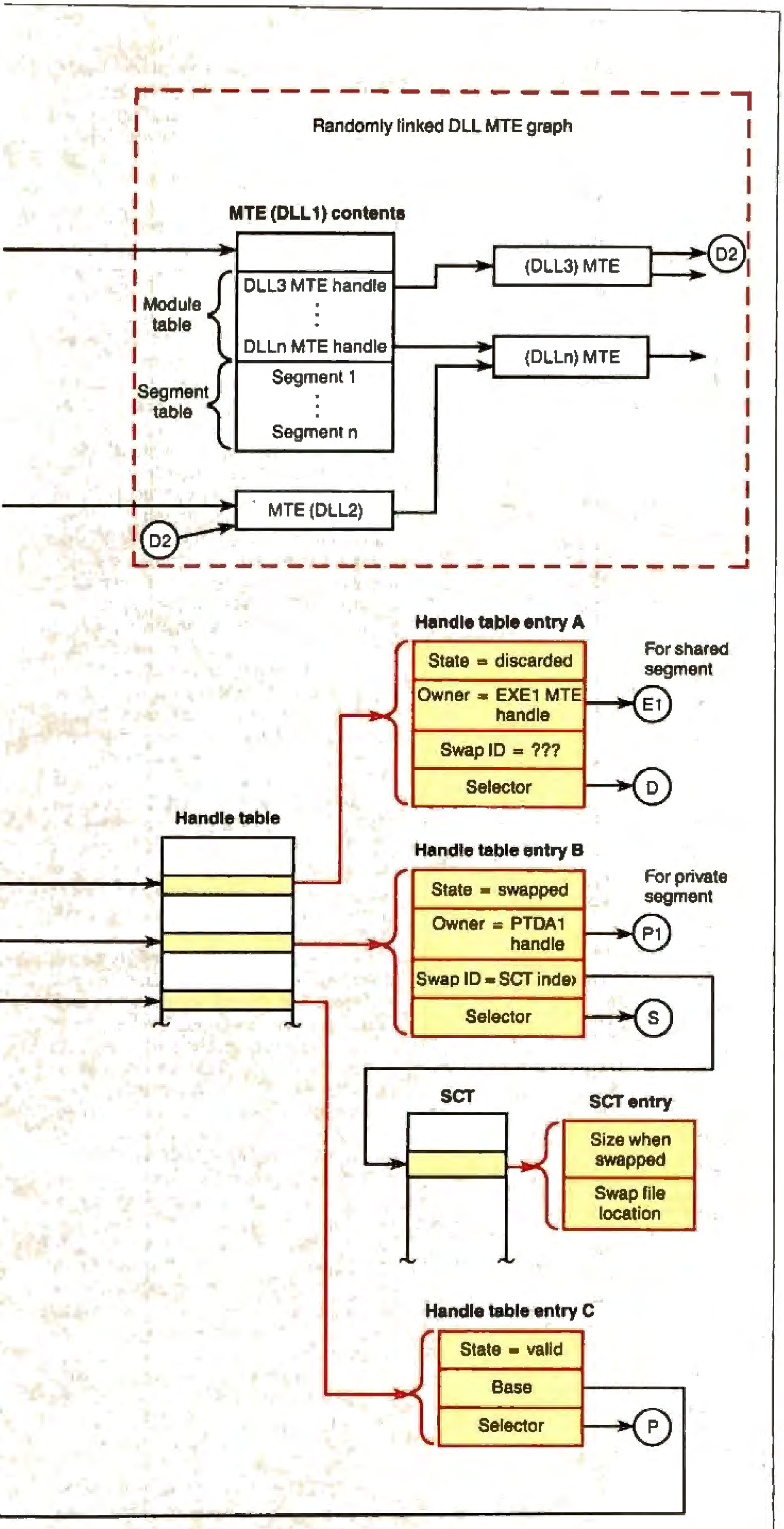


Figure 1: *The hardware and software data structures that OS/2 uses. This example shows the state of three segments in the task EXE1. Segment A is an example of an EXE file code segment that is currently discarded. Notice it uses a private selector, and the handle table entry shows that segment A's owner is EXE1's MTE. Segment B is currently swapped to disk and has a shared selector. The owner of segment B is EXE1's PTDA. Segment C is present in memory and has a private selector. Since it is present in memory, its physical arena header points to its owner, EXE1's PTDA. Notice the shared and private segment descriptors are interleaved in a 3-to-1 ratio.*



Private, dynamically allocated data segments also use private selectors and private memory. Shared, dynamically allocated data segments (both named shared and unnamed shared) use shared selectors and shared memory to let an application dynamically attach to shared segments.

When the system allocates a shared selector, the corresponding descriptor is reserved in all tasks for the purpose of mapping a single segment. Shared selectors are always used for library module segments, because an application can dynamically attach to any library module. If the library module is in memory, its selectors have already been allocated, and they must be available in the caller's context to map the library's segments.

OS/2 uses private selectors for all of an executable module's segments. If shared selectors were used, large numbers of shared selectors would be reserved. Since a task can attach only to an executable module while the task is being created, OS/2 can guarantee allocation of specific private selectors, because the LDT starts out empty.

To show why an executable file must use private selectors, consider an executable file that contains 100 segments and uses shared selectors: When this executable file is active, 100 shared selectors would be reserved in every task's context, including tasks that do not (and cannot ever) reference the executable file. When new segments that require shared selectors are created (i.e., another executable file is added to the system), numerically greater selectors must be allocated, which results in the growth of every LDT that contains a reference to the new segments. LDT memory waste would increase with each executable file in use.

Executable and library module code segments always share their contents. You can declare data segments at link time as private or shared. If a segment is shared between tasks, the system duplicates the LDT descriptor contents among all tasks that reference the segment, and only one handle and physical memory segment exist for the segment. If a segment's contents are private, the system loads a new copy of the segment for each referencing task. The segment's contents may vary from one task to another over time, but each task's copy is referenced using the same selector value and has the same initial contents and size.

The owner ID of a private segment is the handle of the task's PTDA, so that when a segment's state changes, the single appropriate descriptor can be easily found and updated. The example in figure 1 shows that the owner field for the

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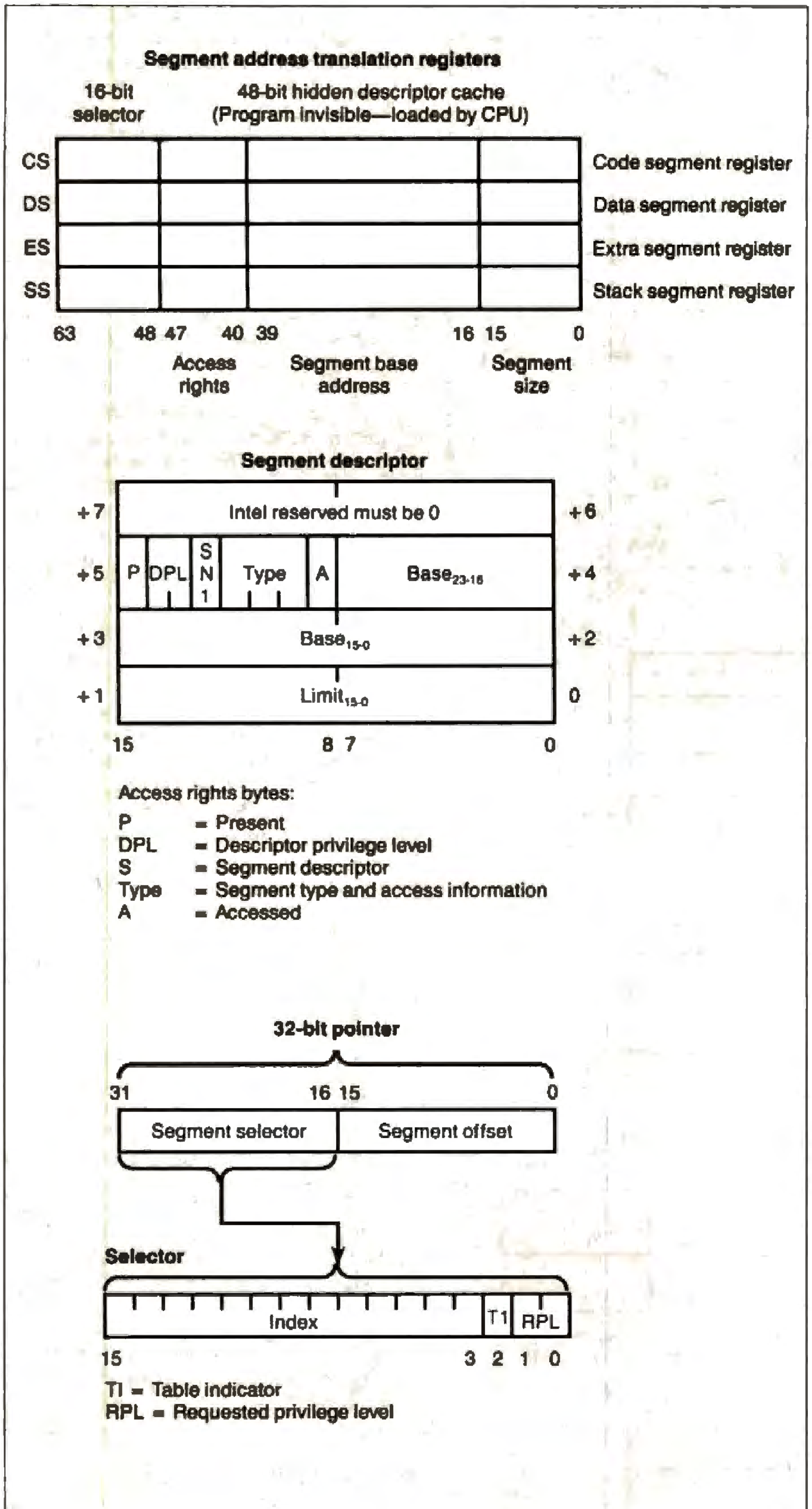

Figure 2: *The 80286 hardware structures work together to provide memory protection. The action of loading a segment selector into a segment register causes the 80286 to use the selector to index into the LDT and use the corresponding segment descriptor for limit and access checking.*

two private segments points to the task's PTDA; the owner for the discarded segment can be found in the handle table entry A, while the owner for the present segment can be found in the physical arena header.

The owner ID of a shared program or library module segment is the handle of the module's MTE segment. The PTDA cannot be used as the owner because multiple LDTs can reference the same shared segment. One descriptor in each LDT must be examined to see if it maps the same segment prior to performing descriptor updates. For the shared segment in handle table entry A in figure 1, the owner field points to the EXE1's MTE.

When a shared segment changes state, the system must find and update all descriptors that map that segment. To avoid the overhead of maintaining an additional data structure to enumerate the tasks that reference each shared segment, the system examines the appropriate descriptor in each LDT to see if that segment is being referenced. It then updates each descriptor that matches the search criteria.

Private segments may be allocated because of an executable or library module segment definition, or they may be dynamically allocated via a system call. Since the hardware does not support simultaneous read/write/execute access via a single LDT selector, OS/2 allows an LDT code alias selector to be created to execute code in private data segments (non-"huge" data segments only). You can use this feature to support efficient video display raster operations needed by graphics software.

Two additional types of dynamic shared memory are also available: named and unnamed shared segments. Named shared segments, allocated via a system call, allow communication between tasks that don't already share program or library references. Unnamed shared segments (also allocated via a system call) let the caller specify any combination of GIVE, GET, and DISCARD attributes.

If a segment has the GIVE attribute, any task that has access to the segment can give another task access. If a segment has the GET attribute, any task can obtain access if it knows the shared selector reserved for the segment. Finally, if an unnamed shared segment is allocated as DISCARDable, the user can change the segment back and forth between swappable and discardable. When discarded, any data stored in the segment will be lost. The application is responsible for being able to re-create the data (if necessary).

One use of discardable segments of this type is to store video display data that is

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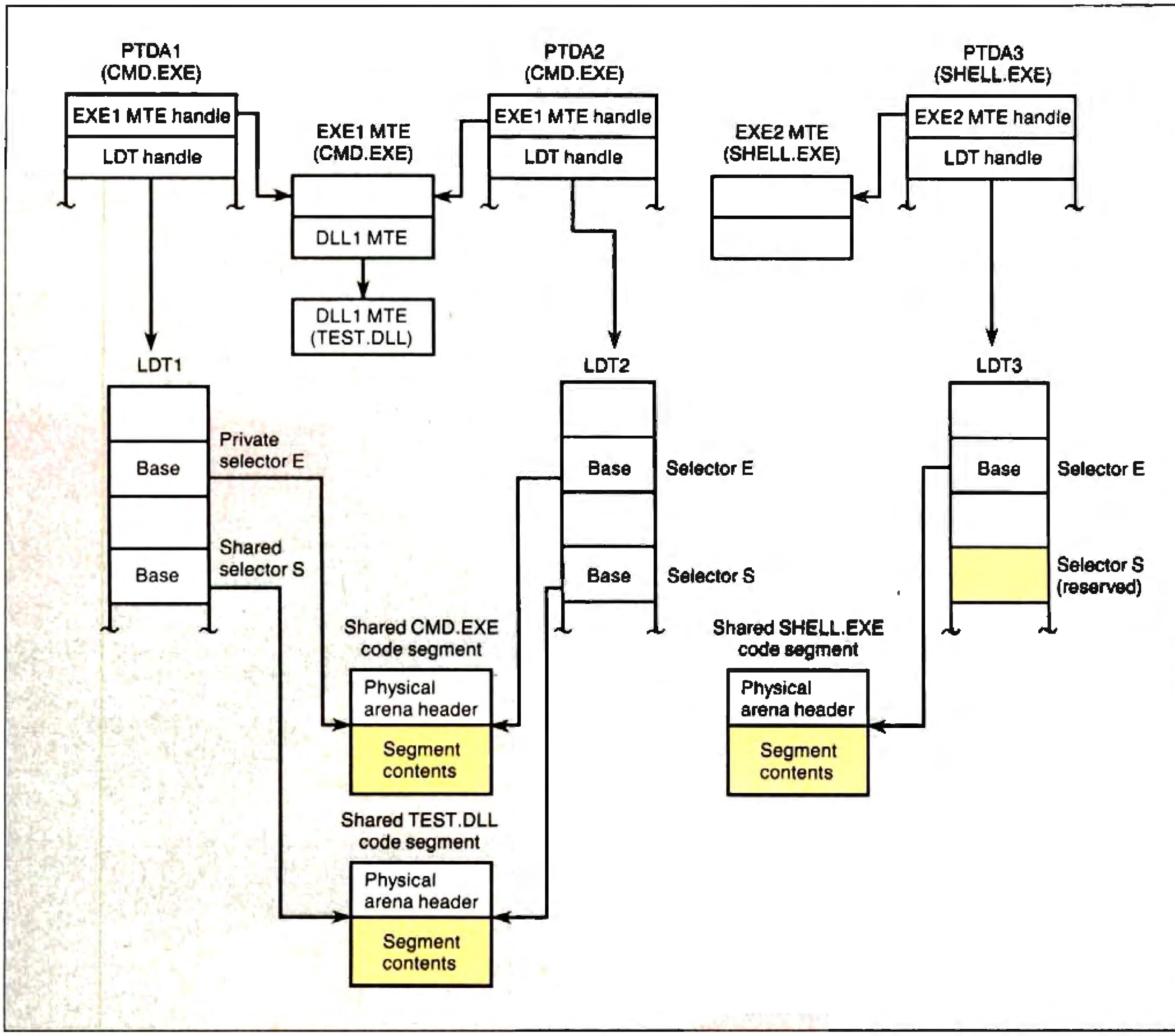

Figure 3: *The difference between private and shared selectors. Private selector E maps the same shared (code) segment for all invocations of an executable file. Other tasks may use selector E for other purposes. Shared selector S maps the same shared (code) segment for all tasks attached to the TEST.DLL dynalink library. Shared selector S is reserved for the TEST.DLL segment; other tasks cannot use selector S for any other purpose.*

Table 1: *Four combinations of shared and private selectors and shared and private memory are possible.*

Selector	Memory	Origin
Private	Private	EXE file private data segment
Private	Shared	EXE file code or shared data segment
Shared	Private	DLL file private data segment
Shared	Shared	DLL file code or shared data segment

temporarily overwritten and restored. If the system discards the display data due to low-memory conditions, you can always recreate it. If the video data is still available when needed, you can easily and quickly update the display.

Since many data structures are much larger than the 64K-byte segment size supported by the 80286, OS/2 provides for "huge" segment allocation. This is made up of an array of individual segments; all but the last in the array are exactly 64K bytes in length, and consecutive segments are addressable by adding a constant increment multiple to the selector of the first segment.

The constant to be added to the base selector is available to an application through a special dynamic-link reference. High-level language support for huge pointer manipulation is available that makes use of this constant; the value of the constant can change, so it should never be embedded in an application. This is the only case where an application can perform arithmetic on selector values.

Consecutive full-size data segments with consistent attributes that appear in a program or library module will be treated as adjacent huge subsegments. You can also allocate private and unnamed shared memory as huge segments.

When loaded from nonremovable media (e.g., a hard disk), the system always makes program and library module code segments discardable. Since these segments cannot be modified, you can restore their contents at any time by reading the program or library module file and performing any necessary relocation fixups. Program and library module writable segments and most run-time allocated segments are made swappable, since their contents may have changed from when they were initially loaded.

Some dynamic allocation requests result in allocating segments not present in physical memory. When the application first accesses the segment, the system allocates the memory. This is done when huge segments are allocated, to avoid unnecessary swapping when allocating enough memory to completely satisfy the huge allocation request.

The total of free, discardable, and swappable memory must always be large enough to let at least one task at a time reload enough segments to execute. Fixed and locked segments can reduce this total. The system performs overcommit accounting to ensure that a demand load request can be satisfied at any time. (Overcommit accounting is the allocation of more virtual memory than can be stored at once in the available physical memory.) Fixed allocation and long-term lock requests will fail if the resulting total of free, discardable, and swappable memory would be too small to reload one task's currently referenced segment.

The system swaps segments to a data file, which cannot always be grown at the time of a swap-out request; the disk space may not be available. The system must keep the swap file large enough to handle swapping out a predictable amount of memory, in advance of the need. To accomplish this, the system grows the swap file whenever it allocates new swappable segments. If a growth attempt fails, it refuses the new segment allocation request.

Some Tips on Usage

All system services are referenced via dynamic links to library modules. OS/2 kernel code supports some services directly, while others are part of bona fide library modules. A programmer references a system service as if it were a normal far procedure call with the Pascal calling convention (the callee cleans parameters off the stack). Having a consistent procedure-call interface makes system services directly available to assembly language programs and several high-level languages, including Pascal, FORTRAN, and C, assuming a small amount of compiler support for the latter. The linker recognizes a dynamic-link definition in a provided library, and it turns the reference into a relocation record processed at program load time to resolve the final virtual address.

OS/2 kernel code supports some services directly, while other services are part of bona fide library modules.

It is best to minimize the number of individual code and data segments. This is because segment allocation requests are rounded up to the granularity of the physical memory manager (32-byte multiples), and because additional memory is consumed for LDT descriptors, handles, and physical arena headers. You must separate program and library module shared and private data, so one type of data should be eliminated if it can be done without compromising the rest of the module. Reducing or eliminating library module private data is particularly useful because the effect is multiplied by the number of processes attached to the library module.

It is also helpful to put nontrivial initialization code and data into segments separate from the main code and data. Explicitly freeing these segments after initialization will release valuable memory or swap-file space if swapping is disabled or if the module is loaded from removable media. Also, rarely used code should be put into separate segments. This will reduce overall memory requirements because only the most frequently used portions of the program will be in memory. ■

Vic Heller is the lead technical system software engineer for OS/2's virtual memory manager at Microsoft Corp., Redmond, WA.

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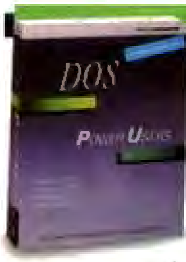

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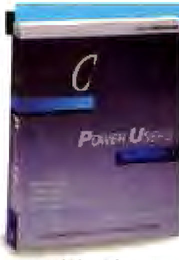

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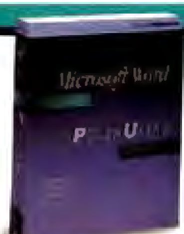

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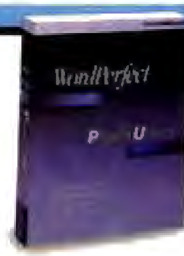

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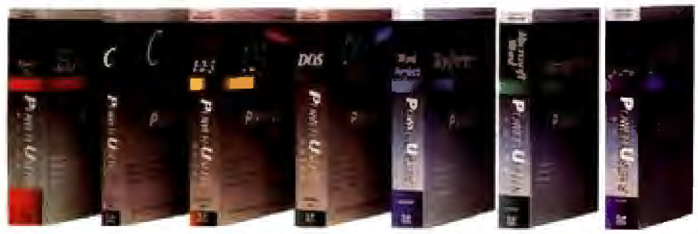

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Marrying Unix and the 80386

How a Unix kernel design takes advantage of the 80386's memory management hardware

Carl Hensler and Ken Sarno

A CRITICAL ISSUE in designing a multitasking operating system such as Unix is how to protect the programs that are sharing system memory. This is called memory management. The Unix executive program, called the *kernel*, solves the memory protection problem by giving each program its own virtual address space. The memory management hardware and software must map the virtual address space seen by a program into the physical memory that has been allocated to the program, and must prevent access to memory that has not been allocated to it.

The Intel 80386 processor provides powerful, flexible, and extremely fast memory management hardware that makes implementing Unix relatively easy. It provides paged virtual memory with all the segment translation and protection architecture of the 80286 and can execute in a 16-bit mode to maintain backward compatibility with 80286 versions of Unix.

In virtual 8086 mode, the 80386 emulates the 8086, making it possible to run MS-DOS programs under Unix. In the standard 32-bit mode, segments can be made so large that only one segment is needed, simplifying programming and eliminating cycle-wasting segment register loading.

How can the 80386's memory management hardware be best used in a Unix kernel? We will discuss a series of design issues and the alternatives. The design we describe is not identical to any existing implementation of the Unix kernel on the 80386, but it is quite similar to the ones with which we are familiar.

However, before leaping into kernel design, let's briefly review the multistep process through which an 80386 translates a program's virtual address into the corresponding physical memory address.

Address Translation

A virtual address generated by instruction fetching or execution is translated by segmentation hardware into a 32-bit, intermediate *linear address*, which is in turn translated by paging hardware into a 32-bit physical memory address, as shown in figure 1.

In the 80386, a virtual address has two components: a segment register specification and an offset in the memory segment described by the segment register. A virtual address is translated into a linear address by adding the offset component to the segment base value in the specified segment register.

Pages are 4096-byte memory units, and *page frames* are pages of physical memory. The processor's page directory base register (PDBR) points to the *page directory*, entries in the page directory point to *page tables*, and entries in the page tables point to pages of physical memory. The page directory and the page tables are each one page in size, and each contains 1024 4-byte page table entries (PTE). A PTE contains a page frame address and some page attribute bits.

The processor translates a linear address by breaking it into directory, page, and offset fields. The 10-bit directory field is used as an index into the page directory to select a PTE that points to a page table. The 10-bit page field is used as an index into the page table to select a PTE that points to the page that contains the linear address. The 12-bit offset field is combined with the address of the page to form the physical address.

Thus, each entry in the page directory maps a 4-megabyte (1024 × 4096 bytes) section of the linear address space to a page table, and each entry in a page table maps a 4096-byte section to a memory page, as shown in figure 2. Note that the mapping between virtual and physical addresses can be changed incrementally by changing a PTE, or it can be changed completely by loading the address of a new page directory into the PDBR.

Page Faults

Each PTE has a *present bit* that indicates whether the entry can be used for address translation. If the present bit is not set in a PTE when it is used for translation, execution of the instruction that caused the translation is terminated as if it had not begun; the address that was being translated is put in a register where it is accessible to operating system software; and a page fault exception is generated.

The software that handles the page fault exception can correct the fault by allocating a page frame, loading the appropriate data into the page frame, putting the page frame address into the PTE, setting the present bit, and returning from the exception to the instruction that caused the fault. This time, the present bit is set and the translation succeeds. The ability to correct page faults by

continued

allocating a page that was not present and then restarting the instruction is essential for implementing demand paging.

Memory Protection

The 80386 provides memory protection during segment and page translation. The processor runs at a *current privilege level* that is compared to the privilege levels of segments and pages during address translation. The processor completes a segment or page address translation only if it is running at a current privilege level as high as that of the segment or page. Unix runs at two privilege levels: a lower level when running user programs, and a higher level when running the kernel.

In addition to privilege restrictions, the 80386 checks segment offsets against a segment limit in the segment register to verify that the virtual address is within the segment's boundaries. Segments and pages can be marked read-only, so that they are protected from writing. Unfortunately, read-only protection for pages works only when the processor is running at user level. Read-only protection for pages is ignored at kernel level.

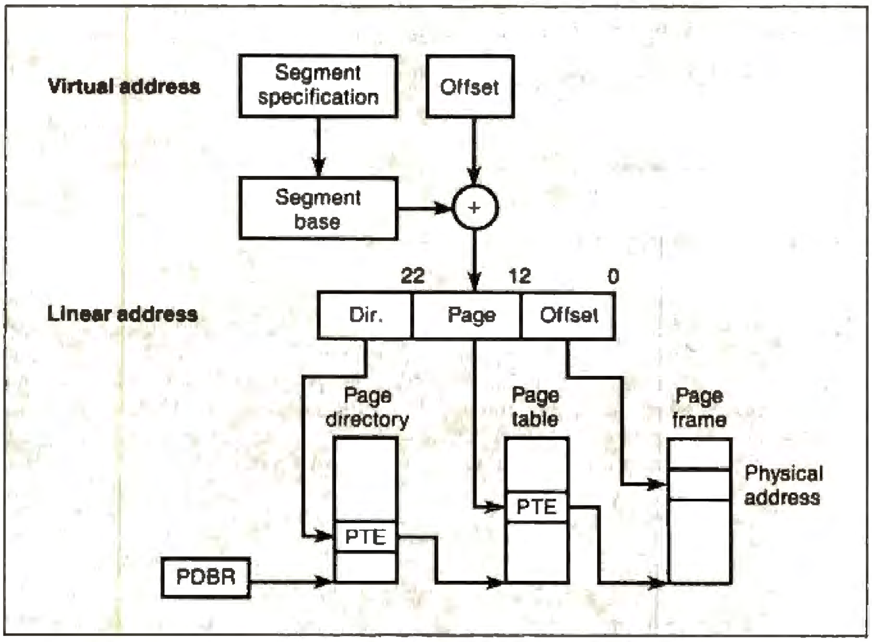

Figure 1: *The 80386 uses segmentation and paging to translate a virtual address into a physical memory location.*

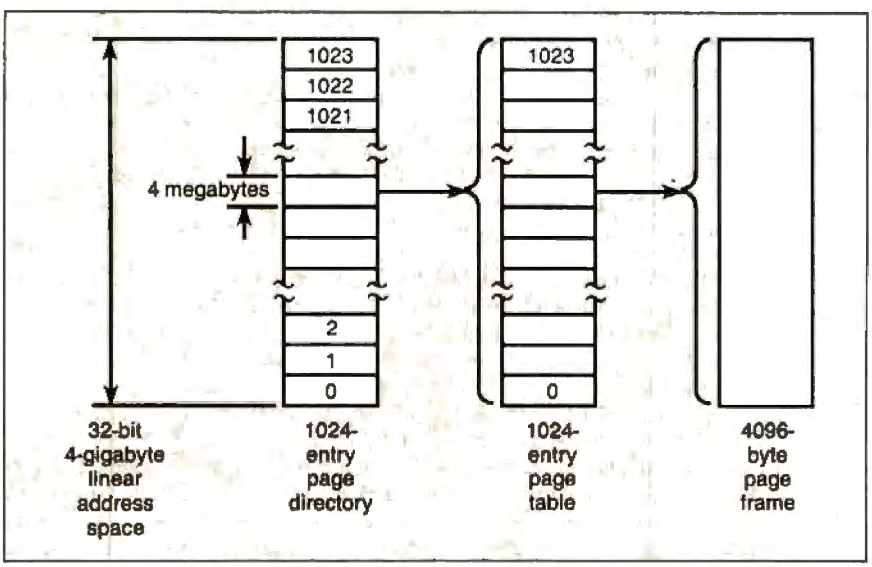

Figure 2: *The 80386's page translation uses page directories, page tables, and page frames.*

Segmented versus Nonsegmented Addressing

There are two addressing models, segmented and nonsegmented, that can be used on the 80286 and 80386. The segmented model allows a program to use many segments. Before a program can access a variable, it must load a segment register, unless it knows that a register already specifies the segment that contains the variable. This means that a C language pointer variable must include both a segment selector and an offset. Dereferencing a segmented pointer is very slow on the 80286 and 80386 because the selector must be loaded into a segment register, and loading a segment register takes 8 times longer than loading a data register.

The alternative is the nonsegmented model, in which a program uses only one segment, and virtual addresses are simply offsets in that segment. All the segment registers have the same segment base and limit and are never reloaded while the program is running. This limits the program size to the maximum segment size, but the maximum segment size on the 80386 is 4 gigabytes, the full 32-bit linear address range.

Thus, we can use the faster nonsegmented addressing model and still have an address space much larger than the amount of memory that could be installed in any contemporary computer. This is the simplest and most efficient way to use the 80386, and our design will assume it.

A special case of the nonsegmented model on the 80386 is the *flat* model, which uses segments that have a segment base value of 0. Since offsets are added to 0 to produce linear addresses, virtual and linear addresses are identical in the flat model, and segmentation becomes invisible unless we use segment limits for protection. This simplifies some things, and both 80386 Unix kernels with which we are familiar use the flat model.

Separate or Combined User and Kernel Address Spaces

A Unix process is the environment in which a user program runs under control of the kernel. A process runs in either *user mode* or *kernel mode*. When user program instructions are being executed, the process is in user mode and can access only the memory allocated to the user program. It cannot access memory allocated to another process or to the kernel.

When kernel program instructions are being executed to provide a service for the user program, the process is in kernel mode, and it has access to both the user program's data and the kernel program's data. A process switches from user mode to kernel mode when it requests an operating system service, and it switches back to user mode when the service has been performed.

Our first design issue is whether to separate the user and kernel mode linear address spaces. It is possible to run the user program and the kernel in entirely different linear address spaces, so that the user program could not possibly access the kernel's memory. This would require having two different page directories for user and kernel modes, and making the transition from user to kernel mode through a *task gate*, because that is the only way to get a new page directory base pointer loaded automatically.

The simpler and more efficient solution is to have a single linear address space that is shared by both the user process and the kernel. Most of the linear address range is reserved for the user program, and only a small part is used by the kernel. Thus, a process can use the same page directory in user mode and kernel mode, and it can switch from user to kernel mode without reloading the PDBR. When you have 4 gigabytes to play with, taking a small fraction of it away from the user program is a small price to pay for simplicity.

Who's on Top?

The next issue is how to divide up the linear address space. The kernel could be at the lower end or the higher end of the linear address space. This issue is decided for you if you wish to be able to use the 80386's *virtual 8086 mode*, which lets you run 8086 programs in protected mode, and thus run MS-DOS programs under Unix. In this mode, the 8086's 1-megabyte address range is translated to the low end of the linear address space, bypassing the usual protected-mode segment translation. If we want to be able to use virtual 8086 mode, we must therefore put the user program at the low end.

If we do not care about virtual 8086 mode, we might choose to put the kernel at the low end of the linear address space because then we could run the kernel without page translation enabled during start-up. However, the implementations with which we are familiar both place the kernel at the high end, and we will assume the same arrangement here.

User and Kernel Segment Layout

Now we must decide how to lay out the user and kernel segments. Since the user program is at the lower end of the linear address space, we base the user segments at linear address 0, and we set their limits so that they do not extend into the kernel's part of the linear address space.

continued

This protects the kernel from user programs without using page protection.

We can base the kernel segments at 0 so that they overlap the user segments, or we can base them at the linear address at which the kernel starts so that the segments do not overlap. If the segments overlap, we run the risk that a bug in the kernel code will accidentally access a location in the user program without causing a protection exception.

Thus, from a protection standpoint, it is better to keep the segments separate, but it is simpler and more efficient to base them all at 0, so that a piece of data in the user program is at a kernel virtual address that is the same as the user virtual address. Then, when a user program passes an address in a system call to the kernel, the kernel can access that address without loading the user data segment selector into a segment register.

Kernel Sections

How is the kernel's part of the linear address space to be mapped to physical memory? The kernel has three sections that use fundamentally different page mappings:

- Statically mapped physical memory.
- Dynamically allocated kernel memory.
- The U area.

The kernel text and static data are loaded from the kernel executable file during Unix start-up. They are typically loaded as contiguously as possible into low physical memory by the boot loader, though the hole between 640K bytes and 1 megabyte on AT clones presents an obstacle. Thus, the lower end of physical memory contains the kernel code and static data.

It is convenient if all physical memory is mapped into the kernel virtual address space so that the kernel can get to any of it without changing page tables. One or more page directory entries and page tables can map the low end of the kernel's section of the linear address space to all physical memory. This maps the virtual address range of the kernel's code and static data into the physical memory address range in which they are loaded, and also gives the kernel easy access to all physical memory. The virtual address of a byte of physical memory is its physical address plus the base linear address of the kernel.

Usually, most of the memory needed by the kernel for its own internal use is statically allocated at the time the kernel is linked. In addition, the kernel must be able to dynamically allocate pieces of memory for its own use. Since the page frames of physical memory that are free for allocation at any point are unlikely to be adjacent in memory, the kernel must be able to map a contiguous section of its virtual address space, of the size needed, into randomly located pages. This means that the kernel must have one or more page directory entries and page tables it can use for mapping dynamically allocated memory.

The U area, which contains the kernel stack and process information that is needed only when a process is running, is mapped into the kernel address space at a fixed location. When the kernel switches from one process to another, it changes the mapping of the virtual U area to the physical memory that contains the U area of the new process. We can dedicate a page directory entry and a page table to the U area, but this wastes most of the page table, because the U area is probably only one or two pages in size. It is more efficient to map the U area through the first few pages of the dynamically allocated kernel memory section. Then the virtual address of the U area is the base address of the dynamically allocated memory section.

So how big a piece of the linear address space should we reserve for the kernel? The biggest potential requirement is for mapping physical memory. Even if we reserve 256 megabytes for the kernel, that is still only 1/16 the linear address space.

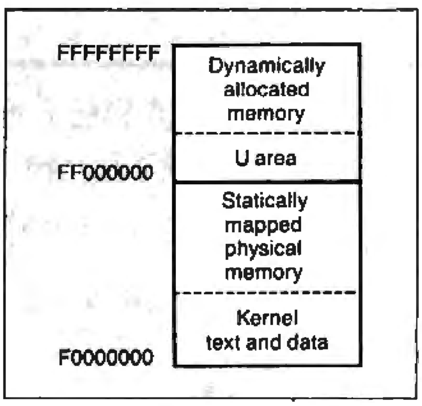

Figure 3: *The kernel's virtual address space.*

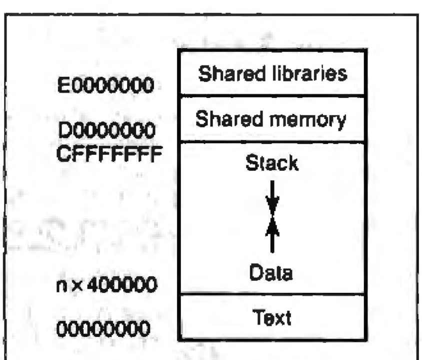

Figure 4: *The user program's virtual address space.*

Figure 3 shows our layout of the kernel part of the virtual address space. All addresses are in hexadecimal. The kernel occupies addresses F0000000 through FFFFFFFF. The statically mapped physical memory section takes up most of that, from addresses F0000000 through FEFFFFFF. The dynamically allocated memory area occupies FF000000 through FFFFFFFF, and the U area is at FF000000.

The page table overhead for a typical kernel is minimal. For a machine with 4 megabytes of physical memory, we need one page table each for the statically mapped physical memory and dynamically allocated memory sections. This is less than the page table overhead for a single process.

User Program Sections

A Unix process must have three distinct sections of memory:

- A text section that contains the program instructions and can be shared with other processes running the same program.
- A data section containing static and dynamically allocated data.
- A stack section containing function call linkage and automatically allocated local variables.

In addition, a process can also have an arbitrary number of shared memory and shared library sections. How should these be laid out in the user virtual address space?

A fundamental consideration is that both the data and stack sections can grow in size, and we want to leave room for them to grow. Most applications will use only a small fraction of the 32-bit address space, and most use a lot more data than stack. Yet we want to avoid layout decisions that will interfere with the efficient execution of future applications whose needs we can only guess.

Unix assumes that the data section grows upward toward higher addresses. The 80386 stack must grow downward, because the PUSH instruction decrements the stack pointer. Only the text section is fixed in size. Our layout, shown in figure 4, has the text section starting at virtual address 0, and the data section starting at the next multiple of 4 megabytes above the top of the text.

The gap between text and data is necessary because the two sections are mapped by different page tables, and each page table must be mapped by a different page

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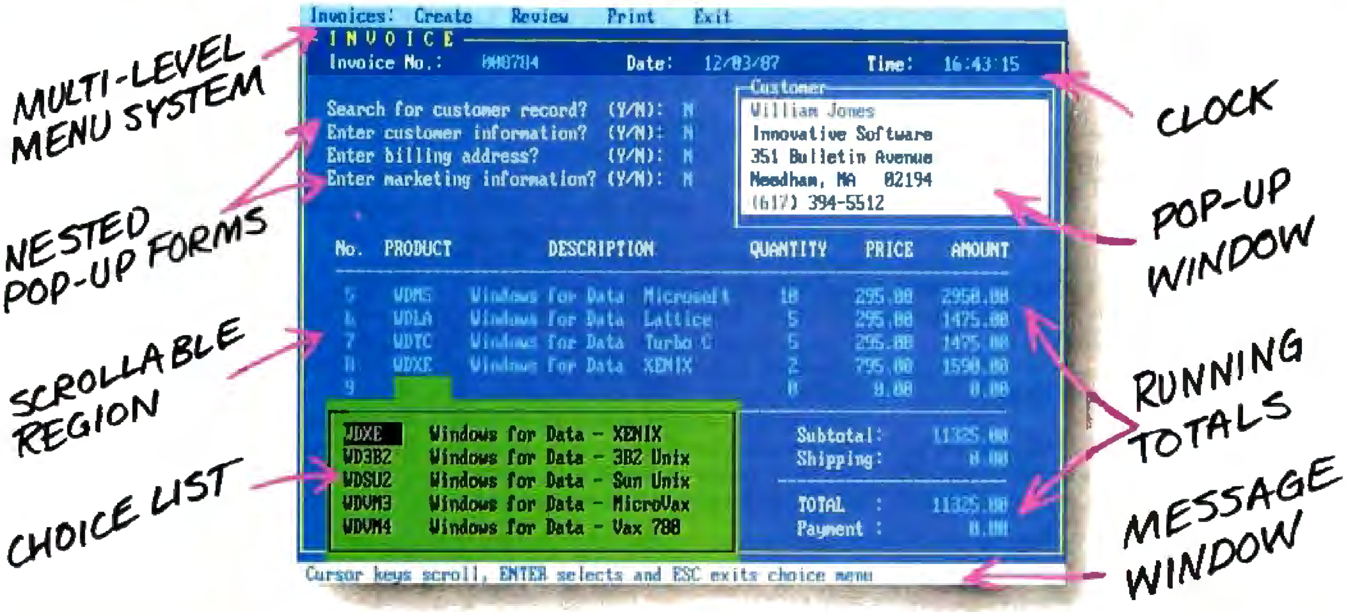

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directory entry. The stack is near the high end of the user address space, so that there is plenty of room for the data section to grow upward and the stack to grow downward.

Exactly where we put the stack depends on where we put shared memory and shared library sections. We can put them between the data and the stack, or we can put them above the stack. There are things to be said for and against both arrangements, and with such a big address space, it is not clear that it makes much difference. In figure 4, we show shared libraries at E0000000, shared memory at D0000000, and the stack starting down from CFFFFFFF.

Memory Management Data Structures

Thus far our design has focused on abstract issues of address space layout. Now it is time to turn to the more concrete task of deciding how to organize the part of the kernel program that manages memory. We have already discussed the basic building blocks: processes, sections, page directories, page tables, and page frames. Figure 5 shows how we put them together.

Processes and Sections

Shared text, shared memory, and shared library sections can all be attached to more than one process. Since a section can exist independently of any single process, information about sections must be kept separate from the process information in the process table and the U area. Thus, we assume that there is a section table with an entry for each section that currently exists.

An entry contains information about the type and state of the section, the number of processes to which it is attached, its size, and a way to find its page tables. Note that page tables are associated with sections, not processes, because the page tables that map a section to physical memory are the same for every process that shares that section, and it would be silly to duplicate them. Since there is only one page directory per process, it is associated with the process.

How do we associate a process with its sections? We must keep in mind that a shared memory section can appear at different virtual addresses in the processes to which it is attached, and it can be attached as either read/write or read-only. Thus, we need to distinguish between information about a section that is the same for all processes that share it, and information that differs among those processes. The former information goes in the section table, and the latter is kept in the process's *process section table*.

This table could be located in the pro-

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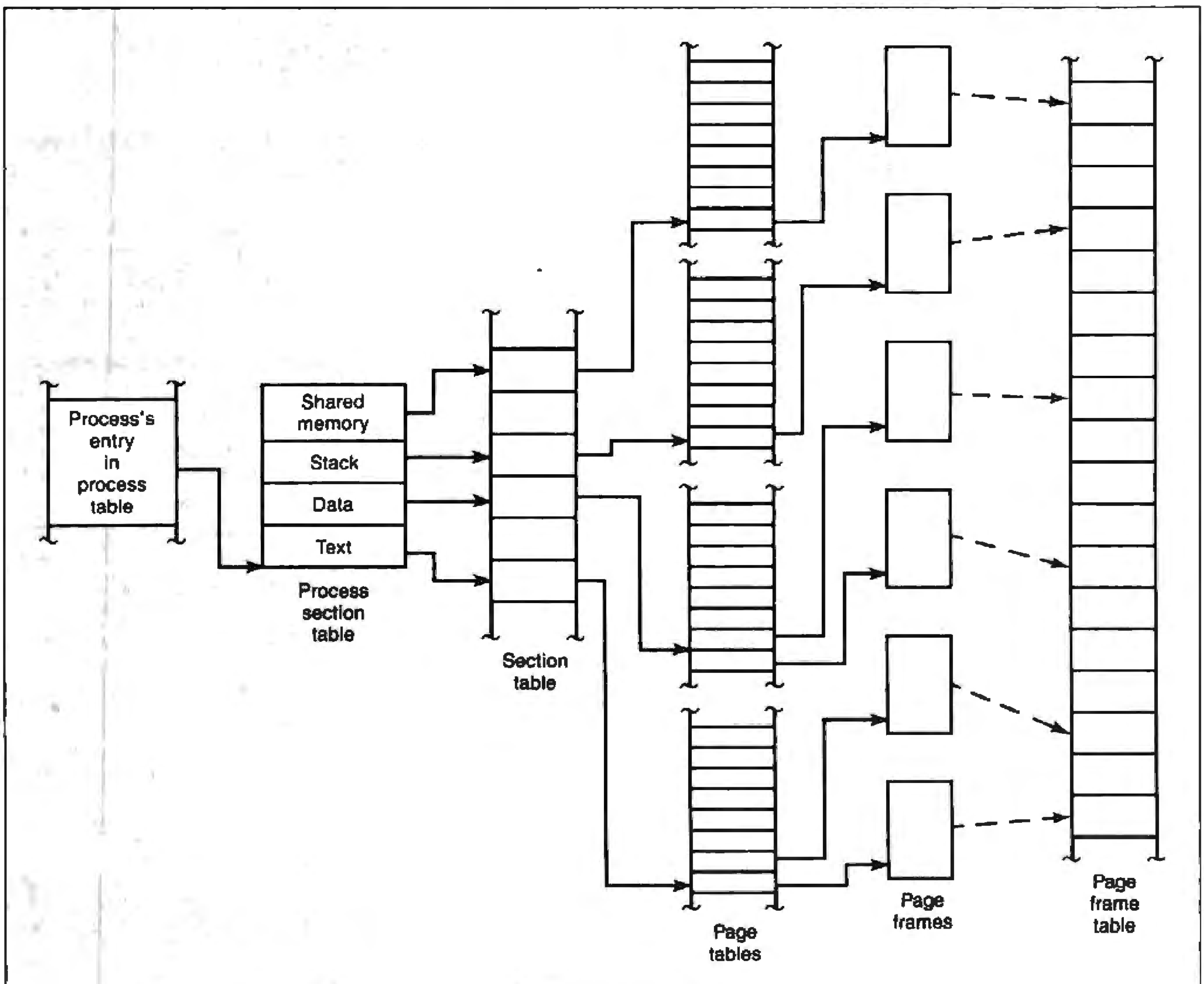

Figure 5: *The entire memory management organizational hierarchy.*

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A process has at least three sections, and unless we engage in some trickery, each has its own page table.

cess's entry in the process table or in the U area, or it could be allocated separately and linked to the process table entry or U area. Each entry in the process section table points to a section table entry.

Page Table and Page Frame Management

It must be possible for a section to map a large virtual address area so that we can run those few applications that use a large amount of memory. Thus, we must be able to attach an arbitrary number of page tables to a section.

However, because a single page table can map 4 megabytes of virtual address space, most sections have only one page table, and that is the case we wish to handle most efficiently. Each section table entry contains the first (and usually only) element of a list of pointers to page tables. Pages for page tables are dynamically allocated as needed.

The page frames at the low end of physical memory are dedicated to kernel code and static data when the kernel is loaded. Page frames above these can be allocated as needed.

Information about these allocatable page frames is kept in a *page frame table* established by the kernel at start-up after it has determined how much memory it has. Page frames available for allocation have their table entries linked on a *free list* so that it is easy to find the next one to be allocated.

Pages in Memory and on Disk

A page of a user program's virtual address space can be in memory, where it is accessible to the program, or it can be on disk, in either an executable file or the page swapping area. If a page is not in memory when it is referenced by the program, the page fault handler allocates a page frame and reads in the page from disk. Both the memory and disk forms of a page can coexist. For example, a text page always has an image in the executable file, even if it is in memory, because text pages are read-only.

Because a page can reside both in memory and on disk at the same time, we must be able to keep track of both of them. The straightforward solution to this problem is to use arrays of *disk page descriptors* that parallel the page tables. Each PTE has a corresponding descriptor that tells whether the page is on swap, is in a file, or is a demand 0 page. If the page is on swap or in a file, the descriptor specifies where it is on disk. A demand 0 page is cleared to 0s when it is allocated, and it has no image on disk. Demand 0 pages are used for uninitialized data, the stack, and dynamically allocated memory.

The trouble with the disk page descriptor solution is that it increases the page table overhead. A process has at least three sections—text, data, and stack—and unless we engage in some complex trickery, each has its own page table. On a processor with 512-byte pages, this would be only 1.5K bytes of page tables per process. But the 80386 has very large 4096-byte pages, requiring 12K bytes of page tables per process. If we allocate a page of disk page descriptors for each page table, which is the straightforward thing to do, we double this already large memory overhead.

The alternative is to put the disk information in the PTE when the page is not in memory, and put it in the page frame table entry when the page is in memory. Using the PTE for both memory and disk information is a bit more complex than the disk page descriptors but uses much less memory.

Page Caching

When a page frame contains data that is also on disk, its entry in the page frame data table shows where its image is on disk. When a page frame is put on the free list, it retains its disk identity until it is reallocated for a different use. If the page with that identity is needed again before the page is reallocated, it can be reused without reading from disk, because it already contains the needed data. Being able to locate a page frame with a particular disk identity is called *page caching*. It improves system performance by avoiding unnecessary disk reading.

Page frames that do not have a disk identity, such as the modified data and stack pages of a defunct process, are placed at the head of the free list when they are freed, and those that do have a disk identity are placed at the tail. That way, page frames that cannot be reused are reallocated first, and those that can be reused are reallocated in least-recently used order.

How It All Works

Now that we have presented our memory management design for Unix on the 80386, let's briefly discuss how it works. When the kernel executes a program, it creates text, data, and stack sections and allocates page tables for them. The PTEs in the text section and in the initialized part of the data section are set up to point to the corresponding pages in the program executable file. The PTEs in the uninitialized part of the data section and in the stack section are marked demand 0.

When the process first starts to run, it immediately accesses the text page containing its entry point, causing a page fault. The page fault handler corrects the fault by bringing in the page of text from the executable file. The first instruction accesses the stack, causing another fault. Stack pages are demand 0, so the page fault handler simply allocates a page frame and clears it to 0s. Another instruction accesses an initialized static variable, causing a fault on a page in the data section, and the page fault handler brings in the data page from the executable file. This process continues until all the pages accessed by the program have been faulted in.

As long as there is enough physical memory so that the pages needed by all the processes can be in memory at the same time, the kernel can run without paging out. But when the kernel runs out of free page frames, it must free some for reallocation. This is sometimes called page stealing.

The prime candidates for stealing are pages belonging to processes that are waiting for events that may not occur for a while, such as a keystroke at a keyboard. If a process is waiting for a "slow" event, it is swapped out entirely. Otherwise, the kernel frees the pages least likely to be accessed again soon.

Text pages, and initialized data pages that have not been modified, can be freed without writing, because their images are in an executable file. Stack and modified data pages must be written out to the swap area on the disk before they can be freed. The PTEs for the stolen pages are changed to point to the pages on disk.

If a page frame is stolen away from a process and reallocated, the page must be read in from disk when it is accessed again. But if the process accesses the page before it is reallocated, the page frame is found in the page cache, and no I/O is necessary.

A Happy Marriage

Unix and the 80386 are a happy marriage. The processor is fast, has a large address space, and provides on-chip memory management that supports demand paging. Everything you need to implement Unix efficiently is there. ■

Carl Hensler and Ken Sarno are software engineers at Interactive Systems Corp., Santa Monica, California.

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Macintosh Memory Management

With the Mac's generalized design, you can use the same software on a Mac 512KE or on a Mac II

Alan Anderson

MOST NEW INVENTIONS in the computer industry are evolutions. When a computer company decides to develop a new machine, the design is usually done within the constraints of the company's existing products, making it harder to come up with something innovative. Why is this? Because the company isn't likely to create a product that can't be used by past customers, who have made a tremendous investment in the older computers with the purchase of software and peripherals. The most recent example of this phenomenon is OS/2, which includes the ability to run MS-DOS applications that were created long before OS/2 was conceived.

Once in a while, though, engineers are allowed to invent a system without having to worry about compatibility. Obviously this is a pretty risky thing to do, but it can produce major leaps in the state of the art. This is what Apple Computer did with the Macintosh in the years before its introduction in 1984. The Macintosh didn't have to run existing software. Of course there were constraints, but they involved the computer's physical size and cost.

Unhampered by software compatibility requirements, the Macintosh designers were free to invent and borrow whatever they wanted to reach the goal of a powerful, easy-to-learn computer. Two parts of the design were improved significantly. The first was the now-familiar Mac user interface of mouse, windows, and icons. The second improvement was internal and involved a generalized system design. An important part of this generalized system is the Macintosh Memory Manager.

Memory Manager Background

Currently, there are seven different Macintosh models (the Mac 128K, the Mac 512K, the Mac XL, the Mac 512KE, the Mac Plus, the Mac SE, and the Mac II), using 68000 and 68020 microprocessors and perhaps having one or more slots. However, thanks to the generalized system design, the programmer's view of all of them is very much the same. Each machine contains a large part of the user-interface routines (called the Toolbox) and operating system in ROM, with additional routines loaded into RAM from a system disk.

The requirements of the Macintosh made it clear that it had to have good control of RAM use. The Macintosh was to be a very busy system: At any time, the screen contains a menu bar, windows, controls like push buttons and check boxes, and other miscellaneous graphic objects. Each object is controlled by a part of the Toolbox—the Menu Manager for menus, the Window Manager for windows, and so on. Each of these managers has to allocate memory for its objects without stepping on the application or its storage. The Memory Manager was created to act as a clearinghouse for memory allocation requests and to keep its clients from overwriting each other.

The Memory Manager also has to handle a large amount of traffic, with new objects being allocated and old ones being deallocated constantly as an application executes. Ideally, the Memory Manager needed a way of ensuring that the free memory opened up between allocated objects as other objects were released didn't go to waste. This was especially true for the Mac 128K, where objects had to be shoehorned into a cramped memory space. To fulfill these design goals, the Memory Manager was given the ability to allocate memory blocks that can be moved around, or relocated, in memory and to deallocate memory blocks as necessary.

The Memory Manager allocates these objects from an area in RAM called a *heap*. Most operating environments use a stack for various purposes: variables, return addresses, and stack frames, among other things. The Macintosh also has a stack, a separate structure from the heap, which it uses for these conventional things. Register A7, the stack pointer, contains the address of the top of the stack. In a typical Macintosh application, the stack contains the program's declared variables, while the heap holds its dynamically allocated objects.

Of course, without any hardware memory management support, there is no way to physically prevent a program from writing anywhere in RAM, but the Memory Manager at least implements an honor-system rule: *Don't use memory unless you get it from the Memory Manager.*

If you get memory through the Memory Manager, it at least knows what part of memory you're using, and this ensures that future memory requests made to the Memory Manager won't affect your

continued

One benefit of the Memory Manager is that programs take advantage of extra RAM automatically.

block of memory. This system works as long as every program obtains its memory through the Memory Manager.

One benefit of using the Memory Manager to allocate memory is that applications can take advantage of machines with more RAM without requiring special code. The result is that many applications originally written for Macintoshes with 512K bytes of RAM automatically can make use of the 8 megabytes of RAM available in a fully loaded Mac II.

Since the Macintosh Memory Manager presents all available RAM as simply a series of blocks allocated through a procedural interface, seeing a memory map of the system isn't vital for most programmers, although it's useful for debugging. So, before I present a memory map, I'll take a closer look at how the Memory Manager operates.

Purgeable and Relocatable Blocks

The Memory Manager employs some elaborate software techniques to make the most of RAM. Memory blocks can be made *purgeable* if desired. The Memory Manager can return purgeable memory blocks to the free-memory pool when space is needed. How is this feature put to work in the Macintosh?

The answer lies in looking at how Macintosh applications are put together. A Macintosh application is a very granular collection of diverse items: pieces of code, text strings, templates for windows and controls, pictures, menus, icons, color information, and much more. Most Macintosh applications are split into many different code segments, each of which can be loaded separately. All these items are called *resources*.

Each resource can be loaded from disk individually. This characteristic is crucial, because it makes resources perfect candidates for purgeable memory blocks. Since each resource is available on disk, it's still accessible if the in-memory copy is purged. The Macintosh operating system also provides a facility for updating a resource on disk if it's altered in memory. Of course, there are some complications: Some resources are so vital that they should never be purged (more on this later). Since the programmer can make any resource purgeable or nonpurgeable, this normally isn't a problem. In practice, only memory blocks that contain resources are made purgeable.

Another Memory Manager feature that makes good use of available RAM is the ability to manage *relocatable* blocks, which are created with the system call `NewHandle` and are deallocated using `DisposHandle`. To get reasonable system performance, all memory blocks that the Memory Manager allocates must be made up of contiguous bytes.

In a system that constantly loads new objects and deallocates old ones, this can cause lots of free-space "holes" to develop in the heap. To alleviate this problem, memory blocks marked as relocatable can be moved, allowing the free blocks to be fused together into a single, larger free space. The Memory Manager moves relocatable blocks only at well-defined times—specifically, only when a request requires a memory block that can't be allocated using the current free space.

This technique also adds some complications. The Memory Manager must make sure that relocatable blocks aren't moved "out from under" an application. That is, if the Memory Manager moves a block of memory that an application is using, it must provide some means for the application to access the block at its new location.

When a program requests a relocatable block, the Memory Manager allocates it, then stores its address (i.e., a pointer to the block) into a private data structure called a *master pointer*, whose address never changes. Rather than returning that pointer to the caller, the Memory Manager returns the address of the master pointer. This value, called a *handle*, is a double-indirect pointer to the memory block. The handle is used with a double dereference to refer to the block wherever a pointer and a single dereference would normally be used.

What happens when the Memory Manager has to relocate the block? After moving the block to its new location, the Memory Manager stores its new address into the master pointer. Remember that the application knows about the block by its handle, which is the address of the master pointer. The address of the master pointer never changes, so the handle to the block remains valid even if the master pointer's value changes. Note that, for this scheme to work, the master pointers must be nonrelocatable. Nonrelocatable memory blocks are created with the system call `NewPtr` and deallocated with `DisposPtr`.

As with purgeable blocks, there are objects that must not be moved. The best instance of this is a memory block that contains active code. For example, the 68000's `RTS` (return from subroutine) instruction relies on an absolute return address that's kept on the stack. Now suppose a routine inside a relocatable block calls another routine with a `JSR` (jump to subroutine). Next, the block containing the calling routine is relocated while the other routine is running. The `RTS` from the running routine will be disastrous since the address on the stack no longer points to the intended block.

To prevent this problem, the Memory Manager can temporarily prevent relocatable blocks from being moved, or *lock* them. The system call `HLock` locks a memory block's position in memory, and `HUnlock` unlocks it. Code that's not part of the current chain of return addresses can be relocated, or even purged, if necessary.

The Perils of Relocation

This scheme of relocatable objects works very well in general, but there are a few problem situations. One scenario to watch out for is calling a routine that expects a pointer and providing a pointer to a relocatable object. The pointer will be valid only as long as a request to the Memory Manager does not trigger memory relocation. For example, let's assume that `myRecord` is a handle to a record: `FarawayProc (myRecord^);`.

This call passes a pointer to the record. Since the record is a relocatable object, it might be moved. If `FarawayProc` contains a statement that allocates memory, either directly or indirectly, it may cause the block containing `myRecord` to move, causing the pointer to become invalid. A reasonable way to avoid this problem would be to use an assignment statement to make a copy of `myRecord^^` into a global variable, then pass a pointer to that variable to `FarawayProc`. This works because global variables are not kept in relocatable blocks. Another solution would be to lock the block that `myRecord^^` points to before calling `FarawayProc`.

You may be wondering why I pass a handle to a global variable rather than simply a pointer (i.e., `myRecord^`), since I'll use a pointer to reference the global variable and thus create a handle to `myRecord`. The answer is that some Pascal compilers may create implicit dereferences (i.e., convert a handle to a pointer) as they optimize the object code. The only defense against problems like this is a thorough understanding of the Memory Manager and your development system.

Let's look at a more subtle—but just as dangerous—situation. In order to optimize an inner loop and prevent unneces-

continued

sary double dereferencing, programmers sometimes perform one dereference before entering the loop. In this example, I'll assume that matHdl is a handle to an array of 500 integers, and I want to initialize each of them to its index value:

```
matPtr := matHdl^; {deference
matHdl}
for index := 1 to 500 do
  matPtr^.theArray [index] :=
index;
```

In this example, the handle is dereferenced and the master pointer is copied into matPtr. If the block is relocated while the loop is executing, I'm in trouble, since in that case matPtr will no longer point to the block. However, blocks are never relocated unless the Memory Manager is trying to allocate a new block. By examining the source code, you can see that no new memory is being allocated within the loop—it's simply storing values. So, this technique is safe to use.

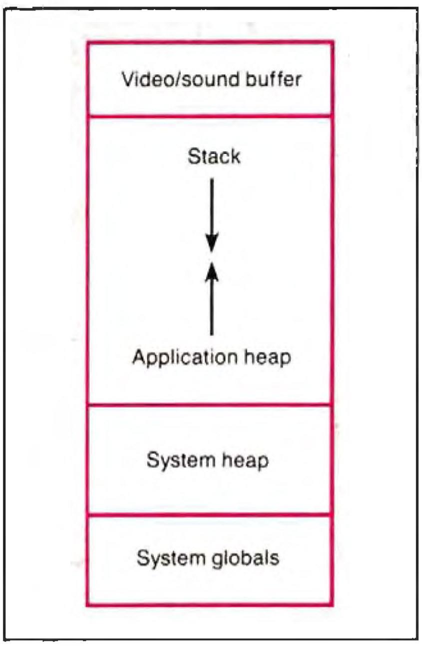

Figure 1: *Memory organization in the Macintosh family. The Macintosh II memory layout is essentially the same, except that the video buffer is located in the NuBus slot space. The application heap is allocated just above the system heap and grows upward in memory, while the stack grows down. The application heap is destroyed each time a new application is loaded, while the system heap and system globals remain intact throughout the operation of the computer. This memory model is valid for any Macintosh running under the Finder.*

What if the loop contains a statement that can cause memory to be allocated, as in the next example?

```
matPtr := matHdl^;
for index := 1 to 500 do
  begin
matPtr^.theArray [index] := index;
DrawText ('Another');    {Trouble!
See below}
  end;
```

This time, the Macintosh ROM routine DrawText is called each time through the loop. Although it's not obvious, DrawText can trigger memory allocation. If the Memory Manager does allocate a new memory object for DrawText, matPtr can become invalid. To prevent problems like this, be sure not to rely on pointers to relocatable objects after using Toolbox calls that can cause memory allocation. *Inside Macintosh* has a list of the ROM routines of this type. The safest technique is to always use the handle and double deference, like this:

```
for index := 1 to 500 do
  begin
matPtr^^.theArray [index]
  := index; {Safe technique...}
DrawText ('Another');  {...since
handle is always valid}

  end;
```

Memory Organization

I've already said that there's a heap and a stack in RAM, so I'll discuss the other important areas of memory (see figure 1). Notice that there are actually two separate heaps, called the system heap and the application heap. The system heap is created as the Macintosh starts up and is never reinitialized. It holds objects that are used exclusively by the system, such as device drivers. By contrast, the application heap is created when an application starts up and is destroyed when the application quits.

Note that the application heap starts just above the system heap. This obviously prevents the system heap from growing further, so it's a fixed size. The application heap, however, has room to grow upward in memory, and the stack can grow downward. The operating system uses a couple of schemes to keep the application heap and the stack from colliding. To avoid collisions from the bottom (the heap growing into the stack), the Memory Manager prevents the heap from growing past a predetermined limit, called ApplLimit.

Restraining the stack is a little trickier, since it grows as a direct result of 68000 instructions, without giving the operating system a chance to intervene. Instead, the operating system frequently checks the stack pointer to see if it has gone below the highest heap address. The routine that performs this check is called the "stack sniffer."

There are two ways to exhaust memory in the Macintosh with this memory model. The first condition occurs when the Memory Manager is unable to find enough memory to satisfy a request by `NewHandle` or `NewPtr`. In this case, the Memory Manager passes an error code to the calling routine and allows the application to respond to the problem in a reasonable manner.

The other out-of-memory condition occurs if the stack sniffer finds that the stack has overflowed into the application heap. Since the damage has already been done in this situation, the Macintosh reports a system error 28 (the infamous "bomb box").

There are two other areas of RAM shown in figure 1. The lowest part of memory, called the system globals area, contains crucial information for the microprocessor, the operating system, and the Toolbox. This area includes the 68000 exception vectors—a table of system routine addresses—and global variables used by all parts of the operating system and Toolbox.

The highest part of RAM on the Mac Plus and the Mac SE is a memory-mapped buffer for video and sound. For the Mac II, the video buffer is physically located on the video card that's mapped to a NuBus slot address range, and the sound buffer is contained in the Apple custom ASC chip, which is also mapped into a different address range. [Editor's note: *For a look at the memory map of the Mac II, see BYTE's* Inside the IBM PCs, *Fall 1987, page 90.*]

The most important rule for using the Macintosh Memory Manager is to try to use relocatable blocks for all heap objects, and to avoid locking them. This allows the Memory Manager to consolidate the free space in the application heap. If you must lock relocatables, be sure you don't allocate any new blocks while another block is locked. If you do, this can fragment the heap temporarily, and the Memory Manager might not be able to find enough free space to fulfill your next request.

Even if you're careful about your relocatable objects, you may still run into some problems. As discussed earlier, code segments have to be locked while they're executing so that the return addresses stay correct. Depending on how your program is segmented, this can lead to a fragmented heap.

There is a two-part strategy for avoiding this problem. First, use the operating system call `UnloadSeg` to make unused code segments purgeable; second, try to allocate all new heap objects from the program's main loop. The main loop is always loaded and is firmly entrenched as one of the first objects in the heap. This will leave most of the heap free of locked segments when new objects are created. Following this strategy will help ensure that new objects have their pick of a heap that's as unobstructed as possible.

For serious Macintosh debugging, you'll get to be pretty friendly with an object code debugger, such as Apple's MacsBug or Icom Simulations's TMON. These programs let you examine memory, display your program's code, and show you what your heap looks like. There are also several books available on the subject to supplement the excellent foundation of knowledge provided by Apple's *Inside Macintosh*.

MultiFinder

The Macintosh world got a lot more interesting last October when Apple released MultiFinder, the first "multitasking" version of the Macintosh operating system. This package of routines gives the Macintosh the ability to open multiple applications at once, with all of them displaying their windows on the screen at the same time. Switching between applications is accomplished simply by clicking on an application's window.

Although MultiFinder can manage up to a maximum of 30 applications, practical use of MultiFinder is limited by the amount of RAM. A Macintosh with 1 megabyte of memory has barely enough memory to manage two typical applications. If you have 4 megabytes of RAM—the maximum RAM available in a Macintosh Plus or SE—you'll probably have enough memory to last you for some time.

One of MultiFinder's most impressive features is that it amounts to no more than a midcourse correction in the Macintosh memory model, and most applications work with MultiFinder without modification. This was no accident, but the result of a lot of work by the MultiFinder team at Apple.

MultiFinder works by creating a separate heap for each application, as well as allocating its own storage space for each application's system global space, microprocessor registers, and other state information. When an application is started under MultiFinder, a predetermined amount of RAM is set aside for the application heap. This amount is read from a `SIZE` resource stored within the application. If there is no `SIZE` resource present,

continued

MultiFinder allocates, by default, 384K bytes of memory to the application.

This multiple-application world changes the memory map, as you can see in figure 2. The most obvious change is that there is now an application heap for each open application. Also, note that the system heap is not necessarily adjacent to the application heap, as it is in the old memory model, since application heaps are now created from the top of RAM down. This created a problem with some existing applications that assumed the application heap was located immediately above the system heap, which was always true under the old memory model. This usually isn't the case under MultiFinder, and an application that makes this assumption breaks under the new memory model.

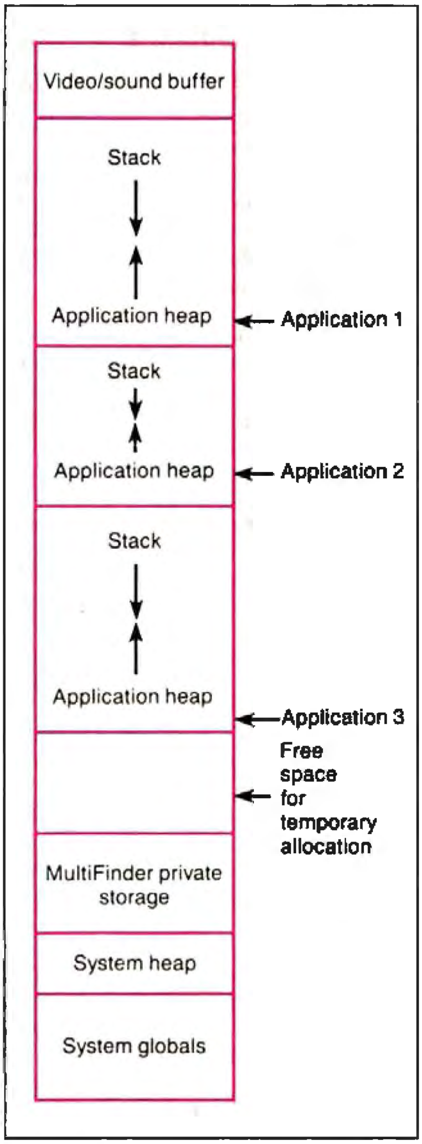

Figure 2: *Memory organization for a Macintosh running MultiFinder. Notice that in this memory model each application is allocated its own stack and heap. The size of each heap is determined from information stored in the application. Application heaps are allocated starting from the top of memory. The MultiFinder private storage area contains the state information for each application.*

Another phenomenon of life under MultiFinder is that there is often a pool of memory that's not allocated to any application—it's just waiting for possible use by applications that may be started in the future. To avoid wasting this valuable RAM real estate, MultiFinder implements the notion of *temporary memory allocation.*

With this scheme, an application can request memory from this free memory pool. Typically, this is done for a modal situation like a file-copy operation, where the extra memory for buffers helps the job go much faster. MultiFinder provides a procedural interface to manage this memory. There are calls named `MFTempNewHandle`, `MFTempDisposHandle`, `MFTempHLock`, and `MFTempHUnlock`. Each of these calls performs the same function as its Memory Manager counterpart, except that the space that's managed is in this free memory pool.

Obviously, the temporary memory idea works only through cooperation and good behavior among applications. There's nothing to stop a single program from grabbing the entire temporary space and not letting go. However, most Macintosh users won't appreciate a single application gobbling up all the remaining RAM in their machines, so it's generally a bad idea to do so.

What's Next?

In the future, Apple will continue down the path started by MultiFinder. This first effort opens the door for more features and stronger services that will complete the transition from a single-task system to a true multitasking environment. However, Apple, its developers, and its customers have a tremendous investment in software. For MultiFinder, its engineers had to be concerned with an installed base of well over a million computers.

The Macintosh has come full circle: Now, it must carefully evolve to its new MultiFinder environment, while still providing compatibility for established users. ■

Alan Anderson has written numerous articles about the Macintosh, Lisa, and Apple III computers for various publications. He is currently a writer/engineer living in Cupertino, California.

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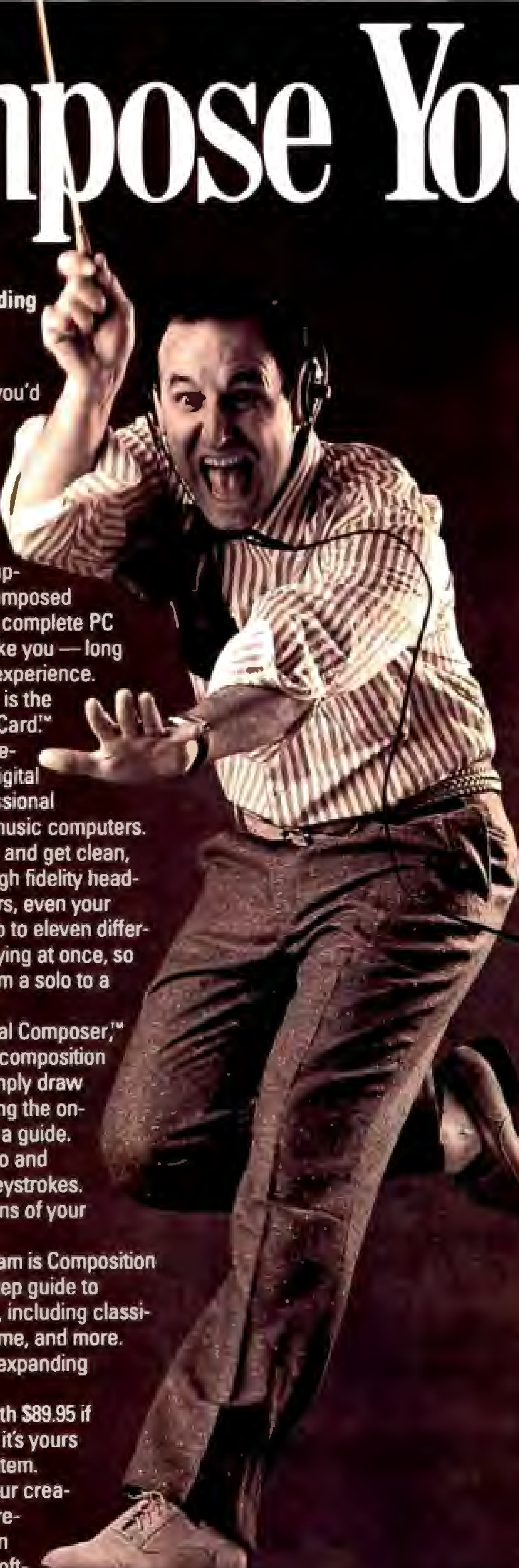

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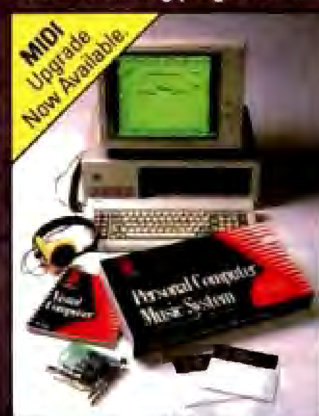

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MEMORY MANAGEMENT
RESOURCE GUIDE

MEMORY MANAGEMENT HARDWARE

Intel Corp.
Literature Distribution
Mail Stop SC6-714
3065 Bowers Ave.
Santa Clara, CA 95051

Fairchild Semiconductor Corp.
Advanced Processor Div.
4001 Miranda Ave.
Palo Alto, CA 94304

Motorola Inc.
6501 William Cannon Dr. W
Austin, TX 78735

Signetics Corp.
Mail Stop 27A
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Sunnyvale, CA 94088

National Semiconductor
P.O. Box 58090
Santa Clara, CA 95052

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Lotus Development Corp.
55 Cambridge Pkwy.
Cambridge, MA 02142

Microsoft Corp.
16011 Northeast 36th Way
P.O. Box 97017
Redmond, WA 98073

Intel Corp.
5200 Northeast Elam Young Pkwy.
Hillsboro, OR 97124

SELECTED READING LIST

These operating system books have sections devoted to memory management issues.

Coffman, Edward G., and Peter J. Denning. *Operating Systems Theory*. Englewood Cliffs, NJ: Prentice-Hall, 1973.

Tanenbaum, Andrew S. *Operating Systems: Design and Implementation*. Englewood Cliffs, NJ: Prentice-Hall, 1987.

Bic, Lubomir, and Alan C. Shaw. *The Logical Design of Operating Systems*. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, 1988.

Two books that describe the Macintosh's handle-based memory manager:

Knaster, Scott. *How to Write Macintosh Software*. Hasbrouck, NJ: Hayden, 1986.

West, Joel W. *Programming with Macintosh Programmer's Workshop*. New York: Bantam Books, 1987.

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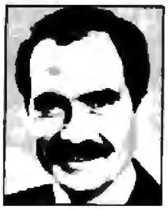

Tech Talk

By Steve Gibson

FEBRUARY 8, 1988

Finding the Ideal Keyboard: One That Won't Throw Spitwads With Its Recoil

You might think that the best keyboard would be the last thing I'd worry about as I was assembling my "dream machine," but it was almost my first concern.

Have you ever stopped to really think about the "feel" of your keyboard? I've long believed that the feel of a computer's keyboard might almost be the single most important aspect of the machine. After all, except for occasional mouse and modem usage, the keyboard is the sole entry point for all of a machine's data. I care tremendously about the feel of the keyboard I'm typing with. I want it to feel just right under my fingers. I want to know from mechanical feedback, without looking, when I've pressed a key successfully. Yet I don't want my biceps enlarged as a consequence.

It's been my experience that most keyboards are utterly horrible, seeming to come only at the far extremes of the scale. Either they just lie there like dead sponges, unresponsive and unreacting, or they fight back tooth and nail, daring you to press the next key. To either extreme I say, "No thanks."

The original IBM keyboard must have been tough to engineer. I can't imagine the mechanical contrivance that was used to induce such a ridiculous snap action underneath such small keys. A keyboard should not be able to launch spitwads across the room with its recoil. Bruised fingertips are not my idea of a typing reward, and it's no fun having to close the windows on a hot summer night for fear of keeping the neighbors awake with the clack-clacking din.

At the other end of the scale we have the ubiquitous sponge-press keyboard. This keyboard dares you to determine whether the computer has sensed your data entry — which is not easy when you sure couldn't sense it yourself. I'm always worried that the keys are just lying there still depressed after I've removed my fingers.

So imagine my joy about a year ago when I stumbled upon a keyboard that knocked me flat (and not from its key recoil). Feeling a bit like Goldilocks, I ran my fingers over its keys. Here was a masterpiece that was neither too stiff nor too mushy — it was just right. It had a marvelous snap action.

Since the company selling this goody was one of those "here today, gone tomorrow" generic Taiwan clone outfits, I purchased seven keyboards on the spot! I was determined never to be caught without one of these beauties underneath me again.

As I proudly carried my collection home, I reasoned that I'd be adding machines over the years, and I needed them all to be outfitted not only with the best feeling keyboard I'd ever had the joy of touching but also with identical keyboards. There's nothing worse than moving to another machine after really getting used to one keyboard only to find that the Esc key has jumped to the other side of the room. Better to have plenty of spares in the garage.

Shortly afterward, the Taiwan-based company from which I'd purchased my keyboards stopped carrying the one I loved, and then it stopped carrying anything.

Well about two months ago I received a call out of the blue from a crazy-sounding guy identifying himself as the president of Northgate Computer Systems. Art asked if I was aware of his ads in the back of *InfoWorld*, and he was a bit peeved when I said, "No, not really." So he made me turn to the back of *InfoWorld* to take a look.

"Oh yeah, that's the ad with the tactile snap action diagram," I said. Art said this was the most incredible keyboard on earth and that he was going to send me one because he could tell from reading my column that I was a "touchy feely" kind of guy.

I warned him about me and keyboards. I told him about my inventory of spare keyboards in the garage, and I said that *nothing* would move me away from these beauties since there was no way to improve upon what I already had. Art was not swayed. He told me about celebrities who were using his keyboard and said he had lots of congratulatory letters, and it was simply the best keyboard anywhere. "Boy, this guy is a pain," I thought. I shrugged and told him to send it out but that I couldn't promise anything.

When it arrived, my curiosity took over. Imagine my surprise and delight when I found myself facing my dream keyboard, exactly like the four I still had in my garage! If you want the best keyboard I've ever had my hands on, check out Northgate's snap action keyboard.

Steve Gibson is the developer and publisher of Flicker Free and president of Gibson Research Corp. of Irvine, California. The views expressed are his own.

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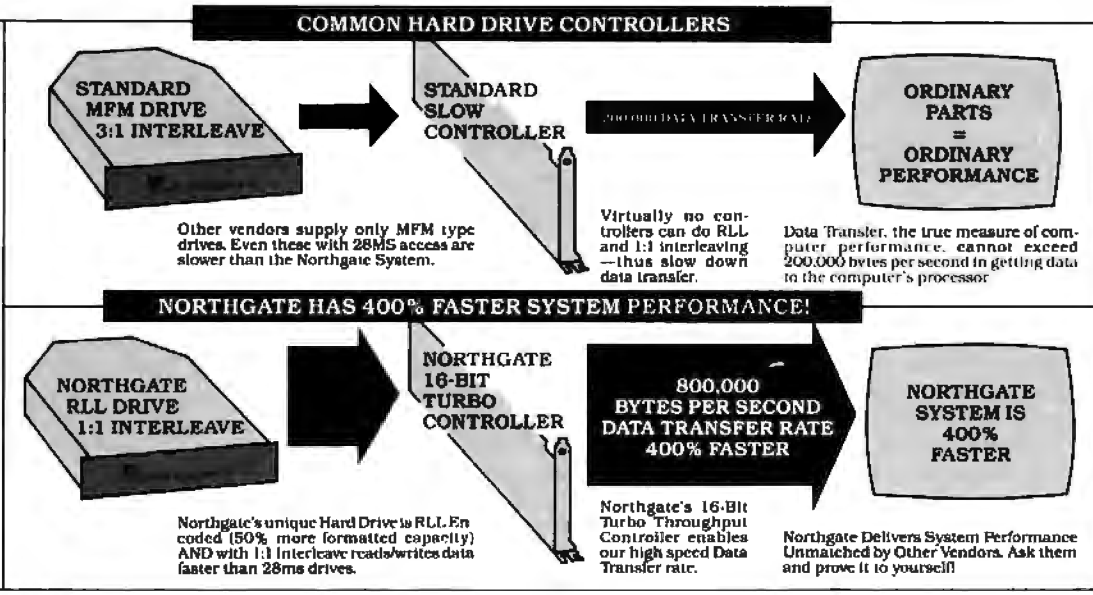

Most computers look similar. Most vendors advertise processor speed and 28MS hard drive access. There is little to distinguish one from another. Thus everyone tends to assume all computers are alike.

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RS232 was developed to simplify communications between computers, peripherals and other electronic equipment. But what started out simple has become more complex, with different manufacturers using different cable configurations. All of which made isolating and fixing problems more time-consuming.

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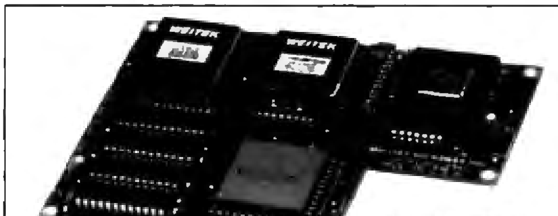

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The compilers are presently available in two formats: Microport Unix 5.3 or MS-DOS as extended by the Phar Lap Tools. MicroWay will port them to other 80386 operating systems such as OS/2 as the need arises and as 80386 versions become available.

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An example of the benefit of excellent code is a 32-bit matrix multiply. In this benchmark an NDP Fortran-386 program is run against the same program compiled with a 16-bit Fortran. Both programs were run on the same 80386 system. However, the 32-bit code ran 7.5 times faster than the 16-bit code, and 58.5 times faster than the 16-bit code executing on an IBM PC.

NDP FORTRAN-386™ $595
NDP C-386™ $595

MicroWay Numerics

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mW1167 16 MHz $1495
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Steve Ciarcia

The SmartSpooler

Part 1: The Spooler Hardware

Steve clears your printer's throughput bottleneck and comes up with more than a buffer

The discrepancy in speed between fast CPUs and slow printers has existed since the early days of computing, and the magnitude of the speed difference is becoming ever larger. When you upgrade and add performance to a computer system, you generally add processing power rather than printing power. The net result is that many 20-MHz 80386 "million-instructions-per-second-class" machines out there are waiting for 100-character-per-second printers.

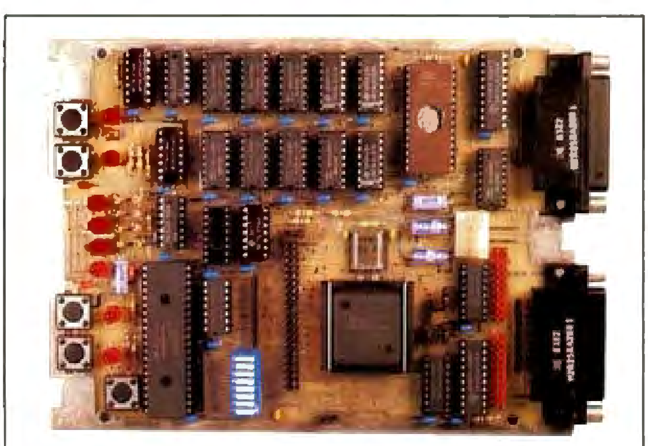
Admittedly, many computer users have light printing requirements, and they don't mind waiting 5 to 10 minutes for an occasional printout. Some, I'm sure, welcome this downtime as a mandatory coffee break. However, those who rely on their computers as a tool for making a living know that time is money.

Spooling to the Rescue

This problem is not new, and one solution has always been spooling. *Spool* stands for "simultaneous peripheral operations on-line." Pioneered on mainframes and minicomputers, spooling solves the CPU/printer speed gap by temporarily buffering printer output on intermediate storage (typically a disk drive) at high speed. Then, you move the stored data from storage to the printer at the latter's low speed. In the meantime, the CPU also runs foreground applications.

Traditional spooling has been tried on personal computers with limited success. One problem is that spooling requires an operating system with either multitasking capabilities or special software patches that effect the appearance of simultaneous operation. Even with a multitasking operating system or a patch, however, spooling often taxes the computer's processing power and affects system performance.

Spooling also creates problems in disk priority and data conflicts. If not properly coordinated through the operating system, a computer's disk can get "trashed" if it has to handle print data and application data at the same time. Given the declining cost of processing power and memory, it finally became obvious that a separate computer should handle the printing task, which led to the dedicated printer buffer.



I have received many letters over the years asking when I would present a printer buffer as a project. Generally, I would avoid answering the question or jokingly say "never." Of course, it really wasn't a joking matter. It troubled me greatly that I couldn't do justice to such an important subject and had to live with such an embarrassing answer until I could invest the time and effort to present a Circuit Cellar–quality design. Let me explain.

Most printer buffer projects are cumbersome and simplistic. The ones I remember seeing offer only rudimentary functions and use 40 or 50 chips for a 64K-byte buffer.

Commercial units, on the other hand, have narrowly defined capabilities enhanced by software-implemented system functions and tricky hardware designs intended to reduce manufacturing cost and complexity.

I recall seeing one rather unique printer buffer design that used an 8051 single-chip microcomputer connected to dynamic RAMs (DRAMs) that operated *serially*. The 8051 would constantly cycle through the DRAM addresses at a rate that precluded any need for DRAM refresh. The system stored text serially in the individual 64K- by 1-bit DRAMs rather than in a parallel bank of them, as you'd usually expect. An 8K-byte text buffer therefore consisted of a single 64K-bit DRAM chip, while a 32K-byte buffer used four, and so on.

While I am not totally opposed to off-the-wall hardware designs, fancy technique has its price. Most computer-based technical designs are a trade-off between hardware and software. Anytime a company expects to be manufacturing something in a high-volume quantity, it tries to minimize recurring hardware costs by doing as much as possible in the one-time nonrecurring software development phase.

In a magazine article, however, there aren't any recurring expenses (beyond a few prototypes), therefore all costs associated with the one-time presentation are essentially nonrecurring. Since most magazine authors don't have infinite software resources (and deep pockets), published print spooler designs have usually ended up as a far cry from commercial units, both in technique and capability.

I could hardly criticize mediocre designs if I presented a piece of hardware that merely

continued

While I've presented SmartSpooler primarily as a printer buffer, it can function as a complete remote data-processing computer.

met the objective with little regard for the hardware costs and complexity. At the same time, it would be insane to custom-mask an 8051 and present a three-chip printer buffer project that demonstrates nothing to readers who want to learn something about the architecture of printer buffers.

Fast Computers, Slow Printers

With the Circuit Cellar SmartSpooler, I have achieved my goal. This is an efficient integration of commercial and educational objectives. I've complemented its hardware design with interrupt-driven software that does not compromise performance to maintain cost-effectiveness. Designated as a spooler rather than as a simple printer buffer, SmartSpooler vastly improves computing throughput with slow peripherals.

SmartSpooler has 256K bytes of memory, serial and parallel I/O ports, and features that improve versatility and ease of use. These include "switchbox" capability for routing serial or parallel computer input to serial or parallel printer output, the ability to print multiple copies, single-sheet feeding mode, and buffer capacity indicators. Also, you can daisy-chain multiple SmartSpoolers to control a whole network of peripherals.

More important, SmartSpooler is intelligent. While I've presented it primarily as a printer buffer, a host computer can completely control its operation. You can even download executable code to SmartSpooler. It can function as a complete remote data-processing computer that analyzes and interprets the data flowing through it.

After a summary of SmartSpooler's features, I'll cover some printer buffer basics and then describe SmartSpooler's hardware and software specifics.

SmartSpooler has the following features:

- 256K-byte buffer capacity = 100 pages (typically)
- Switchable serial (RS-232C) or parallel (Centronics) inputs and outputs
- Serial port data rates: 300, 600, 1200, 2400, 4800, 9600, 19,200, and 38,400 bits per second (bps)
- Serial port handshaking: hardware ($\overline{RTS}$, $\overline{CTS}$, and so on) and software (XON-XOFF)
- Multiple copy capability: 0 to 4 copies plus original
- Pause mode for single-sheet feeding

continued

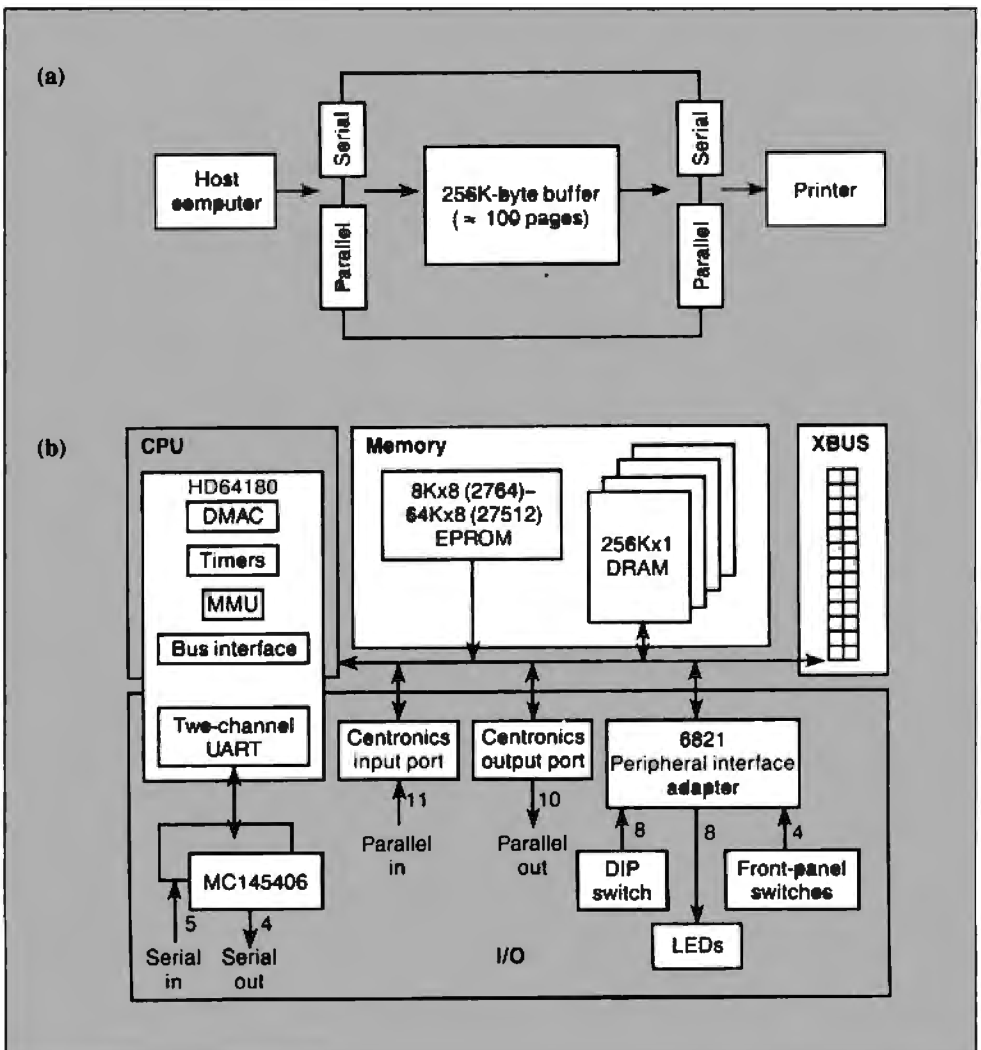


Figure 1: (a) *The SmartSpooler combines the function of a 256K-byte printer buffer and a serial/parallel converter switch.* **(b)** *Its HD64180 CPU—with built-in serial ports, extensive interrupt handling, address range beyond 64K bytes using direct memory access, and easy DRAM interface—is ideal for this application.*

- Real-time clock (power required)
- Front-panel buffer capacity gauge
- Host programmed configuration and operation mode
- Built-in interactive diagnostic monitor program
- Low power (5 volts [V] at 0.5 ampere [A], ±12 V at 0.1 A typical)

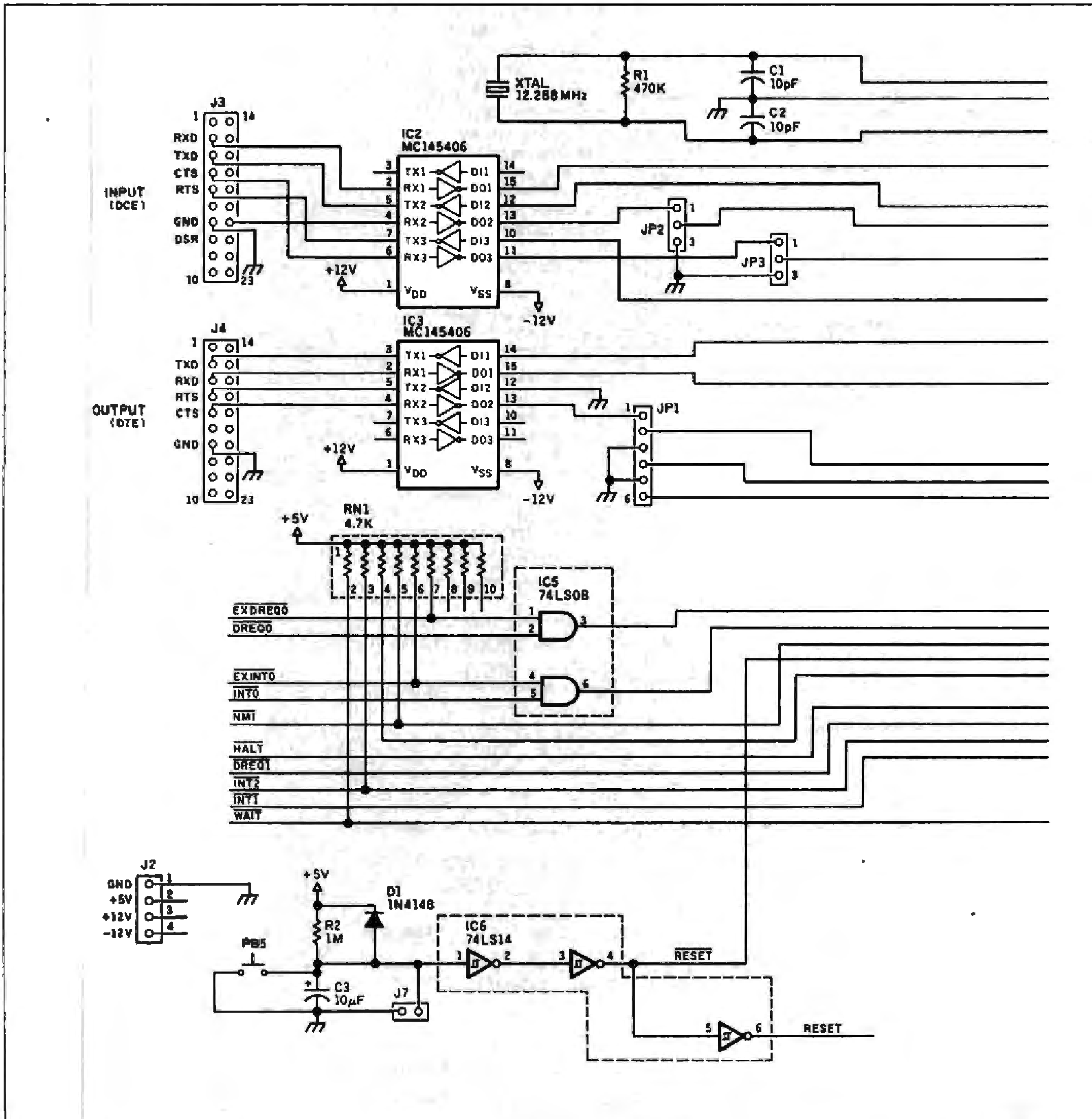
Generic printer buffers come with a variety of functions. SmartSpooler combines the best features of these other printer buffers and adds a few of its own. SmartSpooler sits between a computer printer port and the printer. Since it provides both parallel and serial I/O ports, it adapts between computers and printers of each type.

When the computer prints, SmartSpooler accepts the data at high speed, buffers it, and outputs it to the low-speed printer. From the computer's point of view, printing a document takes only seconds. During the printout, SmartSpooler can make copies, temporarily suspend printing (pause button), and handle embedded formfeeds for single-sheet printing.

Hardware—Keep It Simple

The hardware requirements for SmartSpooler are simple: a CPU, buffer memory, and host/printer ports (serial and parallel). We also need some parallel I/O ports to handle switches and LEDs for SmartSpooler's front-panel operation.

I used the complementary-metal-oxide-semiconductor



HD64180 CPU because it is ideally suited to the task and significantly reduces the hardware complexity. First, it includes two RS-232C serial ports on-chip, eliminating an external dual-UART (universal asynchronous receiver/transmitter) chip.

Second, the need for a large, low-cost buffer demands dynamic memory chips. The HD64180, with its built-in refresh, easily accommodates DRAMs and offers a performance level that can meet today's high-speed communications requirements. (Though the task seems simple, many computers choke when running terminal emulator programs at 19,200 or 38,400 bps.)

The SmartSpooler block diagram in figure 1 shows the three basic components: CPU (i.e., HD64180), memory (i.e., DRAM and SmartSpooler EPROM), and I/O (i.e., host, printer, switches, and LEDs) interface. The SmartSpooler also provides an SB180 XBUS I/O expansion connector for additional I/O (more on that later). See figure 2 for the complete SmartSpooler schematic (less the section covering the DIP-switch settings and LEDs, which I will cover next month).

The EPROM socket (IC7) accepts 8K-byte (2764) to 64K-byte (27512) EPROMs, though the SmartSpooler code presently requires only 16K bytes (27128). Because of the on-chip DRAM refresh controller, connecting 256K bytes of DRAM is relatively easy. All the HD64180 needs are three 74LS157 row/column address multiplexers (IC8 through IC10) and a CAS\

continued

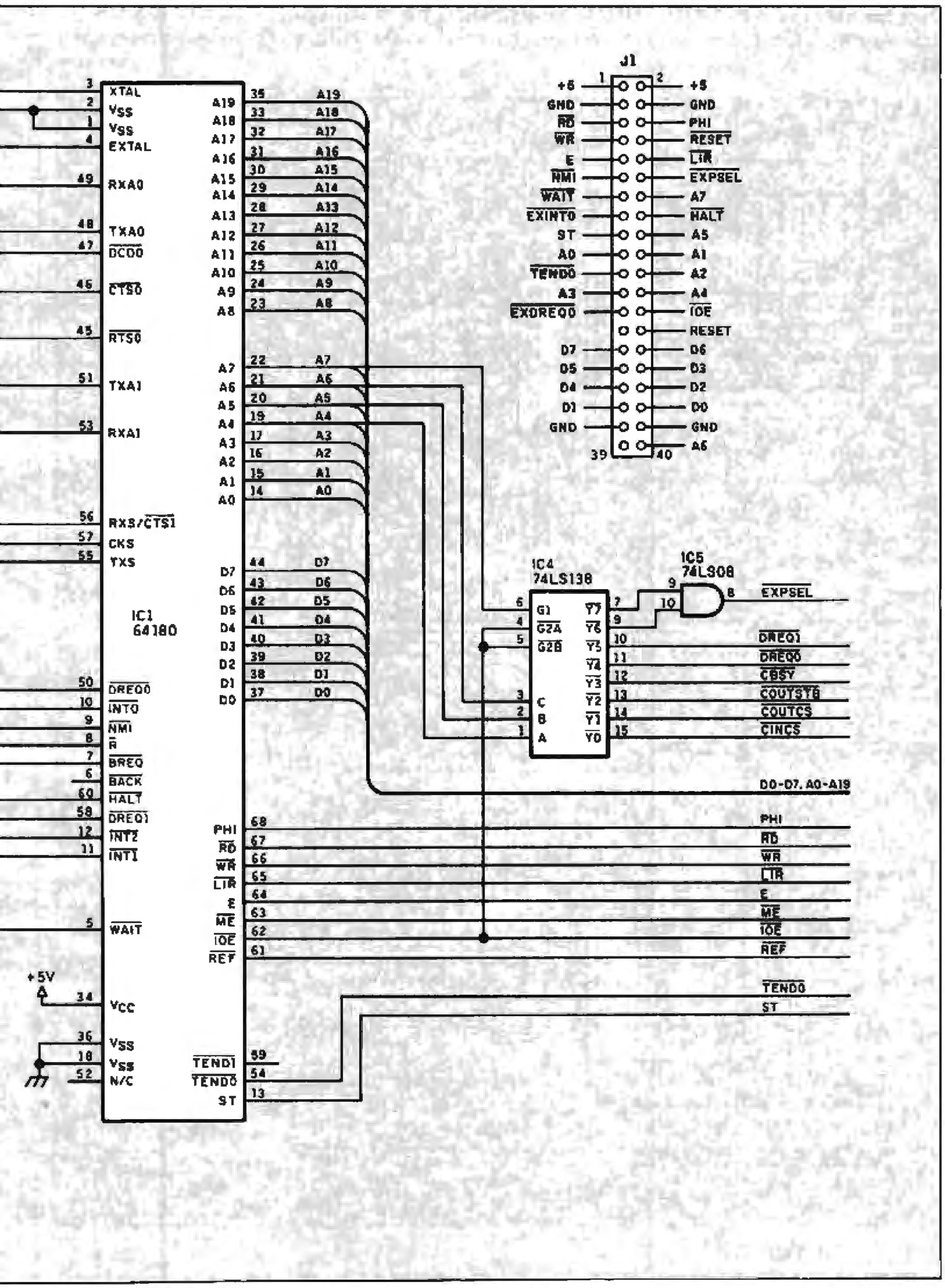


Figure 2a: *Schematic for the SmartSpooler's CPU and serial I/O section. (Not shown this month are the 6821 peripheral interface adapter and other circuitry associated with the switches, push buttons, and LEDs; that portion will appear next month.)*

generator consisting of a flip-flop and a couple of gates (IC5, IC6, and IC19). The plastic-leaded-chip-carrier version of the HD64180 can address 1 megabyte, but I feel that 256K bytes is more than adequate for typical printing applications, and it keeps power consumption low.

If you examine the SmartSpooler's architecture closely, you will note some similarities with the SB180 single-board computer (see the September 1985 Circuit Cellar). Considering the performance and popularity of the SB180, any similarities are purely intentional. The SmartSpooler's core architecture lets it be more or less software-compatible with the BCC180 multitasking controller (presented the last three months) and the SB180. Remember that you can download executable code to the SmartSpooler using its host programmed mode. This code could be a compiled BASIC program generated on a BCC180 just as easily as any HD64180 assembly code produced on an IBM PC cross assembler or the SB180.

SmartSpooler's I/O

SmartSpooler has two serial ports and two parallel printer ports. Since the HD64180 has two on-chip serial ports, the only extra hardware needed for the RS-232C ports are a pair of MC145406 RS-232C level shifters (IC2 and IC3). The rest of the I/O hardware consists of the Centronics I/O ports and the front-panel switch/LED interface.

A 74LS138 (IC4) I/O address decoder generates eight chip selects. Two outputs are reserved for XBUS addressing: I/O addresses E0 to FF hexadecimal. Two chip selects are connected to the HD64180 direct-memory-access request inputs, and the remaining four are associated with the Centronics I/O ports.

The Centronics output port consists of a 74LS374 (IC22), which latches the output data, plus both halves of a 74LS74 (IC23) for controlling the handshaking. To send a character to the device connected to the port, the control software first

continued

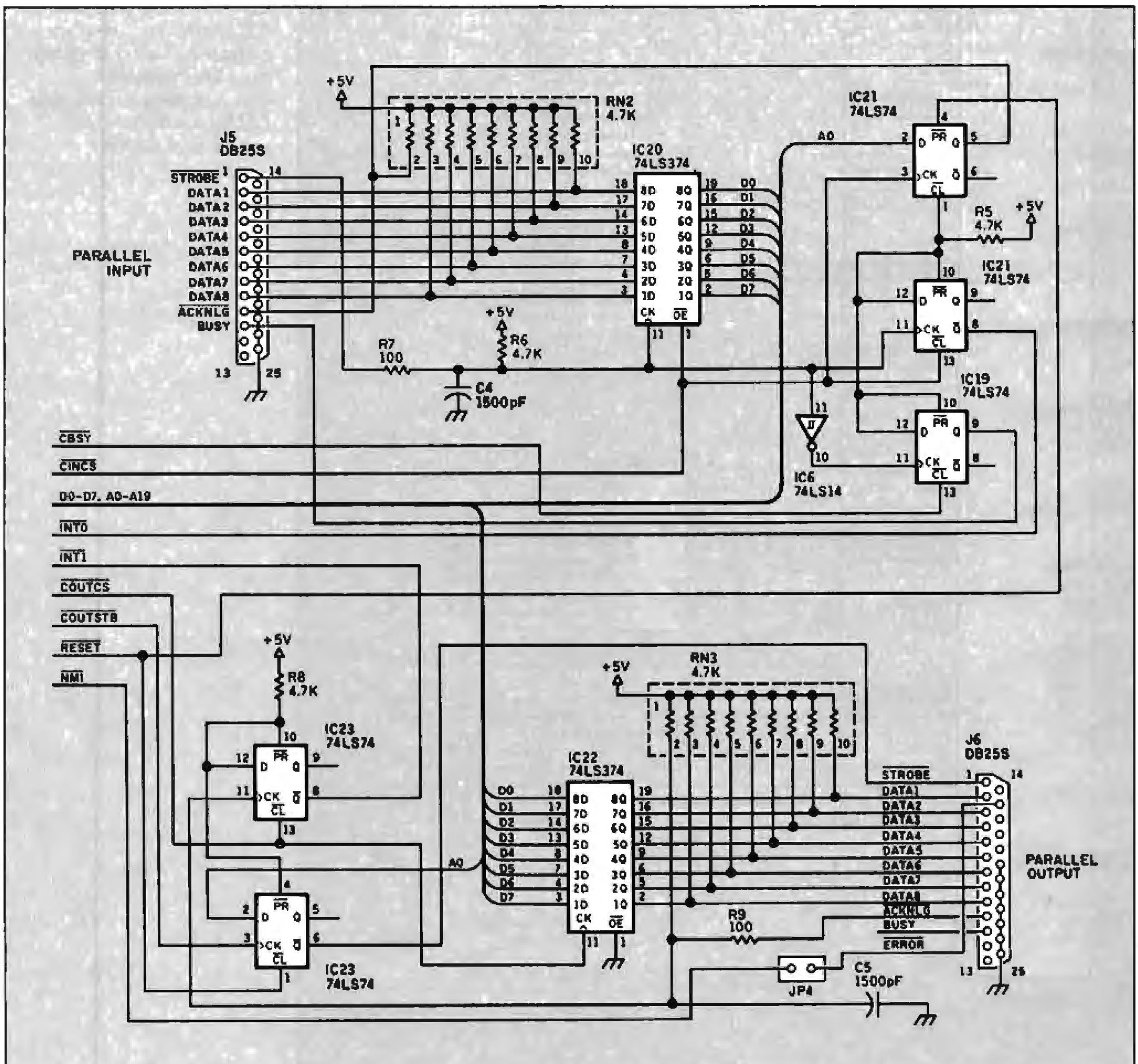


Figure 2b: *The SmartSpooler's parallel I/O section.*

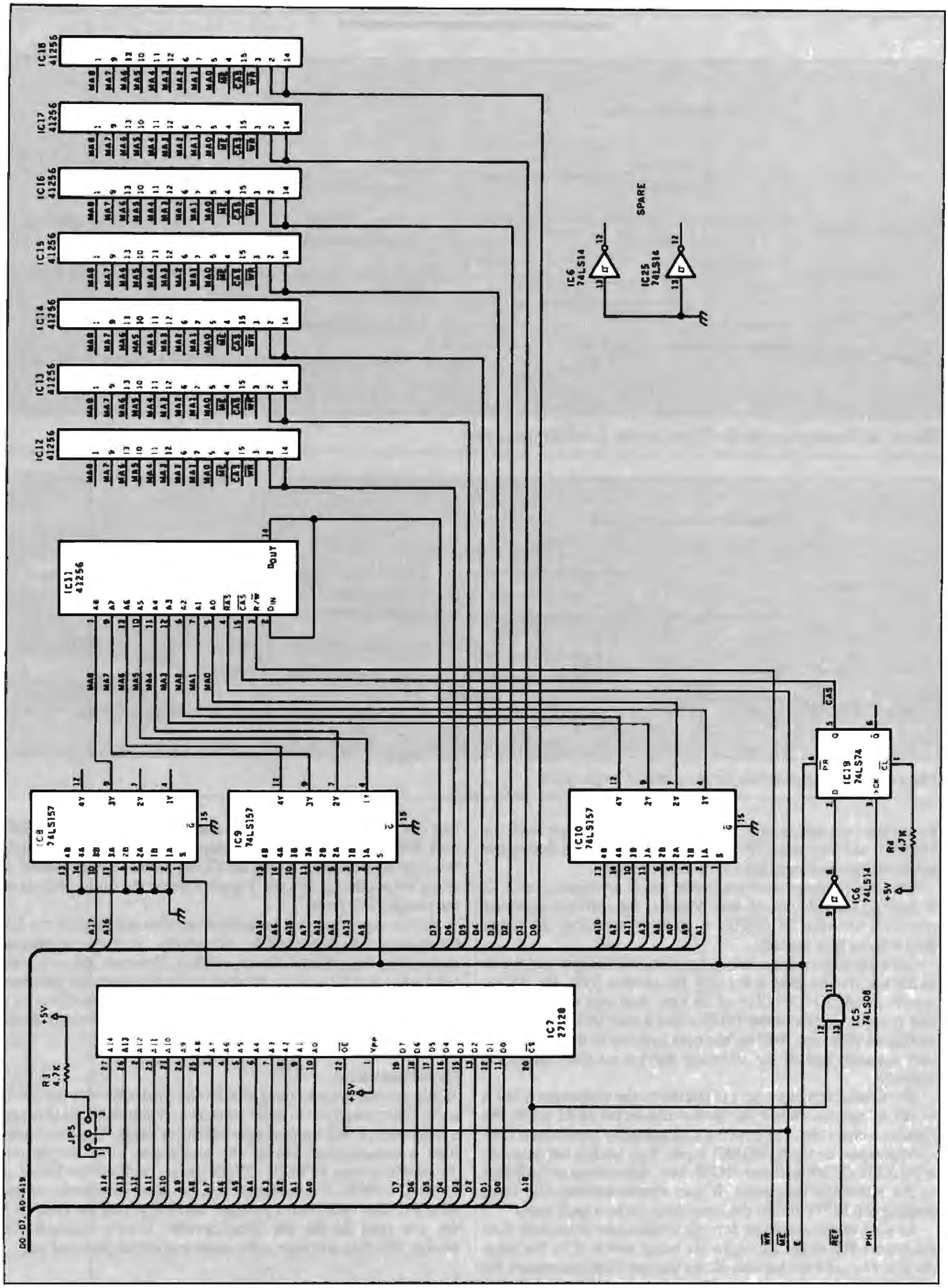


Figure 2c: *The EPROM and DRAM circuitry for the SmartSpooler.*

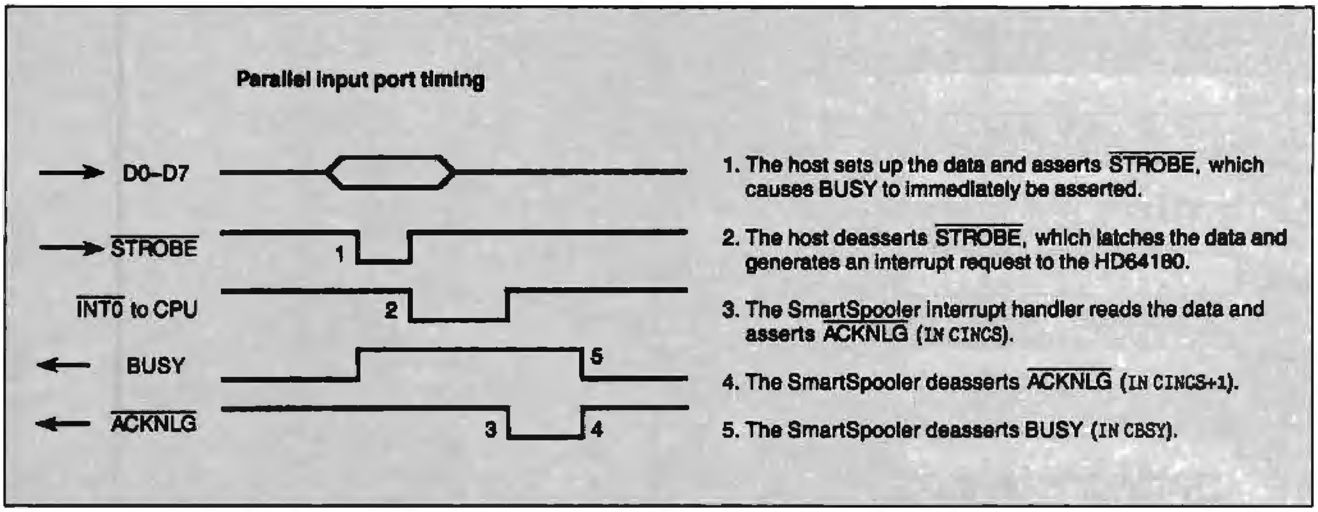


Figure 3a: *Timing diagram for SmartSpooler's parallel input port.*

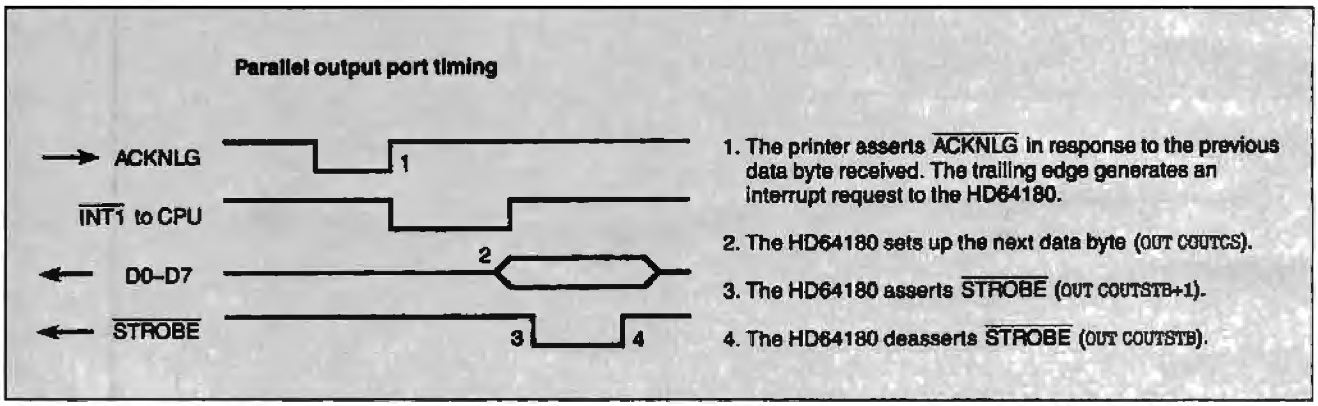


Figure 3b: *Timing diagram for the parallel output port.*

writes the byte out to port 90h. This latches the byte into the 74LS374 and also clears INT1\ high. (INT1\ is used during the acknowledge sequence that I'll describe next.)

Next, the program accesses (either reads or writes) port A1h to assert STROBE\ on J6 low. Finally, the software accesses port A0h to cause STROBE\ to go high, signaling the target device that a byte is ready.

Once the target printer device has retrieved the byte and wants to tell the spooler that it is ready for another byte, the device asserts the ACKNLG\ line on J6 low, then sets it high again. The rising edge clocks the 74LS74 and forces INT1\ low, generating an interrupt. Writing the next byte out to the Centronics port (usually part of the interrupt service routine) clears the interrupt.

The Centronics input port is similar to the output port, but it works in reverse. When the device connected to J5 sends the spooler a character, the device simultaneously generates a low-to-high signal on the STROBE\ input. This latches the data into a 74LS374 (IC20) and sets INT0\ low, generating an interrupt to the HD64180 processor. It also clocks another flip-flop, sending the BUSY line to the input device into a high state.

As part of the interrupt service routine, the processor first reads port 80h to get the character being sent to it by the input device. The port access also clears the interrupt and causes the ACKNLG\ output to go low as the first part of the acknowledge sequence. Next, an access to port 81h sets ACKNLG\ high again, signaling the input device that the character has been read and the spooler is ready for another. Finally, it accesses I/O port B0h, causing the BUSY output to go low. This signals those devices that rely on the BUSY signal that SmartSpooler is ready for another character. Figure 3 shows the timing details of the parallel I/O ports.

Purists may argue that SmartSpooler does not support the full Centronics interface, which, technically, includes additional signals like Paper Error, Error, and Init. However, these signals (and other vendor-unique signals) are inconsistent for different computers, printers, and software. Just in case, SmartSpooler's output port does provide an option for handling a Printer Error input signal. You can jumper it to NMI\.

Experimenters

While printed circuit board kits for the SmartSpooler are available, I encourage you to build your own. If you don't mind doing a little work, I will support your efforts as usual. You can download a hexadecimal file of the executable code for SmartSpooler's system EPROM (27128) from my bulletin board at (203) 871-1988. Alternatively, you can send me a preformatted IBM PC disk with return postage, and I'll put all the files on it for you (add $6 for the SmartSpooler User's Manual). Of course, this free software is for noncommercial personal use.

Next Month

I'll finish the hardware by explaining the switch and LED configuration and describe SmartSpooler's software. ■

I'd like to personally thank Tom Cantrell for his extensive work on this project. Without his software expertise, I'd be hopelessly mired in an ocean of bits forever.

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 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.

The following items are available from

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Inquiry 951.

1. SmartSpooler RAMless full printed circuit board kit for parallel-to-parallel operation. Comes complete with printed circuit board and all printed-circuit-board-mounted components, including HD64180, IC sockets, SmartSpooler software on EPROM, and User's Manual. Less DRAM chips. SS01-KIT $119
2. SmartSpooler experimenter's kit for parallel-to-parallel operation. Comes with printed circuit board, crystal, HD64180 and plastic-leaded-chip-carrier socket, software on EPROM, and User's Manual. Available only through September 30, 1988. SS02-EXP............$89

Optional serial port ribbon cables are available. Call for pricing.

The SmartSpooler design is available for licensing to qualified manufacturers. Call for information.

All payments should be made in U.S. dollars by check, money order, MasterCard, or Visa. Surface delivery (U.S. and Canada only): add $5 for U.S., $8 for Canada. For delivery to Europe via U.S. airmail, add $14. Three-day air freight delivery: add $10 for U.S. (UPS Blue), $25 for Canada (Purolator overnight), $45 for Europe (Federal Express), or $60 for Asia and elsewhere in the world (Federal Express).

There is a multiline Circuit Cellar bulletin board system (running TBBS 2.0M) that supports past and present projects in BYTE and Ink. You are invited to call and exchange ideas and comments with other Circuit Cellar supporters. The 300/1200/2400-bps BBS is on-line 24 hours a day at (203) 871-1988.

To receive information about the Circuit Cellar Ink publication for hardware designers and developers, please circle 100 on the Reader Service inquiry card at the back of the magazine.

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

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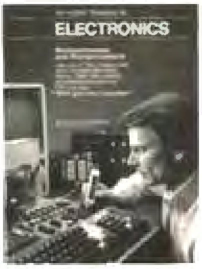

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170-048

Gordon Letwin,
Chief Architect, Systems Software,
Microsoft Corp.

Dynamic Linking in OS/2

Dynlinks make OS/2 programs smaller, more efficient, and easier to upgrade—here's how they work

Most operating systems let you create programs piecemeal. You can compile one piece at a time and have it refer to the other pieces as externals. A linker combines these pieces into one final executable image, fixing up the external references (i.e., references between one piece and another) that those pieces contain.

The primary advantage of linking to external code is that you can use it to refer to a standard set of subroutines—a subroutine library—without compiling or even possessing the source code for those subroutines. Nearly all high-level language packages come with one or more standard run-time libraries that contain various useful subroutines that the compiler can call implicitly and that the programmer can call explicitly.

In this process, called *static linking*, the static code (i.e., the external subroutine) is built into the final executable module. Naturally, this makes the executable file larger, but more importantly, the target code can't be changed or upgraded without relinking to the main program's object files. Because the personal computer field is built on commercial software whose authors don't release source or object files, this relinking is out of the question for the typical end user.

Finally, the target code can't be shared in memory among several different applications that use the same library routines, for two reasons. First, the target code was relocated differently by the linker for each client; so although the code remains logically the same for each application, the address components of the binary instructions are different in each executable file. Second, the operating system has no way of knowing that these applications are using the same library, and it has no way of knowing where that library is in each executable file. Therefore, it can't avoid having duplicate copies of the library in memory.

To do away with these problems, OS/2 uses *dynamic linking*, in which a program's external references to subroutines are resolved either when the program is loaded, or later at run time, as the subroutines are needed by the program. Subroutines are kept in special dynlink libraries, application programs can share subroutines, and programmers can make changes to frequently used procedures (such as user-interface routines) without changing the applications that use them.

Load-Time Dynlinks

On the surface, the process of load-time dynamic linking looks the same as that of static linking. The programmer makes an external reference to a subroutine, and at link time specifies a library file (or an object file) that defines the reference. The linker produces an executable file that OS/2 then loads and executes. Behind the scenes, however, things are very different.

In static linking, the linker finds the actual externally referenced subroutine in the library file. In dynamic linking, the linker finds a special record that defines a module name string and an entry-point name string. For example, in a hypothetical routine called Foo, the library file contains only these two name strings, not the code for Foo itself. (The entry-point name string doesn't have to be the name by which programs called the routine.) The resultant executable file doesn't contain the code for Foo; it contains a special dynlink record that specifies these module and entry-point names for Foo.

When this executable file is run, OS/2 loads the code in the .EXE file into memory and discovers the dynlink record(s). For each dynlink module that is named, OS/2 locates the code in the system's dynlink library directory and loads it into memory (unless the module is already in use; more about this later). The system then links the external references in the application to the addresses of the called entry points (see figure 1).

Although this is just postponing the linkage until load time, the technique has several important ramifications. First, the target code is not in the executable file but in a separate dynlink library (.DLL) file. Thus, the executable file is smaller because it contains only the name of the target code, not the code itself. You can change or upgrade the target code at any time simply by replacing this .DLL file. The next time a referencing application is loaded (with some restrictions, as I'll discuss later), it is linked to the new version of the target code. Having the target code in a dynlink file paves the way for automatic code sharing. OS/2 can easily understand that two applications are using the same dynlink code because it loaded and linked that code, and it can use this knowledge to share the pure segments of that dynlink package rather than loading duplicate copies.

Although you need to understand dynamic linking to create a dynlink module, you can use one without even knowing that it's not an ordinary static link. Dynamically linked programs sometimes take longer to load into memory than do statically linked programs. The performance ramifications depend on the kind of dynlink module that is referenced and whether this executable file is the first to reference the module.

Although I have concentrated on processes that call dynlink routines, these routines can also be called by other dynlink routines. When OS/2 loads a routine in response to a process's request, it examines it to see if it has any dynlink references of its own. Any such referenced dynlink routines are also loaded until no unsatisfied dynlink references remain.

Run-Time Dynamic Linking

Not all dynlink names need to appear in the executable file at load time; a process can link itself to a dynlink package at run

continued

time as well. Run-time dynamic linking works exactly like load-time dynamic linking, except that the process creates the dyn-link module and entry-point names at run time and then passes them to OS/2 so that OS/2 can locate and load the specified dyn-link code.

Run-time linking takes place in four steps:

1. The process issues a `DosLoadModule` call to tell OS/2 to locate and load the dynlink code into memory.
2. The `DosGetProcAddr` call is used to obtain the addresses of the routines that the process wants to call.
3. The process calls the dynlink library entry points by an indirect call through the address returned by `DosGetProcAddr`.
4. When the process has no further use for the dynlink code, it can call `DosFreeModule` to release the dynlink code. After this call, the process will still have the addresses returned by `DosGetProcAddr`, but they will be illegal addresses; referencing them will cause a GP (general protection) fault.

Run-time dynlinks are useful when a program knows it will want to call some dynlink routines but doesn't know which

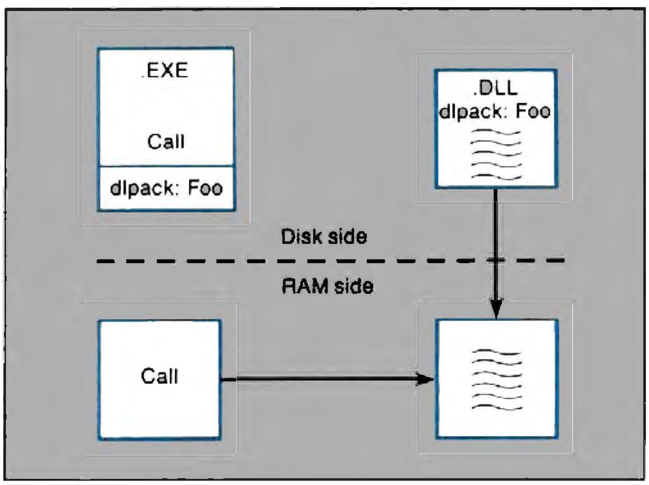

Figure 1: *In load-time dynamic linking, the executable file contains an entry that tells OS/2 where to find the dynlink module,* Foo. *When OS/2 loads the executable file into memory, it also loads* Foo *and fixes all references to* Foo *from the executable file.*

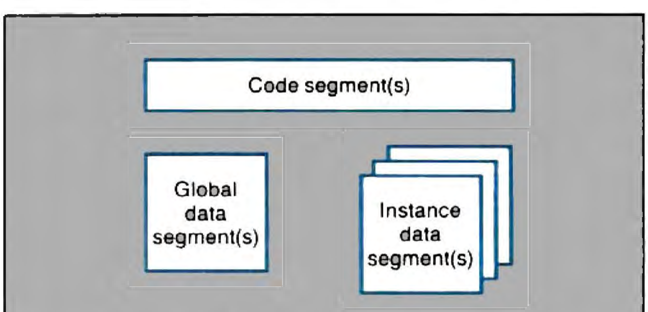

Figure 2: *A dynlink routine can have three kinds of segments. Each process using the dynlink module will get its own copy of the instance data segments while sharing the same copy of the global data segments with the other processes attached to the dynlink module. OS/2 performs an optimization so that code segments are shared transparently among all processes.*

ones. For example, a charting program may support four plotters, and it might want to use dynlink plotter-driver packages. It doesn't make sense for the application to contain load-time dynlinks to all four plotters, because only one will be used and the others will take up memory and swap space. Instead, the charting program can wait until it learns which plotter is installed and then use the run-time dynlink facility to load the appropriate package. The application can even wait until the user issues a plot command before it calls `DosLoadModule`, thereby reducing memory demands on the system.

The application need not even be able to enumerate all the modules or entry points that may be called. The application can learn the names of the dynlink modules from another process or by looking in a configuration file. This allows the user of the charting program, for example, to install additional plotter drivers that didn't even exist at the time the application was written. Of course, in this example the calling sequences of the dynlink plotter driver must be standardized, or you must devise a way for the application to figure out the proper way to call these newly found routines.

Naturally, a process is not limited to one run-time dynlink module; you can use multiple calls to `DosLoadModule` to link to several dynlink modules simultaneously. Regardless of the number of modules in use, you should use `DosFreeModule` if the dynlink module is no longer needed and the process intends to continue executing. But issuing `DosFreeModule` is unnecessary if the process is about to terminate; OS/2 releases all dynlink modules at process-termination time.

Dynlinks, Processes, and Threads

Simply put, OS/2 views dynlinks as a fancy subroutine package. Dynlinks aren't processes, and they don't own any resources. A dynlink executes only because a thread belonging to a client process has called the dynlink code. The dynlink code is executing as the client thread and process because, in the eyes of the system, the dynlink is merely a subroutine that the process has called. Before the client process can call a dynlink package, OS/2 ensures that the dynlink's segments are in the client's address space. No ring transition or context-switching overhead occurs when a client calls a dynlink routine; the far call to a dynlink entry point is just that—an ordinary far call to a subroutine in the process's address space.

One side effect is that dynlink calls are very fast; little CPU time is spent getting to the dynlink package. Another side effect is that there is no separation between a client's segments and a dynlink package's segments, because segments belong to processes and only one process is running both the client and the dynlink code.

Handling Dynlink Data

You might have noticed something missing in this discussion of dynamic linking: I've said nothing about how to handle a dynlink routine's data. OS/2 supports two types of data segments for dynlink routines—instance and global (see figure 2). Instance data segments hold data specific to each instance of the dynlink routine. In other words, a dynlink routine has a separate set of instance data segments for each process using the routine. The dynlink code has no difficulty addressing its data; the code can reference the data segment selectors as immediate values.

A global data segment, as the name implies, is not duplicated for each client process. There is only one copy of each dynlink module's global data segment; each client process is given shared access to that segment. The segment is loaded only once—when the dynlink package is first brought into memory to be linked with its first client process. Global data segments allow a dynlink routine to be explicitly aware of its multiple clients, because changes to a global segment made by calls from one client process are visible to the dynlink code when called from another client process. Global data segments support subsystems, which I'll discuss later.

Because a dynlink routine's data requirements are not known at link time, the technique of fixing up the references that the client code makes to the dynlink routine's data is more complicated than that for statically linked routines. In statically linked subroutines, when the linker binds the external code with the main code, it sees how much static data the external code needs and allocates the necessary space in the proper data segments. References that the external code makes to its data are then fixed up to point to the proper location. Because the linker is combining all the object files into an executable file, it can easily divide the static data segments among the various compilands.

This technique doesn't work for dynlink routines, because their code (and therefore their data requirements) aren't present at link time. It's possible to extend the special .OBJ file to describe the amount of static data that the dynlink package will need, but it won't work. (And even if it did work, it would be a poor design because it would restrict our ability to upgrade the dynlink code in the field.) Because the main code in each application uses different amounts of static data, the data area reserved for the dynlink package would end up at a different offset in each executable file that was built. When these .EXE files were executed, one set of shared dynlink code segments would need to reference the data that resides at different addresses for each different client. Relocating the static references in all dynlink code modules at each occurrence of a context switch is clearly out of the question.

An alternative to letting dynlink routines have their own static data is to require that their callers allocate the necessary data areas and pass pointers to them upon every call. We easily rejected this scheme: It's cumbersome; `call` statements must be written differently if they're for a dynlink routine; and, finally, this hack wouldn't support subsystems, which I'll discuss later.

Instead, OS/2 takes advantage of the segmented architecture of the 80286 to solve the static addressability problem. Each dynlink routine can use one or more data segments to hold its static data. Each client process has a separate set of these segments. Because these segments hold only the dynlink routine's data and none of the calling process's data, the offsets of the data items within that segment will be the same no matter which client process is calling the dynlink code. All you need to do to solve the static-data addressability problem is ensure that the segment selectors of the dynlink routine's static data segments are the same for each client process.

OS/2 does this by means of a technique called the *disjoint LDT space*. I won't attempt a general introduction to the segmented architecture of the 80286, but a brief summary is in order. Each process in 80286 protected mode can have a maximum of 16,383 segments. These segments are described in two tables: the LDT (local descriptor table) and the GDT (global descriptor table). An application can't read from or write to these tables. OS/2 manages them, and the 80286 microprocessor uses their contents when a process loads selectors into its segment registers.

In practice, the GDT is not used for application segments, which leaves the LDT 8192 segments—or, more precisely, 8192 segment selectors, which OS/2 can set up to point to memory segments. The 80286 does not support efficient position-independent code, so 80286 programs contain within them, as part of the instruction stream, the particular segment selector needed to access a particular memory location, as well as an offset within that segment. This applies to both code and data references.

When OS/2 loads a program into memory, the executable file describes the number, type, and size of the program's segments. OS/2 creates these segments and allocates a selector for each from the 8192 possible LDT selectors. There isn't any conflict with other processes in the system at this point, because each process has its own LDT and its own private set of 8192 LDT selectors. After OS/2 chooses a selector for each segment, both code and data, it uses a table of addresses provided in the executable file to relocate each segment reference in the program, changing the place-holder value put there by the linker into the proper segment-selector value. OS/2 never combines or splits segments, so it never has to relocate the offset part of addresses—only the segment parts. Address offsets are more common than segment references. Because the segment references are relatively few, this relocation process is not very time-consuming.

If OS/2 discovers that the process it is loading references a dynlink routine, the situation is more complex. For example, suppose the process isn't the first caller of `Foo`; `Foo` is already in memory and already relocated to some particular LDT slots in the LDT of the earlier client of `Foo`. OS/2 has to fill in those same slots in the new process's LDT with pointers to `Foo`; it can't assign different LDT slots because `Foo`'s code and data have already been relocated to the earlier process's slots. If the new process is already using `Foo`'s slot numbers for something else, then you're in trouble. This is a problem with all `Foo`'s segments, both data segments and code segments.

This is where the disjoint LDT space comes in. OS/2 reserves many of each process's LDT slots for the disjoint space. The same slot numbers are reserved in every process's LDT. When OS/2 allocates an LDT selector for a memory segment that may be shared between processes, it allocates an entry from the disjoint LDT space. After a selector is allocated, that same slot is reserved in all other LDTs in the system. The slot either remains empty (i.e., invalid) or points to this shared segment; it can have no other use. This guarantees that a process that has been running for hours and that has created dozens of segments can still call `DosLoadModule` to get access to a dynlink routine; OS/2 will find that the proper slots in this process's LDT are ready and waiting.

The disjoint LDT space is used for all shared memory objects, not just dynlink routines. Shared memory data segments are also allocated from the disjoint LDT space. A process's code segments are not allocated in the disjoint LDT space, yet they can still be shared. [Editor's note: *For more discussion of the disjoint LDT space, see "OS/2 Virtual Memory Management" by Vic Heller on page 227.*]

Uses of Dynamic Linking

Dynlink libraries can serve as simple subroutine libraries or as subsystems. They can form the interface to other processes, the interface to OS/2 itself, and even the interface to a device without the device driver's overhead.

As I discussed earlier, a dynlink subroutine is written and executes in much the same way as a statically linked subroutine. The only difference is in the preparation of the dynlink library file, which contains the actual subroutines, and in the preparation of the special object file, to which client programs can link. During execution, both the dynlink routines and the client routines can use their own static data freely, and they can pass pointers to their data areas back and forth to each other. The only difference between static linking and dynamic linking in this model is that the dynlink routine cannot reference any external symbols that the client code defines, nor can the client externally reference any dynlink package symbols other than the module entry points. The execution environment is nearly identical to that of a traditional statically linked subroutine; the client and the subroutine each reference their own static data areas, all

continued

of which are contained in the process's address space. Note that a dynlink package can reference the application's data and the application can reference the dynlink package's data, but only if they pass pointers to their data to one another.

The term *dynlink subsystems* is merely a descriptive term that refers to the design and intended function of a particular style of dynlink package. A dynlink subsystem is a module that provides a set of services built around a resource. For example, OS/2's video I/O (VIO) dynlink entry points are considered a dynlink subsystem because they provide a set of services to manage the display screen. A subsystem usually has to manage a limited resource for an effectively unlimited number of clients. VIO does this, managing a single physical display controller and a small number of screen groups for an indefinite number of clients.

Because subsystems generally manage a limited resource, they have one or more global data segments that they use to keep information about the state of the resource they're controlling; they also have buffers, flags, semaphores, and so on. Per-client work areas are generally kept in instance data segments; it's best to reserve the global data segments for global information. Figure 3 illustrates a dynlink routine being used as a subsystem. A dynlink subsystem differs from a dynlink being used as a subroutine only by the addition of a static data segment.

Special Subsystem Support

Two OS/2 features are particularly valuable to subsystems: global data segments (which I've already discussed) and special client-initialization and client-termination support. Clearly, if a subsystem is going to manage a resource, keeping track of its clients in a global data segment, it needs to know when new clients arrive and when old clients terminate. The simple dynlink subroutine model doesn't provide this information reliably. A subsystem undoubtedly has initialize and terminate entry points, but client programs may terminate without having called a subsystem's terminate entry point. Such a failure may be an error on the part of the client, but the system architecture decrees that errors should be localized; it's not acceptable for a bug in a client process to be able to hang up a subsystem, and thus all its clients as well.

The two forms of subsystem initialization are *global* and *instance*. If a subsystem specifies global initialization, the initialization entry point is called only once per activation of the subsystem. When the subsystem dynlink package is first referenced, OS/2 allocates the subsystem's global data segments, taking their initial values from the .DLL file. OS/2 then calls the subsystem's global initialization entry point so that the module can do its one-time initialization. The thread that is used to call the initialization entry point belongs to that first client process, so the first client's instance data segments are also set up and can be used by the global initialization process. This means that although the dynlink subsystem is free to open files, read and write their contents, and close them again, it cannot open a handle to a file, store the handle number in a global data segment, and expect to use that handle in the future.

Remember, subsystems don't own resources; processes own resources. When a dynlink package opens a file, that file is open only for that one client process. That handle has meaning only when that particular client is calling the subsystem code. If a dynlink package were to store process A's handle number in a global data segment and then attempt to do a read from that handle when running as process B, at best the read would fail with `invalid handle`; at worst some unrelated file of B's would be molested. And, of course, when client process A eventually terminates, the handle becomes invalid for all clients.

The second form of initialization is instance initialization. The instance initialization entry point is called in the same way as the global initialization entry point, except that it is called for every new client when that client first attaches to the dynlink package. Any instance data segments that exist will already be allocated and will have been given their initial values from the .DLL file. The initialization entry point for a load-time dynlink is called before the client's code begins executing. The initialization entry point for a run-time dynlink is called when the client calls the `DosLoadModule` function. A dynlink package cannot specify both global and instance initialization; if it desires both, it should specify instance initialization and use a counter in one of its global data segments to detect the first instance initialization.

Even more important than initialization control is termination control. In its global data area, a subsystem may have records, buffers, or semaphores on behalf of a client process. It may have queued-up requests from that client that it needs to purge when the client terminates. The dynlink package need not release instance data segments; because these belong to the client process, they are destroyed when the client terminates. The global data segments themselves are released if this is the dynlink module's last client, so the module might want to take this last chance to update a log file, release a system semaphore, and so on.

Using the `DosExitList` service allows a process to specify one or more subroutine addresses that will be called when the process terminates. Addresses can be added or removed from the list. There can be many such addresses, which are called under all termination conditions. Both the client process and the

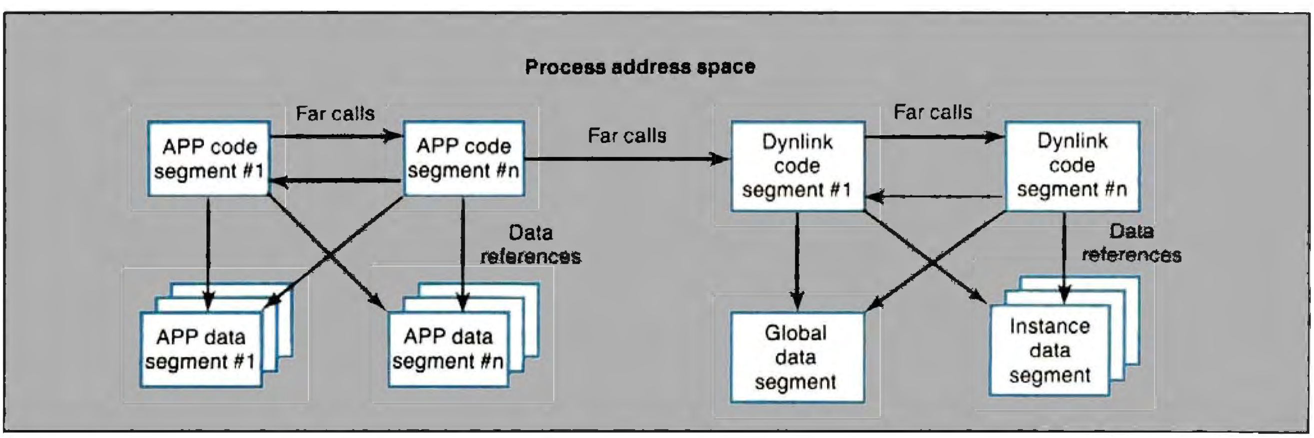

Figure 3: *A dynlink routine used as a subsystem. The main difference between a dynlink subsystem and a subroutine is the presence of the global data segment(s).*

subsystem dynlinks that it calls can have their own termination routines.

Interfaces to Other Processes

Earlier, I mentioned that dynlink subsystems have difficulty dealing with resources—other than global memory—because resource ownership and access are on a per-process basis. Life as a dynlink subsystem can be schizophrenic. Which files are open, which semaphores are owned, and so on, depends on which client is running your code at the moment. Global memory is different; it's the one resource that all clients own jointly. The global memory remains as long as the client count doesn't go to zero.

One way to deal with resource issues is for a dynlink package to act as a front end for a server process. During module initialization, the dynlink module can check a system semaphore to see whether the server process is already running and, if not, start it up. It needs to do this with the `detach` form of `DosExecPgm` so that the server process doesn't appear to the system as a child of the subsystem's first client. Such a mistake could mean that the client's parent thinks that the command subtree it founded by running the client never terminates because the server process appears to be part of the command subtree.

When the server process is running, the dynlink subsystem can forward some or all requests to it by one of the many interprocess communication (IPC) facilities. For example, a database subsystem might want to use a dedicated server process to hold open the database file and do reads and writes to it. It might keep buffers and ISAM (indexed sequential-access memory) directories in a shared-memory segment to which the dynlink subsystem requests access for each of its clients. Then requests that can be satisfied by data from these buffers won't require the IPC to the server process.

The only function of some dynlink packages is to act as a procedural interface to another process. For example, a spreadsheet program might provide an interface through which other applications can retrieve data values from a spreadsheet. The best way to do this is for the spreadsheet package to contain a dynlink library that provides clients with a procedural interface to the spreadsheet process. The library routine itself will invoke a noninteractive copy (perhaps a special subset .EXE) of the spreadsheet to recover the information, passing it back to the client via IPC. Alternatively, the retrieval code that understands the spreadsheet data formats could be in the dynlink package itself because that package ships with the spreadsheet and will be upgraded when the spreadsheet is updated. In this case, the spreadsheet itself could use the package instead of duplicating the functionality in its own executable file. In any case, the implementation details are hidden from the client process; the client process simply makes a procedure call that returns the desired data.

Viewed from the highest level, this arrangement is simple: A client process uses IPC to get service from a server process via a subroutine library. From the programmer's point of view, though, the entire mechanism is encapsulated in the dynlink subsystem's interface. A future upgrade to the dynlink package may use an improved server process and different forms of IPC to talk to it but retain full binary compatibility with the existing client base.

Interface to OS/2 Itself

All OS/2 interface calls are dynlink calls. We implemented some OS/2 calls as simple library routines. For example, in OS/2 version 1.0, `DosErrClass` takes an error code and locates, in a table, an explanatory text string, an error classification, and a recommended action. Services such as these have traditionally been part of the kernel of operating systems, not because they need to use privileged instructions, but because their error tables must be changed each time an upgrade to the operating system is released. If the service is provided as a statically linked subroutine, older applications running on newer releases will receive new error codes that will not be in the library code's tables.

In OS/2, system calls are indistinguishable from ordinary dynlink calls. This gives us the freedom to, in future releases, move functions between dynlink and call-gate entries.

Although OS/2 implements `DosErrClass` as a library routine, it's a dynlink library routine, and the .DLL file is bundled with the operating system itself. Any later release of the system will contain an upgraded version of the `DosErrClass` routine, one that knows about new error codes. Consequently, the dynlink facility provides OS/2 with a great deal of flexibility in packaging its functions.

Some functions, such as "open file" or "allocate memory," can't be implemented as ordinary subroutines. They need access to key internal data structures, and these structures are, of course, protected so they can't be changed by unprivileged code. To get these services, the processor must make a system call, entering the kernel code in a very controlled fashion and there running with sufficient privilege to do its work. This privilege transition is via a call gate—a feature of the 80286/80386 hardware. A program calls a call gate exactly as it performs an ordinary far call; special flags in the GDT and LDT tell the processor that this is a call gate rather than a regular call.

In OS/2, system calls are indistinguishable from ordinary dynlink calls. All OS/2 system calls are defined in a dynlink module called `DosCalls`. When OS/2 fixes up dynlink references to this module, it consults a special table, built into OS/2, of resident functions. If the function is not listed in this table, then an ordinary dynlink is set up. If the function is in the table, OS/2 sets up a call-gate call in place of the ordinary dynlink call. The transparency between library and call-gate functions explains why passing an invalid address to an OS/2 system call causes the calling process to trigger a GP fault. Because the OS/2 kernel code controls and manages the GP fault mechanism, OS/2 calls that are call gates could easily return an error code if an invalid address causes the fault. If this were done, however, the behavior of OS/2 calls would differ depending on their implementation: Invalid addresses for dynlink entry points would cause a GP fault; call-gate entries would return an error code. OS/2 prevents this dichotomy and preserves its freedom to, in future releases, move functions between dynlink and call-gate entries. Because non-call-gate dynlink routines must generate GP faults, call-gate routines produce them as well.

Device Drivers

Dynlinks do much more than act as system calls. They provide an interface that is as device-independent as a device driver, but without the overhead. Using dynlinks, applications can make high-speed calls to a subroutine package that can directly manipulate the device. The call itself is fast, and the package can specify an arbitrarily wide set of parameters. No privilege or ring transition is needed, and the dynlink package can directly access its client's data areas. Finally, the dynlink package can

continued

With an open system architecture, you can add system services simply by plugging in dynlink modules, just as hardware cards plug into an open hardware system.

use subsystem support features to virtualize the device or to referee its use among multiple clients. Device independence is provided because a new version of the dynlink interface can be installed whenever new hardware is installed. VIO and the Presentation Manager are examples of this kind of dynlink use. Dynlink packages have an important drawback when they are being used as device-driver replacements: They cannot receive hardware interrupts. Some devices, such as video displays, do not generate interrupts. Interrupt-driven devices, though, require a true device driver. That driver can contain all the device interface function, or the work can be split between a device driver and a dynlink package that acts as a front end for that device driver.

Dynlink routines can also act as nonkernel service packages—as an open system architecture for software. Most operating systems are like the early versions of the Apple Macintosh computer: They are closed systems; only their creators can add features to them. Because of OS/2's open system architecture, third parties and end users can add system services simply by plugging in dynlink modules, just as hardware cards plug into an open hardware system. The analogy extends further: Some hardware cards like the Hayes modem and the Hercules Graphics Card become so popular that their interface defines a standard. Third-party dynlink packages will, over time, establish similar standards. Vendors will offer, for example, improved database dynlink routines that are advertised as plug-compatible with the standard database dynlink interface, but better, cheaper, and faster.

Dynlinks allow third parties to add interfaces to OS/2; they also allow OS/2's developers to add future interfaces. The dynlink interface model allows additional functionality to be implemented as subroutines or processes, or even to be distributed across a network environment.

Special Considerations

Although dynlink routines often act very much like traditional static subroutines, a programmer must be aware of some special considerations. I have discussed how a dynlink package runs as a subroutine of the client process and that the client process has access to the dynlink package's instance and global data segments. This use of the dynlink interface is efficient and thus advantageous, but it's also disadvantageous because aberrant client processes can damage the dynlink package's global data segments. The measures a programmer takes to deal with the security issue depend on the nature and sensitivity of the dynlink package. Dynlink packages that don't have global data segments are at no risk; an aberrant program can damage its instance data segments and thereby fail to run correctly, but that's the expected outcome of a program bug. A dynlink package with global data segments can minimize the risk by never giving its callers pointers into the dynlink package's global data segment. If the amount of global data is small and merely detecting damage is sufficient, the global data segments could be checksummed.

If accidental damage to the global data segments would be grave, a dynlink package can work in conjunction with another dynlink package acting as a server. The server process can protect the sensitive data and provide it on a per-client basis to the dynlink package in response to an IPC request. Because the server process is a separate process, its segments are fully protected from the client process as well as from all others.

Dynlink Life, Death, and Sharing

Throughout this discussion, I have referred to sharing pure segments, which are segments that are never modified during their lifetime. The ability to share pure segments is an optimization that OS/2 makes for all memory segments whether they are dynlink segments or an application's executable file segments. All code segments (except for those created by `DosCreateCSAlias`) are pure; read-only data segments are also pure. When OS/2 notices that it's going to load two copies of the same pure segment, it performs a behind-the-scenes optimization and gives the second client access to the earlier copy of the segment instead of wasting memory with a duplicate version.

For example, if two copies of a program are run, all code segments are pure; at most, only one copy of each code segment will be in memory. OS/2 flags these segments as *internally shared* and doesn't release them until the last user has finished with the segment. This is not the same as shared memory as it is generally defined in OS/2. Because pure segments can only be read, never written, no process can tell that pure segments are being shared or being affected by that sharing. Although threads from two or more processes may execute the same shared code segment at the same time, this is not the same as a multithreaded process. Each copy of a program has its own data areas, its own stack, its own file handles, and so on. They are totally independent of one another even if OS/2 is quietly sharing their pure code segments among them.

Because the pure segments of a dynlink package are shared, the second and subsequent clients of a dynlink package can load much more quickly (because these pure segments don't have to be loaded from the .DLL disk file). This doesn't mean that OS/2 doesn't have to hit the disk at all: Many dynlink packages use instance data segments, and OS/2 loads a fresh copy of the initial values for these segments from the .DLL file.

When the last client process of a dynlink object dies or otherwise releases the object, OS/2 destroys the object and frees up the memory. This mechanism has the potential to cause a problem only in the management of the dynlink package's global data segment. For example, when the first client (since boot-up) of a dynlink package references it, OS/2 loads the package's code and data segments. Then OS/2 calls the package's initialization routine—if the package has one. OS/2 records in an internal data structure that this dynlink package has one client. If additional clients come along while the first is still using the dynlink package, OS/2 increments the package's user count appropriately. Each time a client disconnects or dies, the user count is decremented.

As long as the user count remains nonzero, the package remains in existence, with each client sharing the original global data segments. When the client count goes to zero, OS/2 discards the dynlink package's code and global data segments and in effect forgets all about the package. When another client comes along, OS/2 reloads the package and reloads its global data segment as if the earlier use had never occurred.

If discarding the global data segment is a problem for a dynlink package, an associated dummy process (which the dynlink package could start during its load-time initialization) can reference the dynlink package. As long as this process stays alive, the dynlink package and its global data segments stay alive.

An alternative is for the dynlink package to keep track of the

continued

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count of its clients and save the contents of its global data segments to a disk file when the last client terminates, but this is tricky. Because a process may fail to call a dynlink package's "I'm finished" entry point (presumably part of the dynlink package's interface) before it terminates, the dynlink package must get control to write its segment via `DosExitList`. If the client process is connected to the dynlink package via `DosLoadModule` (i.e., via run-time dynamic linking), it cannot disconnect from the package via `DosFreeModule` as long as a `DosExitList` address points into the dynlink package. An attempt to do so returns an error code. Typically, you might expect the application to ignore this error code, but because the dynlink package is still attached to the client process, it will receive `DosExitList` service when the client eventually terminates. It's important that dynlink packages that maintain client-state information and therefore need `DosExitList` also offer an "I'm finished" function. When a client calls this function, the package should close it out and then remove its processing address from `DosExitList` so that `DosFreeModule` can take effect if the client wishes.

Note that OS/2's habit of sharing in-use dynlink libraries has implications for the replacement of dynlink packages. Specifically, OS/2 holds the .DLL file open for as long as that library has any clients. To replace a dynlink library with an upgraded version, you must first ensure that all clients of the old package have terminated.

Dynlink segments, like executable file segments, can be marked (by the linker) as *preload* or *load on demand.* When a dynlink module or an executable file is loaded, OS/2 immediately loads all segments marked preload but usually does not load any segments marked load on demand. These segments are loaded only if and when they are referenced. (Segments that are loaded from removable media will be fully loaded, regardless of the load-on-demand bit.) This mechanism speeds process and library loading and reduces swapping by leaving infrequently used segments out of memory until they are needed. Once a segment is loaded, its preload or load-on-demand status has no further bearing; the segment will be swapped or discarded without consideration for these bits.

Finally, special OS/2 code keeps track of dynlink *circular references*. Because dynlink packages can call other dynlink packages, package A can call package B, and package B can call package A. Even if the client process C terminates, packages A and B might appear to be in use by each other, and they would both stay in memory. OS/2 keeps a graph of dynlink clients—both processes and other dynlink packages. When a process can no longer reach a dynlink package over this graph, the dynlink package is released.

Avoiding Side Effects

A well-written dynlink library should have no side effects. It should export to the client process only its functional interface and not accidentally export side effects that might interfere with the consistent execution of the client.

Some possible side effects are obvious: A dynlink routine shouldn't close any file handles that it didn't open itself. The same applies to other system resources that the client process may be accessing, and it applies in the inverse as well: A dynlink routine that obtains resources for itself, in the guise of the client process, should do so in a way that doesn't affect the client code.

For example, consuming many of the available file handles would be a side effect because the client would then be unexpectedly short of available file handles. A dynlink package with a healthy file-handle appetite should be sure to call OS/2 to raise the maximum number of file handles so that the client process isn't constrained. Finally, a dynlink package must not exhaust the available stack space. A dynlink routine should minimize its stack needs, and an upgrade to an existing dynlink package must not consume much more stack space than did the earlier version, lest the upgrade cause existing clients to fail in the field.

Dynlink routines can also cause side effects by issuing system calls that affect the client process. For example, each signal event can have only one handler address; if a dynlink routine establishes a signal handler, then that signal handler preempts any handler set up by the client application. Likewise, if a dynlink routine changes the priority of the thread with which it was called, the dynlink routine must be sure to restore that priority before it returns to its caller. Several other system functions such as `DosError` and `DosSetVerify` also cause side effects that can affect the client process.

Enumerating all forms of side effects is not possible; it's up to the programmer to take the care needed to ensure that a dynlink module is properly house-trained.

Naming Dynlinks

Each dynlink entry point has three names associated with it: an *external name*, a *module name*, and an *entry-point name*. The name the client program calls as an external reference is the external name. The programmer works with this name, and its syntax and form must be compatible with the assembler or compiler being used. The name should be simple and explanatory yet unlikely to collide with another external name in the client code or in another library. A name such as READ or RESET is a poor choice because of the collision possibilities; a name such as XR23P11 is obviously hard to work with.

The linker replaces the external name with a module name and an entry-point name, which are embedded in the resultant executable file. OS/2 uses the module name to locate the dynlink .DLL file; the code for module `modname` is in file MODNAME.DLL. The entry-point name specifies the entry point in the module; the entry-point name need not be the same as the external name. For modules with a lot of entry points, the client executable file size can be minimized and the loading speed maximized by using entry ordinals in place of entry-point names. Run-time dynlinks are established by using the module name and the entry-point name; the external name is not used.

Flexibility, Efficiency, Consistency

Dynamic linking provides not only a uniform interface to OS/2 that is consistent across system calls and most device interfaces, but it also builds in enough flexibility to allow OS/2 to adapt to developments in technology through the use of nonkernel service packages.

Dynamic linking allows you to keep the target code separate from the executable code, which lets you change or upgrade the code simply by replacing the dynlink code. Because the system links in the dynlink routines itself, it knows it can save more space by sharing segments where possible, thus avoiding duplicate copies of code in memory. With run-time dynamic linking, a process can use OS/2 system calls to determine which dynlink modules it wants to run and then load them. Being able to determine the necessary modules at run time can save space by allowing a process to load only what it needs.

Finally, dynlink routines can serve as a subsystem, a set of services built around a resource such as VIO. Dynlinks can also form the interface between processes, which can add a level of control and protection to the processes involved. Devices that do not need to intercept interrupts can be controlled with dynlinks. And finally, dynlinks form the interface to the OS/2 kernel itself, thus providing a truly consistent interface for the programmer. ■

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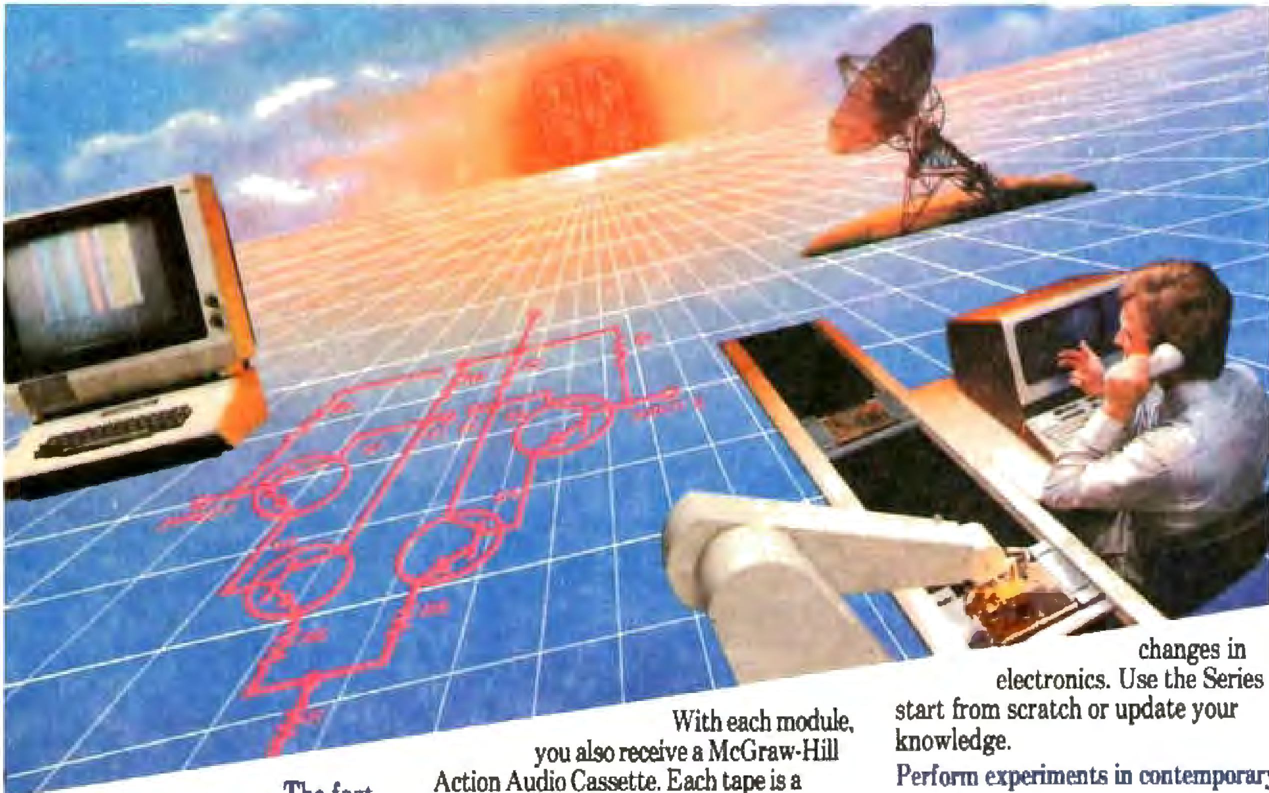

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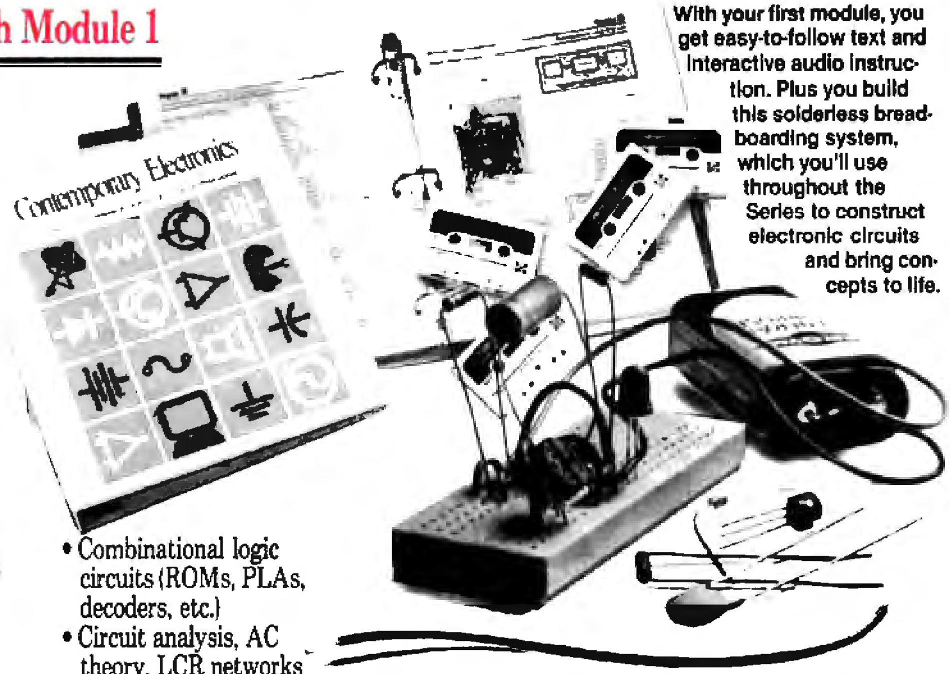

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When Facts Get Fuzzy

Add fuzzy logic to your Turbo Prolog programs and they'll be able to cope with the uncertainties of real-world situations

Most of us like to reason in absolutes. For example, we might say, "If the sky is blue, then it isn't raining." This simple approach works well for reasoning in artificial domains such as formula-proving. But as soon as the meteorologist says "partly cloudy," we are thrown back into the real world, where facts are often ambiguous. If artificial intelligence (AI) is to succeed at modeling human reasoning, it must be able to deal with information that might be uncertain, or even inaccurate.

Fuzzy logic lets us do just that. Programs using fuzzy logic are a series of fuzzy-logic statements, just as ordinary Prolog programs are a series of predicate (i.e., two-valued) logic statements.

Reasoning with Uncertainty

In traditional set theory, an element either belongs to a set or it doesn't. Elements in a fuzzy set may belong only partially to the set. The classic example is the set of "young" people. At what age is someone no longer young? There is no established dividing line, so a fuzzy-set definition might show a person 20 years old as "90 percent young," while someone 60 years old would be only "30 percent young." The degree of membership in a fuzzy set ranges from 0 to 1.

This ability to deal with a continuous range of values, rather than just true and false, is exactly what we need to reason in the real world. However, applications that try to model human reasoning also need additional operations derived from probability theory, since we often think in terms of probabilities. To date, the sets of operations that different applications use to deal with uncertainty have had little in common.

Fuzzy logic defines the minimum set of operations needed by most applications that deal with uncertainty, and is therefore a good candidate to use as a standard. Applications with unusual requirements can define further fuzzy-logic operations by building on this basic set. Fuzzy logic is a superset of predicate logic, which means that nonfuzzy information is handled normally, using the same operators that you would use to handle fuzzy information.

Fuzzy-logic operators are defined on fuzzy truth values, which range from 0 (false) to 1 (true). There are four binary operations: fuzzy AND, fuzzy OR, probability AND, and probability OR (which are written as f-AND, f-OR, p-AND, and p-OR). One unary operation is defined: NOT. We can describe these operations by ordinary arithmetic functions:

$$
\begin{aligned}
a \text{ f-AND } b &= \min(a, b)\\
a \text{ f-OR } b &= \max(a, b)\\
a \text{ p-AND } b &= a \times b\\
a \text{ p-OR } b &= a + b - (a \times b)\\
\text{NOT } a &= 1 - a
\end{aligned}
$$

The three operations f-AND, f-OR, and NOT correspond directly to the predicate-logic operations AND, OR, and NOT. They produce the same results on nonfuzzy values (i.e., 0 and 1), and they obey the same mathematical properties.

Operations from Fuzzy-Set Theory

Fuzzy-set theory, like ordinary set theory, has the three basic set operations: *intersection*, *union*, and *complement*. From these operations we can derive the f-AND, f-OR, and NOT operations, as I'll explain.

- *Fuzzy intersection*. If an element has differing degrees of membership in two fuzzy sets, the *lesser* degree dictates its degree of membership in an intersection of the two sets. For example, if a man is 80 percent young and 40 percent good-looking, he is only 40 percent young *and* good-looking. With the nonfuzzy values 0 and 1, this operation produces the same results as an AND in predicate logic. From this operation we derive the f-AND.
- *Fuzzy union*. Conversely, if an element has differing degrees of membership in two fuzzy sets, the *greater* of the two indicates its degree of membership in a union of two fuzzy sets. Using the previous example, our subject would then be 80 percent young *or* good-looking.

With nonfuzzy values, this operation is equivalent to the predicate logic OR. This becomes the f-OR operation. It is the only significant incompatibility between Prolog and Fuzzy Prolog; the Prolog OR operator is a decision point rather than a true predicate logic OR.

- *Fuzzy complement*. An element's degree of membership in the complement of a fuzzy set is 1 minus its degree of membership in the set itself. Someone who is 80 percent young is, therefore, only 20 percent old. With nonfuzzy values, this operation is equivalent to the NOT in predicate logic and is the basis for the NOT in fuzzy logic. It is not called the f-NOT, since there is no difference between the complement operation we derive from fuzzy-set theory and the one we will derive from probability theory.

Fuzzy-set operations are important, since they essentially extend predicate logic into the realm of fuzzy information without altering the way we think about logic. Past enhancements to Lisp

continued

and Prolog that added fuzzy reasoning abilities have used some or all of these fuzzy-set operations. Unfortunately, fuzzy-set operators are not, by themselves, sufficient to model human reasoning. Most applications require additional operations derived from probability theory.

Operations from Probability Theory

The need for reasoning in probabilities comes up in everyday experience. When you make a decision based on uncertain information, you intuitively weight the data according to their importance and certainty. You then select the course of action which, based on all the evidence, seems most likely to yield a desired result.

Consider, for example, the process of diagnosing a disease. Several symptoms may be characteristic of the disease, and the more symptoms we observe, the more certain we are that the disease is present. Symptoms may not have equal importance—a headache could indicate any number of ailments, but blurred vision is more specific and more indicative of a particular disease.

Fuzzy-set operators provide no good means of combining weightings of symptoms. The best we can do is use the f-OR. If symptom A indicates a 70 percent chance of the disease and symptom B indicates a 40 percent chance, the likelihood of the disease would be calculated as

$$0.4 \text{ f-OR } 0.7 = \max(0.4, 0.7) = 0.7 .$$

This totally disregards the accumulation of evidence; it only considers the single most significant symptom.

Now, let's consider a probability function. Given two independent events A and B, the probability of either occurring is

$$p(A \text{ or } B) = p(A) + p(B) - (p(A) \times p(B)) .$$

If we apply this function to the diagnosis above, we find that the likelihood of the disease is

$$0.4 \text{ p-OR } 0.7 = 0.4 + 0.7 - (0.4 \times 0.7) = 0.82 ,$$

which does show an accumulation of evidence. This is the *probability-OR* (p-OR) in fuzzy logic.

Up to this point, we've assumed that symptoms are either present or absent. This two-valued logic is exactly what fuzzy logic is supposed to avoid. Suppose, for example, that one of the symptoms is an elevated white-blood-cell count. There is no specific value above which the cell count suddenly becomes "elevated." The cell count covers a continuous range; higher counts yield more certainty that something is wrong. So, the proper way to handle this is to map the range of cell counts onto the range of fuzzy values and include this certainty factor in the calculations.

The way to include the certainty factor is to use another probability function. Given two independent events, A and B, the probability of both occurring is

$$p(A \text{ and } B) = p(A) \times p(B) .$$

In the example above, the probabilities are: The chance that a symptom is present (the certainty factor) and the relative importance of that symptom to the diagnosis (the weighting factor). This is the *probability-AND* (p-AND) function in fuzzy logic.

Finally, we can derive a complement operation from probability theory. If we know the probability of event A, then the probability that the event will not occur is

$$p(\text{not } A) = 1 - p(A) .$$

Since this is identical to the complement function derived from fuzzy-set theory, no distinction need be drawn between the two.

Using Fuzzy Logic

The most common method of adding fuzzy-logic capabilities to existing AI languages is to write a shell that runs on top of the existing language. For example, we can add fuzzy-logic operations to Turbo Prolog with the file `FUZZY.PRO` (see listing 1). This file is referenced as an include file by Turbo Prolog programs in which you wish to use fuzzy logic.

Since Turbo Prolog does not allow the definition of new operators, the fuzzy-logic operators are used as predicates, and fuzzy-logic statements are expressed in Reverse Polish Notation. We use the symbols below to represent the five operators in fuzzy logic.

NOT	`f_NOT`
p-AND	`p_AND`
p-OR	`p_OR`
f-AND	`f_AND`
f-OR	`f_OR`

In addition, we define and use the two predicates `fuzzy` and `threshold`. Listing 1, `FUZZY.PRO`, uses `fuzzy` to set and retrieve fuzzy-truth values, and it uses `threshold` to tell the program the lowest acceptable truth value, below which Prolog should backtrack and search for another solution.

In Prolog, the statement (or *rule*)

```
grandparent(X, Z) :- parent(X, Y), parent(Y, Z).
```

means "X is the grandparent of Z if X is the parent of Y and Y is the parent of Z." Similarly, simple facts are represented as

```
parent(betty, tammy).
arent(anna, betty).
```

Given these two facts, and the rule above, if you ask

```
grandparent(anna, tammy).
```

Prolog will respond

```
True.
```

With fuzzy logic, Prolog will also accept facts like

```
scary(king_kong) :- fuzzy(0.5).
funny(king_kong) :- fuzzy(0.1).

scary(american_werewolf) :- fuzzy(0.5).
funny(american_werewolf) :- fuzzy(0.5).
```

and rules like

```
good_movie(X) :- scary(X), funny(X), p_OR,
                 threshold(0.6).
```

The values in the facts are fuzzy-truth values. *King Kong* is moderately scary, but not particularly funny. *An American Werewolf in London* is both moderately scary and moderately funny.

The rule says, in effect, that a movie is good if it is sufficiently scary or sufficiently funny; the threshold of "good" is defined as any truth value 0.6 or higher. You use the p-OR operator in cases like this where evidence is to be accumulated. *American Werewolf* wouldn't be "good" based on either factor

continued

Listing 1: *This file, FUZZY.PRO, adds fuzzy-logic operations to Turbo Prolog when referenced as an include file in Turbo Prolog programs.*

```
database
  truth(real)
  thresh(real)

predicates
  init_fuzzy  fuzzy(real)  threshold(real)
  f_OR  f_AND  p_OR  p_AND  f_NOT

  fuzzy_max(real, real, real)
  fuzzy_min(real, real, real)

clauses

  /* Init_fuzzy must be called before any
     fuzzy  operators or predicates are used.
     It sets the initial search threshold to
     which fuzzy truth values are compared.*/

  init_fuzzy :- asserta(thresh(0.01)).


  /* Fuzzy is used to specify a particular
     fuzzy truth value, or to retrieve the
     current truth value.               */

  fuzzy(Truth) :- bound(Truth),
                  asserta(truth(Truth)),
                  retract(thresh(Thresh)),
                  asserta(thresh(Thresh)), !,
                  Truth >= Thresh.

  fuzzy(Truth) :- retract(truth(Truth)),
                  asserta(truth(Truth)), !.


  /* Threshold sets or retrieves the search
     threshold used by the Fuzzy Logic
     operations. If a call to FUZZY or the
     result of a Fuzzy Logic operator results
     in a truth value less than the threshold,
     the predicate or operator will fail.   */

  threshold(Truth) :- bound(Truth),
                      retract(thresh(_)),
                      asserta(thresh(Truth)),
                      retract(truth(Current)),
                      asserta(truth(Current)),
                      !,Current >= Truth.

  threshold(Truth) :- retract(thresh(Truth)),
                      asserta(thresh(Truth)),
                      !.


  /* Fuzzy logic contains five basic
     operators: fuzzy-AND, fuzzy-OR,
     probability-AND, probability-OR, and
     NOT. In this Turbo Prolog implementation,
     these are represented by f-AND, f-OR,
     p-AND, p-OR, and f-NOT respectively.
     "f-NOT" is used  to avoid conflicting
     with the Turbo Prolog predicate "NOT."
```

continued

```
    Since Turbo Prolog does not support
    true  operator definition, the Fuzzy
    Logic operators are used syntactically
    as predicates, in the order specified
    by Reverse Polish Notation (RPN). For
    example, the clause

      woof :- fuzzy(0.6), fuzzy(0.7),
              p-AND, fuzzy(0.4), p-OR.

    represents the Fuzzy Logic expression

      (0.6 p-AND 0.7) p-OR 0.4

    Note that only predicates which use
    Fuzzy Logic will generate fuzzy truth
    value  operands. Other predicates,
    including those built in to Turbo
    Prolog, do not generate fuzzy truth
    values. Hence, the clause

      woof(X, Y) :- fuzzy(0.6), X > Y,
                    f-AND.

    is incorrect since f-AND requires two
    operands, but only one (from the FUZZY
    predicate) has been generated.      */

f_OR :- retract(truth(X)),
        retract(truth(Y)),!,
        fuzzy_max(X, Y, Z), fuzzy(Z), !.
f_AND :- retract(truth(X)),
         retract(truth(Y)),!,
         fuzzy_min(X, Y, Z), fuzzy(Z), !.
p_OR :- retract(truth(X)),
        retract(truth(Y)),!,
        Z = X + Y - (X * Y), fuzzy(Z), !.
p_AND :- retract(truth(X)),
         retract(truth(Y)),!,
         Z = X * Y, fuzzy(Z), !.
f_NOT :- retract(truth(X)), !,
         Z = 1 - X, fuzzy(Z), !.


      /*  Local predicates used by the
          fuzzy operators           */

     fuzzy_max(X, Y, Z) :- X >= Y, !, Z = X.
     fuzzy_max(_, Y, Z) :- Z = Y.

     fuzzy_min(X, Y, Z) :- X <= Y, !, Z = X.
     fuzzy_min(_, Y, Z) :- Z = Y.
```

alone, but the p-OR will calculate the combined value

$$0.5 \text{ p-OR } 0.5 = 0.5 + 0.5 - (0.5 \times 0.5) = 0.75\,,$$

which is high enough to pass the threshold test and to be accepted. For *King Kong*, on the other hand, the value calculated would be

$$0.5 \text{ p-OR } 0.1 = 0.5 + 0.1 - (0.5 \times 0.1) = 0.55\,,$$

which would not pass the test. So, if we asked

```
good_movie(X).
```

the program would respond with

```
X=american_werewolf
1 Solution
```

indicating that *American Werewolf* is the only good movie it knows of, based on the program's criteria.

As another example of how you can use fuzzy logic, look at listing 2, CITY.PRO. This program evaluates the quality of life in different cities, based on a few factors that reflect one view of what is important. It uses a database of facts that describe the characteristics of various cities: how warm and dry the climate is, the approximate population, and the relative cost of living. All values but the population are rated on a scale from 0 to 1.

The program breaks these criteria into two categories, location and characteristics, and it treats these categories as evidence to be accumulated using the probability operators. It assigns a weight, or importance, of 0.5 to location using the p-AND operator, and similarly assigns a weight of 0.9 to characteristics. The main rule reads

```
nice_city(X) :-
        init_fuzzy, location(X), fuzzy(0.5), p_AND,
        characteristics(X), fuzzy(0.9), p_AND, p_OR,
        fuzzy(Rating),
        write(X, "has a rating of", Rating), nl.
```

The first predicate, init_fuzzy, initializes the fuzzy-logic operations. Location generates the fuzzy-truth value for the city's location. Fuzzy sets a fuzzy-truth value of 0.5, which is then combined with the value from location using the p_AND operator. This sequence is repeated with characteristics, and then the weighted results of location and characteristics are combined with the p_OR. Finally, the program calls fuzzy with the variable Rating (which has no value yet) to retrieve the current fuzzy-truth value, and prints this as the rating of the city.

Not all predicates generate fuzzy-truth values—only user-defined ones that themselves use fuzzy logic, and the predicate fuzzy called with an instantiated value, generate fuzzy-truth values, which can be combined using the fuzzy operators.

In nice_city, the first predicate resolved is location, which contains two predicates and a fuzzy-logic operator

```
location(X) :- city(X), climate(X), f_AND.
```

These provide the name of the city and an evaluation of climate. So long as the database contains a city that hasn't been looked at, predicate city will set X to a city name and return a fuzzy-truth value of 1. This value is combined with the results of climate by an f-AND (which selects the lowest value); hence, location will return the truth value from climate.

Climate evaluates the two climatic factors by using the f-AND

```
climate(X) :- warm(X), dry(X), f_AND.
```

Since the f-AND selects the lower of the two values, this reflects the idea that a climate is only as nice as its worst factor; in order to be pleasant, a city must be both warm and dry.

The characteristics rule evaluates the population and the cost of living:

```
characteristics(X) :-
        population(X,Pop), Val = Pop/2500.0,
        fuzzy(Val), fuzzy(0.9), p_AND,
        expensive(X), f_NOT, fuzzy(0.5), p_AND,
        p_OR, f_AND.
```

The first task of this rule is to map population (given in thousands) onto the range 0 to 1. In this case, the population is simply divided by 2500 and the answer stored in `Val`. The `fuzzy` predicate turns this into a fuzzy-truth value.

The factor for cost of living is higher for cities where the cost of living is higher. To determine the desirability of a city, the program uses f-NOT to invert the truth value of the `expensive` predicate so that less expensive cities receive higher ratings. The population and expense factors are combined using the same method of accumulating evidence discussed above. The final f-AND considers this value and the truth value (1.0) returned by `population` and chooses the lesser of the two, and so does not change the calculated value. The f-AND is required, however, to remove the `population` truth value from the evaluation stack.

To see how all this works, let's trace the execution of the program. If you ask

```
nice_city(Where).
```

the program will enter the `nice_city` rule and begin by evaluating `location`, which, in turn, first evaluates `city`. The `city` predicate searches the database and returns with `X` set to `albuquerque`, the first city appearing in the database; its truth value is 1.0.

`Location` continues by evaluating `climate`. The `climate` predicate gets the values for `warm(albuquerque)` and `dry (albuquerque)`, which are both 0.9, combines them with the f-AND operator, and returns the result of 0.9. `Location` takes this value, f-ANDs it with the truth value returned by `city` (1.0, since it found a city), and hence returns with its own truth value set to 0.9. Predicate `nice_city` weights this with the value 0.5, resulting in an intermediate value of 0.45.

The program must then resolve `characteristics`. In `characteristics`, the program retrieves the population of `albuquerque`, divides it by 2500, and stores the result of 0.2 in `Val`. The evidence accumulation

```
fuzzy(Val), fuzzy(0.9), p_AND,
expensive(X), f_NOT, fuzzy(0.5), p_AND,
p_OR
```

takes the value of `Val`, 0.2, and p-ANDs it with the weighting 0.9, resulting in a value of 0.18. The second half of the expression retrieves the `expensive` value of 0.6, uses f-NOT to invert it to 0.4, and weights it with the value 0.5 for a result of 0.2. The two halves are combined with the p-OR, which yields a value of 0.344.

This value is f-ANDed with the truth value 1.0 returned when the population was retrieved. This results in no change, so the program returns value 0.344 as the truth value of `characteristics`.

Finally, the program can evaluate the `nice_city` clause. The value from `characteristics` is p-ANDed with 0.9, producing a value of 0.3096, and this is p-ORed with the truth value from the first half, which was 0.45. This yields a final rating for Albuquerque of 0.62028. Based on this, the program will respond to our query about where nice cities are located with

```
albuquerque has a rating of 0.62028
Where=albuquerque
```

The program also provides the answers:

```
boston has a rating of 0.74545
Where=boston
```

continued

Listing 2: *The program CITY.PRO uses the fuzzy-logic operations in listing 1 to evaluate the quality of life in different cities.*

```
/*
   City -- This is a simple program which
   uses fuzzy logic to determine how "nice"
   various cities are.                   */


include "fuzzy.pro"    /* Include the fuzzy
                          logic module   */


predicates
  nice_city(symbol)   location(symbol)
  city(symbol)        climate(symbol)
  warm(symbol)        dry(symbol)
  characteristics(symbol)
  population(symbol, integer)
  expensive(symbol)


clauses

  nice_city(X) :- init_fuzzy, location(X),
                  fuzzy(0.5), p_AND,
                  characteristics(X),
                  fuzzy(0.9), p_AND, p_OR,
                  fuzzy(Rating),
                  write(X,
                       " has a rating of ",
                       Rating),
                  nl.

  location(X) :- city(X), climate(X), f_AND.

  climate(X) :- warm(X), dry(X), f_AND.

  characteristics(X) :- population(X,Pop),
                        Val = Pop/2500.0,
                        fuzzy(Val),
                        fuzzy(0.9), p_AND,
                        expensive(X), f_NOT,
                        fuzzy(0.5), p_AND,
                        p_OR, f_AND.


  /*  Data on various cities  */

  city(albuquerque) :- fuzzy(1.0).
  city(boston) :- fuzzy(1.0).
  city(ft_worth) :- fuzzy(1.0).

  warm(albuquerque) :- fuzzy(0.9).
  warm(boston) :- fuzzy(0.5).
  warm(ft_worth) :- fuzzy(0.9).

  dry(albuquerque) :- fuzzy(0.9).
  dry(boston) :- fuzzy(0.6).
  dry(ft_worth) :- fuzzy(0.7).

  population(albuquerque, 500) :- fuzzy(1.0).
  population(boston, 2000) :- fuzzy(1.0).
  population(ft_worth, 1500) :- fuzzy(1.0).

  expensive(albuquerque) :- fuzzy(0.6).
  expensive(boston) :- fuzzy(0.9).
  expensive(ft_worth) :- fuzzy(0.8).
```

```
ft_worth has a rating of 0.69281
Where=ft_worth

3 Solutions
```

From this, we can see that the program continued searching the database for more cities. It evaluated the cities in the order it found them, and printed out the results for each nice city it found.

Creating Fuzzy Prolog From the Ground Up

While you can add fuzzy logic to an existing dialect of Prolog, applications pay a significant penalty in efficiency, since the shell adds another layer of software between the application and the machine. Also, the result is often awkward to use. This is true of my Turbo Prolog implementation in two regards: Using Reverse Polish Notation for fuzzy-logic operators, and remembering which predicates produce fuzzy-truth values can be confusing. In addition, backtracking will not properly undo the results of fuzzy operations, since they are not an implicit part of the language.

The best solution to these difficulties is to build fuzzy logic into a dialect of Prolog from the ground up. I have written a dialect of Prolog called Fuzzy Prolog, which implements fuzzy logic.

Since fuzzy-logic operations are an implicit part of the language, the difficulties mentioned above do not exist. Also, since fuzzy logic is a superset of predicate logic, Fuzzy Prolog remains compatible with Prolog and will run all ordinary Prolog programs. For information on obtaining the source code to Fuzzy Prolog, see the Editor's note at right.

A Fuzzy Standard

Problems are rarely black and white, and answers almost never true or false. Current applications that try to simulate human reasoning must deal with uncertainty before they can begin to address their real objectives.

To date, however, the different approaches that have been developed for dealing with uncertainty have shown little consistency with one another. Fuzzy logic provides a common core of operations and, thereby, a basis for standardization. Making fuzzy logic an implicit feature of a language such as Fuzzy Prolog relieves applications of much of the burden of dealing with uncertainty. Consequently, software development will take less time, and the resulting software will be less complex. Of that, we can be fairly certain. ■

Editor's note: *The Turbo Prolog programs FUZZY.PRO and CITY.PRO and the source code for the Fuzzy Prolog interpreter are available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement. See page 3. The Fuzzy Prolog interpreter is written in Ada, and the source code is public domain. The user's manual, source code listings, and complete documentation for Fuzzy Prolog are also included in the author's master's thesis, "Programming in Fuzzy Logic: Fuzzy Prolog," Air Force Institute of Technology, December 1986, available for $30.95 from the National Technical Information Service, (703) 487-4650. Request document #ADA177940.*

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Mark A. O'Neill

Faster Than Fast Fourier

The fast Hartley transform is twice as fast as the fast Fourier and uses only half the computer resources

Joseph Fourier left to mathematics a rich legacy: The transform that bears his name processes many of today's audio and electromagnetic signals. Image processing and digital filtering of signals use the Fourier transform or its faster descendant.

However, the fast Fourier transform (FFT) requires a large amount of computer resources. The fast Hartley transform (FHT) can accomplish the same results faster, using fewer resources. First described by Ronald Bracewell (see reference 1), the FHT handles many of the jobs now done by the Fourier transform.

Both the FHT and the FFT let you map a continuous signal over time onto a frequency function. The Fourier transform maps a real function of time $X(t)$ to a complex function of frequency, $F(f)$.

The Hartley transform maps a real function of time $X(t)$ onto a real function of frequency $H(f)$. Since the Hartley frequency function is real, you need only single arithmetic operations to compute it.

Compare this to the many arithmetic operations required of the complex Fourier frequency function (four operations for a complex multiply or divide, and two for complex addition or subtraction).

Furthermore, real data arrays require only half the memory storage of complex data arrays. This means that the Hartley transform will require considerably less memory for a given data set than the Fourier transform. Therefore, the Hartley transform will be distinctly faster and use less memory than the conventional Fourier transform in digital filtering and image enhancement applications where you have to process large amounts of data.

A Definition of the Hartley Transform

Equation (1) shows the analytical form of the Hartley transform, and (2) shows its inverse transform, used to map the frequency function back into the time domain:

$$H(f) = \frac{1}{2\pi} \int_{-\infty}^{\infty} x(t)\,\mathrm{cas}(2\pi ft)\,dt, \tag{1}$$

$$X(t) = \int_{-\infty}^{\infty} H(f)\,\mathrm{cas}(2\pi ft)\,df, \tag{2}$$

where $\mathrm{cas}(2\pi ft) = \cos(2\pi ft) + \sin(2\pi ft)$.

The function $\mathrm{cas}(2\pi ft)$ was introduced by R.V.L Hartley (see reference 2), who first proposed the Hartley transform in 1942.

You can see that these equations are very similar to those of the Fourier transform and its inverse:

$$F(f) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(t)\,e^{-j2\pi ft}\,dt, \tag{3}$$

$$X(t) = \int_{-\infty}^{\infty} F(f)\,e^{j2\pi ft}\,df, \tag{4}$$

where $e^{j2\pi ft} = \cos(2\pi ft) + j\sin(2\pi ft)$, and $e^{-j2\pi ft} = \cos(2\pi ft) - j\sin(2\pi ft)$. (These are known as Euler's formulas.)

Note that I'm using the electrical engineering convention of labeling the imaginary unit i as j. The principal difference between the two functions is that the real function $\mathrm{cas}(2\pi ft)$ in the Hartley transform replaces the complex exponential term $e^{\pm j2\pi ft}$ in the Fourier transform pair.

The Hartley and Fourier transform functions in (1) through (4) deal only with continuous variables. As is often the case with computer data in the real world, signals are sampled at discrete intervals of time or for a specific interval. Fortunately, you can define a discrete transform that can represent a quantized continuous signal, or a signal of limited duration. The discrete forms of the Hartley transform pairs are

$$H(f) = \frac{1}{N} \sum_{t=0}^{N-1} F(t)\,\mathrm{cas}(2\pi ft/N) \tag{5}$$

and

$$X(t) = \sum_{f=0}^{N-1} H(f)\,\mathrm{cas}(2\pi ft/N). \tag{6}$$

Again, note the similarities to the Fourier transform pairs:

$$F(f) = \frac{1}{N} \sum_{t=0}^{N-1} X(t)\,e^{(-j2\pi ft/N)}, \tag{7}$$

$$X(t) = \sum_{f=0}^{N-1} F(f)\,e^{(j2\pi ft/N)}. \tag{8}$$

The Fast Algorithm

As it stands in (5) and (6), computation of the discrete Hartley transform presents an analogous problem to the computation of the discrete Fourier transform. That is, you have to perform N^2 arithmetic operations to compute the discrete Hartley transform of an N-element data set.

A classic paper by Cooley and Tukey (see reference 3) in 1965 led to the development of a fast algorithm for the machine computation of a complex Fourier series.

Essentially, the FFT uses a permutation process to bisect the data until data pairs are reached. Calculating the Fourier trans-

continued

form of such data pairs is trivial (i.e., rapid).

The idea behind the permutation process is that it's faster to split the data into pairs, compute the transform of the pairs, and recombine these to make the entire transform rather than to compute the transform for the complete data set.

Permutation is particularly fast when the amount of data is large. If you superimpose all such two-element pairs using a process sometimes referred to as the "butterfly" (due to the appearance of the diagram of the data flow; see figure 1), you can compute the Fourier transform of the input data set. It takes approximately $N \log(N)$ seconds to compute the transform of an N-point data set.

Bracewell (see reference 4) has shown that you can employ a similar methodology in the case of the Hartley transform. Again, you use the permutation process to bisect the data until you get data pairs.

The Hartley transform of a data pair (a, b) is $\frac{1}{2}(a + b, a - b)$, and the computation of such pairs is trivial. You can also superimpose these two-element sequences to calculate the Hartley transform of the input data set. However, to do so requires a formula that expresses a complete discrete Hartley transform (DHT) in terms of its half-length subsequences.

Bracewell has shown by application of the Shift and the Similarity theorems that (9) expresses the general decomposition formula for the DHT. This general decomposition formula generates the desired DHT by bisecting the data.

Put another way, it's the rule used to generate the elements to be used in the butterfly computation of the transform. You can apply similar methodology to the Fourier transform to yield the decomposition formula given in (10):

$$H(f) = H_1(f) + H_2(f)\cos(2\pi f/N_s) + H_2(N_s - f)\sin(2\pi f/N_s), \tag{9}$$

$$F(f) = F_1(f) + F_2(f)e^{i2\pi f/N_s}, \tag{10}$$

where N_s is the number of elements in the half-length sequence, and thus $N_s = N/2$ for a data set of N elements. Figure 1 shows a complete butterfly diagram for computing the FHT for an eight-element data set.

The decomposition formula for the FHT differs from the FFT in one important respect: The elements multiplied by the trigonometric terms are not symmetric. In the FFT decomposition formula of (10), terms multiplied by the trigonometric coefficients involve terms only in $F(f)$. In the FHT decomposition formula of (9), both $H(f)$ and $H(N_s - f)$ have sine coefficients. This asymmetry becomes apparent when you express the discrete transforms as matrix operations: FFT matrix terms are symmetric about the matrices' leading diagonal, while corresponding terms for the FHT are asymmetric.

This introduces some computation problems, because asymmetric matrix processing is difficult to implement. You can deal

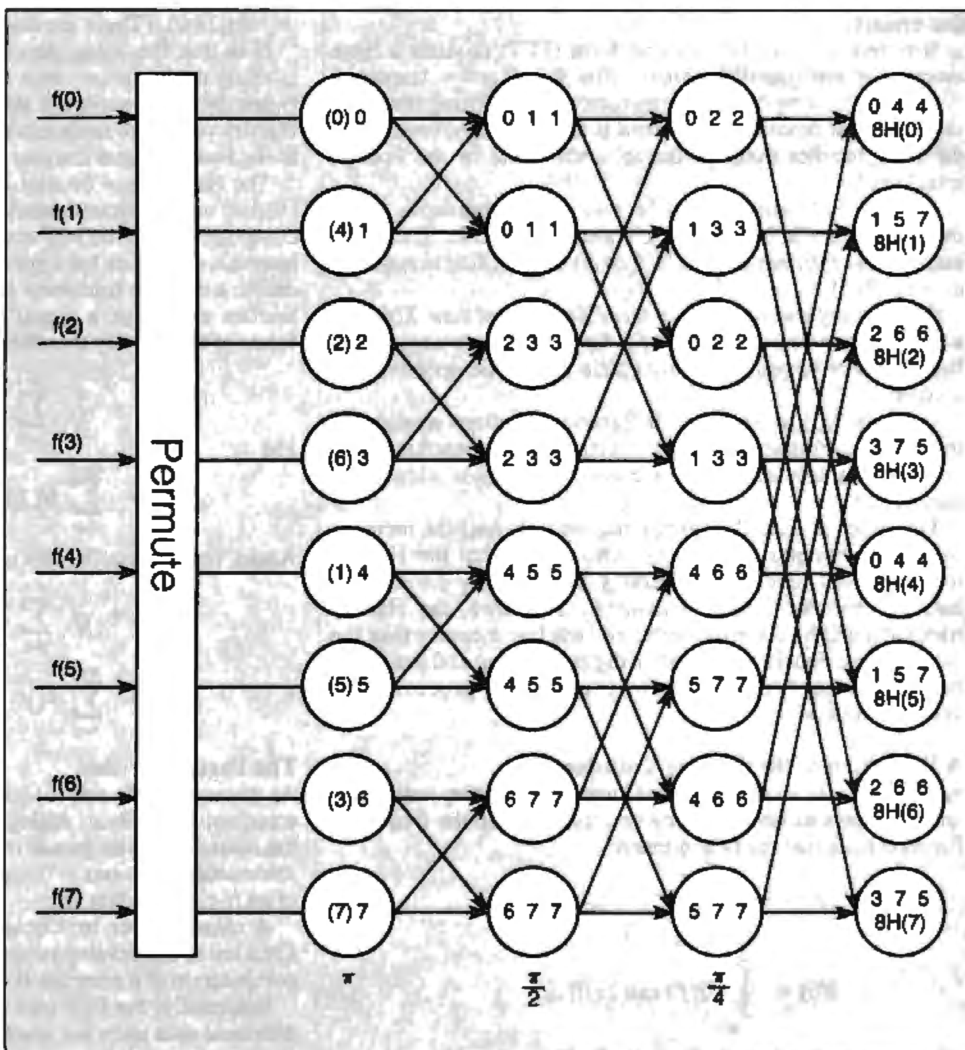

Figure 1: *The butterfly diagram for the fast Hartley transform for an eight-element data set. In the first column of cells, the indexes show the effects of permutation on the data elements. The next three columns represent the data elements as superimposed by the decomposition formula for the butterfly computation. These cells show the three indexes of the elements. You can see the effects of retrograde indexing for an eight-element data set in indexes for the third and fourth iteration of the butterfly. Radians at the bottom of the diagram give the angular spacing between trigonometric coefficients.*

with this asymmetry by using an independent variable as an index for the elements multiplied by the sine coefficients. This index decreases while the other indexes increase; this behavior is called retrograde indexing. Bracewell gives descriptions of the FHT and FFT algorithms using matrix formalism (see reference 5).

You can obtain the inverse Hartley transform by applying the FHT algorithm again to its own output, thus regenerating the input data. This means that you can use the same program code to compute the transform and its inverse. However, there is a slight asymmetry between the FHT and its inverse. In the case of the time-to-frequency transform, you need to scale the result of the butterfly computation. That is, for an input data set of N elements, you must divide the output of the butterfly by N to obtain the discrete Hartley transform.

You don't need to do this for frequency-to-time transform; consequently, the butterfly computation itself constitutes the inverse transform. It is not difficult to add a small amount of code to control whether scaling should be applied during a conversion.

Comparing the FFT and FHT Algorithms

You can use the FHT algorithm for many of the applications for which you would now use the FFT algorithm. These include convolution and deconvolution (used to remove artifacts introduced into data by imperfections in the sensors), and the generation of power spectra for filtering. You can also obtain the Fourier transform itself from the Hartley transform. In fact, it is often faster to generate the Fourier transform and power spectrum with the FHT than with the FFT, because computing the butterfly using real rather than complex quantities requires fewer floating-point operations. You assemble the real and imaginary parts of the FFT at the end of the calculation using the equations

$$F_r = H(f) + H(N-f)$$

and

$$F_{im} = H(f) - H(N-f),$$

where F_r is the real portion of the complex Fourier transform, F_{im} is the imaginary portion, and N is the number of elements in the data set.

You can calculate the power spectrum directly from the Hartley transform using the equation

$$P_s(f) = [H(f)^2 + H(N-f)^2]/2,$$

where P_s is the power spectrum.

The theorem for convolving a pair of functions is almost identical, whether you are considering the Hartley transform or the Fourier transform. Again, the FHT should prove superior to the FFT in terms of speed for any given implementation. Equation (11) summarizes the theorem for the convolution for the Hartley transform, (12) for the Fourier transforms.

$$f_1(t) \circledast f_2(t) = H_1(f)H_{2e}(f) + H_1(-f)H_{2o}(f) \qquad (11)$$

and

$$f_1(t) \circledast f_2(t) = F_1(f)F_2(f). \qquad (12)$$

The $\circledast$ symbol denotes the convolution operation.

The subscripts e and o in (11) denote the even and odd parts of the Hartley transform. Note that if one of the functions being convoluted is either even *or* odd, then the form of the convolution theorem for the Hartley transform reduces to the particularly simple form indicated in (13):

$$f_1(t) \circledast f_2(t) = H_1(f)H_2(f). \qquad (13)$$

In practical applications, many of the convolution functions are even. For example, the Gaussian function, used in image-enhancement work, is an even function. We can take advantage of the nature of these functions to use the computational shortcut provided by (13).

Spectral Leakage

As with the FFT algorithm, the FHT algorithm will produce an erroneous frequency function if the data set to be transformed does not smoothly approach 0 at both ends of its range. Such spectral leakage is undesirable in many cases. You can reduce it

continued

Listing 1: *The code fragment from* hartley.pas *that shows the complete Hartley transform as implemented in TML Pascal.*

```
{-----------------------------------
   Fast Hartley transform routine ...
   version 1.00, Dated 22nd November 1986,

transform:= forward; Forward transform from
time frequency domain. transform := reverse;
Reverse transform from frequency to time
domain.

power_index: Index to which 2 must be raised
to generate a transform containing 'syze'
elements:
      if syze = 8  then power_index = 3;
      if syze = 16 then power_index = 4; etc
...

syze:  Number of element in the input data
array.
-----------------------------------}

const
   datasize = 512;
type
   direction_type = (forward,reverse);
   data_array_type = array[1..datasize] of
real;
var
   dir, test_option: char;
   i,j,syze,iter,demo: integer;
   data_array: data_array_type;
   transform_direction: direction_type;

procedure fht(var data_array: data_array_type;
                      power_index,
                      syze: integer;
                      transform:direction_type);

var
   i,
   j,
   k,
   trg_ind,
   trg_inc,
   power,
   t_a,
   f_a,
   i_temp,
   section,
   s_start,
   s_end: integer;
   sne,csn: array[1..datasize] of real;
   accu: array[1..2,1..datasize] of real;
```

continued

```
{------------------------------------
Permutation routine. This routine
reorders the data before the butterly
transform routine is called ...
------------------------------------}

function permute(index: integer): integer;
var
  i,j,s: integer;
begin
   j := 0;
   index := index - 1;
   for i := 1 to power_index do
   begin
      s := index div 2;
      j := j + j + index - s - s;
      index := s;
   end;
   permute := j + 1;
end;

{------------------------------------
Calculate the trigonometric functions
required by the FHT and store values.
For a N point transform, the trigno-
metric functions will be calculated
at intervals of Nths of a turn ...
------------------------------------}

procedure trig_table(npts: integer);
const
   pi = 3.14159265;
var
   i: integer;
   angle,omega: real;
begin
   angle := 0;
   omega := 2 * pi / npts;
   for i := 1 to npts do
   begin
      sne[i] := sin(angle);
      csn[i] := cos(angle);
      angle := angle + omega;
   end;
end;

{------------------------------------
Calculate the address of the retrograde
index for the sine term for the dual
place algorithm, if it is required ...
------------------------------------}

function modify(power,s_start,s_end,index:
integer): integer;
begin
   if (s_start = index) or (power < 3) then
      modify := index
   else
      modify := s_start + s_end - index + 1;
end;
{------------------------------------
   Butterfly transform an index pair ...
------------------------------------}

procedure butterfly(trig_ind,i_1,i_2,i_3:
integer);
begin
   accu[t_a,i_1] := accu[f_a,i_1] +
           accu[f_a,i_2] * csn[trig_ind] +
           accu[f_a,i_3] * sne[trig_ind];
```

continued

by multiplying the data set to be transformed by a suitable window function before computing the transform.

All these window functions cause the data to smoothly approach 0 at the limits of its range. Stigall, Ziemer, and Hudec have reviewed the effects of these window functions on the power spectrum (see reference 6).

If you're interested in some experimentation, I've provided a number of these window functions below. The triangular window is a low-quality window function whose primary advantage is its speed. An example of its use is to filter noise from telemetry signals in real time.

Triangular window:
$W(n) = 2(n+0.5)/n$,
$W(N-n-1) = W(n)$,

where $n = 0,1, \ldots i, \ldots, N/2$.

The Hanning and Hamming windows feature better reduction in spectral leakage, but at the expense of speed. I've used these window functions to preprocess satellite image data before using the Hartley transform to correct the images for defects in the camera optics.

Hanning window: $W(n) = 0.5(1-\cos(2\pi(n+0.5)/N))$,

where $n = 0,1, \ldots i, \ldots, N-1$.

Hamming window: $W(n) = 0.54 - 0.46(\cos(2\pi(n+0.5)/N))$,

where $n = 0,1, \ldots i, \ldots, N-1$.

The Blackman window is for data sets where the Hamming/Hanning windows would not be suitable.

Blackman window: $W(n) = 0.42 - 0.5\cos(2\pi(n+0.5)/(N-1))$,

where $n = 0,1, \ldots i, \ldots, N-1$.

You can find additional information about spectral window functions in the papers by Harris (see reference 7) and Nutall (see reference 8).

The FHT program

The demonstrator program `hartley.pas` described below computes the Hartley transform and inverse Hartley transform of an N-element data set. The program was originally written in Acornsoft ISO Pascal for the BBC Microcomputer, but few machine-dependent Pascal extensions are used.

The routine has also been successfully ported to a Prime 9975 minicomputer, running Sheffield Pascal, and a Sun-3/160 workstation running International Standard Organization level 0 Pascal.

As an example of just how easy it is to port the fast Hartley routine to other machines, I have included the code for `hartley.pas` as written in TML Pascal for the Macintosh.

The `hartley.pas` program simply generates a suitable function to be transformed and then calls the `fht` procedure twice. Thus, the program calculates both the Hartley transform and its inverse transform. The procedure `fht` is the major routine in the program. Listing 1 is a code fragment of `hartley.pas` that contains the `fht` procedure.

The code within procedure `fht` complies with the ISO level 1 standard for Pascal, except that the program uses the underscore character in variable names. Consequently, you can lift the pro-

continued

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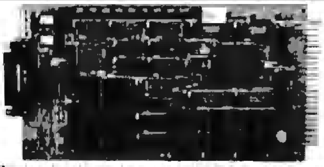

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- [illegible] dynamic RAM [illegible]
- Full-function [illegible] ROM monitor included

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- Console RS-232 serial port with auto baud rate select to [illegible] baud
- Peripheral serial port [illegible] baud, selectable RS-232, RS-[illegible] or RS-[illegible]
- [illegible] bits bi-directional parallel I/O
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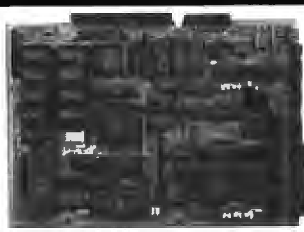

SB180FX TECHNICAL SPECIFICATIONS

PROCESSOR
- Hitachi HD64180 [illegible] CPU in a [illegible] pin PLCC package
- Superset of Z-80 instruction set including hardware multiply
- Integrated Memory Management Unit with [illegible] bytes address space
- Dynamic RAM refresh
- Wait state generator
- Clocked serial I/O port
- [illegible] channel Direct Memory Access Controller
- [illegible] channel Asynchronous Serial Communication Interface
- [illegible] channel [illegible] Programmable Reload Timer
- [illegible] interrupts
- Dual bus interface to [illegible] and [illegible] support chips
- [illegible] MHz system operation

MEMORY
- [illegible] bytes dynamic RAM on board
- Memory [illegible] expandable to [illegible] RAM
- Either [illegible] EPROM socket
- Full function [illegible] ROM monitor

INPUT/OUTPUT
- Console RS-232 serial port with auto baud rate select to [illegible] baud
- Peripheral RS-232 serial port, full hand shaking, [illegible] baud
- Line printer parallel I/O port
- [illegible] bits bi-directional parallel I/O
- [illegible] address decoding, I/O port decoding and dual bus interface brought out to expansion bus connector
- Can be directly attached to [illegible] color graphics adapter
- Fully [illegible] SCSI [illegible] and [illegible] bus interface

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- Uses Standard Microsystems [illegible] disk controller
- Compatible with NEC 765A controller
- On-chip digital data separator
- Can control 3½", 5¼", and 8" floppy disk drives—up to 4 in any combination
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- NCR [illegible] SCSI bus controller for hard disk or network communication

SOFTWARE COMPATIBILITY
- CP/M, ZRDOS, ZCPR Compatible

SB180FX-1	SB180FX [illegible] MHz computer board populated w/ [illegible] bytes RAM, [illegible] byte ROM monitor, without SCSI chip. Add $50.00 for [illegible] MHz	$[illegible]
SB180FX-1-30	[illegible]	$[illegible]

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- Only 3 [illegible]" x 9" piggy backs on either an SB180 or SB180FX computer
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- Hardware drawing commands: LINE, RECTANGLE, POLYLINE, POLYGON, CIRCLE, ELLIPSE, ARC, FILLED RECTANGLE, PAINT, PATTERN, WINDOWS and COPY to name but a few
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- Fast drawing speed of [illegible] million pixels per second
- Provides fully programmable horizontal split screens and window screen
- Fully supported by **GT180** Graphic Toolbox written in Modula-2

GT180-1	Graphic Display Expansion Board (TTL RGB only)	$[illegible]
GT180-2	Graphic Display Expansion Board (TTL RGB and Analog RGB)	$[illegible]

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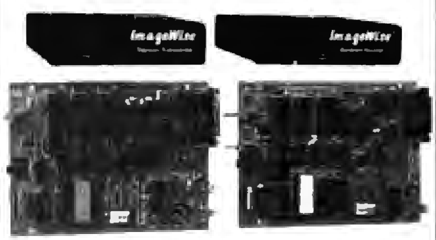

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IMAGEWISE SYSTEM SPECIFICATIONS
- [illegible] bus dependent – can function standalone
- True frame grabber – uses a high speed flash A/D converter and [illegible] bytes of static RAM to capture an image in [illegible]
- Accepts any B/W or color NTSC video signal
- Stores pictures as [illegible] lines of [illegible] pixels, [illegible] levels grayscale
- Resolution of transmitted image is software selectable; all images are represented in [illegible] levels of gray scale

  Selectable Resolutions
  High [illegible]
  Med [illegible]
  Low [illegible]
- Video Input: 1 volt peak to peak B/W or color [illegible] ohm termination
- Video Output: 75 Ohm, 1.5 V peak to peak NTSC composite video
- Serial Input/Output: RS-232 – [illegible] bit, one stop bit, no parity, 300 bps [illegible] selectable data rate. Xon/Xoff Handshaking. Switch selectable data compression on/off
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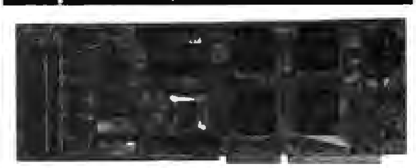

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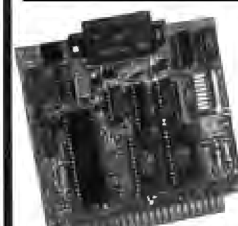

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```
    trig_ind := trig_ind + syze div 2;
    accu[t_a,i_2] := accu[f_a,i_1] +
            accu[f_a,i_2] * csn[trig_ind] +
            accu[f_a,i_3] * sne[trig_ind];
end;




{-------------------------------------
   Main program for the fast Hartley
   transform.
-------------------------------------}

begin

   power := 1;
   f_a := 1;
   t_a := 2;
   trig_table(syze);
   for i := 1 to syze do accu[f_a,permute(i)]
 :=
             data_array[i];

{-------------------------------------
   Start of the Hartley butterfly
   transform ...
-------------------------------------}

   for i := 1 to power_index do
   begin
      j := 1;
      section := 1;
      trg_inc := syze div (power + power);
      repeat
         trg_ind := 1;
         s_start := section * power + 1;
         s_end   := (section + 1) * power;
         for k := 1 to power do
         begin
            butterfly(trg_ind,j,j + power,
                  modify(power,s_start,s_end,j
                                  + power));
            trg_ind := trg_ind + trg_inc;
            j := j + 1;
         end;
         j := j + power;
         section := section + 2;
      until j > syze;
      power := power + power;
      i_temp := t_a;
      t_a    := f_a;
      f_a    := i_temp;
end;

{-------------------------------------
End of Hartley butterfly. The results are
scaled if necessary, and then placed in
back into the array data ...
-------------------------------------}

   case transform_direction of
            forward: for i := 1 to syze do
                              data_array[i] :=
accu[f_a,i] / syze;
         reverse: for i := 1 to syze do
                              data_array[i] :=
accu[f_a,i];
   end;
end;
```

cedure from the demonstration program and use it freely in your own applications.

However, a brief description of `fht` and its embedded subprocedures may be useful if you'd like to experiment with the program.

The procedure `trig_table` precalculates the trigonometric functions required by `fht`. For an input data set containing N elements, adjacent entries in this table are $2\pi/N$ radians apart. This precalculation of the trigonometric terms avoids redundant computations of these values if they are needed frequently during processing.

The procedure `permute` bisects the input data set progressively until data pairs are reached. The algorithm given is adapted from one described by Bracewell, who has also described faster permutation routines (see reference 5) that you can substitute if you want.

The procedure `butterfly` calculates the butterfly of a single index pair. This procedure requires three indexes to use as entry parameters. This takes into account the possibility of retrograde indexing for the data element multiplied by the sine factor. Where retrograde indexing is necessary, the procedure `modify` calculates the retrograde indexes used by the procedure `butterfly`.

The main program of the `fht` procedure first precalculates the trigonometric function tables and permutes the input data. The program then enters an iterative loop that computes the butterfly for the whole of the N-element input data set. You then scale the resulting output by a factor of N if you are computing the time-to-frequency transform.

When you have to deal with the complex form of the frequency transform, you can obtain Fourier transform from the FHT algorithm by operating on the output data of the procedure `fht` using the Pascal procedure `get_FFT.pas`, shown in listing 2. By the time you exit from this procedure, the real and imaginary parts of the Fourier transform will be in the arrays. They are passed via the dummy conformant array variables `r_pt` and `i_pt`, respectively.

A similar procedure in `get_pwr.pas` called `get_power_spectrum` (shown in listing 3) allows you to obtain the power spectrum from the Hartley transform. At exit from this procedure, the power spectrum will be in the array passed to the procedure via the dummy conformant array variable p_sp. You can use both of the above procedures in applications programs without any modification. These procedures conform to the ISO level 1 standard of the Pascal language, and should be usable directly on any computer that supports an ISO level 1 Pascal compiler.

The modifications required to compile these procedures with an ISO level 0 compiler are trivial. Basically, it is just a case of replacing all the conformant array parameters' procedure headers of `get_fft` and `get_power_spectrum`, with array parameters of fixed size.

Performance

The BBC Microcomputer implementation of the FHT program has proved to be fast and is currently running on a 6502A-based BBC Microcomputer with a second add-on 3-MHz 6502 processor, which executes the program. This hardware can compute a 256-point transform in about 32 seconds. This compares favorably with the 2 minutes it took Bracewell's original implementation of the FHT algorithm to accomplish a 256-point transform on an HP-85 system. You can expect even better performance from 16-bit microcomputers.

Table 1 shows the timings for running the FHT program on the Macintosh Plus and Mac II using TML Pascal and the Sun-3/160 workstation using ISO Pascal.

continued

Table 1: *Timings for the* `hartley.pas` *demonstrator program on several machines. For the Macintosh computers, TML Pascal version 2.50 was used, and times are to the nearest second. No 68881 coprocessor code was generated for the test, so the Mac II's 68881 was not used. You can expect better times if you use the 68881. For comparison, the results of the same code compiled on a Sun-3/160 workstation using ISO Pascal are shown. Times are in seconds.*

Number of points	Mac Plus FPU not used	Mac II FPU not used	Sun-3/160 FPU not used	Sun-3/160 68881 FPU used
2	0.00	0.00	0.00	0.00
4	0.00	0.00	0.02	0.00
8	0.00	0.00	0.04	0.00
16	1.00	0.00	0.08	0.02
32	1.00	1.00	0.18	0.04
64	2.00	1.00	0.34	0.06
128	6.00	2.00	0.70	0.08
256	12.00	3.00	1.48	0.18
512	27.00	6.00	3.60	0.40

Listing 2: *Pascal code to compute the Fourier transform from the FHT algorithm.*

```
Procedure get_FFT(var data:
array[l0..h0:s_int] of real;
 var r_pt: array[l1..h1:s_int] of real;
 var i_pt: array[l2..h2:s_int] of real;
 size: s_int);
 var i: s_int;
 begin
 i = 1;
while i<size do
 begin
 r_pt[i] := data[i] + data[size - i + 1];
i_pt[i] := data[i] - data[size - i + 1];
 i := i + 2;
 end;
end;
```

Listing 3: *Pascal code to compute the power spectrum from the FHT algorithm.*

```
 procedure get_power_spectrum
 (var data: array[l0..h0:s_int] of real;
 var p_sp: array[l1..h1:s_int] of real;
size: s_int);
 var i: s_int;
begin
 i := 1;
while i<size do
 begin
 p_sp[i] := (data[i] * data[i] +
      data[size - i + 1] *
      data[size - i]) / 2;
 i := i + 1;
 end;
 end;
```

Note that you can attain very high speeds with the Sun workstation, with its combination of a 20-MHz 68020 processor, 68881 floating-point coprocessor, and optimizing Pascal compiler.

New Limits to Explore

I hope this article has given you enough information to seriously consider using the Hartley transform for your signal processing needs. Since the transform uses only real functions, you don't need computationally expensive complex math to digitally filter or enhance a signal.

The elimination of complex numbers also reduces the amount of memory required to process a signal. Finally, since the Hartley transform uses fewer operations to process a signal, you will have fewer roundoff errors.

The FFT made a lot of what we call image processing possible by manipulating large amounts of data in a reasonable amount of time. The FHT offers better performance using less computational resources. With the same code you use to compute the transform, you can compute its inverse when necessary. It will be interesting to see what new uses will result from the expanded limits of processing that the Hartley transform provides. ■

Editor's note: *Source code listings that accompany this article,* `hartley.pas`, `get_FFT.pas`, *and* `getpwr.pas`, *are available on BIX, on BYTEnet, on disk, and in the Quarterly Listings Supplement.* *See page 3.*

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Terribly Fast

88/286/386

8/10/16 MHz
10/12/20 MHz Optional

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One Year Labor & Parts

SPECIFICATIONS

1. 9" High Res. (750x348) Dual Frequency Amber CRT Monitor Accepts Both Mono and Color Card
2. Three Half Height Drive Slots
3. Reinforced Aluminum Frame
4. 200 Watts 110/220 VAC Power Supply
5. 7 Expansion Slots Available
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11. Brightness Adjusting Knob Installed
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13. Hardware Reset Button Installed
14. Dimensions: 17.3"(W) x 8.2"(H) x 16.9"(D)
15. Weighs 22 lbs in CKD Form
16. EGA Portables Available Now:
    - **9" EGA Monitor w/640x350 (EGA) or 640x200 (CGA)**
    - **220 Watts 110/220 VAC Power Supply**
    - **Dot Pitch: 0.28**

Best Buy

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1. TEAC 5¼" 360K Floppy Disk
2. TEAC 3½" 720K Floppy Disk
3. TEAC 3½" 1.44MB Floppy Disk
4. Seagate 3½" Hard Disk of 20/30/40 MB
5. Hercules Graphics Plus Card or In-Color Card
6. Intel All Above Boards
7. Quadram Quad EGA Plus
8. Everex EV 657 Autoswitch EGA
9. Paradise Autoswitch 480 EGA
10. ATI EGA Wonder
11. Genoa Super EGA
12. Video-7 Vega Deluxe EGA
13. AST Advantage Premium, Sixpac Premium, Rampage
14. Everex Ram Expansion Boards
15. Hayes or Smart 1200 Baud Internal or External Modem
16. Hayes or Smart 2400 Baud Internal or External Modem
17. Microsoft or Genius Mouse
18. Winner Joystick
19. Intel Math Coprocessor
20. 2nd Serial Port Upgrade
21. Epson, Toshiba, Citizen, NEC, and Star Printers
22. Tallgrass Tape Backup of 20/30/40 MB
23. Portable Carrying Bag

CONFIGURATIONS

XT200PX	**BUS88 Portable**	**$1,050**
	Configured Same as BUS88 w/Two 360K	
XT120PX	w/20MB, Seagate ST-225, 65 MS, One 360K	1,350
XT130PX	w/30MB, Seagate ST-238, 65 MS, One 360K	1,400
XT140PX	w/40MB, Miniscribe 3650, 60 MS, One 360K	1,450
XT165PX	w/65MB, Seagate ST-277, 39 MS, One 360K	1,750
AT100PX	**BUS286 Portable**	**1,650**
	Configured Same as BUS286 w/One 1.2MB	
AT200PX	w/One 1.2MB and One 360K	1,700
AT120PX	w/20MB, Seagate ST-225, 65 MS, One 1.2MB	1,900
AT130PX	w/30MB, Seagate ST-238, 65 MS, One 1.2MB	1,950
AT140PX	w/40MB, Miniscribe 3650, 60 MS, One 1.2MB	2,000
AT143PX	w/43MB, Seagate ST-251, 39 MS, One 1.2MB	2,200
AT144PX	w/43MB, Seagate ST-251-1, 28 MS, One 1.2MB	2,300
AT142PX	w/42MB, Miniscribe 6053, 28 MS, One 1.2MB	2,400
AT165PX	w/65MB, Seagate ST-277, 39 MS, One 1.2MB	2,450
AT172PX	w/72MB, Miniscribe 6085, 28 MS, One 1.2MB	2,600
AT184PX	w/84MB, Seagate ST-4096, 28 MS, One 1.2MB	2,650
AT1103PX	w/103MB, Priam ID-100, 25 MS, One 1.2MB	2,800
AT1120PX	w/120MB, Miniscribe 6128, 28 MS, One 1.2MB	2,900
TT100PX	**BUS386 Portable**	**3,100**
	Configured Same as BUS386 w/One 1.2MB	
TT200PX	w/One 1.2MB and One 360K	3,150
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TT130PX	w/30MB, Seagate ST-238, 65 MS, One 1.2MB	3,400
TT140PX	w/40MB, Miniscribe 3650, 60 MS, One 1.2MB	3,450
TT143PX	w/43MB, Seagate ST-251, 39 MS, One 1.2MB	3,600
TT144PX	w/43MB, Seagate ST-251-1, 28 MS, One 1.2MB	3,700
TT142PX	w/42MB, Miniscribe 6053, 28 MS, One 1.2MB	3,800
TT165PX	w/65MB, Seagate ST-277, 39 MS, One 1.2MB	3,850
TT172PX	w/72MB, Miniscribe 6085, 28 MS, One 1.2MB	4,000
TT184PX	w/84MB, Seagate ST-4096, 28 MS, One 1.2MB	4,050
TT1103PX	w/103MB, Priam ID-100, 16 MS, One 1.2MB	4,200
TT1120PX	w/120MB, Miniscribe 6128, 28 MS, One 1.2MB	4,300
TT1140PX	w/140MB, Micropolis 1355, 23 MS, One 1.2MB	5,200
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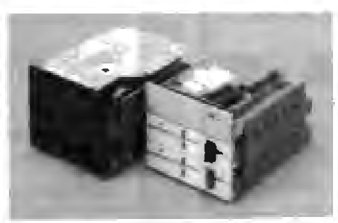
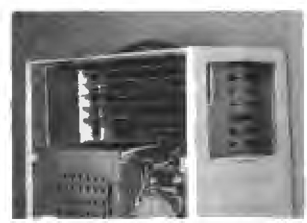


Three Half-Height Drive Slots



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• 40 CPS • Accepts Paper to 15 inches
• Form Length and Pitch Set from Conrol Panel
• Industry compat. ribbon, printwheels and control commands
• RS232 Serial Interface

TECHNICAL DATA

Printing Speed: 40 CPS; 38 CPS Shannon
Printing Method: Full character
Number of char/wheel: 96
Pitches: 10, 12, proportional
Fonts: DIABLO/QUME compatible printwheels
Characters/line: 136/10 pitch
Vertical / Horizontal Increment: 1/48 in. / 1/120 in.
Printing Modes: Serial-unidirectional; Line-bidirectional
Input buffer: 2K standard

Carriage return time: 900 ms (15 IPS)
Noise: 65 dBA
Ribbon Type: Cartridge DIABLO compatible
Ribbon Quality: Multi strike film; fabric
Ribbon Color: Black
Pape Feed: Friction Platen
Optional: Bidirectional Forms Tractor; Cut Sheet Feeder
Number of Copies: 1+ 2
Paper Speed: 4.2 IPS

Max. paper width: 406mm (16 in.)
Operator controls/Indicators
Switches: ON/OFF Line; Form feed/Line feed TOF/Reset; Pitch selector; Format selector
Indicators: Power On; On line; Error
Communication
Interface: RS-232C/CCITTV.24
Protocols: Data terminal Ready/Busy; XON/XOFF, ETX/ACK
Baud Rates: 300—2400

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Seagate

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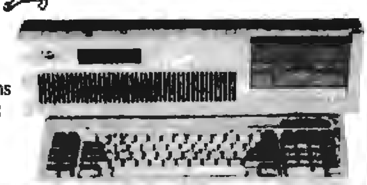

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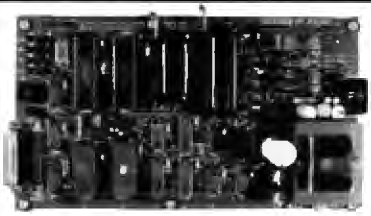

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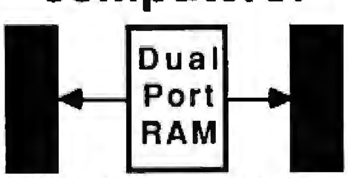

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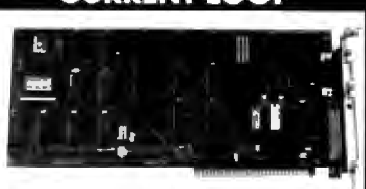

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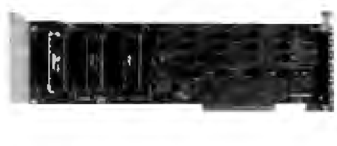

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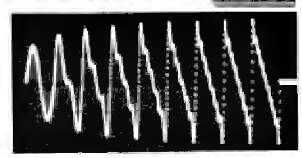

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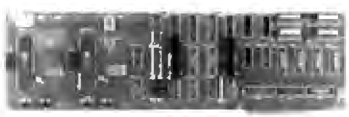

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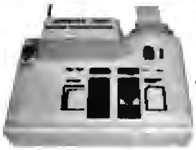

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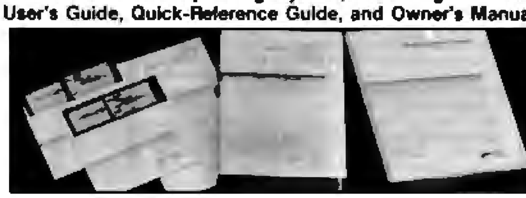

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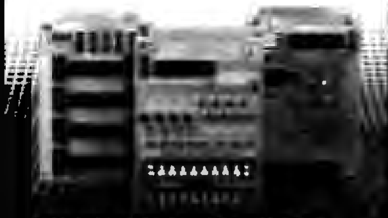

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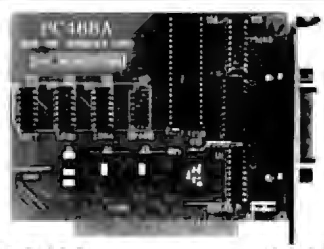

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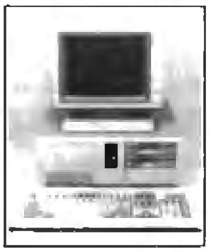

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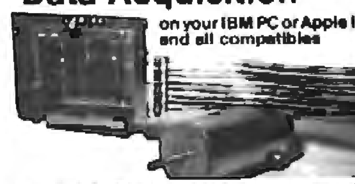

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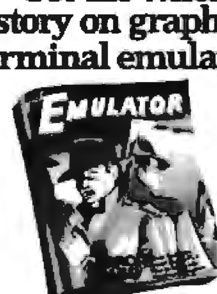

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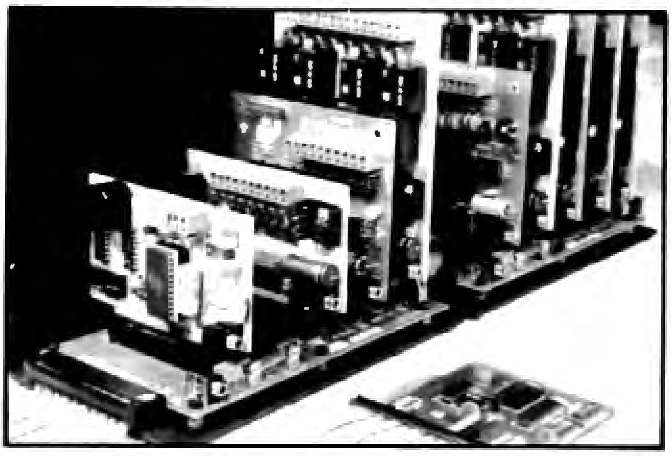

An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

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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

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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.

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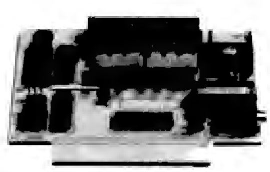
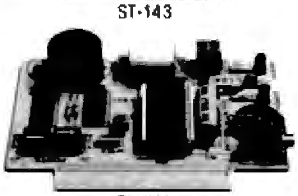
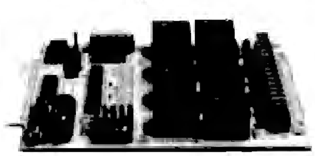


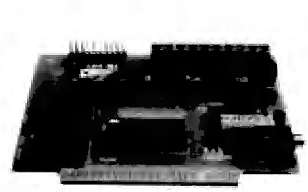
ST-143



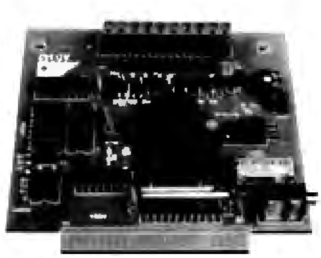
CL-144



RE-140



IN-141



AD-142

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7410	.25	7495	.35	74189	2.95
7414	.35	74121	.35	74193	.65
7420	.25	74123	.45	74195	.65
7426	.25	74125	.45	74198	1.65
7427	.25	74126	.45	74221	.75
7430	.25	74148	.85	74273	1.75
7432	.25	74150	1.20	74365	.50
7438	.25	74151	.65	74366	.50
7442	.30	74153	.65	74367	.50
7446	.65	74154	1.20	74368	.50
7447	.95				

74C CHIPS

74C00	$.25	74C154	$2.85	74C374	$1.69
74C02	.25	74C173	.99	74C903	1.19
74C04	.25	74C174	.99	74C906	1.19
74C08	.35	74C175	.99	74C912	6.95
74C10	.35	74C221	1.25	74C922	3.95
74C14	.49	74C240	1.69	74C923	3.95
74C32	.35	74C244	1.69	74C929	4.89
74C90	1.19	74C373	1.69	74C932	14.89

Partial Listing Only!!! Call us for components...

74LS SERIES

74LS00	$.19	74LS125	$.45	74LS241	$.99
74LS02	.19	74LS126	.49	74LS242	.99
74LS03	.19	74LS138	.45	74LS243	.99
74LS04	.19	74LS139	.45	74LS244	.99
74LS05	.19	74LS153	.59	74LS245	.99
74LS08	.19	74LS154	1.29	74LS257	.69
74LS09	.19	74LS157	.40	74LS258	.69
74LS10	.19	74LS158	.40	74LS259	.99
74LS14	.35	74LS161	.49	74LS273	.99
74LS27	.28	74LS163	.49	74LS322	1.79
74LS30	.25	74LS164	.49	74LS323	1.79
74LS32	.28	74LS165	.49	74LS365	.59
74LS47	.99	74LS166	.99	74LS366	.59
74LS73	.35	74LS173	.49	74LS367	.59
74LS74	.35	74LS174	.49	74LS368	.99
74LS75	.35	74LS175	.49	74LS373	.99
74LS76	.35	74LS189	3.95	74LS374	.99
74LS85	.49	74LS190	.49	74LS393	.99
74LS86	.28	74LS191	.49	74LS624	1.89
74LS90	.45	74LS192	.49	74LS629	1.89
74LS93	.45	74LS193	.49	74LS640	1.89
74LS107	.45	74LS195	.49	74LS641	1.89
74LS109	.45	74LS221	.65	74LS670	.99
74LS123	.49	74LS240	.99	74LS688	1.89

74F SERIES

74F00	$.35	74F153	$.59	74F243	$1.29
74F02	.35	74F157	.59	74F244	1.29
74F04	.35	74F158	.59	74F245	1.29
74F08	.35	74F160	.59	74F251	.79
74F10	.35	74F161	.59	74F258	.79
74F11	.35	74F163	.59	74F280	2.89
74F20	.35	74F174	.69	74F373	1.49
74F32	.35	74F175	.69	74F374	1.49
74F64	.49	74F181	1.99	74F379	1.99
74F74	.49	74F189	2.99	74F399	2.99
74F86	.49	74F219	4.99	74F521	2.99
74F109	.49	74F240	1.29	74F533	2.99
74F139	.49	74F241	1.29	74F534	2.99
74F151	.59				

IC SOCKETS

SOLDERTAIL		HR16S/T	.59	22PINW/W	1.29
8PINL/P	$.10	HR18S/T	.69	24PINW/W	1.29
14PINL/P	.10	HR20S/T	.79	28PINW/W	1.59
16PINL/P	.12	HR22S/T	.89	40PINW/W	1.99
18PINL/P	.16	HR24S/T	.99	HI RES W/W	
20PINL/P	.20	HR28S/T	1.19	HR8W/W	$.79
22PINL/P	.22	HR40S/T	1.49	HR14W/W	1.19
24PINL/P	.25	HR64S/T	4.99	HR16W/W	1.29
28PINL/P	.27	WIREWRAP		HR18W/W	1.39
40PINL/P	.29	8PINW/W	$.59	HR20W/W	1.69
48PINL/P	.99	14PINW/W	.59	HR22W/W	1.79
64PINL/P	2.49	16PINW/W	.69	HR24W/W	1.99
HI RES		18PINW/W	.99	HR28W/W	2.29
HR8S/T	$.39	20PINW/W	1.19	HR40W/W	3.49
HR14S/T	.49				

SPECIAL FUNCTION

VOICE RECOGNITION CHIP SET	$49.95	16450 - 16 BIT USART	$16.95
YAMAHA DXY CHIP SET	29.95	8250 - 8 BIT USART	5.95
TMS 6100 SPEECH CHIP	9.95	5832 - CLOCK	3.95
TMS 5200 SPEECH CHIP	7.95	58167 - CLOCK	8.95

CMOS

CD4001	$.18	CD4017	$.59	CD4047	$.65	CD4069	$.29	CD4510	$.69	CD4543	$.89
CD4002	.18	CD4018	.59	CD4048	.75	CD4070	.29	CD4511	.69	CD4555	.99
CD4007	.59	CD4020	.59	CD4049	.29	CD4071	.29	CD4512	.69	CD4556	.99
CD4008	.59	CD4024	.49	CD4050	.39	CD4072	.29	CD4518	.79	CD4584	.69
CD4009	.59	CD4025	.59	CD4051	.39	CD4073	.79	CD4519	.79	CD14409	6.95
CD4010	.29	CD4027	.35	CD4052	.59	CD4076	.65	CD4520	.79	CD14410	7.95
CD4011	.29	CD4030	.29	CD4053	.59	CD4081	.29	CD4522	.79	CD14411	8.95
CD4012	.29	CD4040	.65	CD4060	1.49	CD4082	.29	CD4538	.79	CD14412	8.95
CD4013	.29	CD4042	.65	CD4063	1.49	CD4093	.35				
CD4016	.59	CD4046	.65	CD4066	.29	CD40103	1.90				

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CO-PROCESSORS V20/30

8087 (5 MHz)	$105.	80287 10 (10 MHz)	365
8087 2 (8 MHz)	160.	V20-5 (5 MHz)	$9.95
80287 (5 MHz)	185	V20-8 (8 MHz)	12.95
80287-8 (8 MHz)	265	V30-8 (8 MHz)	17.95

MOS EPROMS

1702A - 1ms	$5.95	27128 - 450ns	$4.95
2532 - 450ns	4.50	27256 - 200ns	7.95
2564 - 450ns	9.95	27C256 - 250ns	7.95
2708 - 450ns	4.25	27512 - 250ns	13.75
2716	4.95	8741	24.95
2716-1	5.95	8742	24.95
27C16	5.95	8748	16.95
TMS2716-450ns (3v)	8.49	8749	19.95
		8751	49.95
2732 - 450ns	3.95	8755	19.95
2732 - 250ns	4.95	68764	19.95
27C32	8.95	68766	19.95
2764 - 450ns	3.95	68701	24.95
2764 - 250ns	4.95	68705P	19.95
27C64 - 450ns	6.95	2816-EE	7.95
27128 - 250ns	5.95	2864-EE	19.95

Z80 SERIES

Z80CPU	$1.49	Z80ASIO/0	$4.95
Z80CTC	1.49	Z80ASIO/1	4.95
Z80DART	4.49	Z80ASIO/2	4.95
Z80PIO	1.49	Z80ADART	4.99
Z80ACPU	1.99	Z80BCPU	2.99
Z80ACTC	1.99	Z80BCTC	3.99
Z80APIO	1.99	Z80BPIO	3.99

BIPOLAR PROMS/PALS

82S123	$1.29	74S189	$1.69
82S126	1.29	74S287	1.99
82S129	1.99	74S288	1.99
82S137	2.99	74S471	4.99
82S181	7.99	74S472	6.99
82S191	11.99	PAL 16L8	4.99
74S188	1.29	PAL 20L8	9.95

8000 SERIES

8031	$2.95	8212	$1.95
8035/39	2.95	8216	1.95
8080A	3.95	8224	1.95
8085A	2.95	8237A/S	5.95
8086	7.50	8250	6.95
8088	7.95	8251A/S	1.95
8088-2	9.95	8253-S	1.95
80186-6 (5MHz)	14.95	8255-S	2.95
80186-3 (8MHz)	24.95	8257-5	2.95
80286-6 (5MHz)	19.95	8259-5	2.95
80286-8 (8MHz)	34.95	8272/765	4.25
80386 (16MHz)	525.00	8275	24.95
8202	11.95	8279	4.95
8203	14.95	8284	4.95

68000 SERIES

68000/8MHz	$12.95	68020/16MHz	$249.95
68010/8MHz	19.95	68450	49.95
68010/10MHz	39.95	68881/12MHz	179.95
68020/12MHz	149.95	68881/16MHz	219.95

6502 SERIES

6502	$2.95	6520	$2.95
65C02	11.95	6522	4.95
6502A	4.95	6532	4.95
6502B	6.95	6545	9.95
6510	9.95	6551	4.95

6800 SERIES

6800	$2.95	6821	$2.95
6802	4.95	6845	4.95
6810	2.95	6850	4.95

SIMM RAM MODULES

for PC'S	64K x 9(150ns)	$49.95
	256K x 9(120ns)	69.95
	1Mb x 9(120ns)	349.00
for MAC'S	256K x 8(120ns)	69.97
	1Mb x 8(120ns)	329.00

CRYSTALS

1.000MHz	$3.25	5.0688MHz	$2.25	15.000MHz	$2.25
1.8432MHz	3.25	6.000MHz	2.25	16.000MHz	2.25
2.000MHz	2.25	6.144MHz	2.25	18.000MHz	2.25
2.097152MHz	2.25	6.5536MHz	2.25	18.432MHz	2.25
2.4576MHz	2.25	8.000MHz	2.25	20.000MHz	2.25
3.000MHz	2.25	9.000MHz	2.25	22.1184MHz	2.25
3.2768MHz	2.25	10.000MHz	2.25	24.000MHz	2.25
3.579MHz	2.25	11.000MHz	2.25	36.000MHz	2.25
4.000MHz	2.25	12.000MHz	2.25	49.000MHz	2.25
4.032MHz	2.25	13.000MHz	2.25	32.768KHz	1.50
5.000MHz	2.25				

OSCILLATORS

1.000MHz	$5.50	6.500MHz	$5.50	16.000MHz	5.50
1.8432MHz	5.50	7.168MHz	5.50	10.257MHz	5.50
2.000MHz	5.50	8.000MHz	5.50	18.000MHz	5.50
2.4576MHz	5.50	9.000MHz	5.50	18.432MHz	5.50
2.500MHz	5.50	10.000MHz	5.50	19.6608MHz	5.50
3.6864MHz	5.50	11.000MHz	5.50	20.000MHz	5.50
4.000MHz	5.50	12.000MHz	5.50	22.000MHz	5.50
4.9152MHz	5.50	12.500MHz	5.50	24.000MHz	5.50
5.000MHz	5.50	14.318MHz	5.50	24.576MHz	5.50
5.0688MHz	5.50	15.000MHz	5.50	37.250MHz	5.50
6.000MHz	5.50	15.360MHz	5.50	43.200MHz	5.50
6.144MHz	5.50	15.756MHz	5.50		

CONNECTORS

62PIN ST (PC/XT)	$1.95	50PIN W/W (Apple)	4.50
50PIN ST (Apple)	2.50	62PIN ST (AT)	4.95

EXTENDER CARDS

APPLE	$14.95	IBM PC	$24.95
S100	24.95	IBM AT	34.95

PROTO CARDS

APPLE	$12.95	IBM PC	$24.95
S100	19.95	IBM AT	34.95

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1 POSITION	$.49	7 POSTION	$.89
2 POSTION	.59	8 POSTION	.89
3 POSTION	.69	9 POSTION	1.29
4 POSTION	.69	10 POSTION	1.29
5 POSTION	.79	12 POSTION	1.49
6 POSTION	.79		

ECONO ZIFS

16 PINZIF	$3.50	40 PINZIF	$6.95
24 PINZIF	3.95	64 PINZIF	9.95

TEXTOOL ZIFS

16 PINZIF	$4.50	40 PINZIF	$9.95
24 PINZIF	5.95	64 PINZIF	17.95
28 PINZIF	8.95		

IC TEST CLIPS

14 PIN	$3.95	40 PIN	$19.95
16 PIN	3.95	64 PIN	39.95
24 PIN	12.95	68 PLCC	89.95

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2114L-2	1024x4	(200ns)(LOW POWER)	1.49
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HM6116-4	2048x8	(200ns)(CMOS)	1.79
HM6116-3	2048x8	(150ns)(CMOS)	1 89
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1 85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.45
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49
HM43256LP-15	32768x8	(150ns)(CMOS)(LP)	12.95
HM43256LP-12	32768x8	(120ns)(CMOS)(LP)	14.95
HM43256LP-10	32768x8	(100ns)(CMOS)(LP)	19 95

DYNAMIC RAMS

4116-250	16384x1	(250ns)	49
4116-200	16384x1	(200ns)	89
4116-150	16384x1	(150ns)	99
4116-120	16384x1	(120ns)	1 49
MK4332	32768x1	(200ns)	6 95
4164-150	65536x1	(150ns)	1 79
4164-120	65536x1	(120ns)	1 99
MCM6665	65536x1	(200ns)	1 95
TMS4164	65536x1	(150ns)	1 95
4164-REFRESH	65536x1	(150ns)(PIN 1 REFRESH)	2 95
TMS4416	16384x4	(150ns)	3 75
41128-150	131072x1	(150ns)	5 95
TMS4464-15	65536x4	(150ns)	4 95
41256-150	262144x1	(150ns)	3 95
41256-120	262144x1	(120ns)	4 95
41256-100	262144x1	(100ns)	5.49
HM51258-100	262144x1	(100ns)(CMOS)	6 95
1 MB-120	1048576x1	(120ns)	31 95
1 MB-100	1048576x1	(100ns)	34.95

EPROMS

2708	1024x8	(450ns)(25V)	4 95
2716	2048x8	(450ns)(25V)	3.49
2716-1	2048x8	(350ns)(25V)	3.95
TMS2532	4096x8	(450ns)(25V)	5.95
2732	4096x8	(450ns)(25V)	3.95
2732A	4096x8	(250ns)(21V)	3.95
2732A-2	4096x8	(200ns)(21V)	4.25
27C64	8192x8	(250ns)(12.5V CMOS)	4 95
2764	8192x8	(450ns)(12 5V)	3.49
2764-250	8192x8	(250ns)(12 5V)	3.69
2764-200	8192x8	(200ns)(12 5V)	4.25
MCM68766	8192x8	(350ns)(21V)(24 PIN)	15.95
27128	16384x8	(250ns)(12 5V)	4.25
27C256	32768x8	(250ns)(12.5V CMOS)	7.95
27256	32768x8	(250ns)(12.5V)	5 95
27512	65536x8	(250ns)(12.5V)	11.95
27C512	65536x8	(250ns)(12 5V CMOS)	12.95

xxV = Program Voltage

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- BASIC INTERPRETER IS OPTIMIZED FOR CONTROL APPLICATIONS

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8000

8031	3 95
8035	1.49
8039	1 95
8052AH BASIC	34 95
8080	2 49
8085	1 95
8086	6 49
8088	5 99
8088-2	7 95
8155	2 49
8155-2	3.95
8741	9 95
8748	7.95
8749	9.95
8755	14 95

8200

8203	14 95	8255-5	1 59
8205	3 29	8259	1 95
8212	1 49	8259-5	2 29
8216	1.49	8257	2.25
8224	2 25	8272	4.39
8228	2.25	8274	4 95
8237	3.95	8275	16 95
8237-5	4 75	8279	2 49
8243	1 95	8279-5	2 95
8250	6 95	8282	3.95
8251	1.29	8283	3 95
8251A	1 69	8284	2 25
8253	1.59	8286	3 95
8253-5	1 95	8287	3.95
8255	1 49	8288	4 95

MATH COPROCESSORS

8087	5 MHz	$99.95
8087-2	8 MHz	$159.95
8087-1	10 MHz	$229.95
80287	6 MHz	$179.95
80287-8	8 MHz	$249.95
80287-10	10 MHz	$309.95
80387-16	16 MHz	$499.95
80387-20	20 MHz	$799.95

intel®

74LS00

74LS00	16	74LS112	29	74LS241	69
74LS01	18	74LS122	45	74LS242	.69
74LS02	17	74LS123	48	74LS243	.69
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	39	74LS258	49
74LS11	22	74LS138	39	74LS259	1 29
74LS12	22	74LS139	39	74LS260	49
74LS13	26	74LS145	99	74LS266	39
74LS14	39	74LS147	99	74LS273	.79
74LS15	26	74LS148	99	74LS279	39
74LS20	17	74LS151	39	74LS280	1 98
74LS21	22	74LS153	39	74LS283	59
74LS22	22	74LS154	1 49	74LS290	89
74LS27	23	74LS155	.59	74LS293	.89
74LS28	26	74LS156	49	74LS299	1 49
74LS30	17	74LS157	35	74LS322	3.95
74LS32	18	74LS158	29	74LS323	2.49
74LS33	28	74LS160	29	74LS365	39
74LS37	26	74LS161	39	74LS367	39
74LS38	26	74LS162	49	74LS368	39
74LS42	39	74LS163	.39	74LS373	79
74LS47	75	74LS164	.49	74LS374	79
74LS48	85	74LS165	65	74LS375	.95
74LS51	17	74LS166	95	74LS377	.79
74LS73	29	74LS169	95	74LS390	1 19
74LS74	24	74LS173	.49	74LS393	.79
74LS75	29	74LS174	39	74LS541	1 49
74LS76	29	74LS175	39	74LS624	1.95
74LS83	49	74LS191	.49	74LS640	.99
74LS85	49	74LS192	69	74LS645	.99
74LS86	22	74LS193	69	74LS670	89
74LS90	39	74LS194	69	74LS682	3.20
74LS92	49	74LS195	69	74LS688	2 40
74LS93	39	74LS196	59	74LS783	22.95
74LS95	49	74LS197	59	25LS2521	2 80
74LS107	34	74LS221	.59	26LS31	1 95
74LS109	36	74LS240	69	26LS32	1.95

7400

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
74153	.55
74154	1 49
74157	55
74159	1.65
74161	.69
74164	.85
74166	1 00
74175	.89
74367	65

LINEAR

TL071	69	LM567	79
TL072	1 09	NE570	2.95
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TL082	99	LM723	49
TL084	1 49	LM733	98
LM301	34	LM741	29
LM309K	1 25	LM747	.69
LM311	59	MC1330	1 69
LM311H	89	MC1350	1 19
LM317K	3 49	LM1458	35
LM317T	89	LM1488	49
LM318	1 49	LM1489	49
LM319	1.25	LM1496	85
LM320 see7900		ULN2003	.79
LM323K	3 49	XR2206	3 95
LM324	34	XR2211	2.95
LM331	3.95	LM2917	1 95
LM334	1 19	CA3046	89
LM335	1 79	CA3146	1.29
LM336	1 75	MC3373	1.29
LM338K	4.49	MC3470	1 95
LM339	59	MC3480	8.95
LM340 see7800		MC3487	2 95
LF353	59	LM3900	49
LF356	99	LM3911	2 25
LF357	99	LM3909	.98
LM358	59	LM3914	1.89
LM380	89	MC4024	3 49
LM383	1 95	MC4044	3.99
LM386	89	RC4136	1.25
LM393	45	RC4558	.69
LM394H	5 95	LM13600	1.49
TL494	4.20	75107	1.49
TL497	3 25	75110	1 95
NE555	29	75150	1.95
NE556	.49	75154	1.95
NE558	79	75188	1 25
NE564	1 95	75189	1 25
LM565	95	75451	.39
LM566	1 49	75452	.39
NE590	2 50	75477	1 29

H=TO-5 CAN, K=TO-3, T=TO-220

6500

1.0 MHz

6502	2.25
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6520	1.65
6522	2.95
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2.0 MHz

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6520A	2.95
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6532A	11.95
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3.0 MHz

6502B	4.25

6800

1.0 MHz

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6810	1.95
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6847	4.75
6850	1.95
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2.0 MHz

68B00	2.95
68B02	3.95
68B09E	5 49
68B09	5.99
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68B45	4.95
68B50	1 75
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Z-80

2.5 MHz

Z80-CPU	1.25

4.0 MHz

Z80A-CPU	1 29
Z80A-CTC	1 69
Z80A-DART	5 95
Z80A-DMA	5 95
Z80A-PIO	1 89
Z80A-SIO 0	5 95
Z80A-SIO 1	5 95
Z80A-SIO 2	5 95

6.0 MHz

Z80B-CPU	2.75
Z80B-CTC	4 25
Z80B-PIO	4.25
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2797	29.95
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MB8877	12 95
1691	6 95
2143	6 95
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AY3-1015	4 95
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IM6403	9 95
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4.0	1 95
5.0	1.95
5.0688	1.95
6.0	1 95
6.144	1.95
8.0	1.95
10.0	1 95
10.738635	1 95
12.0	1 95
14.31818	1 95
16.0	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

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1.8432	5.95
2.0	5.95
2.4576	5 95
2.5	5 95
4.0	4.95
5.0688	4 95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4 95
12.0	4.95
16.0	4.95
18.432	4.95
20.0	4 95
24.0	4 95

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74F32	.35
74F64	.55
74F74	.39
74F86	.55
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
74S175	79
74S195	1.49
74S240	1 49
74S241	1 49
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4011	19	4069	.19	74HC157	55
4012	.25	4070	.29	74HC244	.85
4013	.35	4081	.22	74HC245	.85
4015	.29	4093	.49	74HC273	69
4016	29	14411	9.95	74HC373	.69
4017	.49	14433	14.95	74HC374	.69
4018	.69	14497	6.95	74HCT00	.25
4020	59	4503	.49	74HCT02	.25
4021	69	4511	69	74HCT04	.27
4023	25	4518	.85	74HCT08	.25
4024	49	4528	.79	74HCT32	.27
4028	25	4538	.95	74HCT74	.45
4027	.39	4702	9.95	74HCT138	55
4028	65	74HC00	.21	74HCT139	.55
4040	.69	74HC02	.21	74HCT161	.79
4042	59	74HC04	.25	74HCT240	89
4044	69	74HC08	.25	74HCT244	89
4046	.69	74HC10	.25	74HCT245	.89
4047	.69	74HC14	.38	74HCT273	99
4049	.25	74HC32	.35	74HCT373	.99
4050	.29	74HC74	.35	74HCT374	.99
4051	.69	74HC86	.45	74HCT393	.99
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4053	.69	74HC139	.45	74HCT4040	.99
4060	.69	74HC151	.59	74HCT4060	1 49

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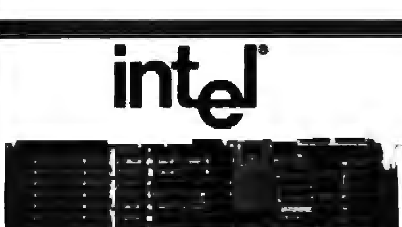

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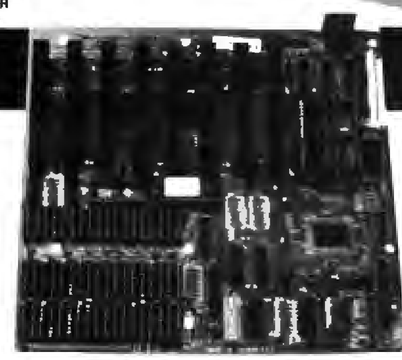

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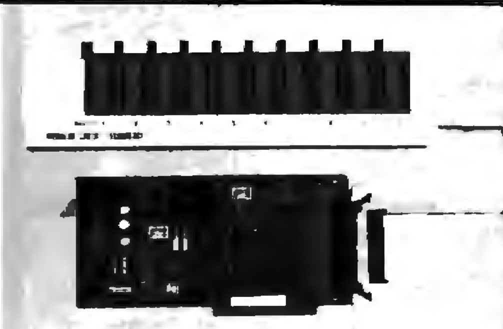

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COMING UP IN BYTE

PRODUCTS IN PERSPECTIVE:

Short Takes for May include Sysgen's BridgeFile; high- and double-density 3½- and 5¼-inch add-on floppy disk drives for IBM's PS/2; Fujitsu's finite-element-analysis package, Elm; WordPerfect for the Macintosh; a fast assembler from SLR, Optasm; a Macintosh desk-accessory scheduler from Mainstay called Think 'N Time; and more.

Ten word processors for the IBM PC family are reviewed in the **Product Focus** for May: new releases of DisplayWrite, MASS-11, Microsoft Word, MultiMate, OfficeWriter, Samna Word IV, Smart Word, WordPerfect, WordStar, and XyWrite.

System reviews consider Amdek's offering in the 80386 competition and the laptop Macintosh from Dynamac.

In the **hardware reviews** section, we look at the Apple LaserWriter II. This printer with interchangeable memory modules is at least two printers right now, with the potential to be more as time goes by.

There are many uncomfortable ways to get Macintosh data to an IBM PC—and vice versa; we'll look at three that are painless.

Software reviews: Windows/386 and Windows 2.0 are programs to enhance your interface. Command Plus replaces your DOS command processor and enhances the basic commands.

Products up for discussion in **application reviews** are Silverado and @Base, two spreadsheet add-ins; Q-Calc, a spreadsheet that runs under Unix; and Nexview, a relational spreadsheet.

Jerry Pournelle's **Computing at Chaos Manor** and Ezra Shapiro's **Applications Only** look at products from unique perspectives.

IN DEPTH:

May is devoted to the subject of **CPU architectures**—everything from the growth and development of CPUs, to parallelism, to RISC, to what's wrong with the ones we've seen so far.

FEATURES:

In the **Circuit Cellar**, Steve Ciarcia concludes his SmartSpooler construction project; Dick Pountain talks about **Pop-11**, a powerful artificial intelligence programming language for the Macintosh.

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San Francisco, CA 94111

Bill McAfee (415) 349-4100
McGraw-Hill Publications
951 Mariner's Island Blvd.—
3rd Floor
San Mateo, CA 94404

BYTE BITS (2x3)
Dan Harper (603) 924-6830
BYTE Publications
One Phoenix Mill Lane
Peterborough, NH 03458

The Buyer's Mart (1x2)
Mark Stone (603) 924-3754
BYTE Publications
One Phoenix Mill Lane
Peterborough, NH 03458

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Peterborough, NH 03458

Regional Advertising
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Ed Ware (603) 924-6166
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One Phoenix Mill Lane
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Computing for Engineers
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Telex: RS35539 SEAVEX

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Telex: 60904 SEVEX HX

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Mr. Ernest McCrary
Empresa Internacional de
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Rua da Consolacao, 222
Conjunto 103
01302 Sao Paulo, S.P., Brasil
Tel: (11) 259-3811
Telex: (100) 32122 EMBN

READER SERVICE

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* Correspond directly with company

Alphabetical Index to Advertisers

INTERNATIONAL SECTION 88 A1-40

No domestic inquiries please.

READER SERVICE

Advertising Supplement included with this issue:
Jade Computer (U.S. Subscribers)

** Correspond directly with company.*

TIPS

SUBSCRIBERS ONLY!*

Use BYTE's Telephone Inquiry Processing System

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.

ENTER YOUR SUBSCRIBER AND ISSUE NUMBERS

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)
Enter □ □ □ □ □ □ □ □ [#] [#]

6) When TIPS says "Enter magazine code & issue code"
Enter [1] [#] [4] [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)

1. □ □ □ [#] [#]
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END SESSION

8) End session by entering [*] [*] [9] [1] [#] [#]

9) Hang up after hearing final message
If you are a subscriber and need assistance, call (603) 924-9281.

Available 24 Hours, 7 Days a Week

If you are not a subscriber fill out the subscription card found in this issue or, call BYTE Circulation 800-423-8912.
***Domestic and Canadian Subscribers Only!**

READER SERVICE

To get further information on the products advertised in BYTE, fill out the reader service card by circling the numbers on the card that correspond to the inquiry number listed with the advertiser. This index is provided as an additional service by the publisher, who assumes no liability for errors or omissions.

* Correspond directly with company

Index to Advertisers by Product Category

READER SERVICE

Advertising Supplement included with this issue:
Jade Computer (U.S. Subscribers)

** Correspond directly with company.*

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.

Fill out this coupon carefully. PLEASE PRINT. Requests cannot be honored unless the zip code is included. This card is valid for 6 months from cover date.

A. What is your primary job function? (Check one only)

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 ____________________
Company ____________________
Address ____________________
City ____________ *State* ____________
Zip ____________ *Telephone* ____________

CIRCLE FOR FREE INFORMATION

APRIL 484RSU

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1 ☐ Business use for yourself
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CIRCLE FOR FREE INFORMATION

APRIL 484RSU

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NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS MAIL PERMIT NO. 176 DALTON, MA

POSTAGE WILL BE PAID BY ADDRESSEE

BYTE
READER SERVICE
PO Box 298
Dalton, MA 01227-0298
USA

NO POSTAGE
NECESSARY
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BYTE
READER SERVICE
PO Box 298
Dalton, MA 01227-0298
USA

IF THE REASON YOU HAVEN'T BOUGHT A 24-PIN PRINTER IS PRICE, YOU'VE LOST YOUR REASON.

You've also lost your last reason for buying a 9-pin printer. Our new Pinwriter® P2200 dot matrix printer is the first 24-pin printer that is priced lower than many of today's 9-pin printers.

However, we didn't strip the price by doing the same thing to features. In fact, we gave the P2200 a few features you won't find on any other printers at any price.

Like more software support than any other 24-wire printer and unrivaled paper-handling capabilities. It feeds from both the rear and the front. And you can print a single sheet without removing your continuous paper. You can also produce up to 128 type variations within a single document.

We also didn't get the price down at the expense of speed. The P2200 prints 55 cps in LQ mode – that's faster than any other printer in its price range. And in draft mode, it speeds along at 170 cps.

So see your NEC dealer today. Anything else would be thoroughly unreasonable.

NEC PRINTERS. THEY ONLY STOP WHEN YOU WANT THEM TO.

NEC

NEC Information Systems, Inc.

For more information, and the name of the NECIS dealer nearest you, call 1-800-343-4418 (in MA 617-264-8635). Or write: NEC Information Systems, Dept. 1610, 1414 Massachusetts Ave., Boxborough, MA 01719.

C&C Computers and Communications

Circle 186 on Reader Service Card

Tandy Computers: Because there is no better value.™

The Tandy® 4000

A price breakthrough in high-performance 80386 technology.

Put a Tandy 4000 personal computer on your desk and unleash the remarkable power of the 80386 microprocessor.

With the Tandy 4000's 16-megahertz clock speed, IBM PC and AT® compatible software comes alive with incredible speed. And new operating systems such as Microsoft® OS/2 will deliver the full potential of the 80386.

The 4000 is just one of a complete line of Tandy computers—the best-selling IBM PC compatibles in America. We have the system solutions your business can depend on . . . for years to come.

Workgroup Solutions. Our 3Com® workgroup lets people and PCs work together, so your entire office can share information and route messages—electronically. And with IRMALAN™, up to 20 people in your workgroup can access your company's IBM mainframe.

Multiuser Solutions. With the XENIX® multiuser operating system you can share the power of the Tandy 4000 with others in your office. The fact is, we have more experience with XENIX® multiuser systems than anyone. And we offer SCO™ business productivity software that's designed expressly for maximum multiuser efficiency.

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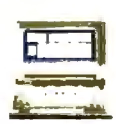

Tandy 1400 LT

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