BYTE

THE SMALL SYSTEMS JOURNAL®

JUNE 1988 VOL. 13, NO. 6

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PRODUCT FOCUS

Ultra-High-Speed Modems

Falling prices, rising speed

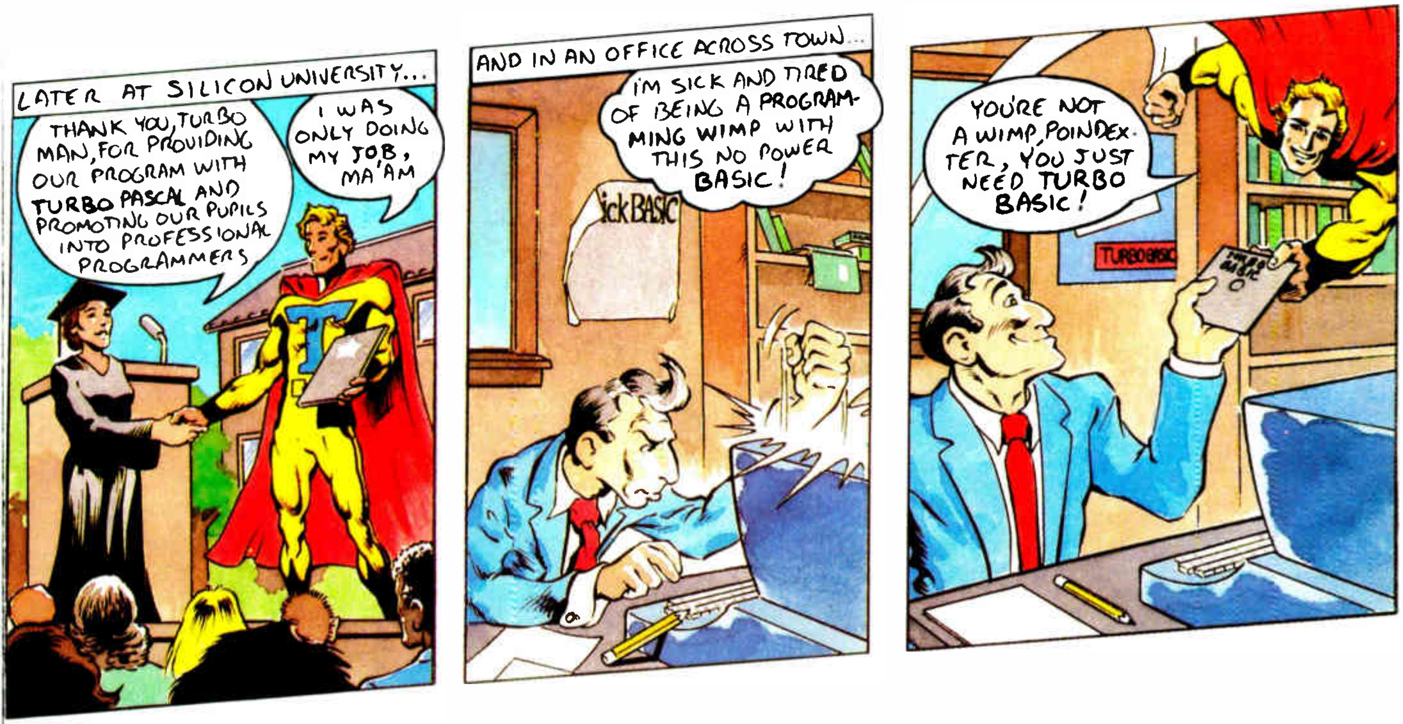
IN DEPTH

BYTE's New Benchmarks

REVIEWS

IBM's OS/2
ALR FlexCache
Quattro vs. Surpass
Double Helix vs. 4th Dimension
80386 Replacement Motherboards

s Turbo Languages are Super!



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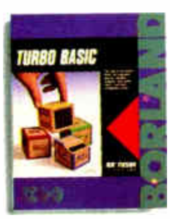

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	Turbo Basic 1.1	QuickBASIC 4.0 Compiler	QuickBASIC 4.0 Interpreter
Compile & Link to stand-alone EXE	*3 sec.*	7 sec.	——
Size of .EXE	*28387*	25980	——
Execution time w/80287	*0.16 sec.*	16.5 sec.	21.5 sec.
Execution time w/o 80287	*0.16 sec.*	286.3 sec.	292.3 sec.

The Elkins Optimization Benchmark program from March 1988 issue of Computer Language was used. The Program was run on an IBM PS/2 Model 60 with 80287. The benchmark tests compiler's ability to optimize loop-invariant code, unused code, expression and conditional evaluation.


BORLAND PRESENTS
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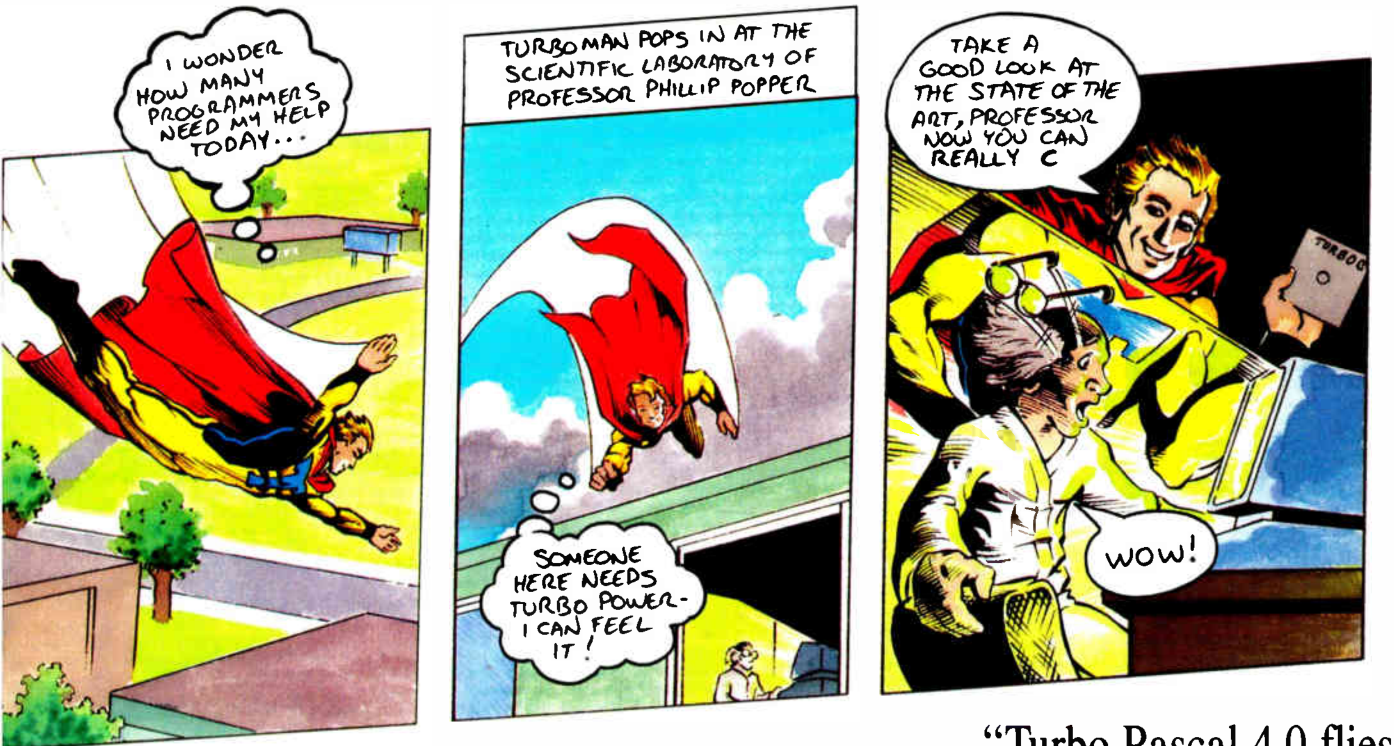

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—Peter Feldman, PC Week"

Heap Sort

	Turbo C 1.5	Microsoft C 5.0
Compile time	4.7 sec.	16.3 sec.
Compile & link time	7.4 sec.	19.5 sec.
Execute time	10.5 sec.	15.5 sec.
Object code size	1119	1313
Execution size	6392	7891

Sort benchmark run on an 8 MHz IBM AT using Turbo C version 1.5 and the Turbo Linker version 1.1; Microsoft C version 5.0 and the MS overlay linker version 3.61.

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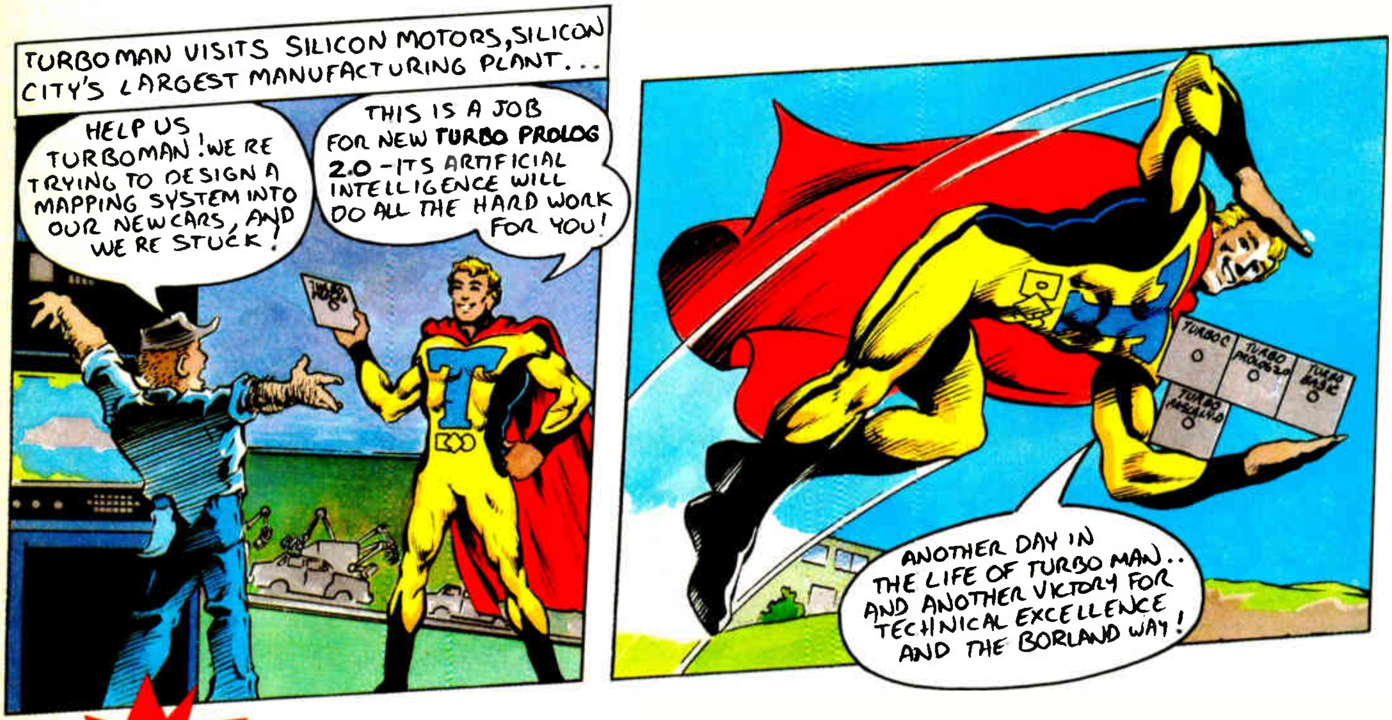

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—Jerry Pournelle, Byte 1/88

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—Darryl Rubin, AI Expert ”

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NUMBER 6

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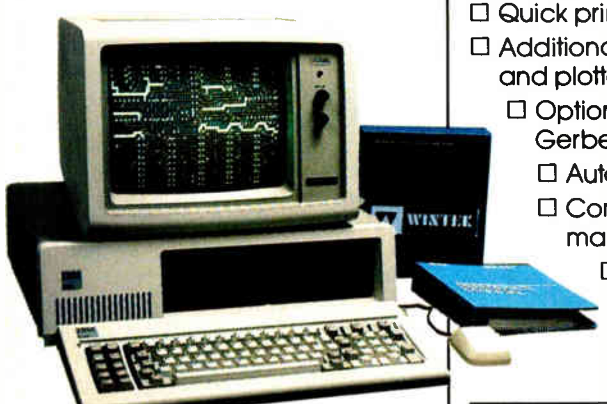

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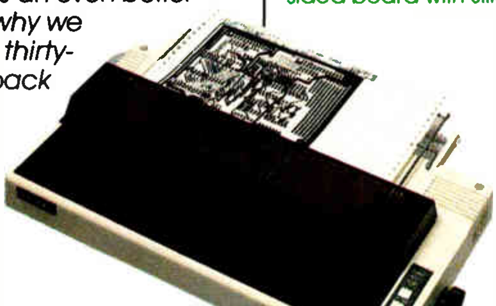

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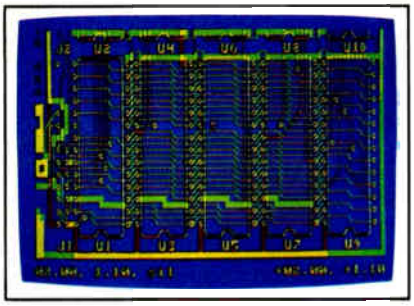

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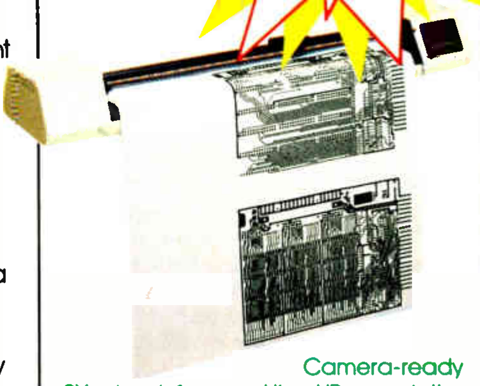

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Circle 289 on Reader Service Card

EDITORIAL

Our New Benchmarks

Here they are: BYTE's new system benchmarks.

Our goals in developing these new benchmarks were very high: We set out to create a new suite of benchmarks that would give you the most comprehensive, accurate, and useful information on microcomputer performance that is available today; benchmarks that were appropriate for the current generation of hardware and software and that would not go out of date at any time in the foreseeable future.

It was a tall order, but based on our experience, research, and consultation with numerous industry experts, we believe we've succeeded. Once you've seen the benchmarks, we're confident that you will agree.

The new suite comprises high-level tests, which examine a machine's real-world performance, and low-level tests, which amplify and illuminate the high-level tests by providing a detailed, specialized examination of each machine's constituent subsystems.

The new benchmarks provide an impressive level of detail—but not merely numbers for numbers' sake. For example, when a machine turns in an unusually good or bad performance, our benchmarks show you exactly where the machine excels or falls short and which kinds of applications are affected. Just as important, they can reveal hidden strengths or weaknesses in machines that turn in otherwise seemingly average overall performance.

The wealth of information provided by our combination of high- and low-level benchmarks means that you're not locked into some narrow, preconceived or subjective interpretation of the results. Rather, you can easily use our benchmarks to estimate how any given machine will perform for *your* unique mix of applications. (If you've ever wasted time trying to guess how an arbitrary and artificial benchmark like the infamous NOP—no operation—test relates to real-world throughput, you'll appreciate the realism and immediate usefulness of our new benchmarks.)

Also, there's our objectivity: BYTE, alone among the leading computer publications, is not allied with a particular family of machines. We have no ax to grind about any particular product, no reason—intentional or otherwise—to stack the benchmark deck one way or another. Our system tests are deliberately *not* optimized to favor any particular brand, chip family, or architecture. This means we have a way to address the thorny issue of accurately and objectively comparing the relative performance of systems with different processors and designs.

We've—in effect—constructed a "level playing field" on which any machine can be put to the test with a minimum amount of tweaking. This also means we'll be able to adapt our benchmarks to handle brand-new chips and architectures in a remarkably short time.

But you don't have to take my word for any of this, because our benchmarks aren't of the "black box" variety—you know, the kind that spits out a result but doesn't tell you how the number was generated or what it really means. The "hows and whys" of our new benchmarks are explained in detail in this month's In Depth section, and the complete source code for all our low-level benchmarks is available via BYTEnet (free, except for the cost of your phone call), on BIX, in print in our Quarterly Listings Supplement, and on disk (see page 3). We invite your close inspection.

In the Reviews section, you'll see the new system benchmarks in action, with the results presented in easy-to-use, informative tables and graphs that should satisfy any level of curiosity about the reviewed systems.

At the top of each page of benchmark results you'll find an overall number, or index. This represents the cumulative performance of the machine on our applications-level benchmarks compared to several "standard" machines, such as the venerable 8-MHz IBM PC AT and the newer Compaqs and PS/2s. (Our new Macintosh benchmarks follow the same pattern; there are no new Macs to review at this time, so the new Mac system benchmarks do not appear in this issue's reviews. However, the Mac benchmarks are discussed in the In Depth section.)

Our high-level benchmarks measure the performance of each machine while running a wide variety of real-world commercial software packages, such as word processors, compilers, databases, CAD packages, desktop publishing packages, spreadsheets, and so on. These tests are designed to realistically exercise each machine's major subsystems—disk I/O, video, CPU, floating-point unit, and memory—in a variety of ways.

The overall index can serve to give you a "quick fix" on a particular machine, but you should be aware that—like all generalizations—this overall number does not in itself provide high precision. That's why the index is visually joined to a graph that breaks down the overall performance into application-by-application results. Here, you can begin to see strengths and weaknesses emerge, and you can begin to use that information to see how a given machine meets (or fails to meet) your own specialized needs.

The numbers to the left of the graph provide the detailed results of the application tests, for even greater refinement and accuracy.

The lower portion of the page contains the low-level test results. On the right, a graph clearly illustrates relative performance on a subsystem-by-subsystem basis; on the left are the detailed, test-by-test results.

You can use the low-level results to examine, in as much detail as you wish, *why* a machine performed as it did in the high-level tests. They also let you compare machines at the most fundamental level, and to tailor our benchmark results to unusual applications not included in our high-level tests: Just examine the subsystem(s) your application will exercise most, and you can get a good idea of how the reviewed system will handle the task.

The Future

These new system benchmarks are the foundation for an entire new set of benchmarks. Over the next few months, you'll see additional refinements and improvements, including a new suite of software benchmarks.

BYTE was the first magazine to use objective benchmarks in evaluating personal computers. We're proud to continue that tradition with these—the first "second-generation" microcomputer benchmarks in the industry.

As always, we welcome your comments and suggestions.

—Fred Langa
Editor in Chief

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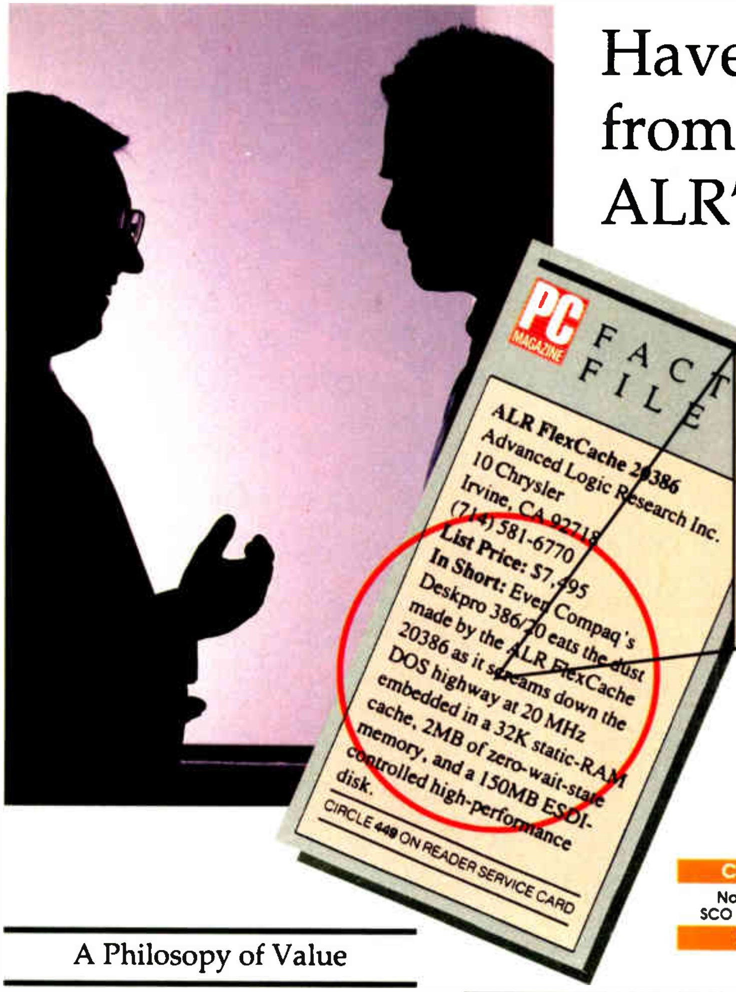
Have you read the latest from PC Magazine about ALR's FlexCache 386?



"Even Compaq's DeskPro 386/20 eats the dust made by the ALR FlexCache 20386 as it screams down the DOS highway..."

PC Magazine, March 15, 1988

Compatible
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Faster Than IBM or Compaq

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Circle 36 on Reader Service Card

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

Device Could Break the Chains Between Portables and Batteries

A new device that converts RF energy into DC is capable of powering small electronic devices, such as laptop computers, and could free portables from "battery bondage." "Using this device, you'll never need batteries for your laptop again," Sonic Electric Energy Corp. president Ray Weilage told Microbytes. He said the company has been showing a "prototype RF-powered computer" at its headquarters in Atlanta.

According to Rick English, technical analyst for Prudential-Bache, "Sonic's patent for the RF conversion device has been approved. They have a lock on the technology."

Weilage said Sonic has successfully shown the device is capable of powering small color TV sets and other little units, such as portable radios. "However, the expansion of the technology into computers and television sets opens a new field for making these units portable and power-source self-sufficient," he said.

"We have a cell that converts radio frequency to direct current under 66 MHz. That's on the other end of the spectrum from NASA's experiments with microwaves to power an airplane type of thing. We're on the other end of the spectrum working with the longer wavelengths," Weilage said.

The actual device is "very similar to the photoelectric cells that convert light to energy. It's the same thing, except that we're converting radio frequency to energy," Weilage said.

To power a laptop computer would take a box about the size of a pack of cigarettes. Weilage said the unit would add virtually no weight to a laptop and would cost a manufacturer "about $20."

The Sonic device draws the RF frequency from an antenna based on the Tesla coil theory. The efficiency of the device, Weilage claimed, stems from having reduced the Tesla coil to a microchip. "Bell Labs was the first to implement the Tesla coil technology on a microchip," said English, "but they were using it for a 'what if we could do this' type of experiment."

"DRAM Scam": Atari Chief Slams Shortage

America's computer industry is starved for computer chips, Japanese semiconductor firms are raking in the profits, and Atari CEO Jack Tramiel thinks it's all a scam—"the DRAM Scam," he calls it.

Tramiel used a press conference at the CeBIT '88 computer exhibition in West Germany to assail the "shortsighted and underhanded" trade policy of the U.S. and to denounce the "so-called DRAM shortage." He claimed there is plenty of chip manufacturing capacity in the world; however, because of trade agreements between Japan and the U.S., the supply can't match the demand.

"This is a case of calculated shortage," said Tramiel; the trade policy has foisted a classic manifestation of the Law of Unintended Consequences on the computer industry. A trade sanction against Japanese chip makers, intended to stop the "dumping" of low-cost chips on the American market while allowing the survival of the U.S. chip industry, has backfired, he said. As a result, there's a shortage of dynamic RAM chips and a dramatic increase in their price, which in turn has meant higher prices for computers.

Nine months ago, DRAMs sold for $1.50. "Today on the spot market, those same chips cost $6," Tramiel said. "That's not profit. That's robbery." The current world demand for DRAMs runs around 100 million per month, according to Tramiel; the total U.S. output is only 10 million. "It didn't take the Japanese long to figure out that they could get a higher price for selling fewer chips. They don't mind profiting from America's stupidity."

Tramiel wasn't totally negative. "I don't see this chip shortage lasting more

continued

Nanobytes

- The hottest thing our traveling news hand saw at the massive Hannover Fair in West Germany—or at least it was treated as if it was the hottest thing—was a **Macintosh 512K-byte clone**. Representatives of a Taiwanese manufacturer had brought the illicit box to show to a select few. The fact that it used illegal copies of the Mac ROMs made the reps a little secretive. "We are not certain that Apple can maintain its grip on the technology," one of them said. "We feel it is a possible violation of U.S. antitrust laws." Asked what such a clone might sell for, the spokesperson said, "We would like to see the computer sell for around $795."
- Although some expect the shortage of memory chips to lighten up soon, computer makers are wrangling to get memory wherever they can. We've heard that certain Japanese semiconductor companies have been quietly distributing **4-megabit dynamic RAM chips** to select customers. The DRAM shipments are invoiced "test samples" or "research samples," which could indicate that the chips are being offered in advance of actual production quantities. Japanese firms are increasing their outputs of dynamic RAMs; analysts say the few U.S. companies that supply DRAMs had better do the same.
- **MIPS Computer Systems** (Sunnyvale, CA) claims "sustained performance" of 20 VAX MIPS with its **new RISC processor**, the R3000, which is about three times the claimed processing power of Sun's SPARC chip. The **25-MHz** chip will be supplied by Integrated Device Technology, LSI Logic, and Performance Semiconductor. Perhaps as important as MIPS's new chip is its agreement with **AT&T** to de-

continued

velop an application binary interface (ABI) that will allow binary compatibility of Unix applications across all systems using MIPS processors. MIPS spokespersons claimed the AT&T deal sets them on equal status with Sun's SPARC architecture in relation to Unix. However, Sun will jointly develop Release V of Unix System V with AT&T.

• **Tandy** (Fort Worth, TX) is now licensing its easy-to-comprehend **DeskMate interface** to developers. DeskMate is a pictorial interface that works on 8088, 8086, and 80286 computers. It takes up only 384K bytes of memory. Some of the software publishers saying they'll write for the environment include Symantec, Electronic Arts, Broderbund, Intuit, Sierra Online, Software Publishing Corp., and Activision. Tandy marketing director Ed Juge said that because DeskMate is so easy to use, it will help sell "a ton of computers."

• **Epson America** (Torrance, CA) cut the suggested price of its Equity III+ computer with a hard disk drive by $196 to $3299 and the floppy disk drive version by $96 to $2199. The bad news is that the price of the LQ line of 24-pin printers went up (except for the LQ-2500): the LS-500 went up $30 to $529, the LQ-850 up $50 to $849, and the LQ-1050 up $100 to $1199.

• **G-2** Inc. (Milpitas, CA) has gotten into the growing IBM-compatible business with three new products: a chipset compatible with IBM's PC XT and PS/2 Model 30 and supporting clock speeds up to 10 MHz, a VGA chip, and a trio of chips that G-2 says "replaces most of the ICs" used to build AT compatibles and systems based on the 80386. Samples are ready now.

• U.S. companies will spend **$20 billion on software** and related services this year, a new report claims. Based on interviews with 137 Fortune 500 companies, Newton-Evans Research (Ellicot City, MD) says packaged software will account for about $12.5 billion of that sum. The researchers say that 350,000 Americans are working in software-development jobs.

continued

than 6 or 9 months," he said. He also announced that Atari hopes to either buy or build its own semiconductor plant within the next 12 months.

Atari will hold the line on the prices of its systems, Tramiel said. (Atari is reportedly currently buying chips, under contract, from Japanese manufacturers for $2.50 each.) "So maybe we only make $55 million next year instead of $57 million," he told an applauding European audience. Europe receives the largest share of Atari's computer output.

Regardless of its causes, the current shortage of DRAM chips is preventing Atari from manufacturing enough Mega STs to supply the U.S. market, company marketing director Neil Harris said.

Because of Atari's popularity in Europe, most machines, which are manufactured in Taiwan, are being delivered to European customers. Atari has held back advertising and marketing of the Mega ST on this side of the Atlantic, Harris said.

The shortage of Mega STs in the U.S. has also put a damper on Atari's laser printer, which depends on the large memory capacity of the Mega ST for effective performance. Unlike most other laser printers, the Atari unit has no internal memory of its own but uses part of the Mega ST's 4 megabytes of RAM, which is actually a more efficient and cost-effective use of memory capacity, according to Harris.

Atari continues to delay production of its MS-DOS computer, announced more than a year ago. "It came down to a choice between manufacturing STs or MS-DOS machines," said Harris. "The MS-DOS machine is ready to go but won't go into production until the RAM shortage goes away." Harris said that Atari expects the DRAM shortage to start easing by the third quarter of this year and still has plans to aggressively market the Mega ST in the U.S.

Motorola Pushing 88000 as Chip of the Nineties

Motorola has established its 68000 as one of the powerhouse processors in the microcomputer market. Now the company's Microprocessor Products Group (Austin, TX) is aiming for similar success with the 88000, its 32-bit reduced-instruction-set computer (RISC) processor. The 88000 is based on a Harvard-style computer architecture, with separate address and data lines for a program's code and data. These dual "paths" allow code and data operations to operate in parallel, which improves throughput.

The 88000 is composed of three chips: the MC88000 central processor and two MC88200 cache/memory management units (CMMUs) that supervise the code and the data paths. The MC88000 has a register file of thirty-two 32-bit registers, built-in integer and floating-point math units, an extensible instruction set, and an extensible architecture. The extensible architecture is made up of eight special function units (one is the floating-point math unit) with 256 reserved op codes that allow a vendor to expand the MC88000's capabilities. Such expansions might include transcendental function support or a serial driver. The MC88200 CMMU has a built-in 16K-byte memory cache and performs bus snooping to maintain cache coherence.

A scoreboarding function in the MC88000 maintains validity of the register file contents. For example, if a multiply operation uses two register values, and the contents of one of the registers is invalid (perhaps the fetch instruction loading the target register is still in progress), the scoreboard will stop the multiply operation until the fetch operation is completed. Scoreboarding lets software designers write RISC software without becoming mired in the details of moving data through the processor. It also allows certain code optimizations to be performed. Programs written for the 88000 are typically 10 percent larger or smaller than equivalent programs written in MC68020 code, according to Motorola officials.

From the beginning, both the MC88000 and the MC88200 were designed to support tightly coupled multiprocessing. You can use up to four MC88000s in parallel to boost processing power, or, if your application demands it, you can combine up to four MC88200s on a path to expand the path's memory cache to 64K bytes (128K bytes total). A single 20-MHz 88000 processor runs at about 15 to 17 million instructions per second and 34,000 Dhrystones. Motorola offers boards with combinations of one, two, and four 88000 processors.

In what's shaping up as a trend, companies are bringing out support tools with their new chips rather than just saying, "Here's the silicon, baby; you're on your own." For the 88000, there's an optimizing C compiler from Green-

continued

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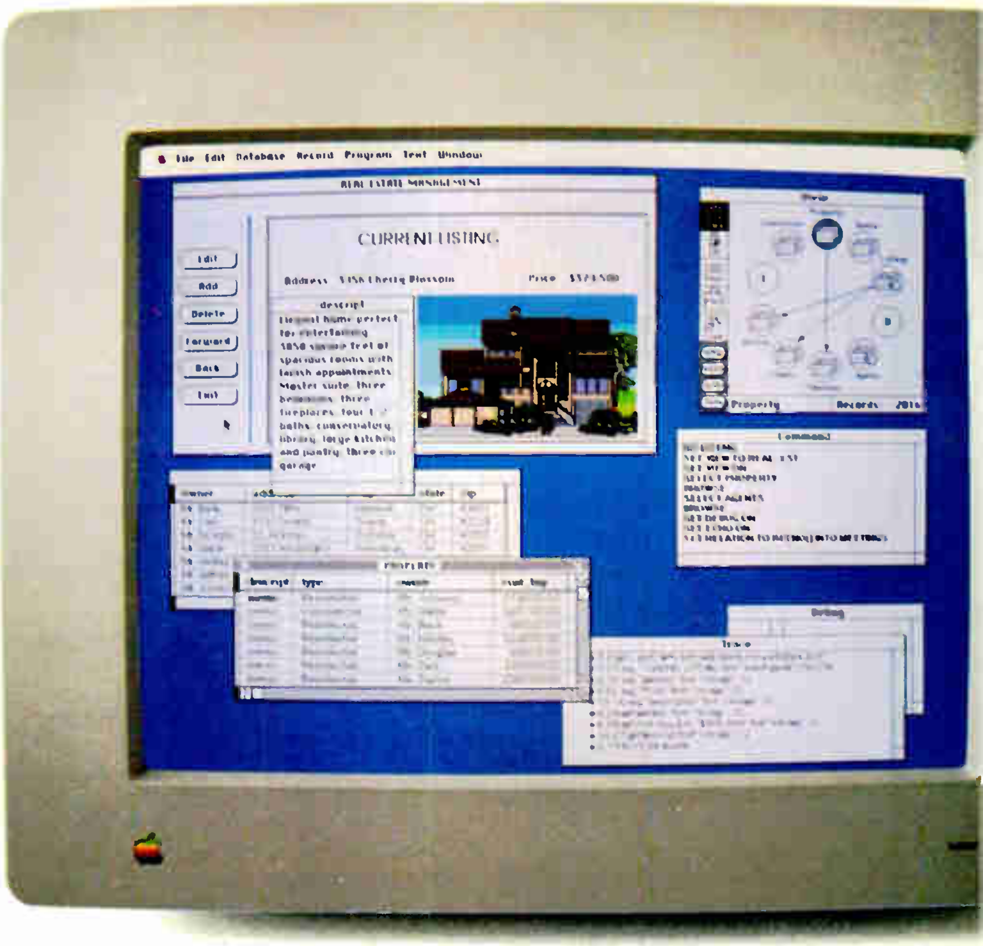

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• C++ is now available for workstations from **Apollo Computer** (Chelmsford, MA). Apollo's version of the object-oriented programming language, called Domain/C++, is based on AT&T's C++ translator. The company intends to integrate the language with its Distributed Debugging Environment later this year.

• Since many IBM-compatible computers have high-resolution EGA or VGA monitors, the company known for bringing graphics to monochrome PCs, **Hercules Computer Technology** (Berkeley, CA), has had to turn to other areas of the graphics market. Hercules is working on several products for enhancing the performance of VGA-based machines such as the IBM PS/2. The firm is also developing similar products for the Macintosh II.

The VGA package will coexist with an existing VGA board, connected via the VGA card's feature connector. It will allow you to use Hercules' RamFonts on a VGA system and will also "improve the performance of current bit-mapped graphics applications," according to Hercules CEO Jim Harris. Hercules hopes to show the VGA board at Fall COMDEX, with a Macintosh version following close behind.

• **Saba Technologies** (Beaverton, OR) has retooled its Page Reader scanner to handle draft type from dot-matrix printers and to be a little faster at reading pages (about one per minute, the company says). The $1299 Page Reader 2.0 also now supports the Tag Image File Format, which means the graphics can be used in PageMaker and other programs that accept TIFF files.

• **The Computer Security Institute** will demonstrate **viruses** and virus detectors at its conference for users of IBM and DEC systems. The program will emphasize network security, with sessions covering Ethernet and MacVAX networks. The event happens this month (June 13–15) in Arlington, VA. For more information, phone Irene at (617) 393-2600.

• The market for **used microcomputers** has reached $1.2 bil-

continued

hill, with FORTRAN, Pascal, Lisp, and Prolog languages available in mid-1988, and COBOL and Ada languages available in the second half of 1988. Tektronix has its DAS 9200 logic analyzer with a MC88000 probe for hardware prototyping and testing. Phoenix Technologies and Insignia Solutions announced programs to allow MS-DOS applications to run on the 88000.

Anticipated uses for the 88000 include large-scale parallel processing projects, big banking systems, AI workstations that use three-dimensional graphics, CAD systems manipulating three-dimensional objects, and jobs (such as in aerospace) that demand fault-tolerant computing. Tektronix has said it will incorporate the 88000 in color graphics workstations.

U.S. Firms Show Workstations Overseas

Although Atari and Commodore are known in the U.S. primarily for their low-cost home computers, both companies continue to work at high-performance machines. At the recent Hannover Fair in West Germany, they talked about their Transputer-based systems and Unix boxes that are in the works.

Atari demonstrated prototypes of its system based on the INMOS Transputer, the Abaq, at COMDEX in November. The company will ship "about 100 Transputers to developers in the next month," president Sam Tramiel told us at Hannover.

Commodore also announced its own Transputer-driven system. The company claims a processing rate about 10 times faster than an IBM PC AT. Each chip has four high-speed serial connections in addition to a normal bus. Four additional Transputers can be connected to the main processor.

Commodore is developing its system with a large-scale research institution, Gesellschaft fur Biotechnologische (the Society for Biotechnology Research). Commodore plans to develop a high-performance workstation around the Transputer for use primarily in laboratories and industries. This project is based on the Amiga 2000, which, when equipped with the Transputer system, offers a greatly enhanced graphics capability for such applications as modeling molecular structures.

Atari showed us a prototype of a Unix workstation. The system, when available, would be shipped with Unix System V version 3.1, according to Shiraz Shivji, Atari's head of research and development. However, the working unit that we saw demonstrated was a wire-wrapped prototype. Shivji said the actual boards are now being manufactured and that Atari will begin shipping systems to developers in "two or three months."

The workstation will have at least 4 megabytes of RAM, use a VME bus, and support Sun's Network File Structure. The system is based on the 68030 chip. It will use the International Standards Organization model for networking, have a SCSI port, and use X-Windows, Shivji said.

Commodore is also developing a Unix workstation. The Commodore model is based on the 68020 chip and will first appear as an add-on board for the Amiga 2000.

Mac the Mouth Shows How We Speak

You speak into a microphone. On the screen of a Mac II, you see a cross-sectional animated diagram of a person's head. As you speak, you see the lips, the teeth, and the tongue move in sync with your voice. You think to yourself, "Gee, I didn't know my tongue moved so much."

What makes this animation possible is a program under development by a small San Diego firm called Emerson & Stern. The primary purpose of the program, informally called Mac the Mouth, is to help people who have speech difficulties.

According to Jan Zimmerman, the CEO of the company, the program will help speech pathologists to correct speech problems that may be caused by hearing impairments, stroke, or head injury. It may also help people who want to lose their accent or develop a different one.

Mac the Mouth works by digitizing the sounds that a person makes when he or she says a word and breaking them down into a series of frequencies, similar to a standard spectrogram. The program then translates these sounds into an animated diagram of a person's mouth. The effect is almost that of being able to look into someone's mouth and watch his or her tongue move.

The program will allow people with speech impairments to have visual feed-

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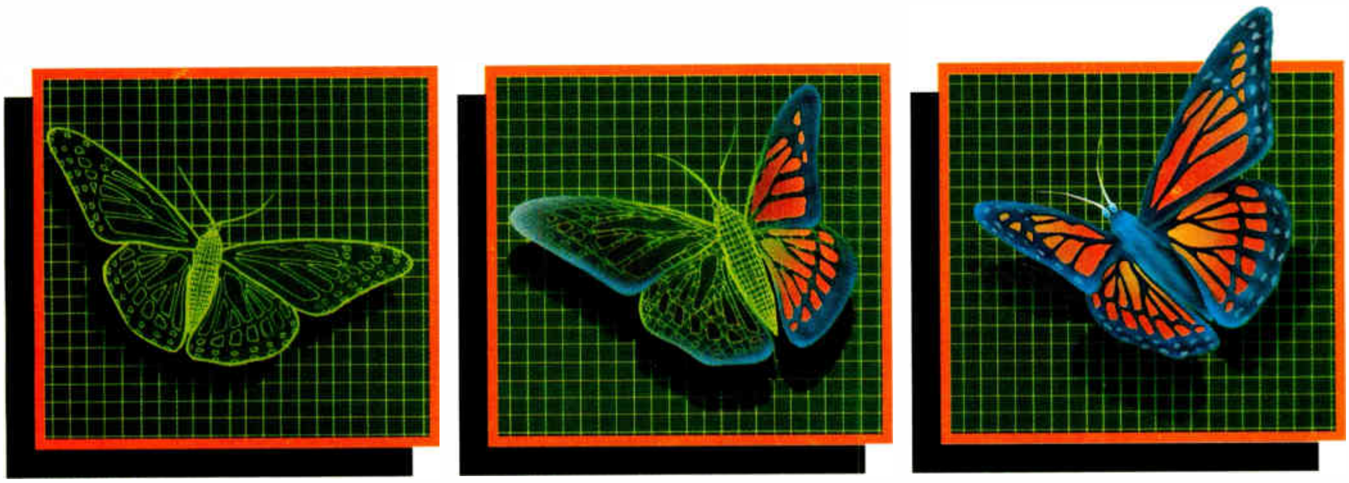

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Circle 19 on Reader Service Card

lion, according to the National Association of Computer Dealers (Houston). Despite specialty stores and "computer brokers," most used computers are sold in traditional ways: friend to friend or via classified ads, an NACD spokesperson said.

• Okay, he's rich and famous. But is he happy? **"I'm frustrated,"** said Apple vice president **Jean-Louis Gassée**. "I see the power of computing, but we're not doing it," he told an audience at the University of California at Berkeley. "We're not building networks or systems that can be used by normal people." Gassée warned that the "techno-clergy" must not become isolated from the rest of society. "The idea of 10,000 remote databases means absolutely nothing to most people," he said.

back on the sounds they are producing and the way they are producing them. In normal operation, a person will watch the diagrams that are produced when a speech pathologist says a word and then try to duplicate those same patterns.

According to Zimmerman, the software has already helped one of the company's programmers. The programmer, who emigrated from Thailand, had trouble pronouncing the "l" sound in words such as "really." By using the program, she was able to see where her tongue should be correctly placed and was able to produce the correct sound.

Zimmerman hopes to have Mac the Mouth ready in about 6 months. It will be available only for OEMs. No pricing data was available.

The significance of Mac the Mouth may extend beyond speech pathology. Emerson & Stern's Zimmerman says the company is exploring the possibility of combining Mac the Mouth with a grammar parser to develop a system for speech recognition. Such a system, Zimmerman says, would be speaker-independent, since we all use the same patterns of mouth movement to produce a particular sound.

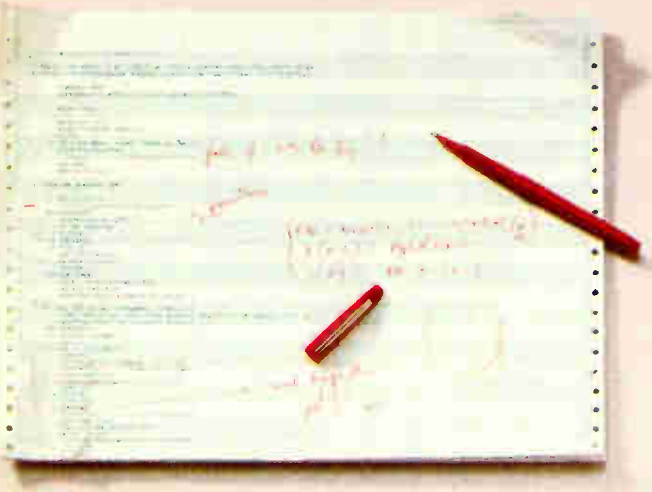
Laser Printers Getting Higher Resolutions

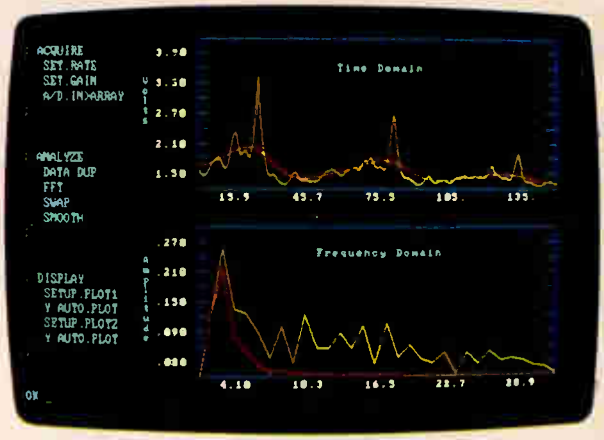
You might not notice it, but higher-resolution laser printing is on the way. Several companies, including Fujitsu, Agfa-Gevaert, and Itek, demonstrated at the recent Hannover Fair in West Germany a new breed of laser printer based on a Canon engine and capable of producing output with a resolution of 400 dots per inch. And at least three companies introduced printers with resolutions of 500 dpi or better. These higher-resolution models represent a coming trend for the desktop publishing market as the gap between typesetting and desktop publishing narrows, according to analyst Tim Bajarin, vice president at the market research firm Creative Strategies.

Although the higher-resolution laser printers (500 dpi and beyond) sound impressive, their effectiveness is lost on the lower-grade paper used in most offices. At 400 dpi, the ink sufficiently

continued

Write. Right.





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"bleeds" to fill in the "step effect" that is typical of desktop publishing fonts. Anything above 400 dpi is wasted because of this bleeding, many desktop publishing experts say. And most eyes can't differentiate between 400-dpi and 600-dpi output.

However, several software houses, including Aldus (of PageMaker fame), say they'd upgrade their page-makeup programs to support 400-dpi printers.

Toshiba and Kentek showed new printers using Phoenix's PostScript clone. Kodak had a four-color laser printer producing 17 pages a minute.

Nashville Cats Plugging into MIDI

Would "Your Cheatin' Heart" sound any different if Hank Williams recorded it today? Nashville, known as America's country music capital, is home to hundreds of musicians who've plugged into computers as a tool for composing and recording.

"This is a pretty computer-based city," said Tom Gerber, a MIDI studio technician and editor of a Nashville MIDI newsletter. "People are surprised when they come here and see what is going on. A lot of people are using Macintoshes for various parts of music publishing." Despite Apple's relatively late arrival on the electronic music scene with its MIDI adapter for the Mac and IIGS, the Macintosh is one of the favorite electronic axes of Nashville musicians.

Gerber noted that already five major recording studios are using Macintoshes in one way or another. "Some of them even started as MIDI studios," Gerber said. "West Park Studios uses three Macs for sequencing, mixing control, and sound editing. DBS Studios uses a number of Macs, and Masterfonics, one of the top CD recording and mastering studios, uses them with MIDI."

"Right now, most of the work is done on Mac Pluses and SEs," Gerber explained. "There are software compatibility problems with the Macintosh II due to copy-protection schemes right now, but that is supposed to change in the next few weeks, and we'll see more Mac IIs involved in MIDI here in Nashville."

"Nashville is more than just country music," Gerber noted. "I've done some 'space' music with the Mac for some performances. And many publishing houses use the Macs and MIDI for their lead sheets."

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LETTERS

Shuddering, Blurring Solved

In his review of multiscan color monitors (February), George A. Stewart found two problems with our Flexscan 8060S when it was connected to the Macintosh II. We have fixed both problems.

The shuddering that occurred during disk access was caused by a special cable for the Mac II, whose proper pin assignment was not available when Mr. Stewart did his evaluation. We now sell the proper cable for the Mac II.

The blurring was not caused by the side of the monitor but generated because of a 0.1-volt difference in signal levels. The Macintosh II's signal level is 0.6 V; the VGA signal level is 0.7 V. As we refined the hardware level for matching both signals, the blurring problem improved.

Ted Fukada
Applications Engineer
Nanao USA Corp.
Torrance, CA

Digivision on Monitors

Having read "Multiscan Color Monitors," I think you may be interested in Digivision's range of multifrequency monitors. Compared to corporate giants Sony and NEC, Digivision is a relatively small company, though it's technically advanced in many areas of display unit development. In July 1987, Digivision successfully launched the world's first 12-inch autosync monitor, which was closely followed by a 10-inch unit in November 1987. At present, we are about to seek UL listing for these products with an eye toward entering the U.S. market.

The article was extremely interesting and technically informative—the best I or any of my colleagues have read on the subject so far. Previous articles have contained minimal technical information and descriptions, so your article was a refreshing change.

Leonora Walker
Marketing Executive
Digivision Ltd.
Leicester, U.K.

Monitor Misconvergence

I recently finished your excellent article on multiscan color monitors. Yours is the first article I've seen that presented an objective instead of a subjective review of monitors.

I'd like to point out, however, a possible problem with some of the measurements. Doing the misconvergence and voltage regulation at a specific brightness level for each monitor is accurate only if each CRT has the same light transmission. The faceplate of the CRT can be made to give off different percentages of the display's light output by using lighter or darker glass. The darker the glass, the less light output there will be from the tube for the same amount of CRT drive. However, the darker glass gives a better contrast ratio, so less light output is necessary. For example, if you had a CRT with a 90 percent transmission and a brightness of 50 footlamberts (ft-L), a darker CRT of 45 percent transmission would require only 25 ft-L for the same contrast ratio. Therefore, it is possible that your tests were unfair if a monitor had dark glass.

Misconvergence is a very important aspect of a monitor to consider. However, judging a series of monitors from looking at only one could be misleading. The CRT specs for misconvergence are typically 0 to 0.6 millimeter. Therefore, it is possible to see one monitor that is near perfect and another that is only good.

For your information, "voltage regulation" is referred to as "high-voltage regulation." The anode voltage of a color CRT is typically 24 kilovolts. If there is no regulation of this voltage, it will decrease as the screen gets brighter, which causes the display size to increase.

Jim Samuels
Chief Engineer
Princeton Graphic Systems
Princeton, NJ

Smart EGA Plus Resolution

In the Product Focus on enhanced EGA and VGA boards (March) by Curtis Franklin Jr., several errors appeared in the chart on page 104. NSI Logic's Smart EGA Plus board has a maximum resolution of 800 by 800 by 16 colors, and it supports VGA modes 11H and 12H, as the article states on page 106. The price of the board is $199.

Also, in 640 by 640 mode, I have not seen a flicker problem on NSI or other boards that are operating normally, so I have to assume that you were operating in 800 by 600 mode. You will see some flicker on all current high-resolution 800 by 600 boards running on the NEC MultiSync. This can usually be adjusted so it is not troublesome to the user. The degree of flicker is a function of the manufacturer of the monitor, the speed of the EGA chip/board, and, in some cases, the applications software.

Robert Gallagher
Director of Sales
NSI Logic Inc.
Marlborough, MA

How About "Ubiquitous Electronic Device"?

"It's All in the Symbols" by Merrill Cornish (March) punctures the lid of what may eventually be the computer industry's biggest can of worms. The household name of these ubiquitous electronic devices signifies a major stumbling block—as if we were to call automobiles "corner turners," ignoring their many other capabilities.

Mr. Cornish admirably points out the difficulties in parsing English language text (other languages have other difficulties), while also mentioning those associated with programming languages. But most people have a problem envisioning all those nonnumeric symbols he talks about—for starters, the 52 characters of the Roman alphabet that the standard keyboard can produce in dozens of fonts and in a variety of enhancements, such as underline, reverse, bold, italics, and so on, not to mention the combinations. This brings us to tens of thousands of possibilities before we start combining these letters into words and then into sentences and then adding symbols and punctuation.

Surely C. L. Sholes (of QWERTY fame) would say something like *#?@"+%$@ if he could see how his

continued

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keyboard has been contorted, augmented, and Mickey-Moused around just to accommodate a tiny number of the possibilities that are available on present-day computers.

Many languages use a variety of alphabets, and some, using pictographs, ideographs, and hieroglyphs, don't even use alphabets at all. And then there are symbols—verbal, graphic, or iconic?—that are used to represent concepts in music, science, religion, finance, road signs, and programming conventions, to name a few. For example, a red circle with a diagonal line drawn in it can represent three words, but a cross may represent several pages of words.

Relational databases, hypertext, expert systems, and so on represent the first step of a thousand-mile journey. It is a paradox that computer cognoscenti who can't abide last year's 16-bit processors wrestle daily with a keyboard that was designed for mechanical typewriters about 115 years ago and ASCII that was designed for teletype machines about 45 years ago. Mr. Cornish's article has given us a hint of the revolutionary changes that will be necessary in software and in hardware before we can begin to realize the potential of these devices after we change the name of the machine.

Larry Salmon
Comptche, CA

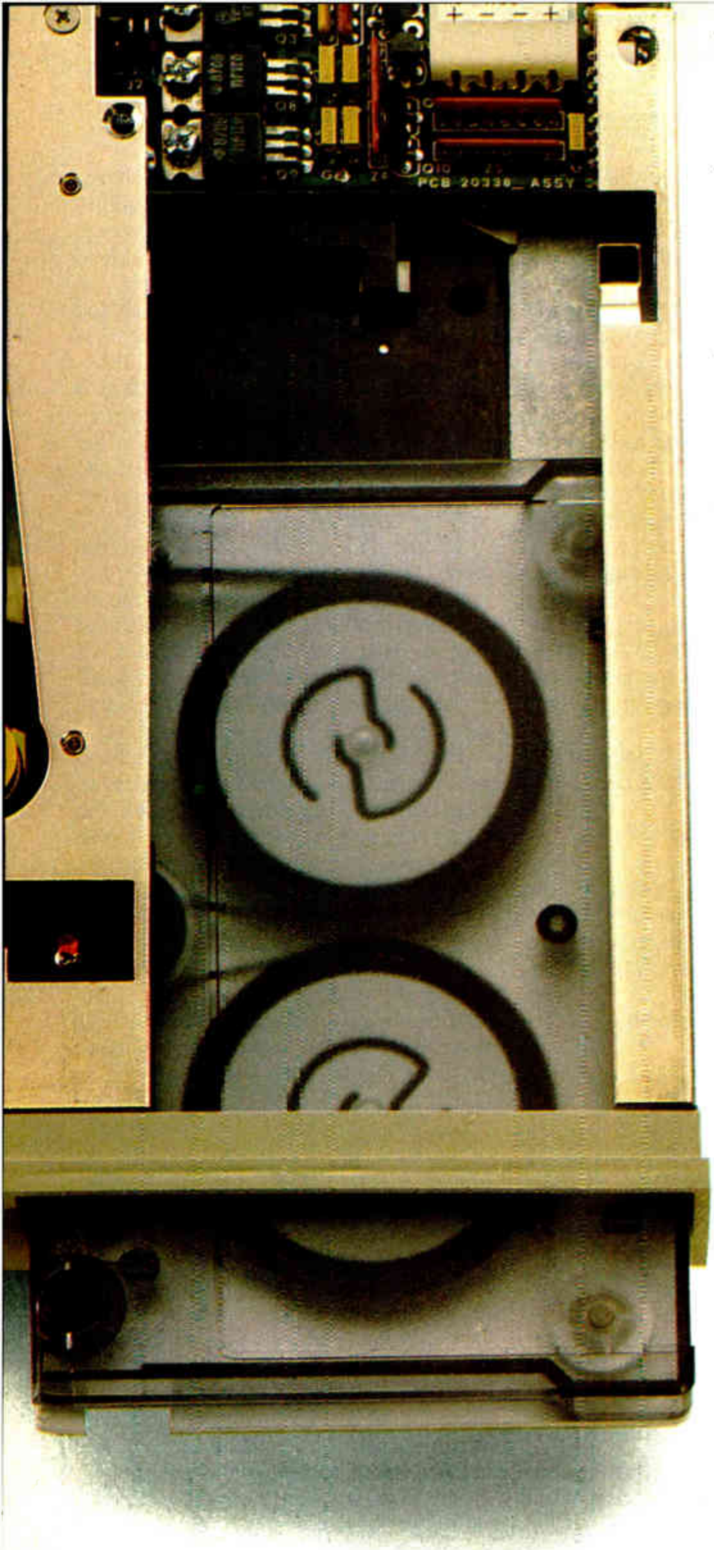
So Much for Symbols

I just read "It's All in the Symbols" by Merrill Cornish. It's true that we use symbols for numbers, but the representation is to represent the process. Generally, in mathematics counting is defined as the concatenation of empty sets (a process), and from this we attempt to prove addition, subtraction, multiplication, and virtually everything else. There are no 0s and 1s inside a computer. What a computer does is complex processing on different levels. There are no symbols inside a machine; there is only a method of processing symbols.

An artificial intelligence unit involved in symbol processing, such as natural language processing, tokenizes the words and parses them according to the specific grammar. Semantic nets are used in conjunction with the cognitive model to attempt to clarify meaning. These semantic nets generally represent a token world or an empirical representation of the organization of human knowledge. A number of simple data structures used in higher-level languages allow for practical representations of the empirical world.

We are living creatures, and one could say that we understand everything as a set of threshold neural responses. This could

continued



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explain why trees have leaves; however, I doubt if it will ever explain trees or leaves. Until computers function on a glandular level, they will never be able to successfully abstract humanly because we are not made of silicon chips. It is true that Godel proved (by the application of the Liar's Paradox) that there are no formal systems that cannot be made inconsistent and that there are no systems made inconsistent that cannot be made consistent. So much for symbols. There are no symbols that cannot be made meaningless and no symbols that are meaningless that cannot be made meaningful. Perhaps this man is just tired of silicon and electricity and is proposing a newer, more progressive, coherent light megabit processor. That may be in the future, but by that time I doubt if the computers will take anything that we say or do very seriously.

Joe Barnette
San Francisco, CA

Making Columns Wrap

Dick Pountain's column-wrap program (Focus on Algorithms, "Multicolumn Paged Text," March) is a fine base on which to erect improvements once you get it running. Unfortunately, in its present form it won't run at all. The problem is function spaces, which reads

```
Spaces := Copy(Blanks, 1, Num)
```

where `Num` is the number of spaces you want. This won't work, because in the Turbo Pascal `Copy` function the third parameter (`Num`) says how many characters to copy from the input string. Here the input string, `Blanks`, is merely 1 character long, so there's no way to copy, say, 38 characters out of it.

The simplest fix is to make the Constant `Blanks` contain 40 spaces between its two quotes, which is probably what Dick had in mind before a typesetter got at his listing.

There's also a typo in procedure `WriteOutPage`: The first appearance of the word `Spaces` should be followed by an end bracket.

Hugh Kenner
Baltimore, MD

Reordering the Alphabet

After doing considerable reading on data-retrieval systems, search and sort algorithms, and the like, I have come to think that we may be letting a historical accident impede the efficiency of our procedures. We inherited our alphabet and the ordering of its letters from the Romans, and we have preserved the order, with minor additions, as though it were something ordained and immutable.

However, the order of our alphabet is by no means the most efficient possible, even for human use in sorting through lists, and for computers' use it is almost criminally inefficient. Unfortunately, the ubiquity of ASCII clearly makes it too difficult and expensive to retool our system of encoding text for use with a CPU.

A few moments' thought shows that if our alphabet were arranged in descending order of frequency of occurrence of the letters, any search based on alphabetic order should go much faster, whether done by humans or computers.

Human nature being what it is, the hope of convincing the great mass of humanity to learn a new ordering of the alphabet is totally in vain. It is a different matter with computers. We could, of course, simply reorder the assigned codes, but this would require massive retrofitting.

Fortunately, there is an easier way to go. It makes no difference what order the characters of a text file are in inside the computer, so long as they appear in the expected order on the monitor screen or in hard copy for human consumption. How many people could or would read *Robinson Crusoe* printed in decimal ASCII code, let alone in binary numbers?

It would be neither particularly difficult nor time-consuming to run text through a filter that would recode the individual characters of the alphabet to match their natural frequency of occurrence. Once converted, data files would, or at least should, be much faster to search or sort. Recoding before printing would be required, but, in general, only selected fragments of data files would be output at any one time.

I believe it would be well worth testing to see whether enough time would be gained by quicker searching to compensate for the encoding and decoding time and leave a net gain in speed. If there proved to be a substantial gain, it would add little to the cost to include the encoding filter in future revisions of existing programs or new software and probably would not be prohibitively expensive to patch into software in the field.

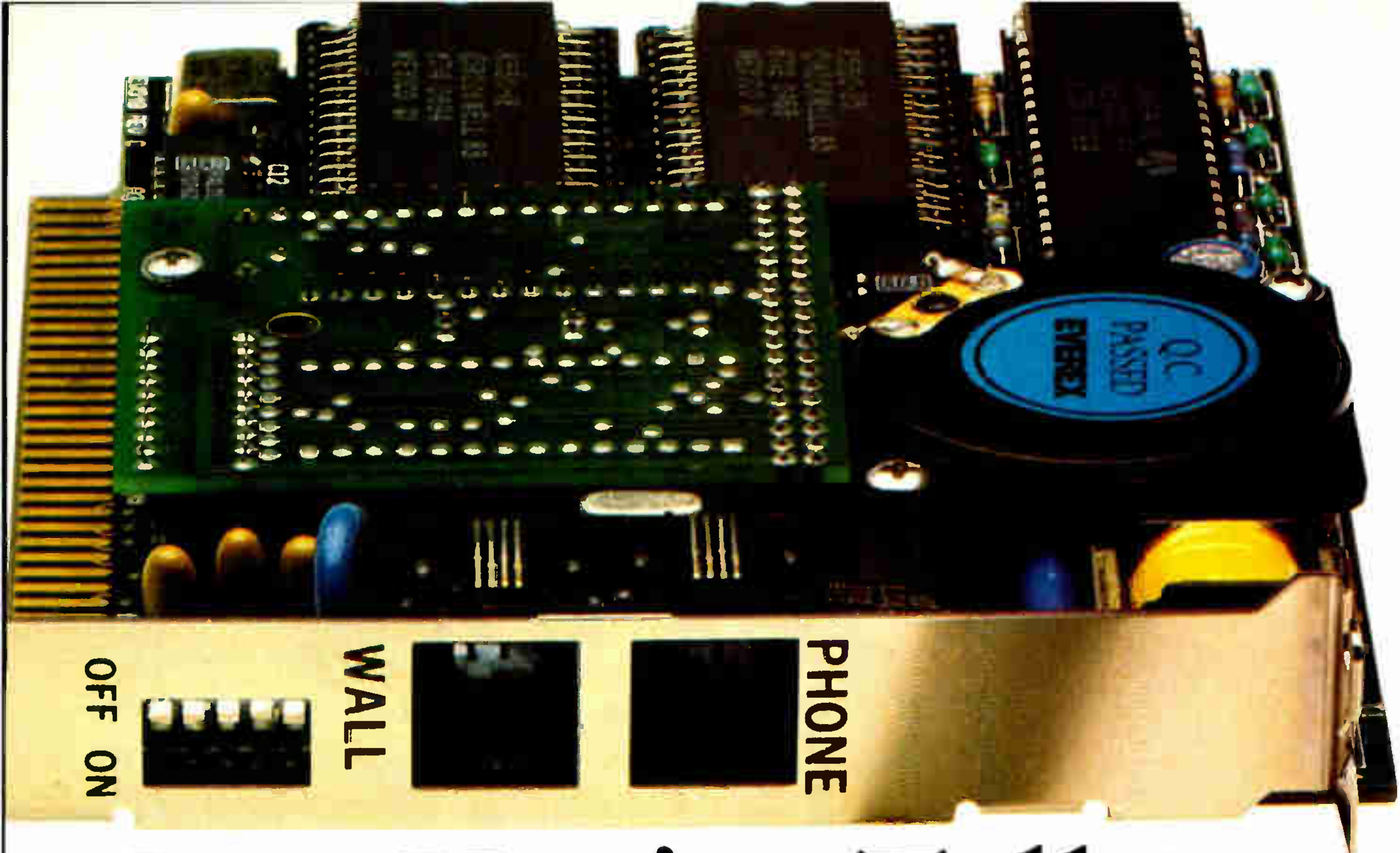
This is just a suggestion—something to think about. If anyone has done any experimenting along these lines, I'd like to hear about it.

Billy R. Pogue
Lake Havasu City, AZ

Objects in Continuous Systems

In object-oriented programming, the programmer thinks in terms of objects, which often have a correspondence in the real world (e.g., a dictionary). These objects can respond to messages (e.g.,

continued



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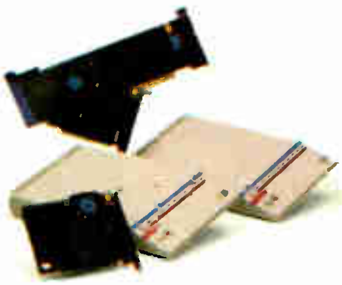

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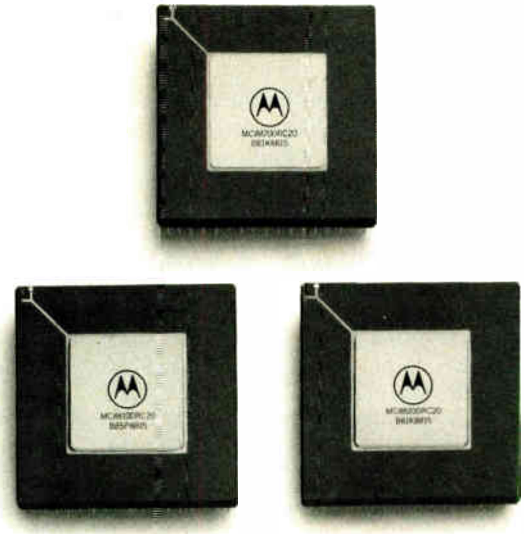

search for a word). The dictionary example seems natural, in that it is inert (shut) until we want it to do something.

But what about continuous systems? Consider the idea of a billiard ball moving toward a cushion (or "rail," as I believe you call it in the U.S.). Clearly, "ball" should be an object—it responds to "hit" messages and knows how to move. But the cushion is not passive—it has elasticity and responds when contact is made. Is the cushion, too, an object? For the sake of argument, assume it is an object. How does it know when contact is made? Is it constantly on the lookout for approaching balls? This doesn't seem to fit the real world.

Another possibility is the addition of a third party—an overseer who spots where and when collisions occur and reports them to the cushion.

I am well aware that billiards video games exist and also of the existence of planetary simulation systems in which the laws of physics can be changed. Is Smalltalk natural for the implementation of such systems, in that the design of the software bears a close relationship to what exists in the real world?

Smalltalk experts, what do you think?

Mike Parr
Sheffield, U.K.

Take Two Computers and Call Me in the Morning

You might well ask why am I writing to a computer magazine about a medically caused problem. I think I had better start at the beginning.

My wife, my son, and I were going to Reno, Nevada, in early June of 1985. I was to attend a week of schooling put on by the National Council of Juvenile Justice. It was funded by the federal government under a grant. I had decided to take my spouse and 15-year-old son with me and make the trip a working vacation. We drove our car during the day and stopped to eat, swim, and sleep in preselected camping areas at night.

We'd been traveling for several days and were almost to Reno when my wife said to me, "Dick, you're not driving very well, and your speech sounds funny. I think we should go to the hospital and see if they find something wrong with you."

We checked into the motel in Reno. I couldn't write very legibly, and I found it very difficult to keep my signature on the line provided for this. Yet I never felt any pain. Through this time I did not suffer from any physical discomfort.

The doctors at a hospital in Reno, after giving me a thorough physical examination and a CAT scan, all agreed that I had had a massive stroke of the right part of the brain stem. I had not only lost much of my sense of balance, but I had great difficulty in speaking, and I had double vision.

I was kept in the hospital in Reno for several days while I was given a battery of tests. When my blood pressure was no longer considered dangerous, my wife and I took an airplane to my home in South Dakota, while my son and brother drove our car back.

When I got home, my wife took me to the local hospital, where the doctor suggested that I go to the physical, occupational, and speech therapy unit. In therapy I was immediately placed on a computer, first the Visi-Pitch that was part of an Apple computer, where I learned to watch the track my speech therapist's voice made across the screen. I then tried to copy her pattern with my voice. She also encouraged me to turn the computer and Visi-Pitch on. I think this exercise helped my coordination, both physical and mental.

Next I was given the task of playing games on the computer. These games helped me reestablish hand-eye coordina-

continued

PSpice

The Standard for Analog Circuit Simulation Now Available on the Macintosh II

Since its introduction just over four years ago, MicroSim's PSpice has sold more copies than all other commercial Spice programs combined. In addition to running on the IBM PC family, including the new PS/2, the Compaq 386, the Sun 3 workstation and the VAX/VMS family, PSpice is now available on Apple's Macintosh II.

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tion; they also made me think, and my ability to problem-solve improved daily. When I finally did return to work, one of my staff members had his own personal Apple IIc at work, and he encouraged me to make use of it at any time. I did this a great deal, using a word processor until I got my own Tandy 1000.

I do like mechanical things, and the computer is an electrical/mechanical device. Also, my son was heavily oriented to the use of computers, and to keep up with the rest of the world and my own child, I wanted to know more about them. Both my son and I now have computers at home. I can use both of my hands, and I attribute this digital dexterity to the use I gave to my hands while using the keyboard of my computer. I probably would never have written this letter if I had to rely on a typewriter, or a pen and paper. The desire to become proficient in using a computer was the motivating agent I needed—physical as well as emotional.

My doctor agrees with me. He gave me a prescription for a computer. My tax accountant said I could deduct most of the cost as a medical expense.

I will admit that I can type only about 12 words a minute, versus the 60 words a minute I could type before I had my stroke. I can no longer touch-type but have to watch my fingers all the time to make sure they go where I want them to. But at least they all still work.

So now you can see why I am writing this letter to a computer magazine. I simply want to say thanks, and I don't know who to say thanks to.

Richard F. Stanford
Pierre, SD

Heatsinking 80387s

I would like to commend you on your In Depth section about floating-point processing (March). I particularly liked Mauro Bonomi's article, "Avoiding Coprocessor Bottlenecks." I liked the whole concept of the graphic beach ball.

The Weitek/80387 combination is fantastic, but, based on table 1 in the article, the over one million Whetstone-per-second difference does not warrant the additional cost of $1000 to $1500. I have friends who heatsink their 16-MHz 80387s and run them between 23 and 25 MHz with good success, which brings their efficiency even closer to the Weitek/80387 combination.

Please let me know whether your Float, Calcpi, Savage, Dhrystone, and Whetstone programs are available for us BYTE readers to run in our own hardware through your bulletin board.

Doody R. Ungson
San Jose, CA

BYTEnet carries listings for all programs mentioned in BYTE articles. The phone number is (617) 861-9764.—Eds.

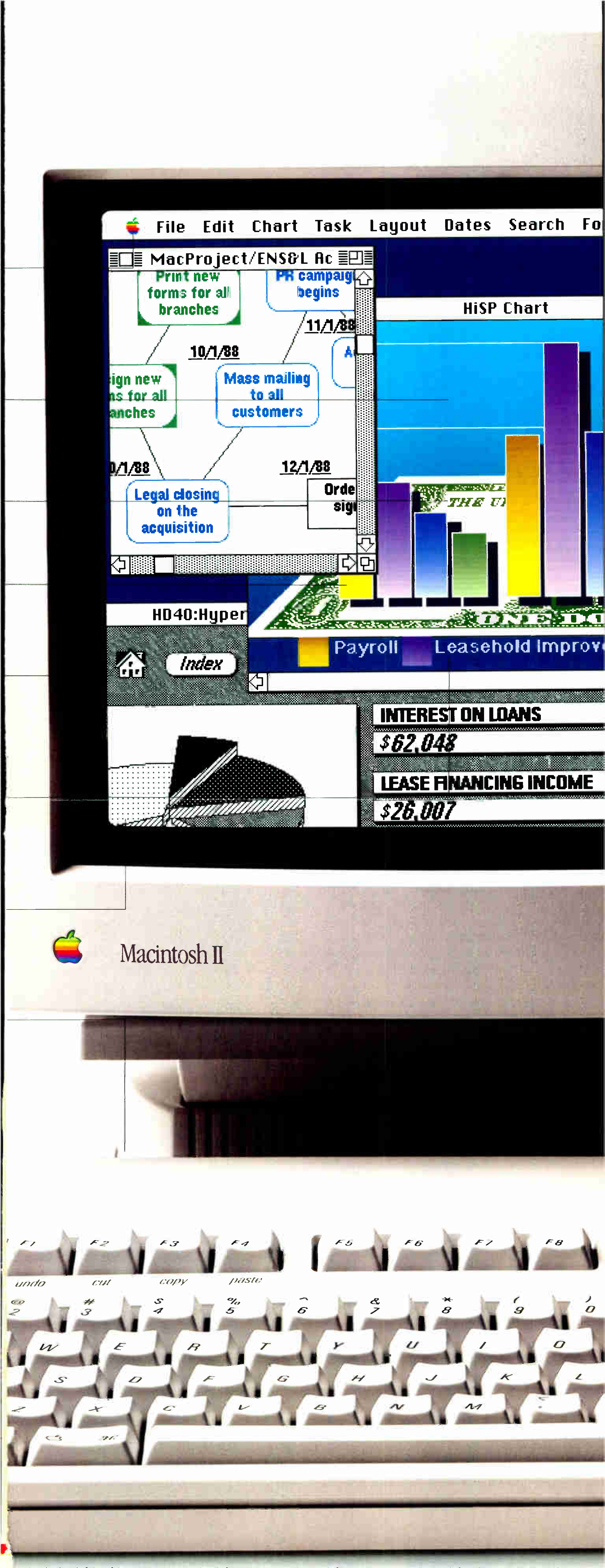
Up the Down Mouse

If anyone, for whatever reason, would like to learn opposite movements (i.e., moving your hand *up* creates an action *down* and vice versa, and moving your hand *left* creates an action *right* and vice versa), the solution is simple. Take your mouse, turn it 180 degrees and go to work. After a little practice, you may become quite good at it.

Bob Hester
Toulouse, France

FIXES

In the review of enhanced EGA and VGA graphics boards (March), we stated that Sigma Designs' SigmaVGA board does not work with the IBM 8513 analog color monitor. Sigma Designs says that its board *does* work with the monitor when equipped with the correct cable. ■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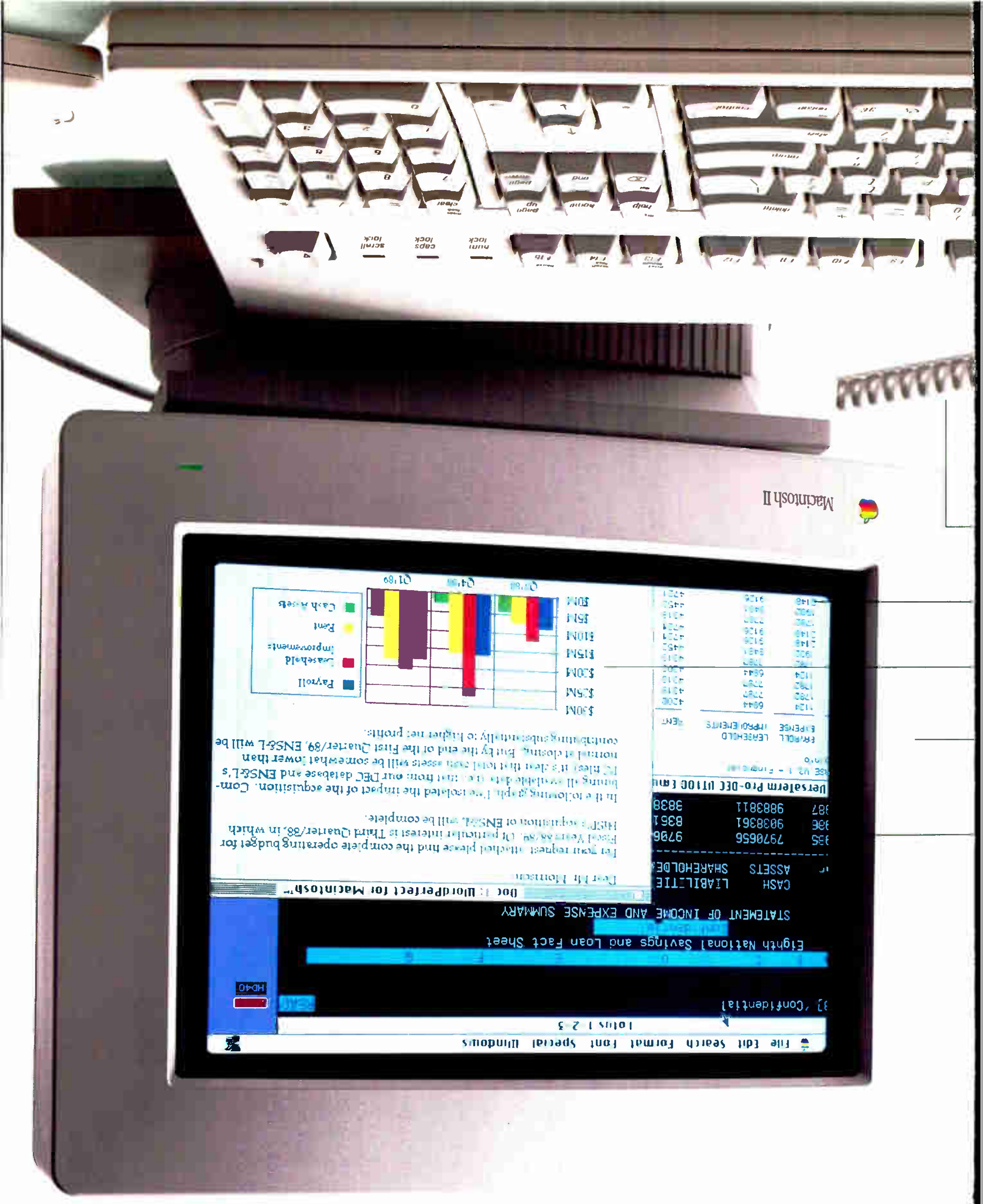


Get a second opinion.

At this point, we'd hardly stand in the way if you were determined to own a Macintosh.

But may we suggest, in the interest of complete safety, that you start with one simple phone call.

In return, you'll get an executive summary of a study that was conducted by Peat, Marwick, Main & Co., examining the effect of Macintosh computers on business productivity.

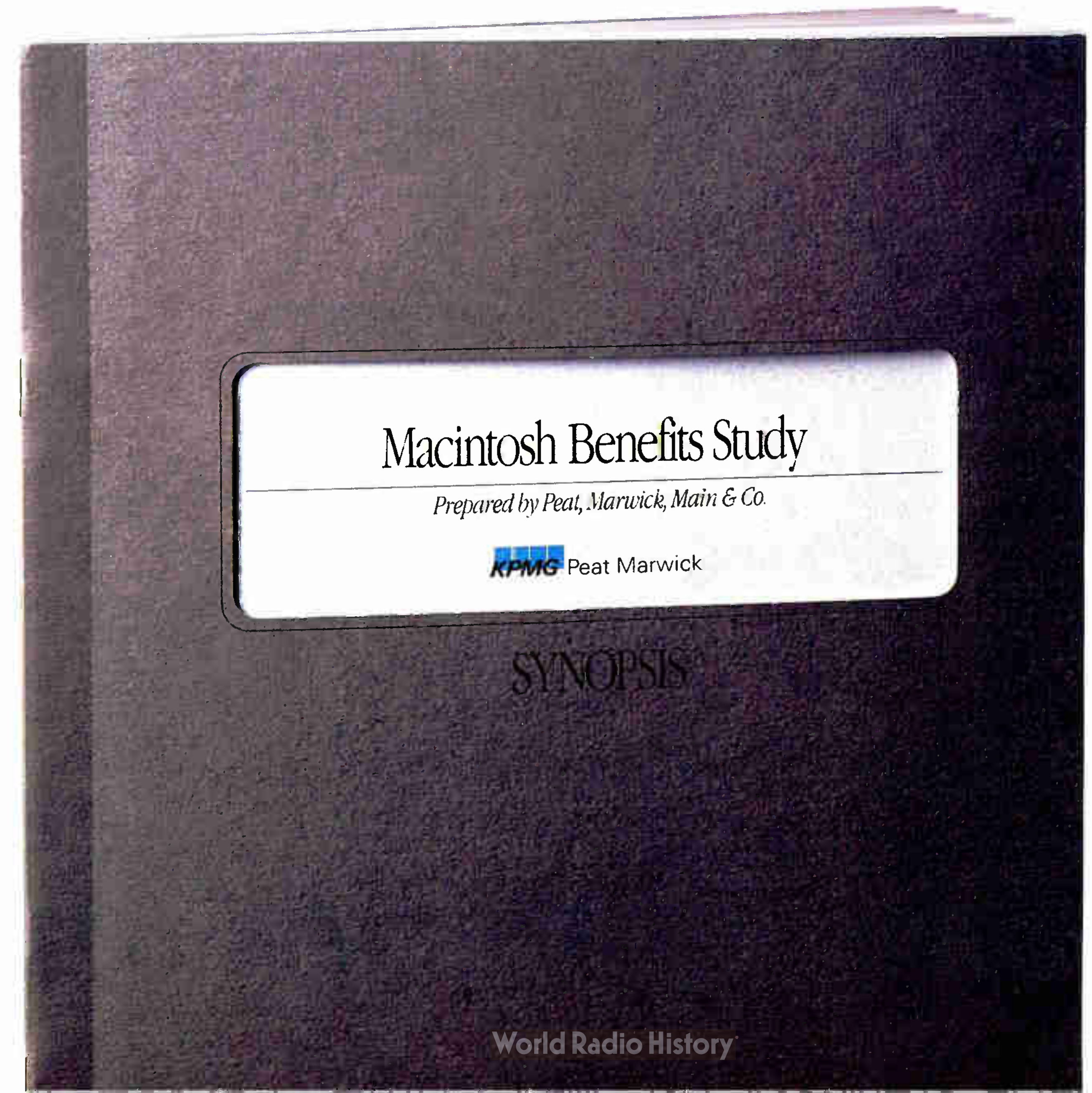
At the risk of spoiling the ending, we'll tell you this. In the cases studied, it was found that the use of Macintosh raised productivity as much as 25%.

Now then. All those interested in receiving a free copy of this report, please raise your finger.

And use it to punch 800-446-3000, ext. 333.

Then you can easily ponder the implications for your own business. And make the safest decision feel even safer.

The power to be your best.™



Then, we raised them.

There's more to good business than simply meeting standards. Which is why we've put so much effort into exceeding them.

Macintosh II is, first and foremost, a Macintosh–using the graphics-based interface we pioneered.

Beyond that, it's a new generation of computer, working at full strength with an operating system that exploits every bit of its power.

The latest part of that system, MultiFinder™, adds multitasking capabilities.

So you can go about your work even more naturally, switching back and forth between jobs as the situation requires. Or doing a number of things at once.

Practically speaking, that means you can print a document while you compose a letter. Or receive E-Mail while you recalculate a spreadsheet.

It means you can use Macintosh to move information effortlessly between programs, merging graphics and text. Even link data dynamically, so changes in one document are automatically incorporated in another.

This higher standard adds new value to existing Macintosh software (and to existing Macintosh computers).

But even more intriguing, it creates a world of new possibilities.

For example, now you can use advanced programs for Apple® Desktop Publishing–the standard we created over two years back–right alongside your business programs. So it's even easier to integrate a number of different efforts into a single document.

And, in the Macintosh tradition, what you see on screen is what you can expect to see on paper.

Like all Macintosh programs that have come before, the new generation offers a consistency that's unique to computing.

Use any one and you quickly gain a feel for the others–something that can translate very quickly into reduced training costs.

The best part is, this technology lets you raise the basic standard of how you get your information.

On your desk, Macintosh II becomes a window to all your computers, be they PC or mainframe. And lets you access and analyze different kinds of information in the same, intuitive Macintosh way.

Which means not only higher standards for the people using Macintosh, but higher standards for the equipment you already own.

Now, if you'd like to find out more about raising the quality of your work, it might help if you do a little sight-seeing.

Visit an authorized Apple dealer, and examine Macintosh II in detail, along with the new family of LaserWriter® II printers. (Call 800-446-3000, ext. 333, if you need the address of one nearby.)

Then you'll understand why so many business people feel the same way about getting a Macintosh II:

Better safe than sorry.

Graphical Interface. *We pioneered the operating system that others are only now beginning to imitate. Macintosh programs offer consistency, with clear graphical options instead of mysterious commands. So training costs are cut drastically.*

True WYSIWYG. *As in "what you see is what you get." Macintosh is designed for graphics from the ground up. You don't have to guess about what's going to appear on paper.*

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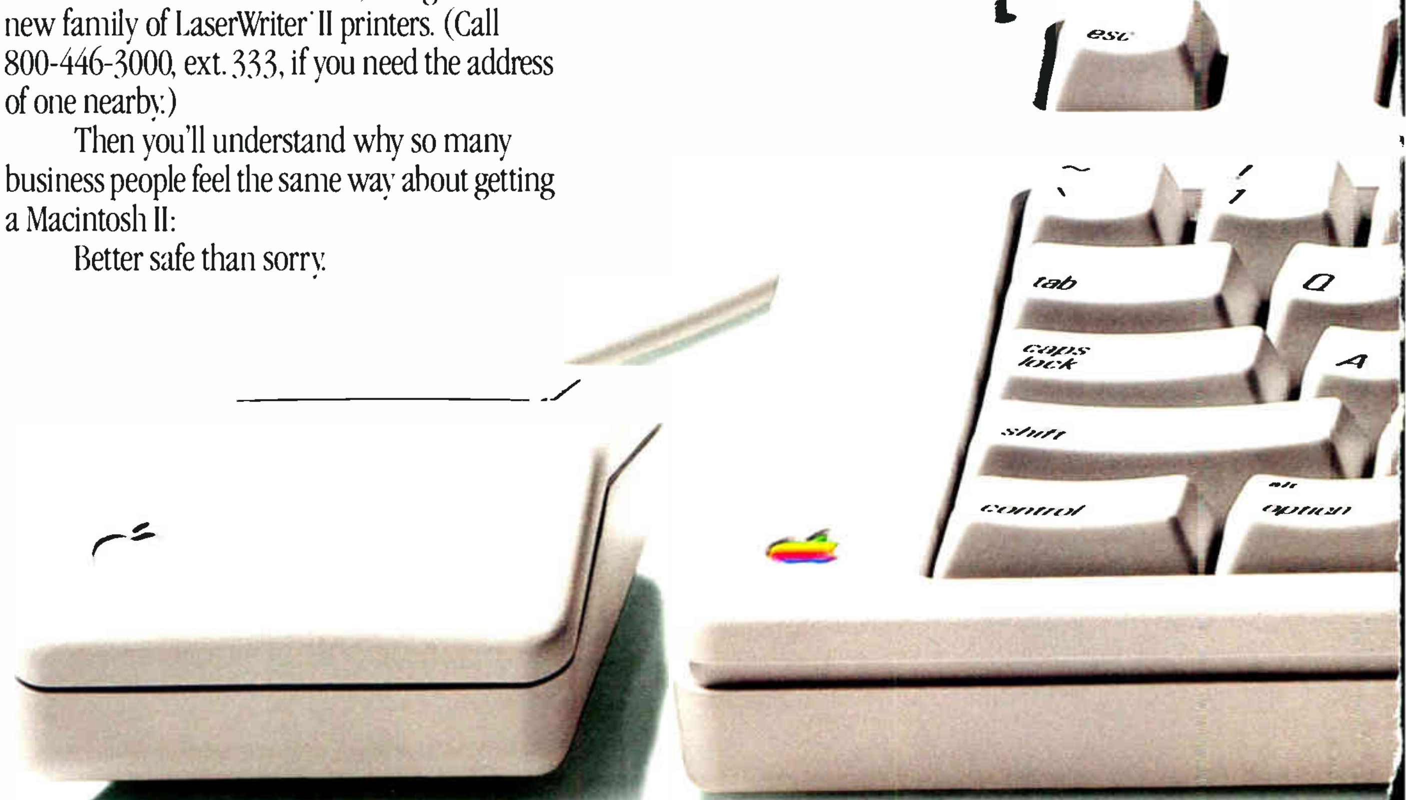
Integration. *Cut and paste information freely between applications, even those made by different software companies. Combine text and graphics as you please.*

HyperCard.™ *A revolutionary tool that lets you link "stacks" of information by simple association, instead of complex command. Without extensive training, you can create your own powerful programs to manage ideas and information.*

Applications. *Just what you'd expect from a new-generation computer: new-generation programs in every area of business use, designed to take full advantage of the power of Macintosh II. Not next year. Today.*

Transparent Access. *Use Macintosh II as your window to the world, and all your information is accessed the same, intuitive way. Whether it's in a Macintosh, PC, or in minis and mainframes from IBM and DEC.*

NuBus™ Technology. *Add vast memory, run alternative operating systems or tie into networks and mainframes. Unlike other computers, Macintosh II offers 32-bit expansion slots based on a published architecture–so future development is uninhibited.*



How Macintosh II came to be one of the safest decisions in business.

First, we met your standards.

Business computing has recently undergone some fairly radical changes. Consequently, so has the idea of "safety."

Because, at present, only one computer offers all the promise for the future, and delivers on it today: the Macintosh II personal computer.

Rest assured, it has the power to meet every standard that serious business demands.

Like breakneck speed. Full expandability. A wide choice of sophisticated programs for every business use. And the capacity to store even the most intimidating mountain of information.

It has memory that grows beyond megabytes, all the way to gigabytes. And can display your work in a choice of millions of colors, on monitors that show up to four pages at once.

Its own power aside, Macintosh II is perfectly prepared to meet the standards of other machines as well. Whether they speak MS-DOS, UNIX or assorted dialects of mainframese, from IBM to DEC.

So it can work with files from–and run–DOS programs like Lotus 1-2-3 and WordPerfect.

Connections are painless via the AppleTalk network system, using a variety of cabling, including Ethernet.

Keep in mind, you can use Macintosh technology no matter what size your thirst for power. There's a whole family of Macintosh computers, all designed to connect to existing equipment.

Macintosh II just happens to make a perfect place to start, because you can add so many options down the road.

Except, of course, the warm feeling of security.

That comes standard.

Compatibility. *Easily digests data from–and even runs–MS-DOS programs.*

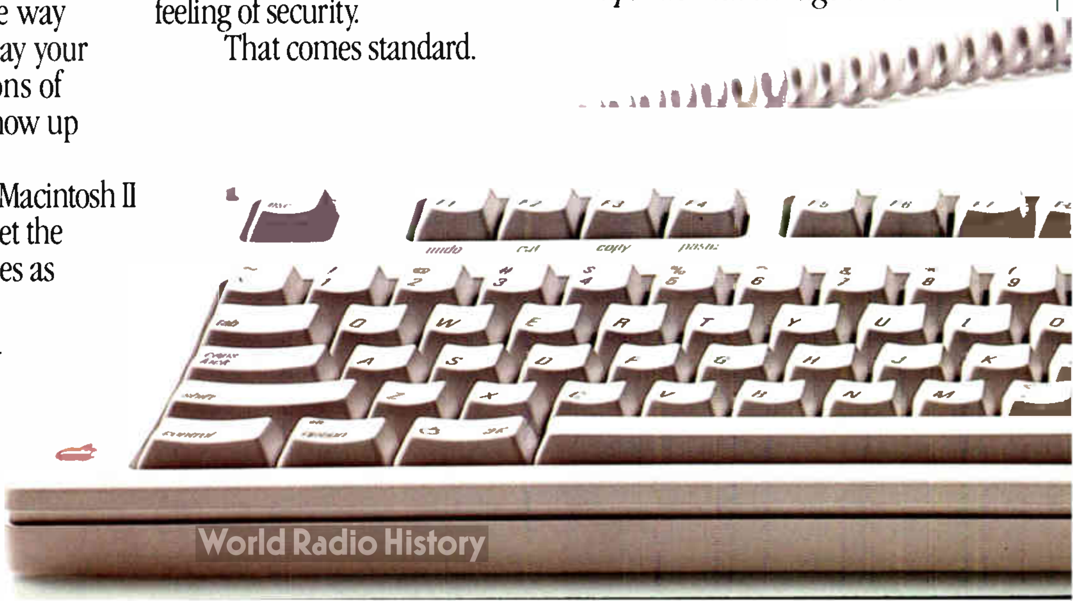
Display. *All sizes and shapes, including color and large-screen.*

Applications. *A wide choice for every business use.*

Connectability. *Via AppleTalk, using cabling such as Ethernet.*

Expandability. *Six expansion slots for future growth.*

Raw Power. *Math co-processor standard. Vast memory 1 MB and up. Internal storage to 80 MB.*



CHAOS MANOR MAIL

Jerry Pournelle answers questions about his column and related computer topics

The Ice Age Cometh

By way of background for the following letter: My talk to a meeting of authors of books in the Yourdon Prentice-Hall series was titled "We're Eating Your Eggs." It was built around the theme that much of the MIS community reminds me of dinosaurs having a debate over whether to evolve bigger teeth or longer tails, while the mammals are chowing down on their eggs. . . . —Jerry

Dear Jerry,

Just a note to you mammals to let you know how things are going here at Dinosaur Central. . . .

I just got a call from a fellow who wanted a price on converting 13,000 programs—about 7.8 million lines of code—from one system to another (incompatible) system. I gave him a price—I'm in business to do this sort of thing—but I thought *this is really stupid.*

I'm being asked to clone a dinosaur. The agency that wants the new dinosaur is willing to consider spending millions of dollars so that it will have a newer version of exactly what it has now. Incredible!

There's a lot of this dinosaur cloning going on these days. Companies are moving their systems from IBM to DEC, or you can pick any other combination you want. If you think there are problems with compatibility between systems in the micro world, you ought to see how the dinosaurs have screwed it up. Even moving from one IBM system to a larger one requires the sort of planning previously reserved for D day.

All this cloning takes up a lot of time and energy. Once the dinosaur keepers have spent the time they need to keep their beasts in order, there really isn't much time left for actual users who want the system to do something new or something old a little better.

Enter the mammals. The sales manager in the West Fencepost office can't afford to wait for the dinosaur keepers to do their thing, so he goes out and gets himself a PC and gets someone to show him how to use Reflex or dBASE. He doesn't care so much about what the dinosaurs are doing, except when they louse up an order for one of his customers.

Eventually, however, this guy is going to move upward in the company. He, or someone like him, is going to become president, and he's going to remember how the dinosaurs hurt his efforts and how the mammals helped him. That's when the Ice Age will start. Any vestiges of the dinosaurs that remain will have to earn their keep, either by keeping gigabytes of data accessible or by providing very fast computation in special situations. The mammals are going to call the tune.

John Boddie
Newark, DE

It does seem to me that rather than build ever-larger COBOL programs for those giant machines that lurk in climate-controlled rooms, big companies might think about reverse engineering: Figure out what their programs actually do, and commission someone to write code for micros to accomplish that. Of course, that would decentralize control and give computing power to people who don't work for the MIS, so I suppose it will never happen.
—Jerry

Amiga vs. Atari

Dear Jerry,

I'm afraid your biases toward the Atari ST showed again in the November 1987 Computing at Chaos Manor.

Like all software-only emulations, pc-ditto is unacceptably slow. Unfortunately, the ST cannot make use of the Motorola 68020 microprocessor (as you implied), because the TOS operating system will not support it, as does the Amiga's. Nor will it support more than 4 megabytes of memory, as does the Amiga's.

The Amiga 500 offers far greater performance for a modest price difference. The Amiga 2000 makes true high-performance PC compatibility possible and can use a 15-MHz 68020 add-in card that offers most of the performance of a Macintosh II at about one-third the price.

The same individual who was responsible for one of your favorite computers,

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.

the Commodore 64, also guided the development of the Atari ST: Mr. Jack Tramiel. Accordingly, the ST was designed and built with but one thing in mind—cheapness. This would be apparent to anyone who has lifted the cover off an ST and examined its innards (I have).

Generally, Amiga software is of higher quality than comparably priced ST software. I will admit that there is slightly more ST software available, but is quantity more important than quality? I think not. More Amiga software will appear as programmers become accustomed to the computer's more sophisticated operating system.

Jeff Joseph
Minot AFB, ND

Well, sir, you have one view. I have both machines, and I have another view. True: pc-ditto is quite slow, about 80 percent as fast as a PC, while the Amiga 2000 is exactly the speed of a PC; as for the 68020 card for the Amiga side, I haven't seen one yet.

Actually, like most people who've been around as long as I have, I followed the Tramiel odyssey from its inception; and I've done quite a bit of poking around inside the Atari ST, including installing extra memory on a 540. I assure you I've had more Guru Meditations (Amiga's system error messages) than cherry bombs (Atari's).

I hope you're right about the upcoming software for the Amiga.—Jerry

Medical Spelling Checker?

Dear Jerry,

My mother is a physician who has trouble spelling. We have an IBM PC, which she uses for word processing, and a couple of spelling checkers (Word Proof and the one in PC-Write). However, we have been unable to find a medical word list for any IBM PC spelling checker. Do you know of a spelling checker that comes with a medical dictionary, or a medical dictionary that we could add to one of our current spelling checkers? (Since PC-Write can add words to its list, all we really need is a file of medical words on an IBM PC disk with enough information to decode the file format.)

We tried to contact Oasis Systems, the maker of Word Plus, which you've mentioned favorably. Our letter was returned. Has the company moved?

I enjoy reading your column in BYTE, but could you cover the Amiga more?

Michael Hanson
Seattle, WA

I don't know of a medical dictionary. It is relatively easy to make one if you have the kind of spelling checker that adds update words easily. The simplest way would be to get one of the medical CD-ROM units, put the text on-screen, aim the spelling checker at it, and add the medical words to the dictionary. A couple of hours of that should build one heck of a dictionary.

A second method would be to write as you normally do, look up every word the first time it comes up on-screen, be sure it's right, and add it to the dictionary. It won't take long before you've built a pretty powerful dictionary.

Oasis Systems is located at 6160 Lusk Blvd., Suite C-206, San Diego, CA 92121, (619) 453-5711.

Incidentally, the folks at Microlytics are always looking for new dictionaries to incorporate into their packages. They've got the one I built out of these columns in their latest one; it even knows how to spell Pournelle.—Jerry

The Trouble with Turbo

Dear Jerry,

I noted with interest your discussion of C compilers in your October 1987 Com-

continued on page 322

11 Important Reasons C Programmers Use Our File Manager

1. It's written in C.

Clearly the growing language of choice for applications that are fast, portable and efficient. All of db_VISTA's source code is written in C.

2. It's fast – almost 3 times faster than a leading competitor.

Fast access that comes from the unique combination of the B-tree indexing method and the "network" or direct "set" relationships between records. A winning combination for fast performance.

3. It's flexible.

Because of db_VISTA's combination of access methods, you can program to your application needs with ultimate design flexibility. Use db_VISTA as an ISAM file manager or to design database applications. You decide how to optimize run-time performance. No other tool gives you this flexibility without sacrificing performance.
db_VISTA is also well behaved to work with most any other C libraries!

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db_VISTA operates on most popular computers and operating systems like UNIX, MS-DOS and VMS. You can write applications for micros, minis, or even mainframes.

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- **Multi-user** support allows flexibility to run on local area networks
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- **Operating systems:** MS-DOS, UNIX, XENIX, ULTRIX, Microport, VMS, Macintosh
- **C compilers:** Lattice, Microsoft, IBM, Aztec, Turbo C, XENIX, UNIX and LightspeedC

8. SQL-based db_QUERY

is the query and report writing program that provides a relational view of db_VISTA databases. Use ad hoc or link into your C applications. Royalty-free. Source code available.

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Mono System includes 14" Flat Screen, Tilt/Swivel base and Hercules compatible graphics card.

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80286 8MHz, 6 16 bit and 2 8 bit expansion slots, plus basic features.

Mono System	$995
Mono System with 20MB	$1274
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Small footprint chassis with 80286 12MHz, 0 wait state, 1MB 100ns DRAM, 4 16 bit and 4 8 bit expansion slots, plus basic features.

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ASK BYTE

Circuit Cellar's Steve Ciarcia answers your questions on microcomputing

Printer Woes

Dear Steve,

My NEC CP6 printer is capable of producing 360- by 360-dot-per-inch graphics, but the results that I have seen are far from this. (I have been using the Epson JX-80 printer definition for the best results, which are still poor.) It seems that the printer produces plenty of dots of resolution on the *x*-axis but far too few on the *y*-axis. This creates images that appear to have bands in them. I notice this fault with every bit-mapped reproduction I make.

Why is this happening? I would think that a simple dot-replication scheme built into the printer definition would create denser, darker graphics by simply replicating the solid lines.

Also, is it possible to use an analog monitor, such as an NEC MultiSync, as a standard color TV if it's hooked up to a tuner?

Chris Durst
Laytonsville, MD

I think the bands in your printed output come from irregularities in the paper feed. Take a very careful look at the paper path and see if anything is binding or sticking, or if the paper is snagging on the cables in the back. Then make sure that the paper exits smoothly and doesn't bunch up or drag on the way out.

The real reason why you aren't seeing more dots on the page is that the printer driver software in the computer isn't sending them out. The printer commands provide the ability to put a dot nearly anywhere on the page; the software has to translate the screen image into the appropriate dot patterns.

You'd think that the printer could "fill in the dots" and produce a good-looking image, but it's not quite that simple. The problem boils down to the ratio between the dot's horizontal and vertical sizes, called the aspect ratio (there's also a screen aspect ratio, which is a different matter). Because each display mode has a different dot aspect ratio, there's no one way to translate a bit-mapped image from screen to paper. For example, the aspect ratios that show up in normal use are shown in table 1.

But the aspect ratio of a printer dot depends on the horizontal dot spacing and vertical line spacing. Only the software knows both the screen aspect ratio and the printer aspect and can (presumably) reach a compromise. Given the number of different screen modes and printers, it's a wonder anything comes out at all.

Table 1: *Dot aspect ratio for various IBM PC screen modes.*

Mode	Aspect ratio
320 by 200 CGA	1.12
640 by 200 CGA	0.56
640 by 350 EGA	1.28
640 by 480 VGA	1.00

As a simple example, take a 640 by 200 CGA image with a 1.12 dot aspect ratio. Try to find a way to represent that image on the paper with your NEC's 1.00 aspect ratio dots so that the image comes out about 8 inches wide and 6 inches tall. Be sure to look up the details of the print head dot patterns and restrictions on pin-firing order. You'll probably have to move the paper in an irregular fashion to get the dots in the right places.

Once you've done that, repeat the exercise for the EGA display and see what changes. At some point you'll realize that you need a fraction of a dot to make the answer come out right, and that's where the problem lies.

Also, despite everyone's best efforts, paper just doesn't move reliably in tiny fractions of an inch. The resulting twitches cause painfully obvious glitches in the dot patterns, and nobody's happy. The good news, though, is the last line in table 1. VGA displays have 1-to-1 aspect dots, exactly matching laser printer dots. That means it's easy to get good-looking results on screen and paper. All you need is the right hardware.

Unfortunately, the MultiSync won't work with a stock TV tuner. The problem is that the tuner produces standard National Television System Committee (NTSC) composite baseband video on a single output, while the MultiSync expects to see separate RGB and synchronous inputs.—Steve

Expert Nutrition System

Dear Steve,

I am currently developing a set of rules for an expert system that will be used as an advisor in enteral and parenteral nutrition systems in intensive care unit patients. What is the best way to go about creating such an expert system? Should I learn a language such as Lisp or Prolog to write my own, or should I use some form of expert system shell? If the latter is the best, could you please let me know what is available?

J. D. Harrison
Nottingham, U.K.

Although not as extreme, the difference between programming an expert system in Lisp or Prolog and using an expert system shell is much like the difference between programming in assembly language and programming in a high-level language, such as BASIC. You'd have much finer control over your program if you used Lisp or Prolog, but you would also have the overhead of much of the "housekeeping" (e.g., the user interface, input screens, and file handling).

Since your object is to encode your expert knowledge of nutrition systems, it would be far easier to use a shell. You will have to do some additional homework to find the shell that is best for you. I recommend that you check out KnowledgePro from Knowledge Garden (473A Malden Bridge Rd., Nassau, NY, 12123). It's very easy to use and would be especially suited to a teaching-type expert system because of its built-in hypertext capabilities. Also contact EXSYS (P.O. Box 75158, Contract Station 14, Albu-

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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c/o Steve Ciarcia
P.O. Box 582
Glastonbury, CT 06033

Due to the high volume of inquiries, we cannot guarantee a personal reply. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

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

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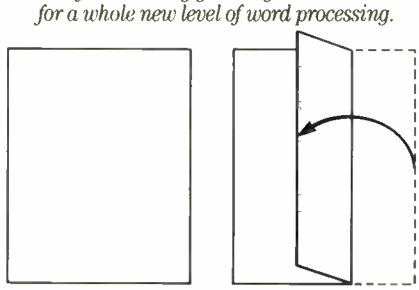

querque, NM 87194) for information on its EXSYS program.—Steve

Dead Drive Blues

Dear Steve,

Last weekend, a drive bearing on my 20-megabyte Hardcard started going bad.

I bought the drive 17 months ago from Logic Array of Costa Mesa, California. Alas, the company is apparently no longer in business, so I can't get the drive replaced or repaired under my 2-year warranty.

Is there a company that sells 3½-inch 20-megabyte hard disk drives without a controller? The dead drive is an NEC D3126, part number 134-200420-001.

David G. McDonald
Ames, IA

If you've got a genuine Hardcard from Plus Development, you should be able to get factory service. If, on the other hand, you've got one of the clones, you're sunk.

Although I hate to say this, I think the cheapest way out for you is to buy another card. While it's possible to pick up just the drive, you'll have to worry about connectors, cabling, mechanical hardware, and all that.

"But," I hear you say, "isn't all that stuff standardized?" The answer, regrettably, is "not quite." The only way to find out whether a new drive will fit is to buy it and see. You can accumulate quite a pile of parts while you're thrashing around.

Given the price competition in hard-disk drive cards, I suspect you can replace that thing for about half of what you paid for it originally.—Steve

Help with Heath

Dear Steve,

I teach a course in which we use Heath trainers (5-MHz 8088 microprocessor, 64K bytes of RAM). These machines have an editor, an assembler, a debugging program built into ROM, and all the 8088 control signals (minimum mode) available for building circuits on breadboards. They're nice machines, but they lack disk drives and sufficient memory, so we can't use them to teach anything about the use of a disk-based operating system, a higher-level language, or disk files.

Heath also sells an upgraded version of the basic machine that you can fit with two 360K-byte floppy disk drives and 196K bytes of RAM. Except for the limited memory, this is what I'd like to use, but it costs twice as much as a good-quality IBM PC AT clone.

There ought to be an expansion board for a standard PC that would bring the microprocessor signals (through buffers and isolators) out to a breadboard. Do you know of any products of this kind? The only one I've heard about is the eZ Board from Sabadia Export Co., but a friend told me that he had severe problems trying to use it.

Maynard Fuller
Montreal, Canada

Given that you can buy an IBM PC clone for about $600 complete with monitor, drives, DOS, and keyboard, you would expect that someone would have a useful breadboard accessory for it. But I haven't seen one anywhere.

Perhaps the best thing to do is to get a cheap computer and a standard IBM PC prototyping card and have your classes roll their own. JDR Microdevices sells PC prototyping cards—check the back of a recent BYTE. The circuitry is simple enough that your students can probably handle the design on their own, and it will be a real learning experience.

One suggestion: If you're going to use ribbon cables to bring the signals out, make sure you have a ground lead between every signal wire, put the control signals in a separate cable, and keep the length down. Don't try to save wire by running 26 signals in a single cable. Although I haven't heard of the Sabadia board, I bet that's what the company tried to do. Even though we think of the PC as being pretty slow, those signals are still fast and delicate.—Steve

Memory Mayhem

Dear Steve,

I have an Intel 2010 Above Board/AT memory expansion board from Mead Computer. When I placed the order, Mead told me that I wouldn't have to disable the 384K bytes of my 1-megabyte motherboard.

After delivery, I phoned Intel technical support to ask about switch settings, and I was told that I'd have to disable the 384K bytes (above 640K) of my motherboard.

Mead Computer then told me that the 2010 board would work without complication in extended memory if I would start my extended memory location at 1.5 megabytes rather than at the customary 1.0 megabytes.

It will be a while before I actually start running OS/2. Please straighten me out regarding memory configuration.

Americus Mitchell
Kilmarnock, VA

If you don't disable the 384K bytes of RAM on the system board, you'll wind up with a "hole" between the end of the RAM at 1.384 megabytes and the start of the Above Board at 1.5 megabytes. All

continued

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the programs I know of assume that the RAM is contiguous, so that hole is going to cause some problems. You've probably found that out, right?

Mead is correct in saying that the board will work, but only custom code that you write can take advantage of the disconnected RAM on the Above Board. All the standard code will fall into the hole and die.

The best solution is to disable the 384K bytes of system board RAM and have everything work. Anything else isn't going to be worth the effort. You'll wind up wasting a little chunk of those RAM chips, but so it goes.

As far as OS/2 goes, there's going to be a lot of blood in the streets when people find out that they can't run a "standard" version of OS/2 on clones that were sold as compatible with IBM PC ATs. The reason is that OS/2 can't use the BIOS routines in those clones: It must talk directly to the hardware because the BIOS code won't run in protected mode. And that means the clone vendors must supply modified versions of OS/2 for their machines.

If you've added oddball displays or other hardware, you won't be able to run the standard OS/2 from the vendor because it won't talk to the display. It's not at all clear how this problem is going to be resolved, but I'm certain that the final answer isn't going to make everyone happy.—Steve

Designing Chips

Dear Steve,

I've been working on an idea that may have commercial value, and I need to look into having a custom chip designed. Could you give me some insight into what to expect in terms of minimum quantities, design and production time, chip costs for the initial run, and so on? The chip I have in mind shouldn't require a dense mask, such as the 68020, but it does require a very high pin count (68 to 166 or more). All the major functional blocks are in commercially available chips, so a lengthy design phase shouldn't be necessary. Where should I start?

Your article "The BCC180 Multitasking Controller" (January through March) was very interesting, and I'd like to see more in the same vein. It's fairly obvious that the chip you're using is the most suitable one available today for general-purpose controller work. Way back when you started out with designs based around Zilog or Intel processors, why did you choose these architectures over Motorola's 6802, 6808, and 6811? I'm no expert, but it seems to me that if I have a specific control application, I can usually use a Motorola processor to accomplish the task and end up with a lower chip count than I can with a Zilog or Intel processor.

Finally, with regard to programming languages, when I do control work, I prefer using Forth. I know most of the arguments in favor of using BASIC. I don't agree with all of them, but I can understand why you've chosen to use BASIC. The fact remains, though, that Forth is the only language available that gives you an operating system and language in 16K bytes or less and that runs on almost every processor available today. Its code is compact, and execution is fast. I'd like to see Forth as an alternative to BASIC in your future articles.

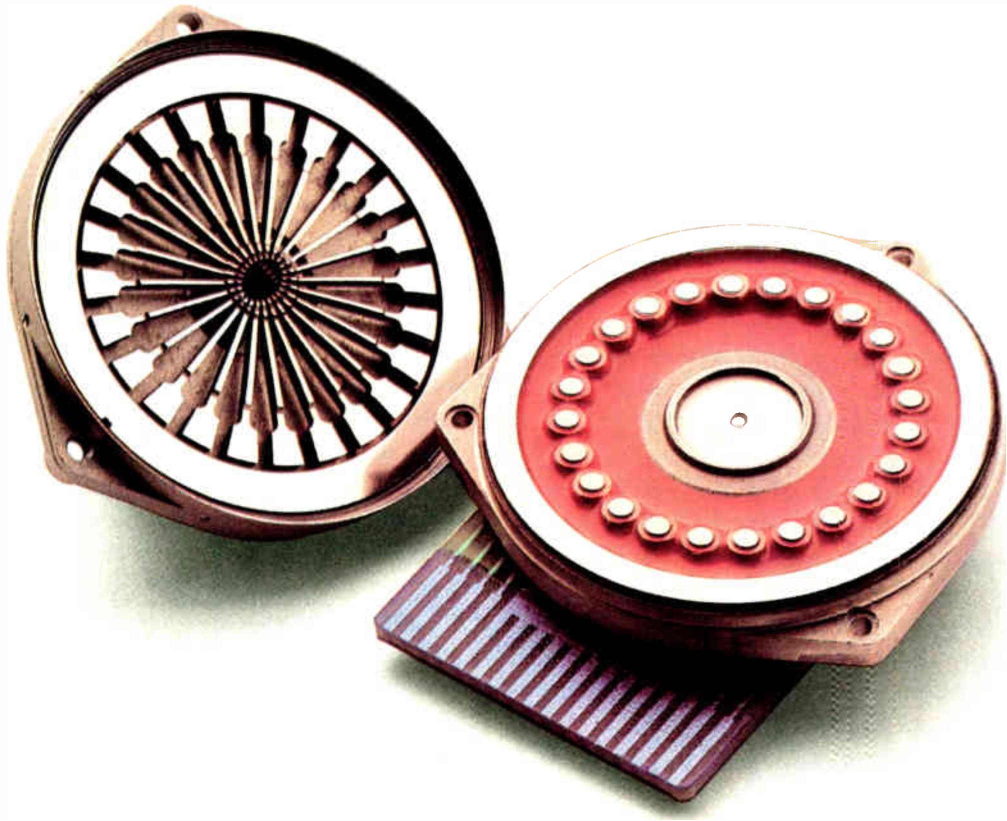
Ken Martinson
Ringgold, GA

I assume that the custom chip you are asking about is an application-specific IC (ASIC). ASICs include programmable logic devices (PLDs), gate arrays, standard cells, or handcrafted full-custom ICs. The advantage of an ASIC is a single chip that replaces perhaps 30 or more standard logic parts and the board space that they would normally occupy. The design is more difficult to copy, and you can realize optimum performance because of reduction in pin and circuit board delays.

Designing with PLDs requires only a personal computer equipped with PLD software and a PLD programmer (which costs approximately $10,000). In comparison, setup costs for gate arrays or standard calls include nonrecurring engineering (NRE) fees, and the equipment requirements might include a CAE/CAD workstation, a timesharing computer, or both. The NRE costs for gate arrays range from $5000 to $80,000. For standard cells, this figure runs from about $20,000 to $150,000. Production turnaround for gate arrays and standard cells can run anywhere from 2 months to a year; turnaround for PLDs is perhaps a few minutes.

The choice of a microprocessor is not an easy one. Certainly it would be nice to choose the best chip for every job, but that's not practical. A number of factors—familiarity with the family, programming knowledge, software development equipment, factory support, and parts and sample availability—determine the processor of choice. In most cases, these items weigh more heavily when comparing architecture than does saving a chip or two in a design. Only in designs where constraints are rigidly dictated (such as volume productions and a small physical size) would I trade the things I

continued



mentioned for a lower chip count.

BASIC is an interactive language that is easy to learn and available on virtually every computer. Forth is also interactive, but it's not nearly as popular. The virtues in each have caused many to suggest the need for a single language that combines their best features. I use BASIC because of its popularity, but I will consider using Forth in a future article.—Steve

Optical Scanning

Dear Steve,

My company, Hemisphere Software, does contract programming and sells IBM PCs to small businesses and municipalities. We've been working on a project that is missing one important part. I need a scanner with an automatic feeder to read a continuous form 2.4 inches wide. This scanner will have only one typeface to read. The scanner must meet the following criteria:

- It must read a continuous form of paper 2.4 inches wide. The paper will hold text only, in black or blue ink. The paper has 22 character positions and no special spacing at the top and bottom of each page.
- The text is in code. The code equivalent for one word appears on each line.
- The text consists of 17 letters of the alphabet, numbers 1 through 9, and the asterisk. The letters can appear only in the following sequence, and only in these locations:

STKPWHRAO*ELFRPBLGTSDZ

Consequently, the letter *T* can appear only in the second or nineteenth position of the line, and so on. Numbers can appear instead of certain letters, as diagrammed below:

```
STKPWHRAO*ELFRPBLGTSDZ
12 3  4  5      6  7 8 9
```

For example, line position 1 can be either blank, *S*, or 1.

- The scanner's output is to be sent to an ASCII file. Each line of input will be one record.
- The scanner's operation (start and stop) will be controlled from an MS-DOS IBM-compatible microcomputer.

To keep the price of the system as low as possible, we're trying to keep the cost of the scanner below $1500. We'll need two scanners as soon as possible, and we'll be purchasing more later. Thanks for any help you can offer.

Stephen A. Gonslaves
Wilmington, NC

continued

Every now and then I get a letter that reminds me just how weird the real world can get. A scanner to read 2.4-inch continuous paper with everything in 22-character codes? Zounds!

Although you call it a scanner, what you describe is really an OCR (optical character recognition) system in disguise. Mercifully, you've simplified some of the most vexing parts of the project by using only one typeface and two possible characters per position, so you don't have to solve the general problem.

I first thought that a linear charge-coupled device (CCD) array would make a nice line sensor, with scanning down the paper handled by a gear motor pulling the sheet through the reader. Unfortunately, that puts the mechanical design in the critical path: The motor has to be fairly precise, the optics need to be quite good, and the whole assembly reeks of precision machine shop work. Ugh.

Another way to handle it would be to use a TV camera with a macro lens and an ImageWise (see the May 1987 Circuit Cellar) digitizer to grab an image of the sheet. With a full line extending completely across the screen, there's enough resolution to get about 100 pixels on each character. That should be enough to handle the recognition part of the problem.

The reader might look something like this: a TV camera with macro lens and some lights, peering down at a flatbed section holding the paper. A motor and traction wheels draw the paper lengthwise across the flatbed. The ImageWise digitizer sends the TV picture of the PC over a serial link. The RTS and DTR lines can control the motor and lights, with CTS, DSR, and CD returning some status bits. All the OCR logic is in the PC, which keeps the cost of the scanner down by eliminating a lot of dedicated computing.

You don't mention the throughput you need, but I doubt that the speed will get better than a few tens of seconds per line. That may sound slow, but even simple OCR requires a lot of computations because there are many bits in each line.

I'm not sure there's enough room in your budget for development and manufacturing, even at $1500 per unit. At 25 units a year, you've got a buy of $37,500. Figuring a parts cost at $750 (even simple optics are expensive), you're allowing about $19,000 for nonrecurring engineering, design, and programming expenses—figuring no profit at all on each unit. Not good.

If you take a look at standard OCR scanners, I think you'll find they're much more expensive than $1500, even though they're in volume production. Even though you've simplified the problem, it still isn't trivial.—Steve ■

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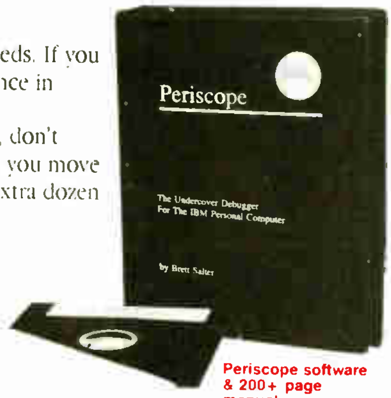

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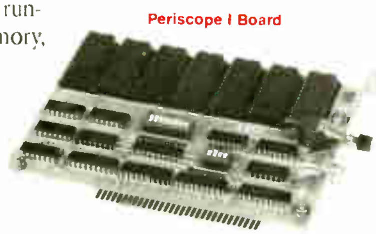
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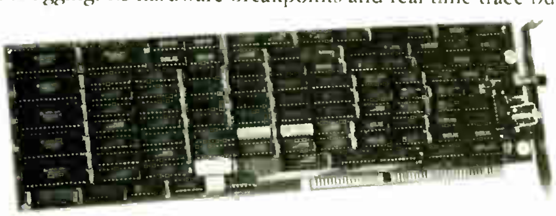
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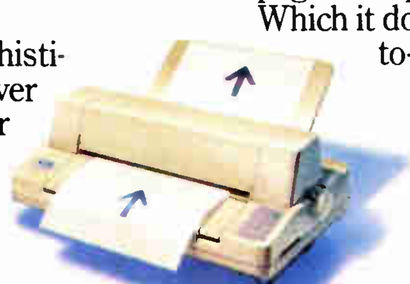

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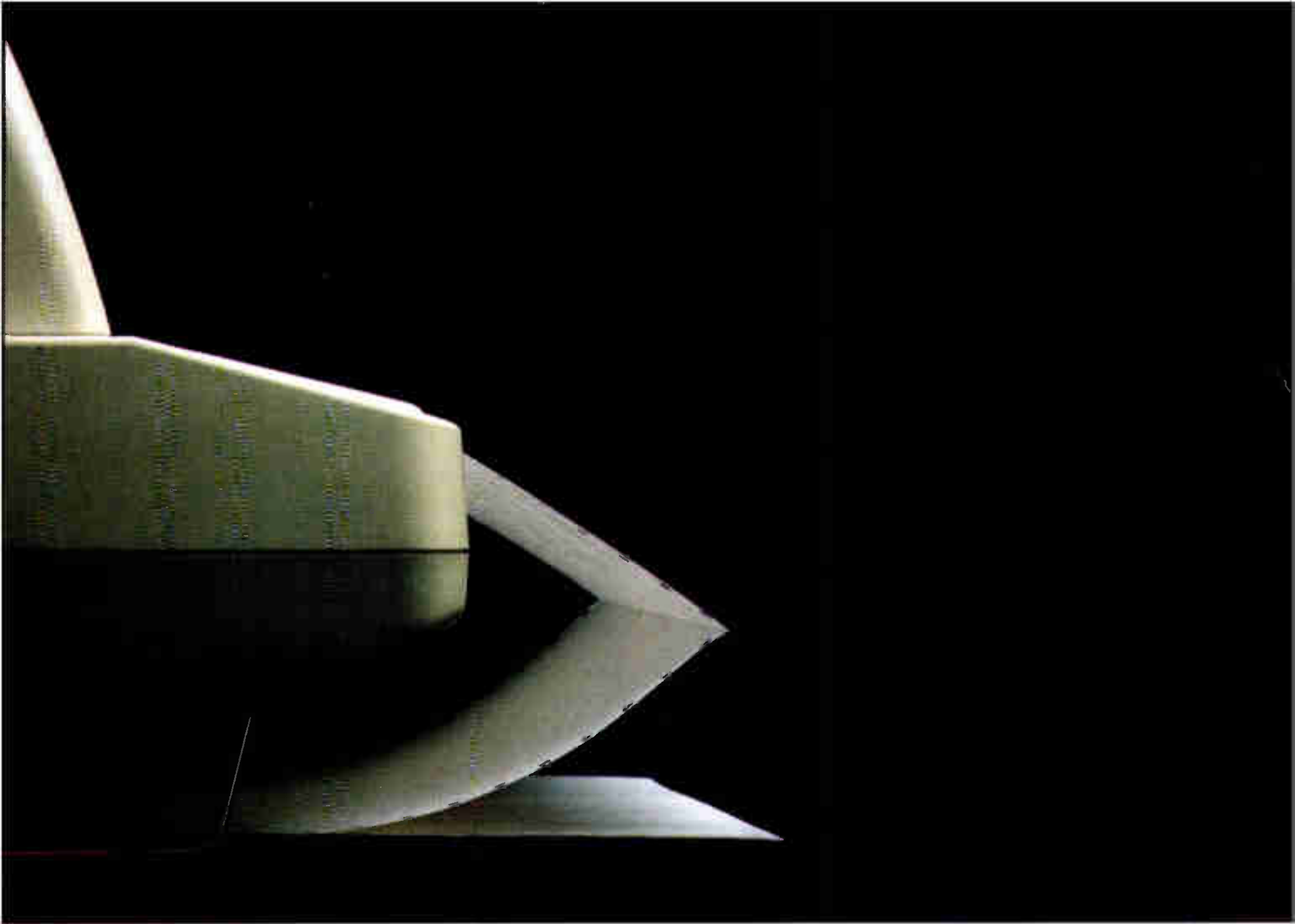

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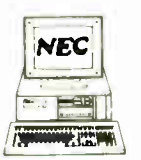

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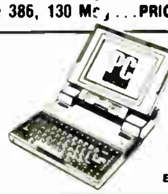

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BOOK REVIEWS

PostScript for Programmers

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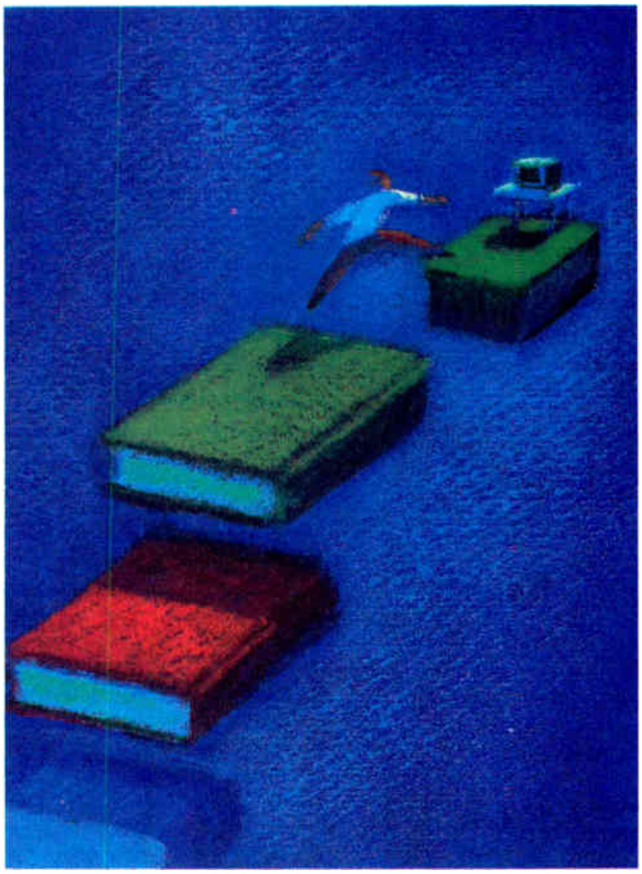

POSTSCRIPT LANGUAGE PROGRAM DESIGN
Glenn C. Reid

Adobe Systems Inc., Addison-Wesley Publishing Co., Reading, MA: 1988, 224 pages, $22.95

Many programmers find their first experience with PostScript as refreshing and exciting as a badly needed vacation from run-of-the-mill work. It is an elegant and powerful language for putting words and images on the page. Fortunately, it is also very well documented.

Until recently, the primary PostScript resources have been two books from Adobe Systems, published by Addison-Wesley—the *Language Tutorial and Cookbook*, or "the blue book," and the *Language Reference Manual*, or "the red book." Glenn C. Reid's *PostScript Language Program Design*, the newest offering from Adobe, will certainly become known to PostScript aficionados as "the green book," and it will almost certainly become an indispensable companion to its two predecessors.

The blue and red books were written by the designers of PostScript. They are sufficient if you want merely to learn about the language. The new green book was written by a PostScript programmer. It is essential if you want to bridge the gap between theory and practice—to actually *use* the language.

Read the blue book before you begin using PostScript. It provides a feel for how to work with the language, using short examples to illustrate individual features.

The red book provides the rationale for PostScript and a formal definition of the language. It is a well-written reference. Keep the red book at your side as you code; it's invaluable when you need to know the fine points about a particular keyword.

Absorb the green book. Make its style and programming structure your own. The green book will teach you to *think* in PostScript.

A basic premise of the green book is that you must understand how the PostScript interpreter works if you are to use it efficiently. Reid states that the difference in execution speed between a poorly written PostScript program and a well-written one can be as great as a factor of 10 or more. He therefore carefully explains what the PostScript interpreter does when it encounters different language constructs, and why.

The many examples Reid uses serve a dual purpose. First, they serve as dissection models; he subjects them to a statement-by-statement analysis, explaining how each piece of code integrates with the rest and, in cases where a variety of means might have been used to reach the same end, detailing why he deemed the particular method selected to be the best.

The examples also serve as paradigms for your own code. In fact, permission is explicitly given for readers to incorporate actual code from the book into their own applications. This license would be hollow if the code were trivial. It isn't. Most of the examples represent substantial programming efforts. Taken as a whole, they embody many hours of

continued

ALSO REVIEWED

Electric Language

Advanced C Programming for Displays

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programming that you won't have to do. See, for example, the four-page printer emulator listing. The groundwork has been carefully set, preliminary procedures have been written and analyzed, and a substantial and usable piece of code is wrought.

The green book opens with an overview of PostScript (it's interesting to compare Reid's overview with that of the authors of the red book). Chapter 2 provides a mild peek under the PostScript interpreter hood. This lays a groundwork for many of the rules that the author presents as the book progresses (more about those later). Chapter 3 describes the PostScript imaging model—the controls you'll be using as you "drive" PostScript.

The individual chapters that follow deal with different aspects of the language. I recommend that serious users of PostScript read the book from cover to cover, then return to chapters of special interest. The chapters are generally self-contained, with occasional references to code from previous chapters.

I particularly appreciate Reid's down-to-earth approach to programming. Too often, programming texts ignore some of life's less pleasant realities, like the fact that memory isn't an infinite resource, and that programmers spend far more time debugging code than writing it. Reid devotes chapter 13 to memory and file resource management, and it's clear here (as it is throughout the book) that he speaks with the voice of experience. The issue of resource shortage isn't delegated to chapter 13 exclusively; Reid deals with it as it arises in the context of other topics as well.

Chapters 14 ("Error Handling") and 15 ("Debugging Techniques") address the very important concept of what to do when things go wrong. Appendix A contains the listing of a PostScript error handler. Again, Reid doesn't shirk the issue of debugging PostScript code, because it comes up in other chapters.

I spoke earlier of rules laid down by the author. I'm generally uncomfortable with what has been called the "programming proverbs" approach to teaching. Short, arbitrary rules (like "never use goto") have so many exceptions that the rule, unqualified, is misleading or meaningless. But the approach can be effective if used with intelligence, as it is here.

For example, chapter 10 concludes with a brief set of guidelines for properly structuring documents. These fill up a page, not a single line, and are thus both easy to remember and qualified enough to be useful. Again, in section 12.3, the author provides an approach for dealing with printer error messages. These occupy half a page and provide a methodology, not a rote cookbook-style solution. The book does contain a series of italicized notes that contain unqualified rules, where appropriate. Case in point, section 5.2: *"Note: Never initialize or replace the existing state of the interpreter . . . "*

One would expect a book on PostScript to be attractively laid out, and the green book doesn't disappoint. The format is clear, with plenty of white space. Listings and examples are clearly set apart. The entire book is set in a new and very attractive Adobe type family called Stone.

This is an excellent book. I would have added a section on Display PostScript and the programming issues it raises and included more detail on using PostScript with color output devices, since these seem just around the corner. But I suspect that we'll see more from Adobe beyond the green book—and I'll be looking forward to those additions. ■

BRIEFLY NOTED

ELECTRIC LANGUAGE: A Philosophical Study of Word Processing by Michael Heim, *Yale University Press, New Haven, CT: 1987, 305 pages, $19.95.* Philosophy teacher and writer Heim argues that word processing changes "the way we think about anything and everything." Word processing encour-

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ages "on-screen thinking," and thinking—especially thinking in print—is bound with "existential commitment"; it "establishes and reflects our identity." Word processing removes anxiety about establishing that identity because a word-processed document is so easily revised. This also means word processing "reinstates some of the formlessness of conversation or soliloquy," especially compared with the strict linearity of typewriting. Further, "word processing reveals knowledge to be a flowing process, a process parallel to ideational flow" as opposed to knowledge modeled on dialogue (give and take) or on reading and writing printed pages (argumentation).

Michael Heim considers word processing a mixed blessing: "The thoughtful paging and browsing through tangentially related books, all done at a leisurely pace, will no longer be afforded by computerized writing and reading." (Heim doesn't consider hypertext systems, which promise to restore browsing in a big way.) And while he draws the consequences of the text being presented as a pageless scroll of characters by the current generation of word processors, the new generation presents a full-size image of paper on screen, restoring the sense of borders and divisions.

The arguments range over all of Western philosophy (and some Eastern as well), from the ancient Greeks to contemporary phenomenology. This is a difficult, thoughtful exposition of primary interest to the philosophical community. But everyone who has used a word processor will find much to think about in Heim's ideas. *—David Weinberger*

ADVANCED C PROGRAMMING FOR DISPLAYS by Marc J. Rochkind, *Prentice Hall, Englewood Cliffs, NJ: 1988, 331 pages, $40 (hardcover), $27 (paperback).* Despite its title, this is not a book on computer graphics; it is limited to alphanumeric displays. But that's not a fault. If you're at all involved in getting alphanumeric data out of the keyboard and onto the display (and what programmer isn't?) on a Unix- or MS-DOS-based computer, then Marc J. Rochkind's book definitely belongs on your library shelf.

Wisely selecting the C language as his vehicle, the author tackles terminal emulation (for the Z-19; he should have selected the more common VT-100), raw and buffered keyboard I/O, an elaborate window system, and virtual screen handling. Keep in mind that, throughout the book, the author presents plenty of source code for both Unix and MS-DOS systems (he even dips into assembly language code on the 8088 to speed critical functions). You'll find the early chapters particularly helpful in demystifying the Unix `termcap` database and `curses` screen management utilities.

The C source code presented is compatible with Microsoft and Lattice compilers on the MS-DOS side, and Unix System III, Xenix (based on Unix version 7), and 4.2 BSD and 4.3 BSD on the Unix side. The source code is available on floppy disk at extra cost. *—Richard Grehan*

PROLOG PROGRAMMING IN DEPTH by Michael A. Covington, Donald Nute, and Andre Vellino, *New York: Scott, Foresman and Co., 1988, 506 pages, $24.95.* Aimed at readers somewhat familiar with computer programming (but not necessarily artificial intelligence (AI) techniques or languages), this book starts with the basics and delivers on its title, covering Prolog in depth. Intermediate and advanced Prolog users will also find the book's comprehensive coverage of algorithms and techniques a useful reference.

The book has been classroom-tested, and the polish shows: The text is uniformly good. Discussions on expressing procedural algorithms in Prolog and on Prolog as its own metalanguage are outstanding. A chapter titled "Additional Tech-

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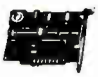

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niques" contains genuine nuggets about trees, sorting, and object-oriented programming.

The second half of the book (on AI applications) is mostly expert-system-oriented; other chapters are devoted to discussions of natural language processing and Prolog's logical basis. Noteworthy among the expert-system topics are representation of uncertainty and extension of the Prolog inference engine.

The programming examples are written in Edinburgh Prolog, and they're practical, plentiful (80K bytes overall of source code), and available by mail or network. Turbo Prolog users will benefit from reading this book, too, even though not all the code can be translated into the Turbo dialect.

Appendixes describe the features of Arity and Turbo Prolog and how to use the Prolog debugger. *—Alex Lane*

COMPUTER VISION: A FIRST COURSE by R.D. Boyle and R.C. Thomas, *Blackwell Scientific Publications, Oxford, England: 1988, 210 pages, $29.25.* This textbook is aimed at advanced undergraduate computer science students, though anyone who doesn't mind a lot of math in the text could profit from it. The material is not strictly state-of-the-art or detailed, but it provides a solid background in established theory.

The authors distinguish three levels of vision tasks—low, medium, and high—and examine each in turn. Particularly good chapters cover low-level processing and segmentation. The material on knowledge representation concentrates heavily on semantic nets and frames, while the material on rule-based systems considers only production systems. R. D. Boyle and R. C. Thomas touch on neural networks briefly, more as an example of what can be done without using the ideas in the rest of the book.

The appendixes augment sections of the text instead of merely bulking up the book. They consist of C source code for histogram equalization and hierarchical edge detection, a brief introduction to Fourier theory, a table of three-dimensional interpretations of two-dimensional junctions, and a discussion of Goad's algorithm. The remaining end material includes an appendix of solutions to chapter exercises, a list of references, a separate bibliography, and separate author and subject indexes.

As a brief, technical introduction to computer vision, this tome deserves a place on your shelf. *—Alex Lane*

ILLUSTRATING PASCAL by Donald Alcock, *Cambridge University Press, Cambridge, England: 1987, 184 pages, $12.95.* Like its forerunner, *Illustrating BASIC*, this introductory programming text combines a visual emphasis and a totally hand-lettered format. The method can be very fast once you've adjusted. For instance, why use many words warning the reader *never* to write `constant` for `const`, when you can just display the word `constant` surrounded by little black bugs?

I'm not sure that the "Utter Beginner" Alcock presupposes will find the early pages transparent. Though each statement is clear, the tax on memory is great. Also, his examples often employ terms (e.g., `trunc`) that he hasn't yet gotten around to defining formally.

But as things get more complex, and the diagrams that generally go with exposition *become* the exposition, the method pays off. By about midjourney, even experienced Pascalers may want to jump aboard. If there's a clearer exposition of QuickSort than Alcock manages on one page, I don't know it. As for pointers, stacks, queues, rings, binary trees, and even hashing: Alcock's drawings and pithy comments are of unparalleled clarity, and his sample programs are fun. He claims to be covering the whole of the language as defined by ISO 7185. Though I haven't checked that claim in detail, I'm inclined to believe it. I recommend the book. *—Hugh Kenner*

continued

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HOW TO THINK ABOUT STATISTICS by John L. Phillips Jr., *W.H. Freeman and Co., New York: 1988, 198 pages, $17.95 (hardcover), $9.95 (paperback).* Tools for doing statistical calculation are becoming commonplace in personal computer software—from spreadsheets to high-level languages to specialized math programs. Dedicated statistical packages are bringing the most sophisticated tools to personal computer users. With all that power, however, comes the potential for a great deal of confusion and misinformation: Statistical measures are easily misused.

This book's admirable goal is not to teach you how to *do* statistics, but to teach you how to *understand* the statistics that others (or personal computers) do.

The front cover of the book claims that it "will help you understand statistical concepts vital to your education, your business, or your profession; evaluate the news, polls, and trends that affect you as a consumer and citizen; and make better sense of the social statistics, advertising claims, economic forecasts, and political issues you encounter every day." *How to Think About Statistics* might actually deliver on 80 percent of that claim—if you're willing to work at it.

This well-written book is really an introductory undergraduate text focusing on applications of statistics to education, political science, psychology, social work, and sociology. The textbookish outlook shows from the first sentence in the introduction, "You may be planning to study statistics not because you want to but because you have to." The author overcomes the reluctance of a coerced undergraduate audience through the use of sample applications that follow each chapter.

The sample applications take the place of exercises found in most textbooks. They present a seemingly real-world problem (e.g., measuring the incidence of coups in Latin America) and then ask the reader, "How would you approach this problem?" The author warns that to get the most out of this book, it will probably be necessary to engage in a lot of page flipping. He even suggests that the reader keep two bookmarks handy for just that purpose. He's right. The author's solutions list the appropriate statistical approach and are followed by possible ways the resulting statistic could be misinterpreted. Unfortunately, the solutions buried in the back of the book contain some of the best parts of this book.

Phillips makes no assumptions on the mathematical capabilities of his audience, placing essential calculations inside boxes where they can be studied by those who have the background or interest, otherwise ignored or simply glanced at. The book leads the reader from understanding the purpose of a simple mean to contrasting means using analysis of variance, pausing along the way to explain standardization, correlation, causation, and contingency tables. Throughout, the emphasis is on understanding the purpose and shortcomings of the individual statistics rather than on the nitty-gritty of calculation.

People who have wondered what statistics are about (or who plan on using statistical software) will find this book a useful beginning. —*William Gould*

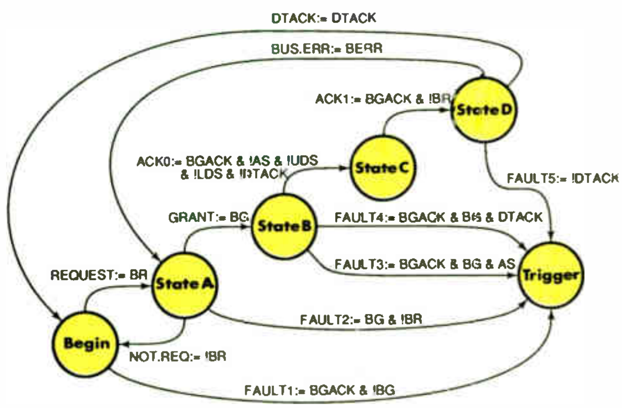
CONTRIBUTORS

LEAD REVIEW: ***Eliakim Willner*** *is vice president for research and development at Pecan Software Systems Inc. and coauthor of* Advanced UCSD Pascal Programming Techniques (Prentice Hall, 1985). BRIEFLY NOTED: ***David Weinberger*** *(Brookline, MA) is a writer for Interleaf.* ***Richard Grehan*** *is a senior technical editor at large for BYTE.* ***Alex Lane*** *is a knowledge engineer for Technology Applications Inc. in Jacksonville, Florida. Critic and author* ***Hugh Kenner*** *lives in Baltimore.* ***William Gould*** *is president of the Computing Resource Center (Los Angeles, CA) and a manufacturer of statistical software.*

OUR MOVE

	Pc/La	HP1651A *	Phillips 3633 *	Tektronix 1220 *
Total Channels	32	32	32	32
Max Timing Rate	100 Mhz	100 Mhz	100 Mhz	100 Mhz
# Channels @ Max Rate	16	16	8	8
Max State change Rate	25 Mhz	16.6 Mhz	12.5 Mhz	10.0 Mhz
Max State Clock	50	25	25	25
Data Storage (per chan)	4K	1K	1K	2K
Storage Method	Linear	Transitional	Linear	Linear
Trig Method	Multi-Way Branch & Loop	Linear Sequential	Linear Sequential	Linear Sequential
Number of Match Regs	28	8	8	8

* Based on published specifications



Trigger program to detect 1 of 5 possible faults in the DMA cycle of a MC68000. This example uses only a fraction of the capabilities of the Pc/La.

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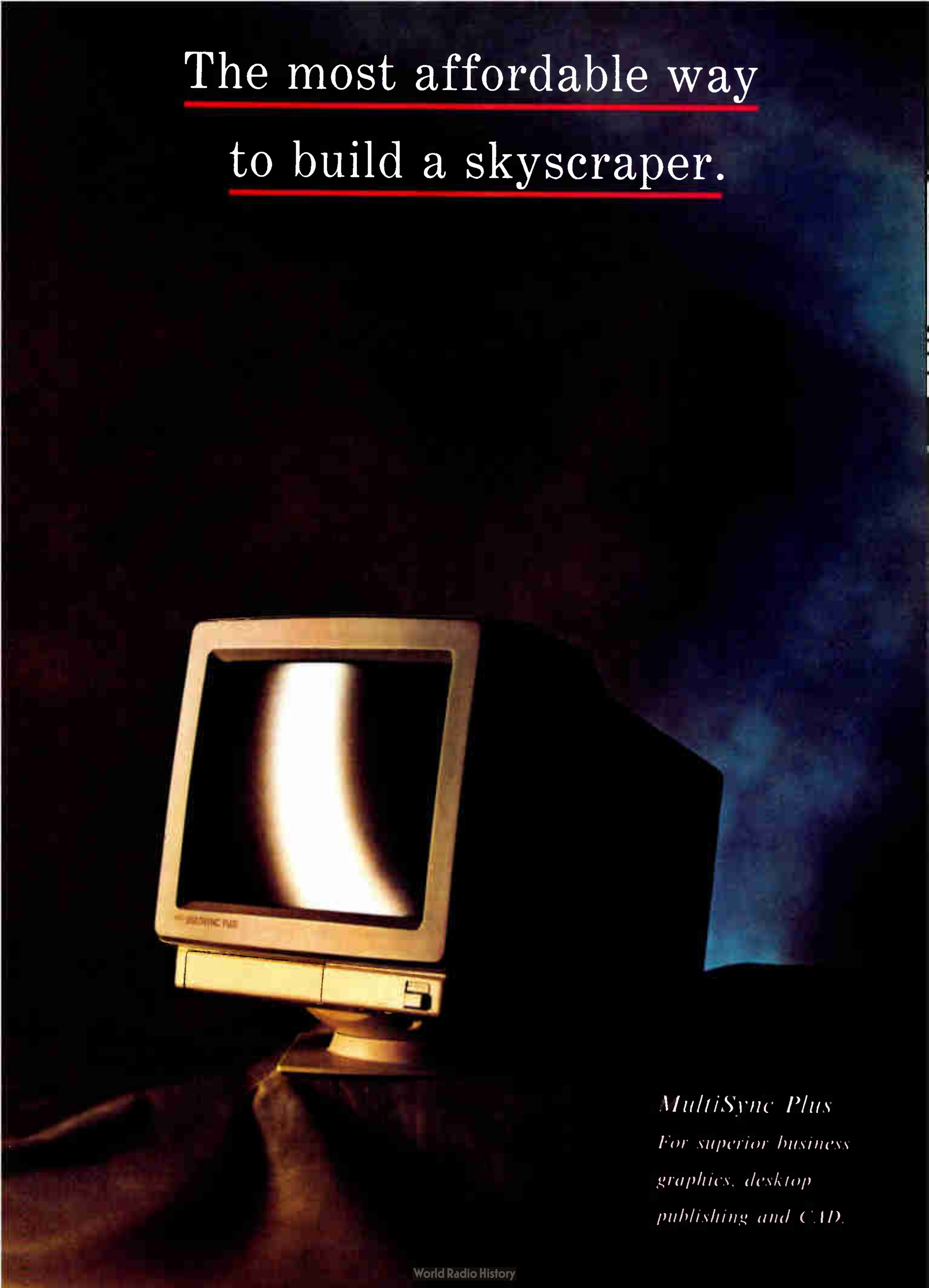
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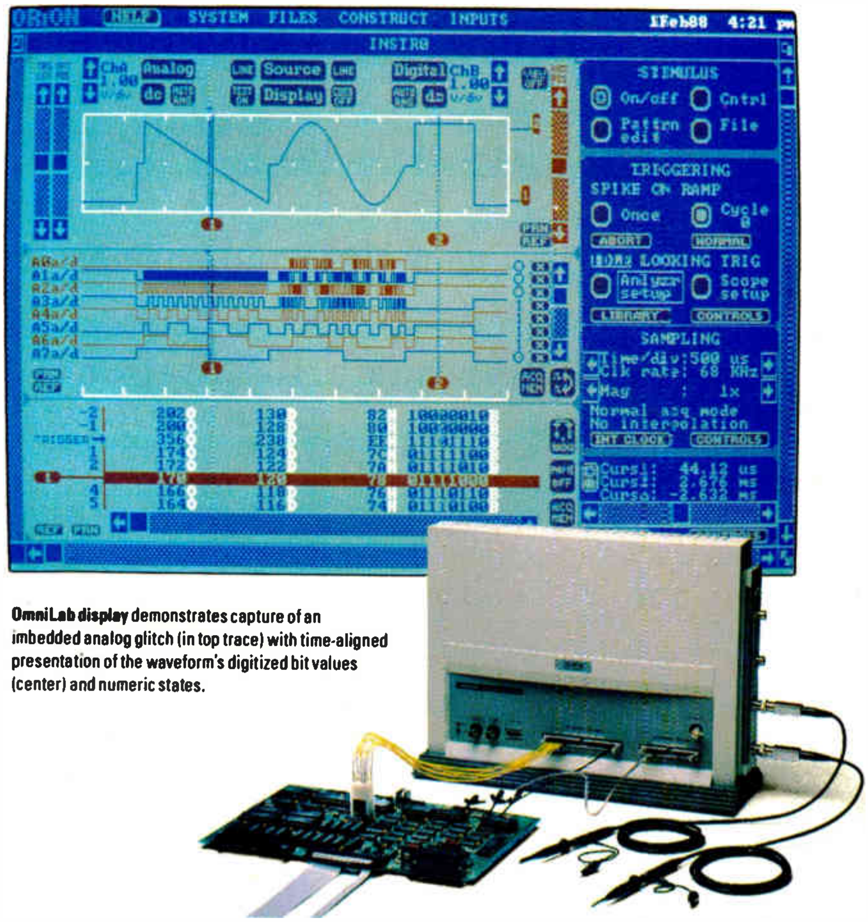

OmniLab display demonstrates capture of an imbedded analog glitch (in top trace) with time-aligned presentation of the waveform's digitized bit values (center) and numeric states.

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Clocking:	34 S/s to 34 MS/s
Functions:	Record, edit and playback

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Products in Perspective

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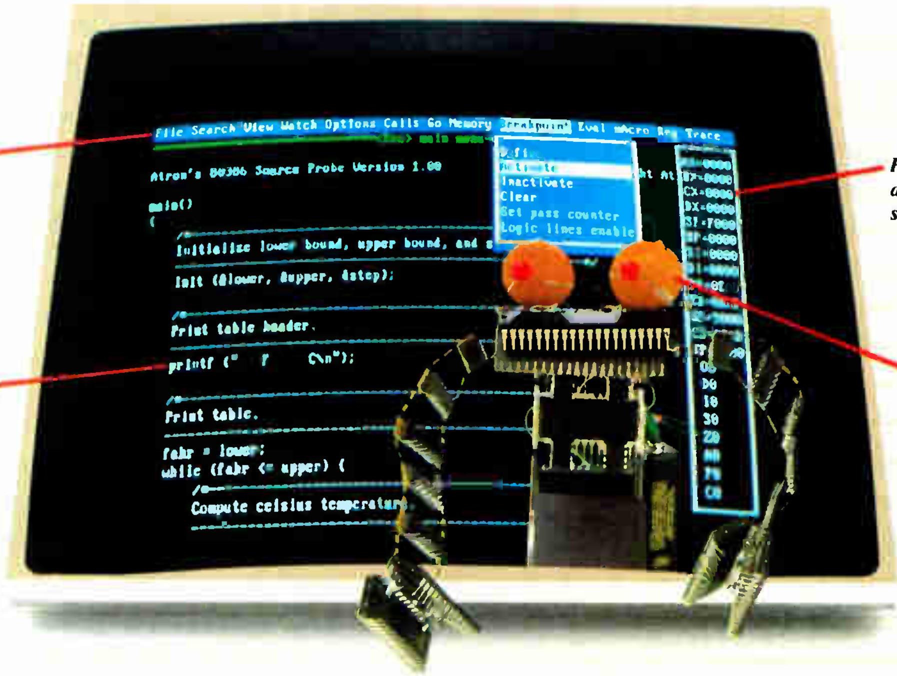
PROBE has source-level debugging to let you "C" your program.



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This is an out-of-range memory-overwrite bug. Since it is interrupt related, it only appears in real time.

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!

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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.

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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.

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SYSTEMS

Stacked Planes for the Little Board

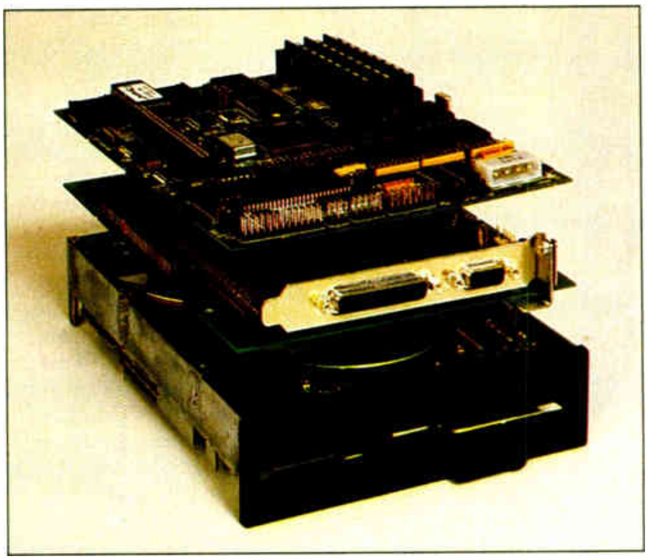
Thanks to a new expansion adapter, you can now use standard IBM PC-style expansion cards with Ampro's Little Board/PC single-board computer. The StackPlane/PC adapter lets you install plug-in cards in parallel to the computer board. Ampro says this means no more card cages and backplanes in embedded applications where space is tight.

The Little Board itself, measuring 5½ by 8 inches, is a PC-compatible CMOS module with an 8-MHz 8088-compatible processor. It can be configured with 256K bytes to 768K bytes of dynamic RAM, 32K to 288K bytes of EPROM, a floppy disk controller, a keyboard interface, a speaker interface, two serial ports, a parallel port, a PC expansion bus, and a SCSI bus. It needs about 4 watts of power from a 5-volt DC power supply, and it comes in eight versions.

Price: Little Board/PC, starting at $393; StackPlane/PC, $43.

Contact: Ampro Computers Inc., 1130 Mountain View-Alviso Rd., Sunnyvale, CA 94089, (408) 734-2800.

Inquiry 751.



The Ampro Little Board/PC uses standard expansion cards.

A Rugged 386

Do you need powerful computing capabilities under adverse conditions? KMS Advanced Products says you can take its new ruggedized computer "to the field or behind the lines"; in other words, just about anywhere.

The RMC-3000 is an 80386-based system in a case that looks like a Kaypro transportable except for the heavy metal housing and rows of rivets; there's also a rack-mount model available for your tank or air transport vehicle.

The system is fully compatible with the PC XT and PC AT, KMS says. The company will assemble just about any configuration you can come up with. The basic machine has 10 slots (one 16-bit and the rest 32-bit) and one serial and one parallel port, and it weighs about 45 pounds. You can mix storage options; KMS offers both 5¼-inch and 3½-inch floppy disk drives, hard disk drives, and tape drives.

Price: Starting at $13,900.

Contact: KMS Advanced Products Inc., 3850 Research Park Dr., P.O. Box 1868, Ann Arbor, MI 48106, (800) 521-1524; in Michigan, (313) 769-1780.

Inquiry 752.

A Powerful Crayon for Graphics Applications

This Crayon isn't for kids, and it's probably not for people who just want to put a little more speed into their day-to-day applications. This species of Crayon is an 80386-based rack-mounted system for folks who work in advanced graphics, CAD/CAM, animation, video, and other areas that require sophisticated imaging capabilities.

Inside the box is a motherboard holding an 80386 processor (20 MHz, no wait states), 1 megabyte of memory (expandable to 16 megabytes using single in-line memory modules), and a socket for an 80387 or Weitek 1167 math coprocessor. The Crayon 386 SP motherboard also supports "shadow RAM," which lets the Award BIOS run in high-speed RAM for increased performance. You can set the bus speed to 8 or 12 MHz, and there are two serial, one parallel, one SCSI, and one game port.

For storage, the basic system comes with one 1.2-megabyte 5¼-inch and one 720K-byte 3½-inch floppy disk drive, but the case has room for a total of six half-height drives. The proprietary multidrive controller can handle two floppy disk drives, two hard disk drives, and seven SCSI devices. For hooking up the sorts of equipment that graphics types will need (e.g., digitizers, pointing devices, and high-resolution cards), the system has six 16-bit and two 8-bit expansion slots. The Crayon has three fans to keep things cool.

Its maker says the Crayon 386 SP is fully compatible with the IBM PC AT and will run MS-DOS (3.3 comes with the basic box), OS/2, or Unix and supports EMS 4.0. For looking good in those contemporary art and video houses, the system is housed in a black case.

Price: $7495 for the basic system.

Contact: Video Graphic Systems, 4163 St. Clair Ave., Studio City, CA 91604, (818) 509-5738.

Inquiry 753.

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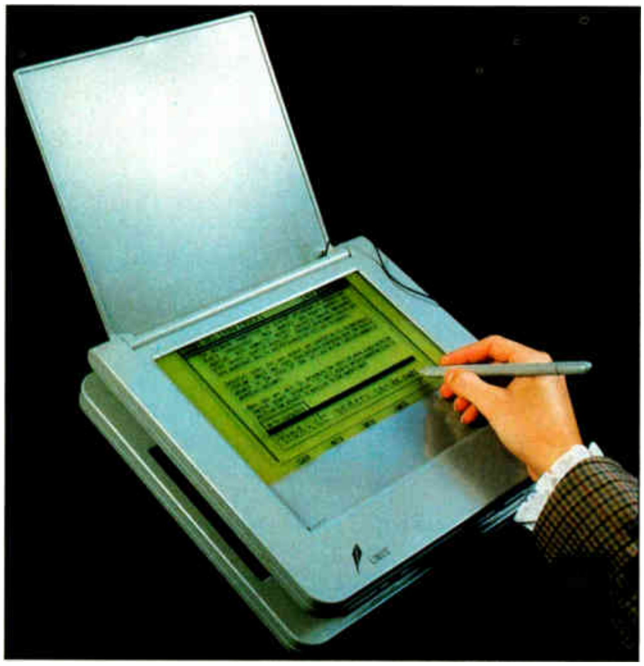
PERIPHERALS



The Write-Top is a computer without a keyboard.

Look Ma, No Keyboard

Now there's an IBM PC-compatible laptop system that neither needs nor comes with a keyboard. Of course, a keyboard is available as an option, but you can simply input data into the system using your own handwriting.

The Linus Write-Top, from Linus Technologies, combines a laptop computer with a transparent digitizer tablet and a handwriting-recognition algorithm. The tablet is situated right above the computer's flat panel display. The computer uses an 8- by 5-inch backlit supertwist LCD display with a resolution of 640 by 200 pixels. When you draw on the tablet, the display underneath responds as if you were actually drawing on paper. The company also claims that the computer can be taught to recognize any handwritten character and convert it to a standard character entered via a keyboard.

The Linus Write-Top features 640K bytes of CMOS static memory, an 8088-compatible processor, an internal modem, and a 3½-inch floppy disk drive. The computer weighs 9 pounds and is the size of your typical small laptop. The display/digitizer, which can be detached from the rest of the system, is about 11 by 11 inches and less than an inch thick. Options include a keyboard and a software package called Code-Write that allows developers to adapt existing applications to receive handwritten input. Another package, Just-Write, is a word processor designed for handwritten input.

Price: $2995.

Contact: Linus Technologies Inc., 1889 Preston White Dr., Reston, VA 22091, (703) 476-1500.

Inquiry 754.

Output to Your Heart's Delight

Do you need *lots* of printouts every day? Are you sick of waiting for your printer to tap, tap, tap along at its snail-like pace? If 600 lines per minute (lpm) of draft-quality text is fast enough, you might consider Output Technology's OTC 2161. This dot-matrix printer gets its speed by using a three-headed print mechanism that prints two lines of text with each pass. And if you need higher-quality output, it prints 325 lpm in correspondence mode and 90 lpm in near-letter-quality mode.

The 2161 features a control panel with 16 switches and an expandable 8K-byte buffer. A parallel interface is standard, but you can also get RS-232C, RS-422, twinaxial, coaxial, or PrintNet interfaces. The printer emulates the Dataproducts LB600, Printronix P6080, and Epson FX-286e.

In addition to standard ASCII, the OTC 2161 comes with 12 international character sets, IBM Character Sets #1 and #2, and the IBM Code Page #437 and #850 sets. Options include extra font cartridges, additional emulations, additional character sets, a paper stacker, and a quietized pedestal. The 2161 weighs 80 pounds and includes free installation in addition to 6-month on-site service.

Price: $6450.

Contact: Output Technology Corp., East 9922 Montgomery, Suite 6, Spokane, WA 99206, (800) 468-8788; in Washington, (509) 926-3855.

Inquiry 755.

A Security Guard for Your Modem

Gateway II prevents unauthorized folks from stealthily sucking data from your computer. Installed between a serial port and your modem, the stand-alone Gateway II prompts a caller to enter a name and password before permitting system access. If the correct information isn't entered within a user-designated period, Gateway II rudely hangs up.

Every call is logged in Gateway II's memory. You can even pick up that report from a distant system by using a modem.

Two models are available. Gateway II can store up to 100 passwords and telephone numbers (250 optional). For extra peace of mind, Gateway II DB (dial back) provides the additional security of logging the user into the Gateway II system and then calling back to a predetermined telephone number. It requires an external Hayes-compatible auto-dial modem.

Both Gateway II devices operate at from 300 to 19,200 bits per second (bps).

Price: $395 for Gateway II; $495 for Gateway II DB.

Contact: Adalogic Inc., 7844 McClellan Rd., Cupertino, CA 95014, (408) 257-1352.

Inquiry 756.

continued

OTC's latest model prints 600 lines per minute.

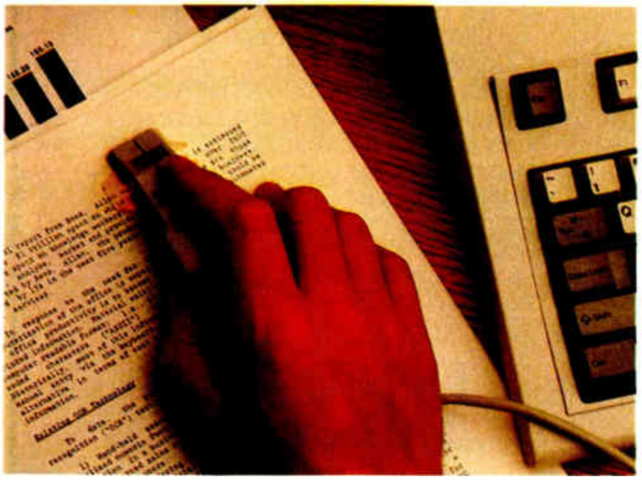
PERIPHERALS

A Clean Sweep for Data

It may not have the power of your fairy godmother's magic wand, but DataSweep 1 is a hand-held character reader that lets you enter typed or printed information into your IBM PC by sweeping the reader across text.

According to Soricon Corp., the reader can scan 120 words per minute, with an accuracy of 99.3 percent. It can read from 8- to 14-point type and scan up to 8 inches of characters in one stroke. The two-button wand lets you activate reading with the front button and program the rear button to keyboard functions such as Return, Tab, and Indent. A multi-font feature automatically recognizes most popular font styles, including proportionally spaced text and some typeset text. You can use the reader with most word-processing, spreadsheet, database, and desktop publishing programs.

DataSweep 1 comes with the hand-held character reader, an interface board, and software. It requires an IBM PC, XT, AT, or compatible running under DOS 2.1 or higher with at least 256K bytes of RAM and a full-size expansion slot. To get the most from DataSweep, you should also have a hard disk drive.
Price: $1250.
Contact: Soricon Corp., 4725 Walnut St., Boulder, CO 80301, (800) 541-7226; in Colorado, (303) 440-2800.
Inquiry 757.



Data Sweep 1 scans up to 120 words per minute.

See It All on Your Mac SE

If your eyes are complaining about the Mac SE's paltry 9-inch display, help is on the way in the guise of the V-Screen monitor from New Image Technology. Based on Princeton Graphic Systems' LM-300 high-resolution monitor, the V-Screen lets you view a whole page of text and graphics on its 15-inch screen. An 8½- by 11-inch page appears "life-size" with a resolution of 72 dots per inch and a 1-to-1 aspect ratio.

The V-Screen uses paper-white (P-138) phosphors and has a hardware mechanism that lets the 600-pixel screen pan left to right across a full 1024-pixel virtual screen.

The monitor comes on a tilt-and-swivel base and includes a controller card, software, and all connecting cables.
Price: $1150.
Contact: New Image Technology Inc., 9701 Philadelphia Court, Lanham, MD 20706, (301) 731-2000.
Inquiry 759.

...And Also on Your PS/2

If you're using your PS/2 for those same desktop publishing and CAD applications as the Mac above, you too can get eyestrain relief with the king-size Ventek PS 2000, an ultra-high-resolution monochrome text and graphics display for PS/2s equipped with the Micro Channel.

The PS 2000 has a truly Promethean 20-inch diagonal screen. It is VGA-compatible and has a maximum resolution of 1280 by 1024 pixels. It comes with an IBM PS/2 Micro Channel card and all the necessary cables. On the software side, the PS 2000 includes drivers for most popular desktop publishing and CAD packages.
Price: $2495.
Contact: Ventek Corp., 31336 Via Colinas, Suite 102, Westlake Village, CA 91362, (818) 991-3868.
Inquiry 760.

GIVE YOUR LAPTOP A 5¼-INCH COMPANION

Laptop computers and their 3½-inch high-capacity floppy disks are great. But for better or worse, most of the world still runs on old-standard 5¼-inch floppy disks. There's no need to fear The Great Incompatibility: You can transfer and share data between disk sizes using the W525 Subsystem, an external 5¼-inch 360K-byte floppy disk drive that plugs right into your Toshiba, Tandy, Zenith, Sharp, Datavue, or NEC laptop computer.

The W525 Subsystem attaches to the external floppy disk drive port and comes with a power supply and cable for your specific model of laptop computer. It measures 2½ by 10 by 6½ inches.
Price: $249.
Contact: Weltec Digital Inc., 17981 Sky Park Circle, Suite M, Irvine, CA 92714, (800) 333-5155; in California, (714) 250-1959.
Inquiry 758.

123-Key Keyboard Remembers Macros

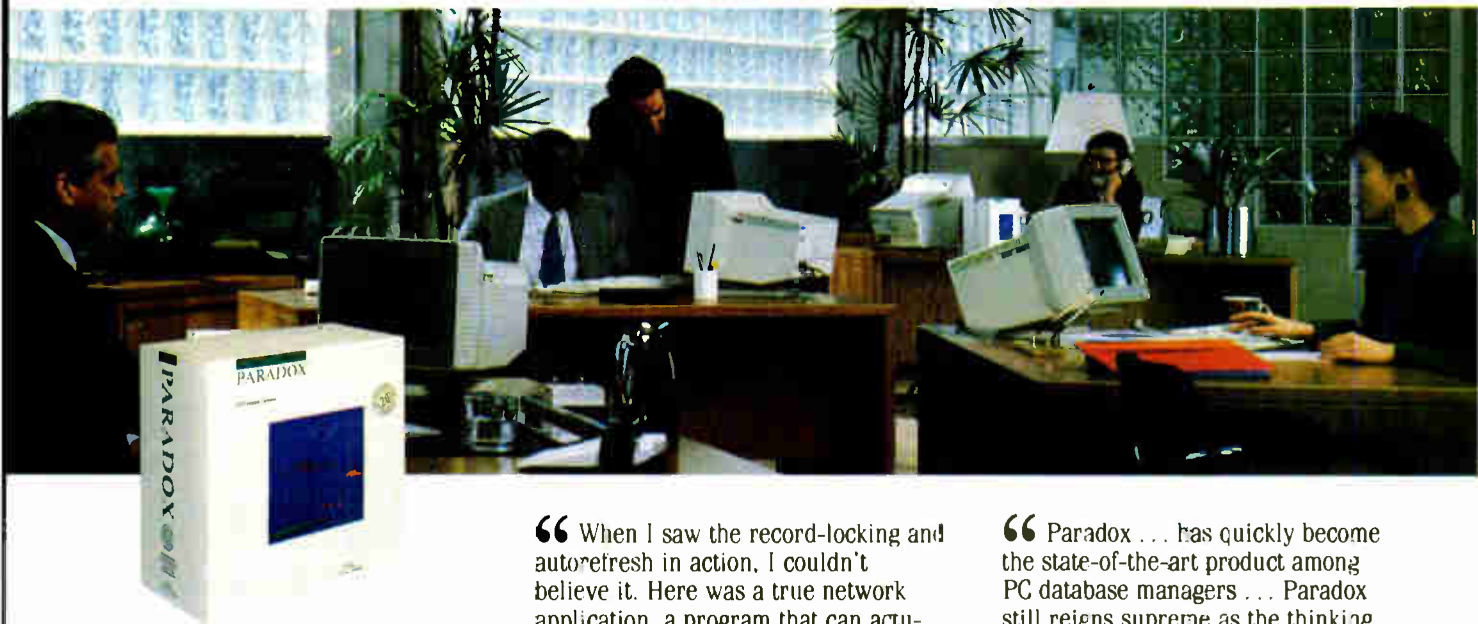
EECO, the company that manufactures the popular DataDesk keyboard, is coming out with a new keyboard that offers more features. The Maxi-Switch Memory Pro for the IBM PC and AT includes a whopping 123 keys and can remember its own macros.

The keyboard includes nonvolatile EEPROM (electrically erasable programmable ROM) to allow it to record keyboard macros. According to the company, you can reprogram any of the keys from the keyboard or by running a utility program on the system. Having the macros stored inside the keyboard avoids compatibility problems that can be caused by garden-variety RAM-resident keyboard macro programs.

The Memory Pro includes many more keys than the familiar 84-key or 101-key keyboards of the IBM PC and AT. For example, two sets of function keys are provided: the traditional 10 keys to the left of the typewriter keypad, and a horizontal row of function keys above the typewriter keypad. These latter keys have removable transparent tops to accommodate legends describing their function. The keyboard also has separate numeric and cursor keypads.
Price: About $150.
Contact: EECO Inc., 1601 East Chestnut Ave., P.O. Box 659, Santa Ana, CA 92702, (714) 835-6000.
Inquiry 761.

continued

Why Paradox 2.0 makes your network run like clockwork



Paradox® runs smoothly, intelligently and so transparently that multiple users can access the same data at the same time—without being aware of each other or getting in each other's way.

With Paradox news travels fast and it's always accurate

Paradox *automatically* updates itself with a screen-refresh that ensures that all the data is up to date and accurate all the time. Record-locking, Paradox-style, safeguards data integrity by preventing for example, two different users from making changes to the same record at the same time.

How to make your multiuser network work

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 1.45 or higher
- AT&T Starlan version 1.1 or higher
- Banyan VINES version 2.10
- Other network configurations that are 100% compatible with DOS 3.1 and one of the listed networks

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

*Customer satisfaction is our main concern, if within 60 days of purchase this product does not perform in accordance with our claims, call our customer service department, and we will arrange a refund.

Circle 44 on Reader Service Card (Dealers: #5)

"When I saw the record-locking and autorefresh in action, I couldn't believe it. Here was a true network application, a program that can actually take advantage of a network to provide more features and functions, things that can't be done with a stand-alone PC.

Aaron Brenner, LAN Magazine

With Version 2.0, Paradox becomes a sophisticated multiuser product that boasts an impressive selection of data-production features and password-security levels.

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.

Queries are flexible and interactive. And in Paradox, unlike in other databases, it's just as simple to query more than one table as it is to query one.

"The program elegantly handles all the chores of a multiuser database system with little or no effort by network users.

Mark Cook and Steve King, Data Based Advisor"

"Paradox . . . has quickly become the state-of-the-art product among PC database managers . . . Paradox still reigns supreme as the thinking user's DBMS.

Jim Seymour, PC Magazine"

You don't have to be a genius to use Paradox

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.

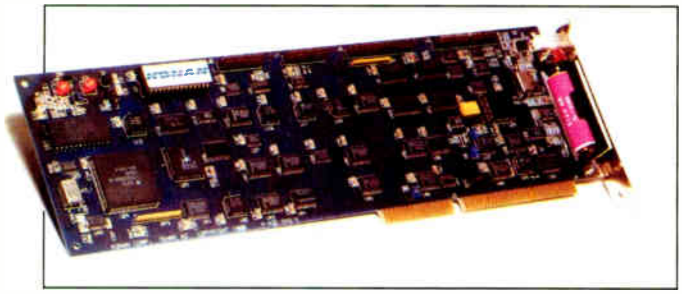
Because Paradox is driven by the very latest in artificial intelligence technology, it does almost everything for you—except take itself out of the box. (If you've ever used 1-2-3® or dBASE,® you already know how to use Paradox. It has Lotus-like menus, and Paradox documentation includes "A Quick Guide to Paradox for Lotus Users" and "A Quick Guide to Paradox for dBASE users.") Paradox, it makes your network work.

60-Day Money-back Guarantee*

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

BORLAND
INTERNATIONAL

ADD-INS



Konan's Ten Time transfers data at 4 megabytes per second.

Konan the Controller

It's a claim and a name: Konan's Ten Time disk controller accesses data 10 times faster than most controllers, the company reports. Using an on-board RAM cache, the controller features a caching algorithm that results in a transfer rate of 4 megabytes per second for most data requests.

Both disk reads and writes are cached. When you write to the disk, it goes to the cache and is then written to the disk in the background. A 4-year battery protects your data if your computer goes down. If you request data that isn't waiting in the cache, a zero-latency read capability hastens disk access by reading and transferring data immediately, regardless of which sector the head lands on.

Ten Time features a 1-to-1 interleave and can control up to two hard disk drives and two floppy disk drives. It's compatible with DOS, Unix, Xenix, and Novell and 3Com networks, and requires an IBM PC AT or compatible.
Price: $595 for the hard disk controller; $695 for the hard and floppy disk controller.
Contact: Konan Corp., 4720 South Ash Ave., Tempe, AZ 85282, (602) 345-1300.
Inquiry 785.

Capture that Image!

FreezFrame lets you mix standard video and computer graphics. It's a full-slot board that provides a window into your VCR, video camera, laser disk player, or other standard NTSC video source. The board lets you capture images in real time, with up to 32,768 colors, and then superimpose text and graphics on top of the image.

FreezFrame has five display modes: EGA-Passthrough displays EGA images on the monitor; Real-Time lets you view video input directly on your screen; Freeze lets you display a still image captured during Real-Time mode; and EGA/CGA Low-Resolution Overlay lets you overlay text or graphics on a full-screen captured image.

FreezFrame gives you a maximum image resolution of 512 by 256 pixels. It captures images in 1/60 second and comes with 256K bytes of video RAM. The system runs on the IBM PC, XT, AT, and compatibles running DOS 3.0 or higher and requires a multifrequency analog monitor, and an EGA or CGA card for overlay capabilities.
Price: $1749.
Contact: VuTek Systems Inc., 10855 Sorrento Valley Rd., San Diego, CA 92121, (619) 587-2800.
Inquiry 786.

Hard Power for Your PS/2 Model 25 or 30

If you've been putting off adding a hard disk drive to your IBM PS/2 Model 25 or 30 for lack of a controller, your wait is over. Data Technology's 5150CR2 and 5160CR2 each occupy a half slot and support both hard cards and 5¼- and 3½-inch hard disk drives.

The 5150CR2 uses modified frequency modulation (MFM) and supports drives with up to 16 heads and 1024 cylinders. The 5160CR2 uses run-length-limited (RLL) technology to increase storage capacity by 50 percent and reduce the data transfer rate. It supports drives with up to 16 heads and 2048 cylinders.

Software is included that assists you in installing the controllers. You can choose from among the drives of 15 manufacturers and add other drive models to the menu. You can also split your drive into partitions and enter media defect tables.
Price: 5150CR2, about $80; 5160CR2, about $95.
Contact: Data Technology Corp., 2551 Walsh Ave., Santa Clara, CA 95051, (408) 727-8899.
Inquiry 787.

NuVista Delivers Ultimate Mac II Video

Truevision's NuVista is a 32-bit video-capture and display board that occupies one NuBus slot in your Mac II.

The board is based on Texas Instruments' powerful 34010 graphics processor and features a custom video cross-point chip. It supplies up to 16.7 million colors and provides a resolution of 1024 by 1024 pixels in 32-bit mode, though the resolution can be as high as 2048 by 2048 pixels in 8-bit mode. You can also capture a video signal in real time, and generate an analog video output signal. The board functions as the Mac II's standard graphics controller.

NuVista comes with either 2 or 4 megabytes of dual-ported CMOS video RAM. It also includes input and output lookup tables, four channels of A/D and D/A conversion, and a programmable pixel clock.
Price: $4250 with 2 megabytes of RAM; $5995 with 4 megabytes.
Contact: Truevision Inc., 7351 Shadeland Station, Suite 100, Indianapolis, IN 46256, (800) 858-8783; in Indiana, (317) 841-0332.
Inquiry 788.

continued

SKY SCANNER IN A SLOT

After you've scanned through the 200 channels received by your backyard satellite dish, then what? Norsat's Micro-Sat is a satellite dish receiver that plugs into a full slot in an IBM PC or compatible. It lets you receive audio, video, and data signals at up to 9600 bps. Jacks on the board's rear-edge connector output the audio, video, and base band. You can send data directly to your RS-232C serial port and view video input directly on your computer monitor.

You tune Micro-Sat using EPROM, binary-coded decimal switches, or through the data bus. It captures signals at a frequency between 950 and 1450 MHz. You can reset frequencies while running `AUTOEXEC.BAT`, and you can also select video invert and audio bandwidths via DIP switches or directly from your computer. The board is compatible with the VC II, B-Mac, and Oak descrambling systems and the C and Ku satellite bands.
Price: $1000.
Contact: Norsat International Inc., 302-12886 78th Ave., Surrey, BC, Canada V3W 8E7, (604) 597-6200.
Inquiry 789.

The LOGITECH HiREZ Mouse—the only mouse expressly designed for high-resolution screens.

With a resolution of 320 dots-per-inch (as compared with 200 dpi or less for ordinary mice), it covers the same area on your high-res screen, but needs less of your desk to do it. More than 50% less. Saving you valuable desk space, and effort: mouse maneuvers that used to require a sweep of the hand are now reduced to a flick of the wrist.

The LOGITECH HiREZ mouse needs 50% less desk space to cover the same amount of screen area as a 200 dpi mouse.

Which makes this new mouse a hand's best friend. And a more reliable, long-lasting companion—fully compatible with all popular software, and equipped with a Lifetime Guarantee.

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

So if you've got your eyes on a high-res screen, get your hands on the one mouse that's agile enough to keep up with it.

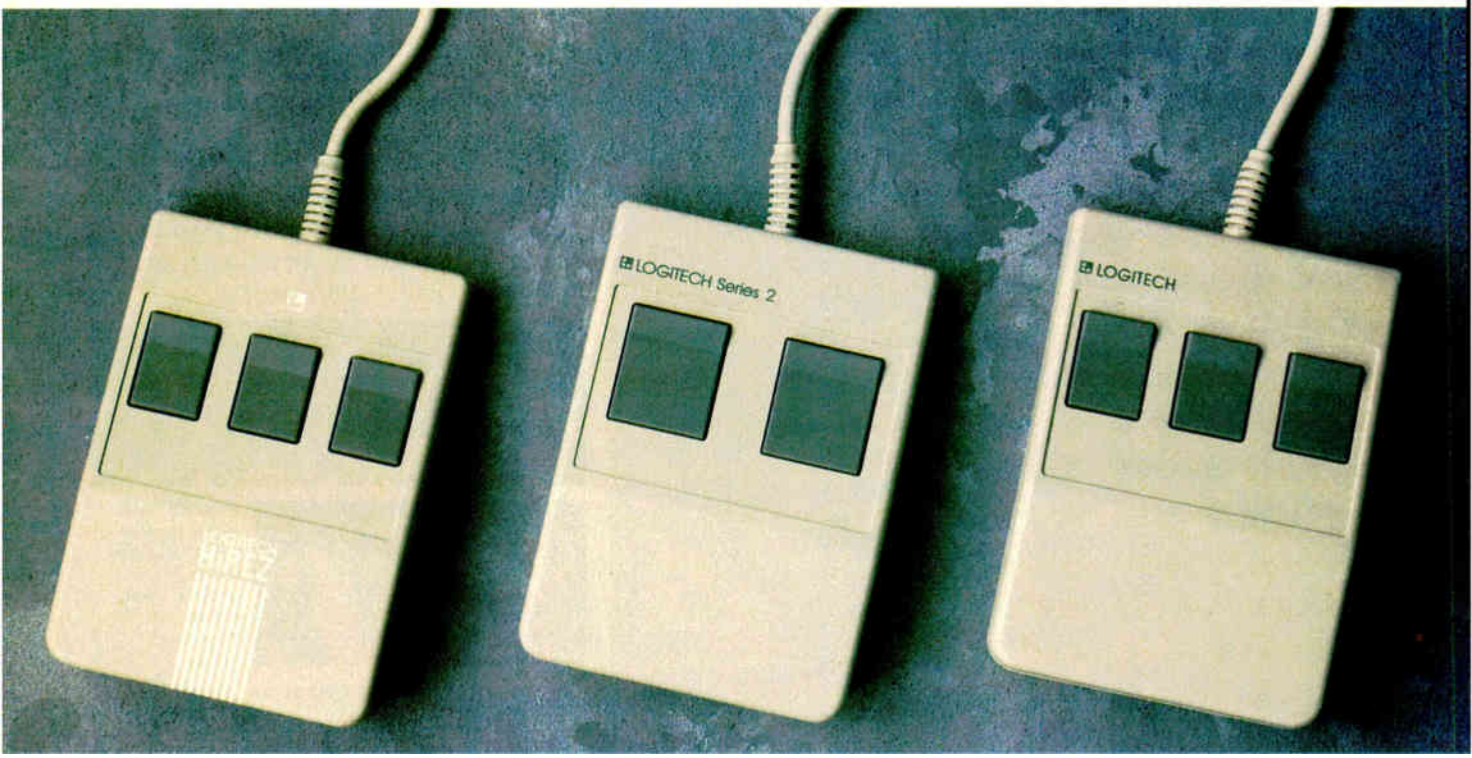
The LOGITECH HiREZ Mouse.

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

LOGITECH

Circle 159 on Reader Service Card (Dealers: 160)

How to pick th



Good instincts run in this family (left to right): the new LOGITECH HiREZ Mouse ($179), the only mouse designed expressly for high-res screens; the LOGITECH Series 2 Mouse for the IBM PS/2 ($99, plugs right into mouse port); and the LOGITECH Mouse for standard screens ($119, in bus and serial versions).

All come with Logitech's own Plus Software, which assures ease of use with virtually any software, mouse-based or not.

Though most mice out there look pretty much alike, they're not all equal in performance. It pays to be just a little choosy to make sure you end up with the right mouse for your needs.

Starting with software. If you want full compatibility with all of your software, all you have to do is look for a mouse with the Logitech name. There are four in all, each one designed for different hardware needs.

THE HiREZ MOUSE

If you've got your eyes on a high-resolution screen, the mouse to get your hand on is the new LOGITECH HiREZ Mouse.

With a resolution of 320 dots-per-inch (as compared with 200 dpi or less for ordinary mice), it covers the same area on your high-res screen but needs less of your desk to do it. More than 50% less. Saving you valuable desk space, and effort: mouse maneuvers that used to require sweeps of the hand are now reduced to a flick of the wrist.

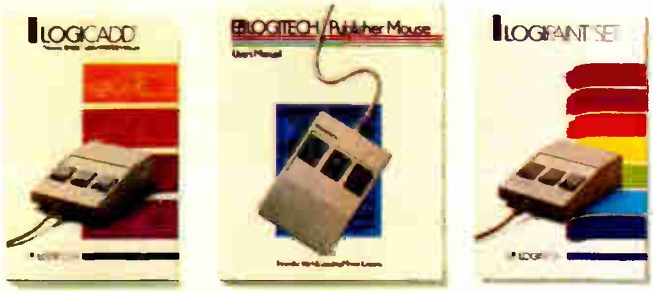
The LOGITECH HiREZ Mouse needs 50% less desk space to cover the same amount of screen area as a 200 dpi mouse.

Which makes this new mouse a hand's best friend. And a more reliable, long-lasting companion. And, like all Logitech mice, it's fully compatible with all popular software, and equipped with a Lifetime Guarantee.

THE SERIES 2 MOUSE

For those who've chosen the Personal System/2,™ the most logical choice is the LOGITECH Series 2 Mouse. It's 100% compatible with PS/2, and plugs right into the mouse port, leaving the serial port free to accommodate other peripherals.

e right mouse.



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

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

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

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

THE ALL-PURPOSE MOUSE: SERIAL OR BUS

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

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

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

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

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

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

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

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

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

Name ____________________

Company/Title ____________________

Address ____________________

Phone ____________________

LOGITECH

Personal System/2 is a trademark of International Business Machines, Corporation.

Circle 161 on Reader Service Card (Dealers: 162)

HARDWARE • THER

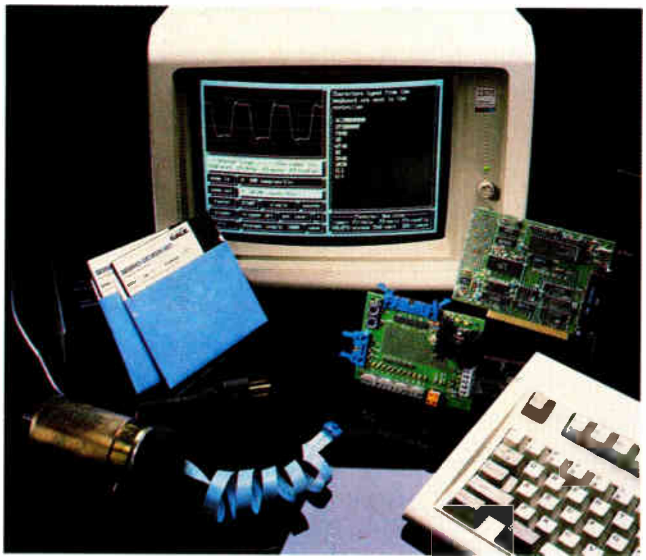
Let the Computer Design that Servo

With the SDK-400, your computer designs, connects, and tests motion-control systems. Included in the servo design kit is a PC-compatible motion controller, a servo motor with encoder, and a power driver. It also comes with a power supply, connectors, and design software.

The motion controller plugs into the PC bus and accepts over 40 ASCII commands and motion profiles. The controller accepts ASCII commands from the keyboard.

Assembling the hardware is simplified by step-by-step graphic explanations included with the software. Diagnostic routines make sure you've connected everything properly, and then the software tunes the system for optimum performance. The software also includes modeling and analysis programs that let you evaluate system performance and teach you about the theoretical aspects of servo design.

The SDK-400 servo design kit requires an IBM PC, XT, AT, or compatible with DOS 2.0 or higher, at least 512K bytes of RAM, and a Hercules or EGA board.
Price: System 1, with motor encoder size 5-500, $1145; System 2, with motor encoder size 50-1000, $1175.
Contact: Galil Motion Control Inc., 1054 Elwell Court, Palo Alto, CA 94303, (415) 964-6494.
Inquiry 767.



Design and test motion-control systems with the SDK-400.

Mr. Mox Powers up Your PC

Do you ever need to power up your PC to access files from a remote location? Mr. Mox, an AC power switch that you control with an external modem, may be the solution.

Mr. Mox features four grounded outlets, two of which are always hot; you control the other two with the Carrier Detect signal in your modem. You plug your PC into the outlets and attach the DB-25 cable to the modem outlet on Mr. Mox and to the external modem.

Mr. Mox also includes a manual-override switch, a 100-second power-off delay, built-in surge protection, a 125-volt 15-amp circuit breaker, and a DB-25 cable.
Price: $99.95.
Contact: Kenmore Computer Technologies, 30 Suncrest Dr., Rochester, NY 14609, (716) 654-7356.
Inquiry 769.

PURE PC POWER PROTECTION

When lightning's crashing down, your hard disk drives and modems are safe with the DSDLP surge protector—at least from a surge of up to 6000 volts, according to Dynatech.

The DSDLP has sensors that detect undervoltages and power-line losses on up to four AC outlets and two telephone receptacles. It also filters RFI (radio-frequency interference) and EMI (electromagnetic interference) noise.
Price: $139.95; includes a 10-year warranty.
Contact: Dynatech Computer Power Inc., 5800 Butler Lane, Scotts Valley, CA 95066, (800) 638-9098; in California, (408) 438-5760.
Inquiry 768.

ASCII on the Wall

What is the hexadecimal ASCII code for a check mark? Which color codes will give your screen yellow letters on a blue background? What are the keyboard scan codes for your function keys? You can answer these questions with a quick glance at Topspot's computer reference wall chart. The chart features an ASCII table with all 256 symbols; keyboard scan codes; codes for the 16 basic colors and gray scales; tables of hexadecimal, decimal, and binary numbers; box-drawing codes; and a musical-note frequency chart.

The wall chart measures 24 by 36 inches and has a metal edge and hook for easy hanging.
Price: $15.
Contact: Topspot, P.O. Box 881, Marion, IA 52302, (319) 377-0207.
Inquiry 770.

A PC-Based Digital Scope

Rapid Systems says its PC-based R1200 digital scope is ideal for transient, vibration, modal, audio, and physiological waveform analysis. It features sampling rates selectable from 1 Hz to 1 MHz, a 64K-byte data buffer, 12-bit A/D converters on each channel, and antialiasing filters on each channel.

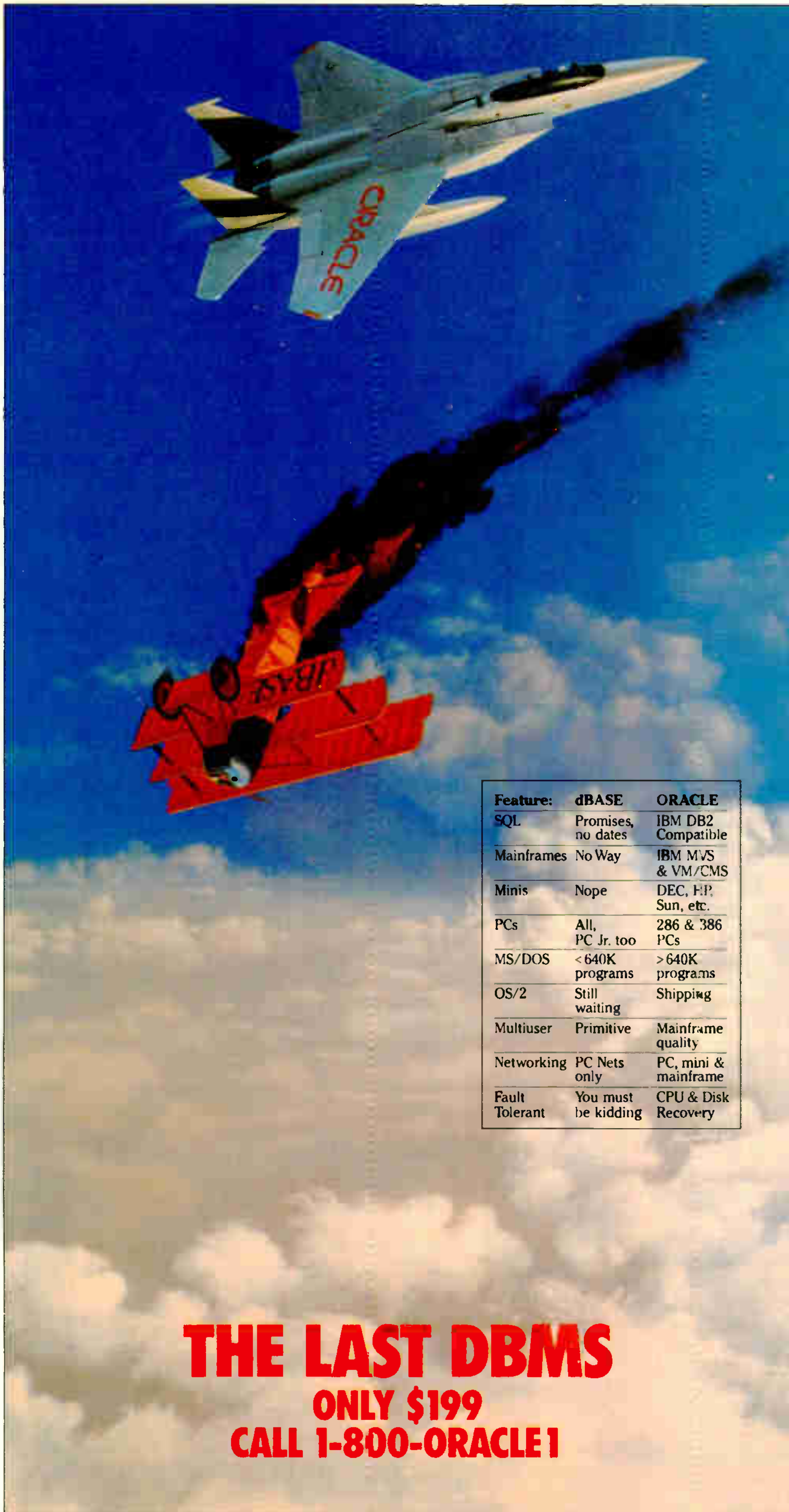
The R1200 is capable of zooming in vertically on waveforms to see increased 12-bit resolution. An autosave feature stores the sweeps mode to disk, and the scope offers optional real-time fast Fourier transform spectrum analysis.
Price: $2995.
Contact: Rapid Systems Inc., 433 North 34th St., Seattle, WA 98103, (206) 547-8311.
Inquiry 771.

Extend Your SCSI

The SCSI 50-pin parallel protocol normally operates to only 19.6 feet, or, with the differential version, it can be extended to 82 feet. But Paralan reports that with the Paraline SCSI enhancement products, you can operate at distances of up to 1000 feet, or up to 2 miles with fiber optic models.

The Paraline SCSI bus extenders are freestanding units that operate from wall-mount power supplies. The single extenders have one parallel interface and one serial connection. You mate the serial interface with coaxial or fiber optic cables (depending on the model). Hub models are also available, and they have one parallel and four serial connections.
Price: $305 for the coaxial version; $820 for fiber optic; $1195 for Parahub-4; $2625 for Parahub-4 fiber optic.
Contact: Paralan Group, C.D.R. Systems Inc., 7171 Ronson Rd., San Diego, CA 92111, (619) 560-1272.
Inquiry 796.

continued



Feature:	dBASE	ORACLE
SQL	Promises, no dates	IBM DB2 Compatible
Mainframes	No Way	IBM MVS & VM/CMS
Minis	Nope	DEC, HP, Sun, etc.
PCs	All, PC Jr. too	286 & 386 PCs
MS/DOS	<640K programs	>640K programs
OS/2	Still waiting	Shipping
Multiuser	Primitive	Mainframe quality
Networking	PC Nets only	PC, mini & mainframe
Fault Tolerant	You must be kidding	CPU & Disk Recovery

[1] Revenue doubled in 9 of Oracle's 10 years. [2] Sales rate over $200 million in current fiscal year. [3] For PC development use only. Requires a 286/386 PC plus 1-MByte extended memory. Offer valid only in US & Canada. © 1988 by Oracle Corp. ORACLE® is a reg. trademark of Oracle Corp. dBASE is a reg. trademark of Ashton-Tate. Microsoft & IBM own numerous reg. trademarks. TRBA

Oracle Corporation, the world's fastest growing software company,[1] has just climbed past Ashton-Tate to become the world's largest supplier of database management software and services.[2]

Why?

• Because ORACLE® runs on PCs, plus mainframes and minicomputers from IBM, DEC, DG, HP, Prime, Wang, Apollo, Sun, etc. — virtually every computer you have now or ever will have. Ashton-Tate's dBASE runs only on PCs.

• Because ORACLE is a true distributed DBMS that connects all your computers — PCs, minicomputers and mainframes — into a single, unified computing and information resource. dBASE supports only primitive PC networking.

• Because Oracle has supported the industry standard SQL language since 1979. Ashton-Tate promises to put SQL into dBASE sometime in the indefinite future.

• Because ORACLE takes advantage of modern 286/386 PCs by letting you build larger-than-640K PC applications on MS/DOS that run unchanged on OS/2. dBASE treats today's 286/386 PCs and PS/2s like the now obsolete, original PC.

Don't go down in flames. Bail out from dBASE. Call 1-800-ORACLE1 and order your $199-PC copy of ORACLE[3] today. Or just ask and we'll send you information on ORACLE, the number one selling DBMS on minicomputers and mainframes.

ORACLE®

COMPATIBILITY • PORTABILITY • CONNECTABILITY

Call 1-800-ORACLE1, ext. 149 today.

Dear Oracle,

PC ORDER PROCESSING
Oracle Corporation
20 Davis Drive • Belmont, CA 94002

I want ORACLE to be THE LAST DBMS for my 286/386 PC. Enclosed is my ☐ **Check** or ☐ **VISA** ☐ **MC** ☐ **AMEX** credit card authorization for $199 (California residents add 7% sales tax). I understand this copy is for PC development only. Offer valid only in the US and Canada.

Print Name ____ Date ____

Title ____

Company ____

Street *(PO Box numbers not acceptable)* ____

City ____

State ____ Zip ____

Phone ____

Credit Card Number ____

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I am a value-added reseller (VAR): ☐ YES ☐ NO

SOFTWARE • PROGRAMMING

FloPro 2.2 runs at 5 milliseconds per logic serve.

Real-Time Machine Control on a PC

FloPro 2.2, a CAM program for industrial applications, emulates the programmable controller processes of updating I/O and solving user logic. Using flowcharts as its programming language, the program can run at 5 milliseconds per logic serve, according to Universal Automation.

You can run FloPro in a simulator mode that allows the flowcharts to execute without the I/O attached to the PC.

The FloPro debugger lets you view flowcharts; modify current status of the I/O, flags, timers, counters, and registers; display real-time status while executing; trace flowchart blocks and set breakpoints; cross-reference flowcharts; and terminate or resume execution.

FloPro also works in a multitasking environment.

The program includes 512 (each) inputs, outputs, flags, timers, 16-bit binary counters, and 4-digit binary-coded-decimal registers. A graphics editor lets you put up to a 15-character label on each mnemonic.

FloPro runs on the IBM PC and compatibles with DOS 3.0 or higher, 512K bytes of RAM, an EGA card, and a 132-column printer.

Price: $895 for the development system; $295 for the run-time module.

Contact: Universal Automation Inc., 9G Rebel Rd., Hudson, NH 03051, (603) 880-6553.

Inquiry 772.

Compile any Microsoft BASIC Program on Your Apple IIGS

Based on the Microsoft BASIC compiler, AC/BASIC is a native 16-bit compiler optimized for the IIGS's 65816 processor. The compiler produces stand-alone applications by translating BASIC programs directly into machine language. It does not require a linker, but does require the run-time libraries included with the program. Absoft reports that you can take programs written in Microsoft BASIC for the Mac, IBM PC, or Amiga, and run and compile them on the IIGS through AC/BASIC.

In addition, AC/BASIC supports the IIGS sound and color capabilities. To run the compiler, you need at least 512K bytes of RAM on a IIGS and one 3½-inch floppy disk drive.

Price: $125.

Contact: Absoft, 2781 Bond St., Auburn Hills, MI 48057, (313) 853-0050.

Inquiry 797.

continued

MOVING FORTH WITH OS/2

LMI UR/FORTH for Microsoft OS/2 is a Forth programming environment for 80286- and 80386-based machines running OS/2.

UR/FORTH runs in protected mode and lets you take advantage of OS/2's support for multitasking, interprocess communications, and virtual memory management.

UR/FORTH offers a direct threaded-code implementation, a segmented memory model, a hashed dictionary for fast compilation, use of dynamic memory allocation functions, and a uniform file interface. It includes a battery of string-handling operators, such as search, extract, compare, and concatenate, and a dynamic string-storage manager. A table-driven full-screen editor lets you edit as many as six files simultaneously.

You can invoke OS/2 system functions interactively from the UR/FORTH interpreter by typing the function's parameters, followed by the function's name. When you leave the OS/2 operating system, the status of the operation is left on the Forth stack, and other results are placed in the Forth data segment at addresses specified in the original call. You can also call OS/2 functions from within compiled Forth programs.

UR/FORTH supports text and graphics display modes of the CGA and EGA. It contains graphic drawing routines for reading or setting individual pixels, line drawings, arcs, ellipses, and circles; region filling with patterns or solid color; bit-block moves; and positioning of graphics at arbitrary graphics coordinates.

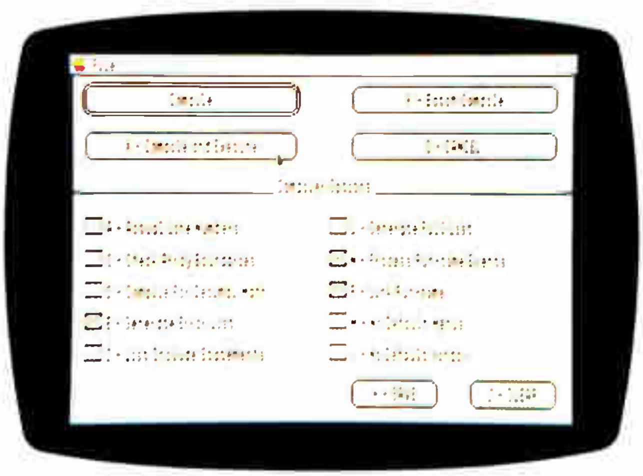
Software floating-point, 80287-assisted floating-point, and 80387-assisted floating-point function libraries are supplied. Laboratory Microsystems reports that you can use the software floating-point library on any 286- or 386-based machine.

To run UR/FORTH for OS/2 you need version 1.0 or higher of OS/2, a 286- or 386-based system, at least 2 megabytes of RAM, and a CGA, VGA, EGA, or monochrome display adapter.

Price: $350.

Contact: Laboratory Microsystems Inc., 3007 Washington Blvd., Suite 230, Marina del Rey, CA 90292, (213) 306-7412.

Inquiry 773.



An AC/BASIC control window.

Take a peek at Genoa's new PC graphics add-ons.

You've known Genoa as a developer of high performance graphics chips, and a leading manufacturer of graphics boards and tape backup. Soon you'll be able to depend on us for all your PC graphics add-on hardware.

Over the next year, we'll be unwrapping a series of graphics products. Each is designed to give you the most reliable, yet innovative engineering features. And above all, the highest performance possible.

Our SuperVGA HiRes family, featured here, is the first in our new product series. SuperVGA HiRes offers breathtaking color and resolution. From 16 colors in 1024x768. Up to 256 colors in 800x600. You'll see more of your spreadsheets at once with SuperVGA HiRes. 132 columns and 60 rows. You'll do Windows or OS/2. In fact, every SuperVGA HiRes feature is designed to turn your IBM PC/XT/AT and PS/2 models 25 and 30 into real graphics engines.

Delivering SuperVGA HiRes™ now!

- 100% IBM VGA compatible
- Advanced features
  - —1024x768 in 16 colors and 800x600 in 256 colors/Model 5200
  - —512x512 in 256 colors/Model 5100
- 132 columns text
- For both analog and TTL displays

If you're looking for PC graphics add-ons, take a look at Genoa first. Our new line of products is starting delivery *now!*

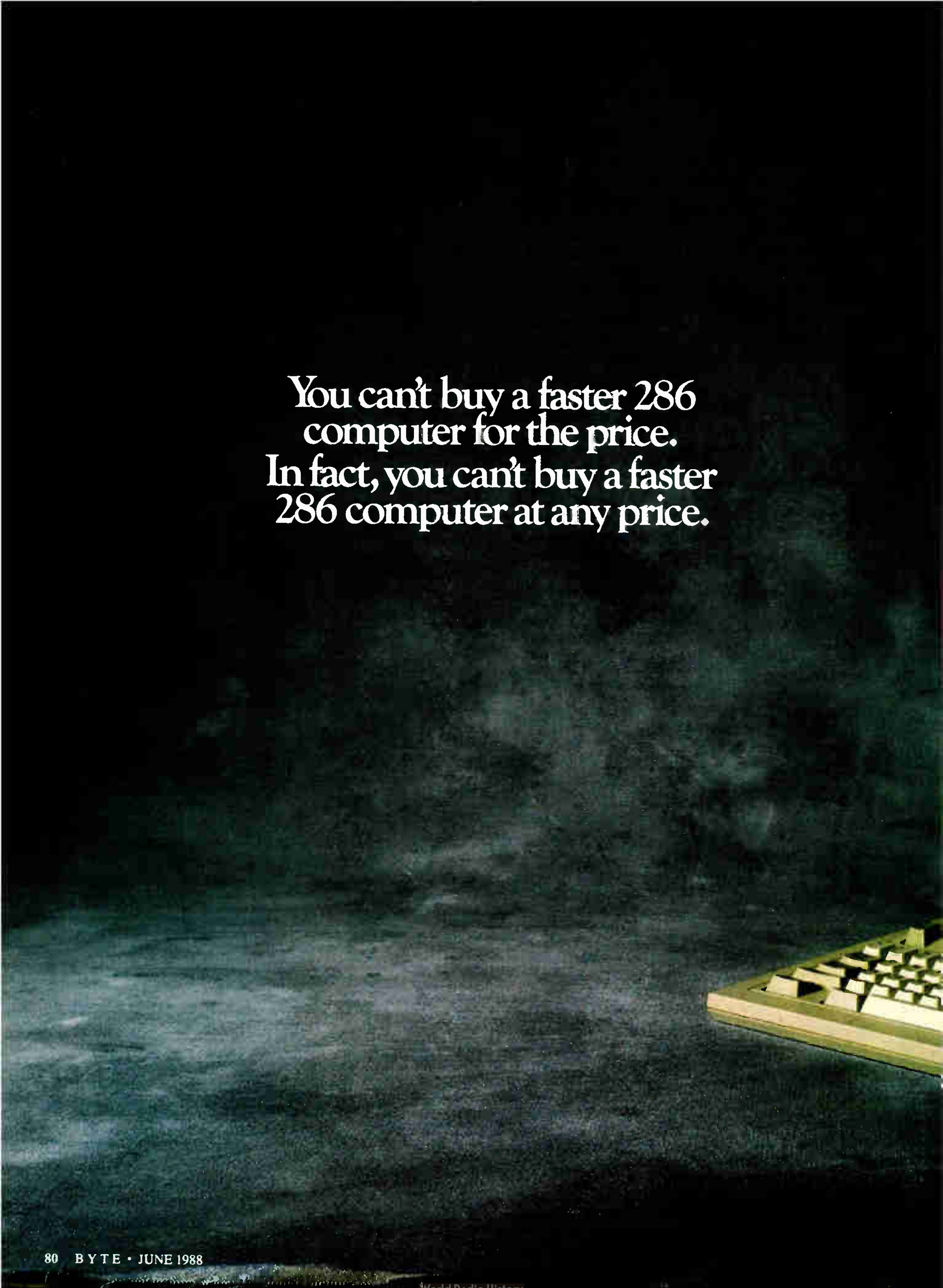
For the Genoa dealer nearest you or to add your name to our mailing list contact: Genoa Systems Corporation, 73 E. Trimble Road, San Jose, CA 95131. Fax: 408/434-0997. Telex: 172319. Or phone: 408/432-9090. In the UK, contact Genoa Systems Limited, phone: 01-225-3247. In the Far East, contact Genoa/Taiwan, phone: 2-776-3933.

Circle 118 on Reader Service Card

Genoa
SYSTEMS CORPORATION

Delivering PC Graphics

408/432-9090


You can't buy a faster 286
computer for the price.
In fact, you can't buy a faster
286 computer at any price.

Because.

The handsome piece of high-tech wizardry you've just been admiring (on the previous two pages) is the new Dell System 220.

The first 286 computer running at 20 MHz. You read it correctly. 20 MHz.

Which means it's as fast as most 386 computers, running MS† OS/2 and MS†-DOS at blistering speed. All from a tiny little corner of your desk.

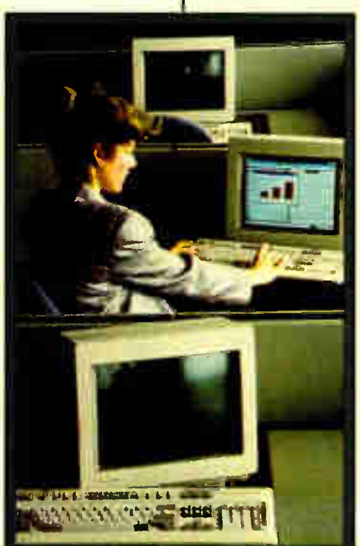
Yet this engineering marvel costs less than half of what most other 386 computers sell for.

Which might lead you, quite reasonably, to wonder:

How can the people at Dell offer you so much for so little?

The short answer is that you buy direct from us, the manufacturer.

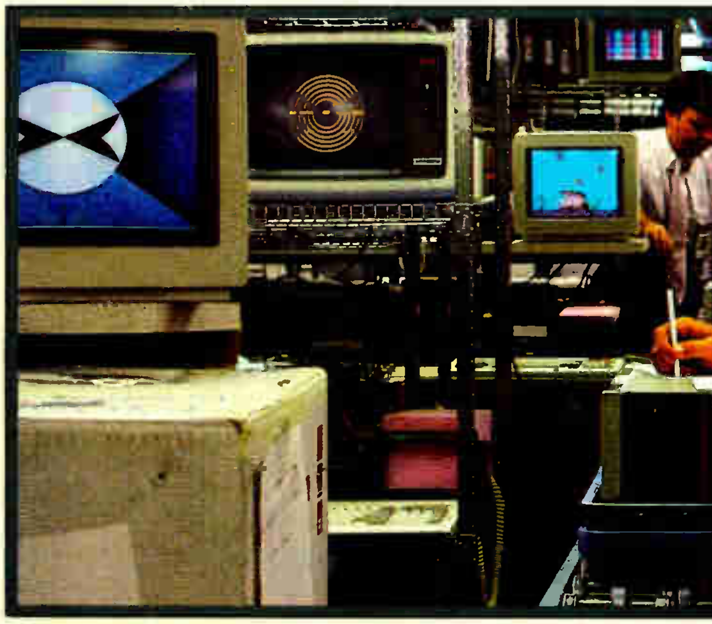
Eliminating the computer stores and their salespeople–who can add thousands of dollars to the cost of every computer.



"Speed is a good thing. Safe, reliable, no hassles speed is better still."
–Al Poor, Editor's Choice, PC Magazine

But while we eliminate the things you don't need, we also make certain we never eliminate anything you actually do need.

The very first thing you need from any computer company, obviously, is terrific computers.



Well, we design and build our computers right here at our headquarters in Austin, Texas.

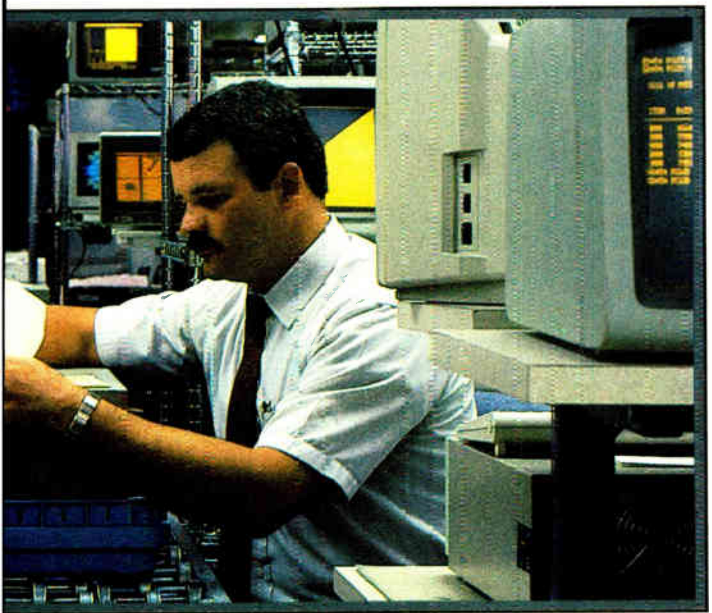
Putting a premium on speed, compatibility, and reliability.

Because we're flexible, we often get new technologies to the marketplace faster than any other computer company.

In fact, we're already shipping our version of MS OS/2, so you can run MS OS/2 applications, now as well as in the future.

"...includes a year's on-site support...in the price of the computer. This is the sweetest support deal offered by any computer vendor in the business."
–Eric Knorr, PC World

As for quality control, around here it's an obsession. Each and every computer goes through a battery of diagnostic checks, including a comprehensive burn-in before we ship it to you.



Every single Dell computer also comes equipped with one other remarkable feature.

A level of service most retail computer stores can only envy.

Starting with expert technical advice before you even buy a computer. To help you decide which system best suits your needs.

Followed by a thirty-day money-back guarantee. To make sure you're completely satisfied.

And all systems come with a one-year limited warranty.

Then, we give you free technical support over the phone. With technicians who know the inside of our computers the way you know the back of your hand.

If on-site service should ever be required by you or your business, we'll send a Honeywell Bull service engineer to your office by the next business day.*

Our attitude towards service is perhaps best summed up by a phrase we hear around here, delivered in a no-nonsense tone by our Chairman, Michael Dell:

"Fix it," he says. "Or give them their money back."

"The combination of technical know-how and service is impressive...it's a good bet the computer world will be hearing a lot more about Michael Dell in the years ahead."

–Stanley W. Angrist, Forbes

In four years, we've become one of the largest personal computer manufacturers in the U.S. We've more than doubled our sales each year we've been in business; last year, our sales grew from $69 million to $159 million.

It shouldn't be any surprise. After all, we've been offering better computers, with better service–at better prices.

All you do is call us and place an order, and we ship it direct to you. Which makes buying a computer as simple as it can be.

Now, if you'd like the rest of the details on our hyper-fast 286 computer, and information on the rest of our line, there's only one more thing you have to do.

Turn the page.

The Dell Computer Store.

Welcome to our store. To buy or lease a Dell computer, call (800) 426-5150. We'll help you select the right system.

For service and technical support, call our highly trained technicians at (800) 624-9896. In almost all cases, any problem can be solved over the phone.

These technicians are also supported by Honeywell Bull service engineers who can be dispatched to your office by the next business day, should on-site service be required. This optional service contract is available in over 95% of the United States, with over 1,000 engineers in 198 service locations.*

We are so confident in our quality products that we also provide a Total Satisfaction Guarantee, which says that any system bought from us may be returned within thirty days from the date it was shipped to you for a complete refund of your purchase price.

We also offer a One Year Limited Warranty, which warrants each system we manufacture to be free of defects in materials and workmanship for one full year. During the one year period we will repair or replace any defective products properly returned to our factory.

Call or write for the complete terms of our Guarantee Warranty, and the Honeywell Bull Service Contract. Dell Computer Corporation, 9505 Arboretum Blvd., Austin, Texas 78759-7299.

Dell products are available on GSA contract #GS00K87AGS6127. Call us to get GSA pricing.

THE NEW SYSTEM 310.

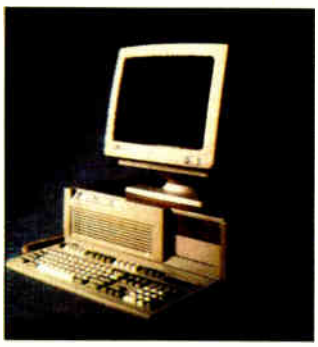
The top of the line. It's the highest performance 80386 computer available, faster than the IBM† PS/2† Model 80 and the Compaq† 386/20. It runs at 20 MHz, with the latest 32-bit architecture for complete MS† OS/2 compatibility and maximum performance. Since it also has Intel's† Advanced 82385 Cache Memory Controller, and high performance disk drives, the System 310 is ideal for intensive database management, complex research and development, CAD/CAM, and desktop publishing. As a network file server the system offers an unbeatable combination of price and performance.

Standard Features:

Intel† 80386 microprocessor running at 20 MHz.
1 MB of 80 ns 32-bit RAM expandable to 16 MB without using an expansion slot.
Advanced Intel 82385 Cache Memory Controller with 32 KB of high speed static RAM.
Socket for 20 MHz 80387 coprocessor.
5.25" 1.2 MB or 3.5" 1.44 MB 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 (6 available with hard disk drive controller and video adapter installed).
Dell System Analyzer.
MS-DOS and MS OS/2 compatible.
Security lock with locking chassis.
12 month on-site service contract (Available on complete systems).

Options:
1 MB RAM upgrade kit.
20 MHz Intel 80387 math coprocessor.
2 MB or 8 MB memory expansion boards.

SYSTEM 310	With Monitor and Adapter		
Hard Disk Drives	VGA Mono	VGA Color	VGA Color Plus
40 MB-28 ms	$3,799	$3,999	$4,099
90 MB-18 ms ESDI	$4,599	$4,799	$4,899
150 MB-18 ms ESDI	$5,099	$5,299	$5,399
322 MB-18 ms ESDI	$7,099	$7,299	$7,399



THE NEW SYSTEM 220.

As fast as most 386 computers, at less than half the price—more power for the money than any other system. An 80286 system that runs at 20 MHz, with less than one wait state. Completely compatible for both MS-DOS and MS OS/2 applications (it runs OS/2 faster than IBM PS/2 Model 80), and with a remarkably small footprint, the System 220 is the ideal executive workstation for database management, business, or sophisticated connectivity applications. The system uses page-mode interleaved memory; the page-mode RAM operates at less than one wait state, and inter-leaving results in a performance increase of about 15 percent.

Standard Features:

80286 microprocessor running at 20 MHz.
1 MB of RAM expandable to 16 MB (8 MB on system board).
Integrated diskette and VGA video controller on system board.
One 3.5" 1.44 MB diskette drive.
Integrated high performance hard disk interface on system board.
Enhanced 101-key keyboard.
1 parallel and 2 serial ports.
LIM 4.0 support for memory over 1 MB.
Real-time clock.
Three full-sized AT† compatible expansion slots.
Socket for 80287 coprocessor.
Dell System Analyzer.
MS-DOS and MS OS/2 compatible.
Security lock with locking chassis.
12 month on-site service contract (Available on complete systems).

Options:
3.5" 1.44 MB diskette drive.
Intel 80287 coprocessor.
1 MB RAM upgrade kits.

SYSTEM 220	With Monitor		
	VGA Mono	VGA Color	VGA Color Plus
One Diskette Drive	$1,799	$1,999	$2,099
40 MB-29 ms Hard Disk	$2,499	$2,699	$2,799
100 MB-29 ms Hard Disk	$3,399	$3,599	$3,699

THE NEW SYSTEM 200.

A great value in a full-featured AT compatible. An 80286 computer running at 12.5 MHz, this system is completely MS OS/2 compatible. It's ideal for general business applications, as well as software development, local area networks, CAD/CAM, and desktop publishing. The System 200 offers high speed drive options, industry standard compatible BIOS, and on-site service. At these low prices, the System 200 is the best value in the 80286 marketplace. As Executive Computing said of this computer's predecessor, "If faster processing speed and low cost are two key issues affecting your purchase decision, this machine might be the ideal choice for your office."

Standard Features:
- Intel 80286 microprocessor running at 12.5 MHz.
- 640 KB of RAM, expandable to 16 MB (4.6 MB on system board.)
- 5.25" 1.2 MB or 3.5" 1.44 MB 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 available with hard disk drive controller and video adapter installed).
- Socket for 8 MHz 80287 coprocessor.
- Dell System Analyzer.
- MS-DOS & MS OS/2 compatible.
- Security lock with locking chassis.
- 12-month on-site service contract (Available on complete systems).

Options:
- 512 KB RAM upgrade kit.
- 8 MHz Intel 80287 coprocessor.

SYSTEM 200	With Monitor and Adapter			
Hard Disk Drives	Mono	VGA Mono	VGA Color	VGA Color Plus
20 MB	$1,799	$1,999	$2,199	$2,299
40 MB-40 ms	$1,999	$2,199	$2,399	$2,499
40 MB-28 ms	$2,199	$2,399	$2,599	$2,699
90 MB-18 ms ESDI	$2,999	$3,199	$3,399	$3,499
150 MB 18 ms ESDI	$3,499	$3,699	$3,899	$3,999
322 MB 18 ms ESDI	$5,499	$5,699	$5,899	$5,999

THE SYSTEM 100.

A full-featured, yet economical one-piece computer for office, school, or home. This system is fast, easy to use, and ready to run with Dell Enhanced MS-DOS 3.3, Microsoft† DOS Manager, and Microsoft Works software—more than a $400 value, included at no extra charge. Complete MS-DOS compatibility means you can run thousands of programs for business, personal finance, education, and entertainment. And the System 100 can grow, with the high quality options listed below. A price leader in 8088 technology, the System 100 boasts an innovative design that allows for more power, speed and convenience than most of its competitors.

Standard Features:
- Intel 8088 microprocessor running at 9.54 MHz selectable to 4.77.
- 640 KB of RAM.
- 3.5" 720 KB diskette drive.
- Diskette drive controller integrated on system board.
- Integrated high-quality 84-key keyboard.
- 1 serial and 1 parallel port.
- Two full-sized expansion slots available when video adapter is installed.
- One half-sized expansion slot used for video adapter.
- Socket for 8 MHz 8087 coprocessor.
- Internal speaker with earphone jack and volume control.
- Security Tie-Down bracket.
- Dell Enhanced MS-DOS 3.3 Microsoft DOS Manager, Microsoft Works.

Options:
- 3.5" 720 KB diskette drive.
- 8 MHz Intel 8087.

SYSTEM 100	With Monitor and Adapter			
	Monochrome	CGA Color	VGA Mono	VGA Color
720 KB Diskette Drive	$799	$899	$999	$1,199
Two 720 KB Diskette Drives	$949	$1,049	$1,149	$1,349
20 MB Hard Disk	$1,299	$1,399	$1,499	$1,699

PRINTERS. We now offer a full line of PC-compatible dot matrix and laser printers. Our dot matrix printers range from inexpensive near-letter quality printers to the highest resolution printers available. Our laser printers include some of the fastest, most reliable printers ever made. All are 300 dots per inch, and all support serial and parallel interfaces. And all printers come with our 30-day money-back guarantee and a one year warranty.

LASER PRINTERS

Laser System 150 $5,995
- 15 pages per minute, text and graphics
- 1.5 MB standard memory, expandable to 2.0 MB
- Dual 250-sheet input trays

Laser System 80 $3,195
- 8 pages per minute text and graphics
- 1.5 MB standard memory, expandable to 2.0 MB

Laser System 60 $2,195
- 6 pages per minute, text and graphics
- 1.5 MB standard memory, expandable to 2.0 MB

DOT MATRIX PRINTERS

Printer System 800 $699.95
- Highest resolution text and graphics from a 24-wire dot matrix printer
- Draft quality at 200 cps
- Correspondence quality at 132 cps
- Letter quality at 66 cps
- Standard parallel and serial interfaces
- Wide carriage

Printer System 600 $499.95
- 9-wire dot matrix
- Draft quality at 240 cps
- Near-letter quality at 60 cps
- Standard parallel interface
- 12.6 KB Buffer (expandable to 28.6 KB)
- Wide carriage

Printer System 300 $199.95
- 9-wire dot matrix
- Draft quality at 144 cps
- Near-letter quality at 36 cps
- Four standard fonts
- Paper parking
- 4 KB buffer
- Standard Parallel interface

PERIPHERALS. With our unique manufacturing capabilities, we can build a system to your exact specifications. We offer monitors, modems, graphics boards, tape backups, hard drives, diskette drives, expanded memory boards, a serial mouse, and more. Call for details.

Operating System Software
- Dell Enhanced MS-DOS 3.3 with disk cache and other utilities $119.95.
- Dell MS OS/2 Standard Edition 1.0 $324.95

SOFTWARE. Complete your system with software: accounting, communications, desktop publishing, graphics, home, spreadsheet, training, word processing, and integrated packages. Call for more information.

DELL COMPUTER CORPORATION

TO ORDER, CALL 800·426·5150

All prices and specifications are subject to change without notice. Please inquire for current details. Dell cannot be responsible for errors in typography or photography. In Canada, leasing is not currently available, and configurations and pricing may vary. *Available on System 100 at extra charge. †Signifies registered or unregistered trademarks owned by entities other than Dell Computer Corporation. 11EF8

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SOFTWARE • SCIENTIFIC AND ENGINEERING

Anvil Forges Designs on Your 386

Anvil-5000pc integrates drafting, wire-frame, surface modeling, section analysis, and numerical control using the same data structure and interactive interfaces for all functions.

Its drafting capabilities include notes, labels, dimensions, cross-hatching, arrow on curve, balloon, text edit, surface finish, and true-position tolerancing. Its geometric features offer points, lines, arcs and circles, splines, conics, strings, and polylines.

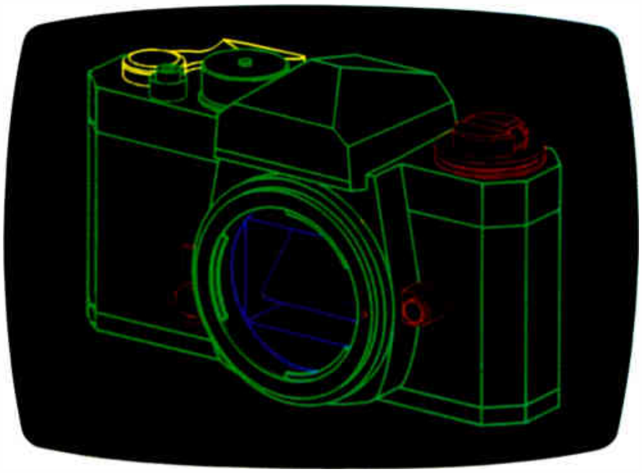
The program has an integrated database, a warm reboot, and an open architecture. It can handle drawings of parts that have more than 340,000 entities.

The program supports VGA, PGA, and EGA. It comes in six software modules, beginning with 3-D Design and Drafting, which is the core module of the system and is available immediately. Other modules will be released throughout 1988.

Price: 3-D Design and Drafting module, $3995; other modules will range from $495 to $1995.

Contact: Manufacturing and Consulting Services Inc., 9500 Toledo Way, Irvine, CA 92718, (714) 951-8858.

Inquiry 774.



Anvil-5000pc does all kinds of 3-D design and drafting.

Astronomical Space Birds

Space Birds is an astronomical program that predicts the visibility of artificial earth satellites. It requires that you obtain information on orbital elements from NASA on forms provided in the package. You enter the elements, your latitude, longitude, and height above sea level, and the time period for which you want visibility predictions.

The program runs on the IBM PC, XT, AT, and compatibles with DOS 2.0 or higher.

Price: $40 for PC and XT version; $45 for PC AT version.

Contact: Astronomical Data Service, P.O. Box 26180, Colorado Springs, CO 80936, (719) 597-4068.

Inquiry 775.

New Mathtool Module

Statistics I is the first module in Gulf's numerical analysis library, Mathtool. Statistics I calculates means, variance, moments, moving averages, frequency distributions, and cumulative frequency distributions. It also performs data smoothing, tests of hypotheses and significance, and confidence interval estimates.

The modules in the Mathtool series offer on-line editing of data, mathematical routines, and graphics output to the screen or printer. You can input your own data, ASCII files, or Lotus 1-2-3 files. Other Mathtool modules will include Matrix Analysis, Regression and Correlation, Probability, Differential Equations, Fourier Series, Bessel Functions, Numerical Integration, Analytic Geometry, Mathematical Functions, and Numerical Differentiation.

Statistics I operates as a stand-alone program or will work with other Mathtool units. They all run on the IBM PC, XT, AT, and compatibles with 256K bytes of RAM. A monochrome or color graphics card is recommended.

Price: $95.

Contact: Gulf Publishing Co., Book Division, Dept. R8, P.O. Box 2608, Houston, TX 77252, (713) 529-4301.

Inquiry 776.

Passage into Two Dimensions

World Precision Instruments has designed Passage for two-dimensional plotting and numerical analysis on a Mac. The program lets you enter data from other programs. It will scale and plot multiple sets of the data, including asymmetrical error values. Passage also analyzes and manipulates the data, using routines to calculate integrals, fast Fourier transforms, and polynomial fits.

Passage runs on the Mac Plus, SE, and II.

Price: $495.

Contact: World Precision Instruments, 375 Quinnipiac Ave., New Haven, CT 06513, (203) 469-8281.

Inquiry 777.

SEGS Plots Engineering Graphics

SEGS is a scientific engineering graphics system that can plot over 5000 data points for each of 10 curves with up to four independent y axes. It features a Lotus 1-2-3-style interface and lets you produce presentation-quality graphics on many plotters and printers, including Hewlett-Packard pen plotters and LaserJets, and IBM graphics-compatible dot-matrix printers.

An internal numeric spreadsheet lets you enter, transform, and manipulate data mathematically to produce plots. You can enter data with the numeric spreadsheet, or you can import data from spreadsheet print files or ASCII data files.

To run SEGS, you need an IBM PC, XT, AT, or compatible with 256K bytes of RAM and DOS 2.0 or higher. It also runs on PS/2s and supports CGA, EGA, VGA, and Hercules Graphics cards.

Price: $195.

Contact: Edmond Software Inc., 3817 Windover Dr., Edmond, OK 73013, (800) 992-3425; in Oklahoma, (405) 340-0697.

Inquiry 778.

PCB Design on the Mac II

EDS-1 is an electronic design program that combines modules for producing printed circuit board designs. Modules include schematic entry, PCB layout, routing, and a Gerber translator.

Vamp also offers EDS-II, which is essentially the same package as EDS-1, but includes a digital simulator.

Price: EDS-1, $1495.

Contact: Vamp Inc., 6753 Selma Ave., Los Angeles, CA 90028, (213) 466-5533.

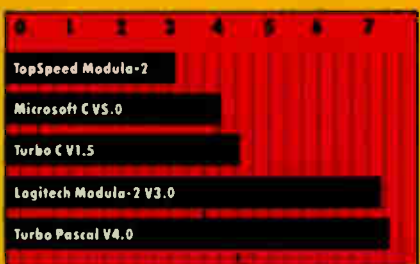
Inquiry 779.

continued

FACT:

THE COMPILER THAT MAKES THE FASTEST CODE FOR SIEVE IS JPI TOPSPEED™ MODULA-2.

The successor of Pascal: *JPI TopSpeed Modula-2* produces better code than Microsoft C, Turbo C, Logitech Modula, and Turbo Pascal 4.0. The figures speak for themselves:



Measured by British Standards Institution (BSI)
(25 iterations of Sieve on 8MHz AT)

JPI TopSpeed Modula-2 is a professional Modula-2 development system with full support of memory models, multi-tasking, long data types, structured constants, long and short pointers, 80×87 inline code and emulator, separate compilation, direct BIOS/DOS calls etc. The comprehensive library includes CGA, EGA and VGA graphics support, math functions, sorting, file handling, window management and more. Here is what our users say:

"JPI Modula-2 is the Modula-2 we have all been waiting for. JPI Modula-2 will do for Modula-2 what Turbo Pascal did for Pascal."

—K N King
Author of Modula-2: A Complete Guide

"JPI Modula-2 is a landmark product. The environment is better than anything on offer from Borland or Microsoft."

—Huw Collingbourne
Computer Shopper

The Compiler Kit includes: High-speed optimizing compiler, integrated menu-driven environment with multi-window/multi-file editor, automatic *make*, fast smart linker. All Modula-2 sources to libraries included. **Bonus:** Complete high-speed window management module included with source.

The TechKit includes: Assembler start-up source code for system, JPI TopSpeed Assembler, TSR module, communications drivers, PROM locator and technical information.

Systems requirements: IBM PC or compatible, 384K available RAM and two floppy drives (hard disk is recommended).

To become part of the excitement, make use of our limited-time introductory price of $59.95 (after July 4, 1988: $99.95). 30 days unconditional money-back guarantee.

To Order:
Call 1-800-443-0100
Ext 255, 24 Hours.
Or mail in the coupon or a letter.

Yes, I want to own the compiler that makes the best code. Please rush me:
☐ Compiler Kit $59.95 ☐ TechKit $49.95 Disk Type: ☐ 5¼" ☐ 3½"
Please add $5 shipping and handling. CA residents add sales tax.
SEND TO: Jensen & Partners International,
1101 San Antonio Rd., Suite 301, Mountain View CA 94043, Phone: (415) 967-3200
Name: ____
Address: ____
City/State/Zip: ____
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In England and Europe contact:
Jensen & Partners UK Ltd., 63 Clerkenwell Rd., London EC1M 5NP, Phone: (01) 253-4333.
In England call Toll Free 0800 444-143.
24 Hours. Compiler Kit £59.95, TechKit £29.95 (introductory offer only valid in the US).

Jensen & Partners International

Circle 146 on Reader Service Card

SOFTWARE • SCIENTIFIC AND ENGINEERING

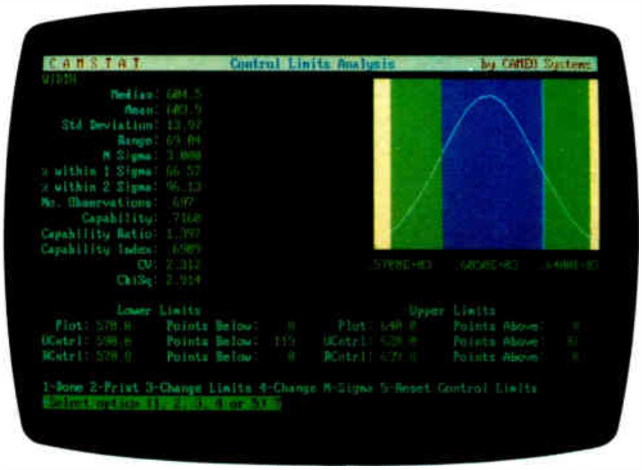
Camstat Analyzes Manufacturing Data

With this set of statistical functions, you can monitor, detect, correct, and improve quality control in manufacturing processes.

You can enter data into Camstat through its editing environment or from files generated by other applications. You can also create a series of prompts that you can use to enter data directly into the system, making it available on the manufacturing floor.

Camstat handles parametric, attribute, date, and character variables. You can split data into subsets, change values, transform values, and filter out subsets of data. Charting features include X-R, trend, and p-charts. Its graphics capabilities include histograms, cumulative sum plots, x,y plots, capability analysis, SPC control charts, and Pareto charts.

Camstat runs on the IBM PC AT or compatibles with at least 640K bytes of RAM, a 1.2-megabyte floppy disk drive, and an EGA or Hercules monochrome adapter. A math coprocessor is recommended.
Price: $649.
Contact: Cameo Systems Inc., 2880 San Tomas Expressway, Santa Clara, CA 95051, (408) 986-9200.
Inquiry 780.



Putting Camstat to use on the manufacturing floor.

Generate Spiffy Scientific Presentations

You can use Ventura or GEM Desktop Publisher to create text for publication, then use Specific Fonts 4 (SF4) to create the scientific and mathematical formulas, expressions, and diagrams to insert into your document.

SF4 provides you with symbol and monospace fonts for GEM users, a set of math and Greek picture fonts in the form of Draw objects, and an art library of numbers and letters for special decorative features.

You can edit SF4 with FontEdit, a GEM-based editor from Specific Solutions.

The program requires GEM or Ventura and runs on the IBM PC and compatibles with at least 512K bytes of RAM.
Price: $75.
Contact: Specific Solutions, 1898 Anthony Court, Mountain View, CA 94040, (415) 941-3941.
Inquiry 781.

Thermal Analyzes Semiconductor Temperatures

Thermal is a three-dimensional thermal-analysis program that assists you in redesigning semiconductor circuits. It calculates a grid of temperatures, up to 30 by 30, on as many as five power sources for a given substrate. A list of 20 substrates is included, or you can define new ones.

The program runs under Microsoft Windows and makes use of Windows' Clipboard, allowing you to integrate any of its display modes into other Windows applications. You can also create text files to use with other non-Windows programs.

You can view your output in graphic or text form. When viewing graphically, you can toggle isothermal and grid lines on and off. In text mode, you can display the cell and substrate input data as well as any calculated output data. You can also page through the data with the keyboard or mouse.

Thermal runs on the IBM PC and compatibles with at least 640K bytes of RAM, a math coprocessor, and Windows 1.03 or higher. A Windows-compatible mouse is recommended.
Price: $449.95.
Contact: Solutions Firmware, 6915 Rendina St., Long Beach, CA 90815, (213) 596-1900.
Inquiry 782.

Analyzing Time Series or Random Data

Micro-Mac/Ran is a microcomputer version of the time-series and spectral-analysis system Mac/Ran, originally designed for mainframes.

The program performs spectral analysis, data correlation, generation and complex arithmetic manipulation of signals, and digital filtering. It comes in modules that can run as stand-alones, interactively, or in batch mode. The modules include shock spectra, multiple-input linear systems analysis, probability function estimation, tracking filters, third-octave processing, and more.

University Software reports that the program was designed so that you need only an elementary knowledge of time-series analysis characteristics.

Micro-Mac/Ran runs on the IBM PC and compatibles with at least 512K bytes of RAM, a math coprocessor, and a hard disk drive. It supports graphics boards and Hewlett-Packard plotters.
Price: Four microcomputer versions range in price from $599 to $2495.
Contact: University Software Systems, 250 North Nash St., El Segundo, CA 90245, (213) 640-7616.
Inquiry 783.

Fit and Plot Your Curves

Curve-fitting routines performed by F-Curve include cubic spline, divided difference, polynomial and multiple linear regression with least squares, and nonlinear fits using the simplex technique. You can use Savitzky-Golay filters to smooth the data. The program also lets you calculate the value of y for any value of x on the smoothed curve, the value of the integral of the smoothed curve for any x interval, and the value of the derivative of the curve for any value of x.

Plotting capabilities let you plot data points with or without the fitted curve. You can plot data points with error bars or symbols or both.

F-Curve runs on the IBM PC, XT, AT, and compatibles.
Price: $59.95.
Contact: LEDS Publishing Co. Inc., P.O. Box 12847, Research Triangle Park, NC 27709, (919) 477-3690.
Inquiry 784.

continued

"There's No Reason To Look Beyond PC TOOLS"

–PC Magazine, Editor's Choice Award, Two-Time Winner

Data Recovery • ***Fast*** *Hard Disk Backup* • *Disk Management*

Now we've given you even more reason–PC Tools™ Deluxe.

PC Tools Deluxe gives you all the best features of **Fastback**,™ **Norton**,™ **XTREE**,™ **Mace**,™ **Sidekick**,® **Lightning**™ and **Disk Optimizer**–a $700 value–for just $79.

Other utilities may claim they "do it all," but only PC Tools Deluxe delivers:

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• **PCFORMAT** for safe formatting of floppy and hard disks.
• A quick, reliable **DISK CACHING** utility for speeding up disk access.
• A *fast* **COMPRESS** feature that like Disk Optimizer dramatically improves hard disk performance. • And a better resident mini **WORD PROCESSOR** than Sidekick, including word wrap, search/replace, formatted page printing and more.

Before you buy any of these other utilities, take a look at PC Tools Deluxe. Like PC Magazine, you'll find there's no reason to look any further. **For the dealer nearest you, or to order direct, call (503) 244-6036,** M–F, 8 a.m.–5 p.m. (West Coast time). Questions? Call us at (503) 244-5782.

Central Point Software
INCORPORATED
9700 S.W. Capitol Hwy.
Portland, OR 97219

Circle 54 on Reader Service Card

SOFTWARE • BUSINESS

Manage Your Money on Your Mac

The Macintosh version of Managing Your Money includes the same capabilities as the IBM version and also allows you to integrate the financial "chapters" to come up with a budget, manage savings, calculate income, and more.

The program performs basic budget and checkbook management, tax planning, portfolio management, and retirement planning.

Managing Your Money for the Mac is not copy-protected and runs on the Mac 512Ke, Plus, SE, and II. You must have two disk drives, one of which must have at least 800K bytes of RAM.
Price: $219.98.
Contact: Meca Ventures Inc., 355 Riverside Ave., Westport, CT 06880, (203) 226-2400.
Inquiry 762.

Low-Cost Turbo-Charged Accounting

Everything you need to perform basic accounting tasks is integrated in InfoTeam Turbo Accounting from Info Designs. The program includes modules for general ledger, accounts receivable, invoicing, accounts payable, and check writing. The modules are integrated so that every time you enter or change information, each transaction is time-stamped, and the general-ledger module is updated. On-line help is included in each module.

InfoTeam Turbo Accounting is available on 3½- and 5¼-inch disks. It runs on the IBM PC, XT, AT, and compatibles.
Price: $99.
Contact: Info Designs Inc., 445 Enterprise Court, Bloomfield Hills, MI 48013, (313) 334-9790.
Inquiry 763.

Financial analysis at your fingertips.

Scoring Big with Mutual Funds

Mutual Fund Scoreboard disks are issued quarterly by *BusinessWeek* and cover equity and fixed-income funds listed in the NASDAQ system. The current version of the Scoreboard includes the critical fourth quarter of 1987 and covers approximately 728 equity funds and 536 fixed-income funds.

The Scoreboard disks offer more than 25 fields of information, including a rating by *BusinessWeek*, which measures a fund's performance adjusted for risk and sales charges. You can retrieve information from the fields in a variety of ways; for instance, you may want to know which no-load funds emphasize growth, or which outperformed Standard & Poor's 500-stock index in the past 5 years.

You can convert the data to Lotus 1-2-3 or ASCII format. The Scoreboard runs on the IBM PC and compatibles with at least 256K bytes of RAM and DOS 2.1 or higher. A data management program is included on each disk, so you can access and print the information.
Price: $49.95 per disk; $149.95 for annual subscription to either Equity or Fixed Income disks; $239.95 for annual subscription to both Equity and Fixed Income disks.
Contact: *BusinessWeek*, 1221 Avenue of the Americas, New York, NY 10020, (800) 553-3575; in Illinois, (312) 250-9292.
Inquiry 764.

Developing Business Programs

Concept 1.0 from Archimedes lets you prepare documents, design forms, write programs, generate spreadsheets, and organize a database. The word-processing, report-processing, and database management functions are integrated with a programming language. Archimedes says you can add macros, templates, and data libraries.

Concept comes with software for word processing and mailing-list management, a pop-up calculator, a calendar, and an accounts receivable module.

The program runs on the IBM PC, XT, AT, and compatibles with 512K bytes of RAM and DOS 2.0 or higher. It also runs on PS/2s.
Price: $195.
Contact: Archimedes Inc., O'Hare Lake Office Plaza, 2350 East Devon Ave., Suite 242, Des Plaines, IL 60018, (312) 635-0715.
Inquiry 765.

A Micro-Based Management Information System

EMIS II (executive management information system) keeps databases of phone calls, letters, prices, invoices, delivery dates, when to call back, and buying cycles. It can offer you figures on sales, call activity, time spent on the phone, internal memos, averages, and summaries.

The Dossier is the program's central file. Stored in the Dossier are names, addresses, phone numbers, ZIP codes, titles, and greetings, along with information fields that you can designate. You can display past activity of the account with the files and include forms, memos, call dates, buying patterns, and other information.

EMIS II has three levels of security. The first requires that you have an operator code. The second limits certain data segments to only those users who have optional passwords. The third level lets managers limit access of certain functions.

The program uses the Btrieve Record Manager, which sorts by midpoints, moving you closer to the desired files than alphabetical sorting, according to the company. You can separate databases into data segments, and transfer files between data segments. You can also import and export ASCII information. The program also has a forms- and report-producing capability.

EMIS II runs on the IBM PC, XT, AT, and compatibles with 512K bytes of RAM. It also runs on PS/2s, and there is a multiuser network version.
Price: $1495 for single-user version; $2495 for three-user version; $1995 for every three users added.
Contact: EMIS Software Inc., 901 Northeast Loop 410, Suite 526, San Antonio, TX 78209, (512) 822-8499.
Inquiry 766.

continued

Some Datacomm Standards Should Be Carved in Stone

In the matter of full-duplex data communication at 9600 bps, a number of approaches have been discussed. There's the CCITT-approved V.32. There are even some "pseudo V.32s" around. Some suggest that, because of their somewhat lower cost, non-standard modems may be the answer.

At Universal Data Systems, our position is carved in stone: for full end-to-end compatibility, regardless of equipment source, standardization on true V.32 is the only workable solution.

That's why the fully featured UDS V.32 is the acknowledged price/performance leader.

Our exclusive near-end/far-end echo cancellation techniques, combined with trellis coding, result in −17 dBm signal-to-noise ratio; that's plenty of horsepower for voice-grade lines.

As back-up for your dedicated four- or two-wire system, or for a 9600 bps upgrade of your present dial-up communications, check out the UDS V.32. It's the standard!

Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35805. Telephone 205/721-8000; Telex 752602 UDS HTV.

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Quantity One

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Universal Data Systems

MOTOROLA INC.

Circle 280 on Reader Service Card

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

SOFTWARE • OTHER

SCORPIO ON THE DESKTOP

The Scorpio desktop publishing system features WYSIWYG editing, up to 4096 pages per document, up to 40 columns per page, automatic text flow, and both automatic and manual kerning. It comes with nine fonts, which include two font families plus a utility font. Other features include automatic text-overflow handling, automatic page numbering, and headers and footers.

Text-formatting capabilities include style-sheet definition and recall, superscript and subscript, and type sizes of up to 72 points in 1-point increments. You can enter text directly on the screen or import ASCII files or files from WordStar or PC Write.

The program supports a variety of scanners, graphics monitors, and mice. It runs on the IBM PC XT, PC AT, or compatible 386 systems. Minimum configuration is 640K bytes of RAM, a graphics monitor, a mouse, and a printer.

Price: $595.

Contact: Via-PC, 1571 West Katella Ave., Suite E, Anaheim, CA 92802, (714) 491-8871.

Inquiry 790.

Take a Closer Look

Zoom in on your text with ZoomText, a RAM-resident character-magnification program. It magnifies text from 2 to 8 times its normal size, and three fonts let you vary the thickness and spacing between characters. When you use it with a monochrome monitor, ZoomText supports all character attributes including reverse video, high intensity, blinking, and underline. With a color monitor, ZoomText supports all foreground and background colors as well.

ZoomText doesn't require any special hardware, according to Algorithmic Implementations. It runs on the IBM PC, XT, AT, and compatibles with DOS 2.0 or higher. It uses 50K bytes of RAM and requires an EGA card and compatible monitor.

Price: $495.

Contact: Algorithmic Implementations Inc., 1463 Hearst Dr., Atlanta, GA 30319, (404) 233-7065.

Inquiry 791.

Turn Your DeskJet into a Plotter

You can turn your Hewlett-Packard DeskJet printer into a plotter to print engineering drawings, business graphics, and other documents with Insight's DeskPlotter utility. Insight claims the software is completely transparent to your plotter applications. A control panel lets you set print characteristics according to your needs, including the plotting resolution, the width of each pen, and the shade of gray. If you need to plot multiple graphs, you can queue as many plot files as you like.

DeskPlotter will run any program that outputs HPGL (Hewlett-Packard Graphics Language). It runs on the IBM PC, XT, AT, and compatibles and emulates the HP 7470A, 7475A, and ColorPro.

Price: $129.

Contact: Insight Development Corp., 1024 Country Club Dr., Suite 140, Moraga, CA 94556, (415) 376-9451.

Inquiry 792.

Multitasking Word Processor

Jandi Technologies calls EPEC the first word processor in a multitasking windowing environment. EPEC stands for "editor for productivity, enjoyment, and creativity."

The windowing system supports overlayed windows and concurrent multitasking. The word-processing features include underline, boldface, text reformat, word wrap, pagination, and multiple undo and redos. You can also edit across windows, moving text between documents, or you can edit the same document in separate windows, so you don't have to scroll to edit.

Other editing features include editing an area as if it were a subdocument, so you can reformat or reshape it if you need to accommodate graphics. You can also generate cross-references by listing lines and line numbers that contain a specific text string. You can assign up to eight function keys as macros.

The program runs on the IBM PC, XT, AT, and compatibles with 256K bytes of RAM and DOS 2.0 or higher.

Price: $99.

Contact: Jandi Technologies Inc., 155-U New Boston St., Woburn, MA 01801, (617) 932-0629.

Inquiry 793.

Bridging CP/M and DOS

DosDisk lets you use DOS disks on your CP/M system, according to Plu*Perfect Systems. You can log into the PC disk and read, write, rename, create, delete, and change the attributes of MS-DOS files. You cannot, however, format DOS disks or run MS-DOS programs. DosDisk will read ASCII, dBASE II, WordStar, and other formats, and it maintains the date and time stamps of DOS files.

The program supports standard 360K-byte disks. A resident system extension version uses about 4.75K bytes of RAM, plus 2K bytes for the command processor. The program runs on many CP/M systems. If it doesn't run on your system and you have experience in Z80 programming, you can purchase a kit version and configure it to your system.

Price: $30; kit version, $45.

Contact: Plu*Perfect Systems, 410 23rd St., Santa Monica, CA 90402, (213) 395-4984.

Inquiry 794.

Stay in Tune with the Weather

Accu-Weather Forecaster translates National Weather Service codes and lets you display them in maps and graphs.

To use Accu-Weather Forecaster, you need to set up an account with Accu-Weather. Metacomet reports that an average forecasting session will cost $2 in connect-time charges with Accu-Weather.

The forecasting program lets you preselect what data you want from the database; it goes on-line and retrieves it, saves the data to disk, and logs off. You can specify temperature, barometric pressure, precipitation, and other variables for the entire country, or you can zoom in on individual regions or cities.

Accu-Weather Forecaster runs on the IBM PC with 256K bytes of RAM, DOS 2.0 or higher, two floppy disk drives, a color or monochrome monitor, and a CGA card or compatible. A version is available for the Mac 512, Plus, and SE. A Hayes-compatible modem is required.

Price: $89.95 for either the IBM or Mac version.

Contact: Metacomet Software, P.O. Box 31337, Hartford, CT 06103, (203) 223-5911.

Inquiry 795.

The 3.5" Migration.

As though by the force of nature, computer users are flocking to the new 3.5" standard.

A Clear Flight: A top-quality 3.5" drive allows direct access between older and newer systems, between IBM PC/XT/AT, compatibles and PS/2 systems, and between home office desktops and laptops in the field. And most experts agree that it's better to upgrade an older system with a 3.5" floppy drive than to downgrade a new system with an old-technology drive.

A Third First: Manzana introduced the industry's first 3.5" upgrade in 1985, and the first 1.44MB drive in 1987. Today, Manzana introduces the 3rd Internal™ drive, for those with room for more than two.

Maximum Versatility: Manzana offers several drive configurations, including an internal, a host-powered external, and a self-powered external. All systems come with Manzana's own 3Five® software, which runs with MS-DOS version 2.0 or higher, to read, write and format disks at 1.44MB, 720K, and non-standard MS-DOS formats, including HP 150 and 110.

Flying to PC Expo? See us in Booth #2520. Or call 805/968-1387, FAX 805/968-5449, TELEX 4932215 or write for the whole story on The 3.5" Migration, and literature on the full line of Manzana drives: Manzana MicroSystems, Inc., P.O. Box 2117, Goleta, CA 93118.

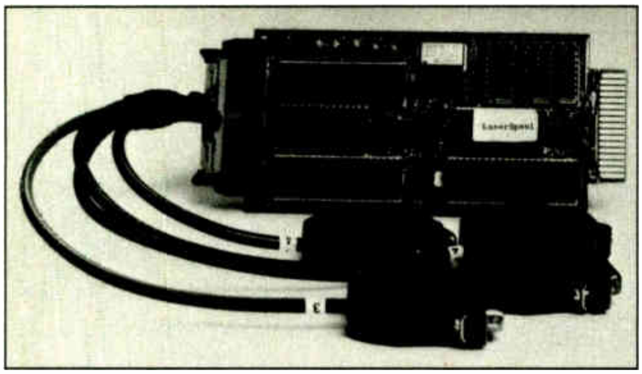
Soon you'll be heading in the right direction from instinct alone.

Manzana™ drives it home.

Circle 484 on Reader Service Card (DEALERS: 485)

REGIONAL SECTION

METRO NEW YORK • NEW ENGLAND



LaserSpool lets three IBM PCs share a LaserJet II.

Share the Jet

LaserSpool is a board that plugs into the Hewlett-Packard LaserJet II I/O slot, allowing three IBM PCs or compatibles to share the printer.

It includes software that enables you to select resident printer fonts and use copy and control functions. The board also includes a 250K-byte print buffer and utilizes DB-25 or RJ-45 connectors for the three serial inputs.

Price: $395.

Contact: PrintManager, 108 Water St., Watertown, MA 02172, (800) 642-5019 or (617) 924-3952.

Inquiry 840.

"Mark Well" Gets Better

Nota Bene is Latin for "mark well," and with about a dozen major features added to version 3.0 of the word-processing program, it will help you "mark" even better. Based on XyWrite and long a favorite in the academic world, the program now offers a 100,000-word spelling checker, a thesaurus, and redlining capabilities.

Text-retrieval capabilities are also added in the new version. You can search for words, phrases, and combinations of phrases using Boolean operators. You can display or print matches and insert them into the document you're working on.

Nota Bene 3.0 supports IBM's DCA (Document Content Architecture) file format. You can automatically print envelopes, selecting from a menu of nine styles. The text-sorting capability has been expanded, allowing you to sort based on values found in any column of text.

The program provides a menu that lets you select printer fonts by name, and another menu that lets you download portrait or landscape fonts on Hewlett-Packard and compatible laser printers. This menu indicates memory requirements for each font and the remaining memory available in the printer. You

continued

Circle 483 on Reader Service Card

HIGH SPEED PC TO PC COMMUNICATIONS

Breaking the Baud Barrier

Here's how your 2400 baud modem can send data as fast as a 9600 baud modem for less than $90.00

Leigh Tracy

When you got your first modem—that neat little 300 or 1200 baud job—you really thought you had it made, all the power, speed and convenience you'd ever need to move data from PC to PC. *Right?*

Now, of course, if you've got lots of data to move, you've recently bought or are considering switching over to 2400 baud speed. And, in reality, if your company is a power user it would make a lot of sense in saved time and telephone bills to be running at 9600 baud, if it were not for the initial overwhelmingly high modem hardware costs.

Enter *TurboCom* high performance PC to PC modem software by Datran, the clever Southern California based state-of-the-art data compression specialists that brought you the great *dCompressor* short card that triples the dBASE storage capacity of any hard disk.

Modems Run 4 Times Faster

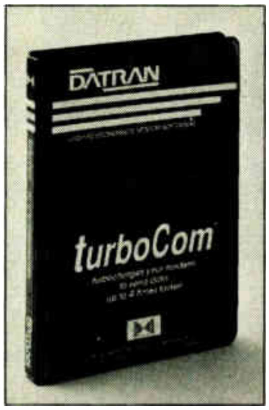
TurboCom turbocharges your Hayes compatible modem to send data files (letters, documents, reports, data bases, spreadsheets, binary files, programs) up to four times faster with your existing 300, 1200 or 2400 baud modems. And it sells for only $89.00 to connect two PCs.

When the good people at Datran sent me *TurboCom 3.0* for a test run, I was amazed at how simple and well thought out it was for the ordinary person (like me) to use.

TurboCom Facts:

Version 3.0	*Requirements*:
Each package has software for use with two PCs.	IBM PC/XT/AT, 386 or compatible. Minimum 384K RAM, PC-DOS, MS-DOS 2.0 or greater.
$89.00	Internal or external Hayes compatible modem. TurboCom at both *sending* and *receiving* PCs.
Datran Corp. Order direct: 1-800-332-0456	

Leigh Tracy is a consultant and freelance writer whose columns have appeared in many microcomputer magazines.



Transfer data files PC to PC up to four times faster.

Easy to Send and Receive

TurboCom is the easiest to learn and use modem software that I've ever tried. No menus are required. It's as simple to use as the COPY command! To send data with *TurboCom*, all you do is type:

```
C>SEND FILENAME PHONE NUMBER
```

To program for delayed transmission you type:

```
C>SEND FILENAME PHONE NUMBER AT TIME
```

That's all you do. Then, the continuing status of the transmission automatically appears on the screen until file transmission is completed.

Receiving transmitted TurboCom messages is automatic and unattended. Simply type **C>RCV** and TurboCom does the rest.

Any businessman, insurance broker, accountant, office manager, secretary or salesman on the road that can use a PC can simply operate *TurboCom*. It's that simple.

Unattended Electronic Mailbox

TurboCom is ideal as a fast, low cost mailing system between offices or companies. The sending PC is aware of how much disk space is available at the receiving end. If a file is transmitted with the same name and extension, TurboCom will assign it a unique extension, i.e., !-1, !-2, !-3. If the receiving PC does not have sufficient disk space for the file you are sending, *TurboCom* terminates the phone connection, saving time and wasted money.

Increased modem speed allows you to save up to 75% on your telephone time and costs. Because *TurboCom* can be programmed for delayed unattended transmission for automatic sending, you can transmit data when telephone rates are lowest. PC to PC data is transferred perfectly because *TurboCom* was designed with an advanced error-free high speed protocol.

Because of *TurboCom*'s high speed, cost savings, flawless operation and sensational low $89.00 price to connect two PCs, I give this product my highest recommendation.

Turbo Your Laptop

Each TurboCom package comes with both 5-1/4" and 3-1/2" diskettes, which makes it ideal to run with laptops, too. It is not copy protected.

To order direct from Datran, you can call toll free at 1-800-332-0456. They accept MasterCard and Visa and will ship within 24 hours with a 30-day money-back guarantee.

ORDER TODAY TOLL FREE:
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$89.00 VISA

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DATRAN

Leadership in Data Compression Technology
Datran Corporation
2505 Foothill Blvd., La Crescenta, CA 91214

can view lines of more than 80 columns without having to scroll horizontally, and you can merge graphics output files from other programs with text when printing.

Nota Bene 3.0 runs on the IBM PC, XT, AT, PS/2, and compatibles with DOS 2.0 or higher and 384K bytes of RAM.
Price: $495.
Contact: Dragonfly Software, 285 West Broadway, Suite 600, New York, NY 10013, (212) 334-0445.
Inquiry 835.

Lotus Crams More into Less

Has Lotus perfected the art of packing everything into a small suitcase? You would think so, looking at what the company has done with this new version of Metro, its desktop-management program.

The TSR (terminate-and-stay-resident) package of desk accessories now requires about half the space of version 1.0, taking up as little as 64K bytes of RAM. It accomplishes this through The Swapper, which is the kernel of the program and is permanently in memory. The Swapper accesses additional memory only when you call on one of Metro's accessories. You can view and change memory allocations and enable or disable The Swapper.

Metro 1.1 includes the same accessories as version 1.0: a macro generator, a list manager, a phone book, an appointment book, a calculator, a DOS file manager, a text editor, a clipboard, a notepad, an activities timer, and a list of special characters.

The program runs on the IBM PC, XT, AT, and compatibles with DOS 2.1 or higher. If you're running the program without The Swapper, it requires two 5¼-inch floppy disk drives or one 3½-inch floppy disk drive; a hard disk drive is required when running The Swapper. It takes up 64K bytes of RAM with The Swapper, and 125K bytes without it. It is not copy-protected and comes on both 5¼- and 3½-inch floppy disks.
Price: $85.
Contact: Lotus Development Corp., 55 Cambridge Pkwy., Cambridge, MA 02142, (617) 577-8500.
Inquiry 836.

Sound Design on the Amiga

SpeakerSim is a CAD program that assists you in designing loudspeaker systems. You can analyze loudspeakers and enclosures in accordance with the Thiele-Small Vented model.

The program comes with data files containing parameters for over 100 loudspeakers, and you can add new loudspeakers to the data files. You can also produce graphs of small signal response, maximum acoustic output, and excursion or thermally limited output.

The program enables you to produce three-dimensional graphs, calculate enclosure vent dimensions, and save screens in IFF format. It supports screen resolutions of 640 by 200 and 640 by 400 pixels with 16 colors from a palette of 4096.

SpeakerSim runs on the Amiga 500, 1000, and 2000. A color monitor is recommended.
Price: $112.
Contact: dissidents, 730 Dawes Ave., Utica, NY 13502, (315) 797-0343.
Inquiry 839.

We Are Moving to a New Facility to Better Serve our Customers

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EGA 286 386

NEW

SYSTEM INCLUDES:
- **3.5" 720KB DRIVE**
- **5.25" 1.2MB DRIVE**
- **20MB HARD DISK**
- **1200/300 INTERNAL MODEM**
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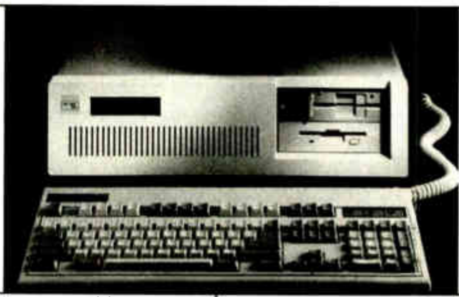

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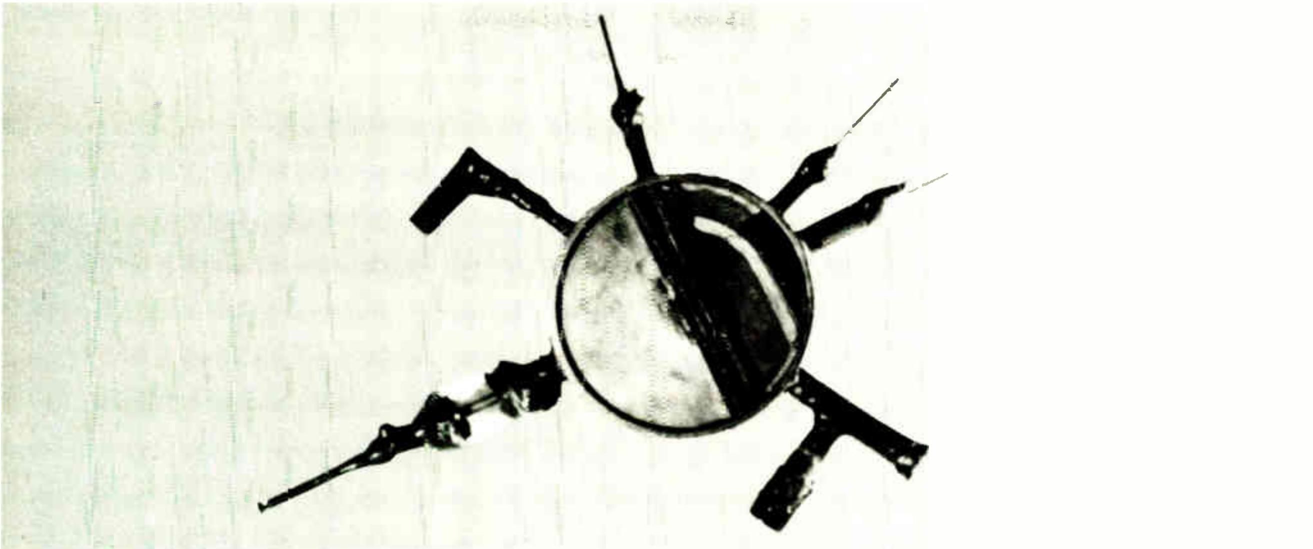

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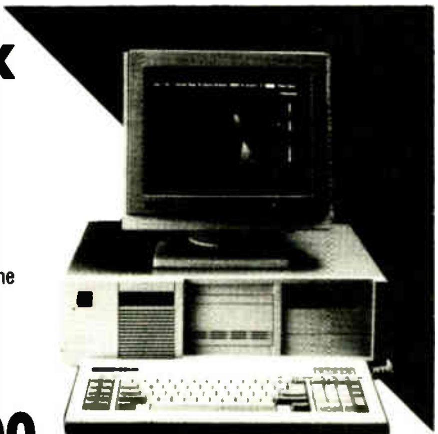

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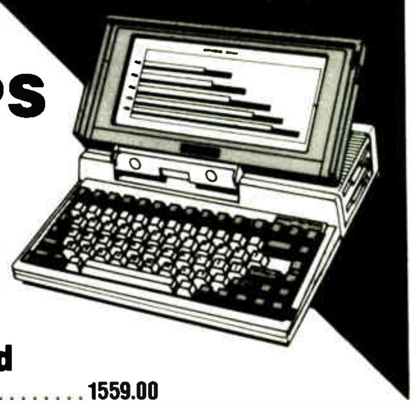

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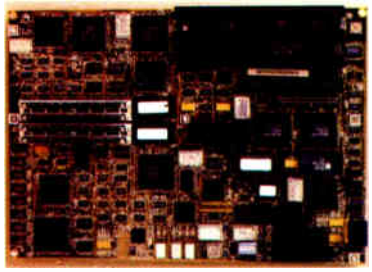

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LetterMaster™

4:30 "Susan—Send our sales letter to all buyers of apples and cherries in Washington and oranges or bananas in Florida, in time for today's 5:00pm pick-up.—Mr. Wermer."

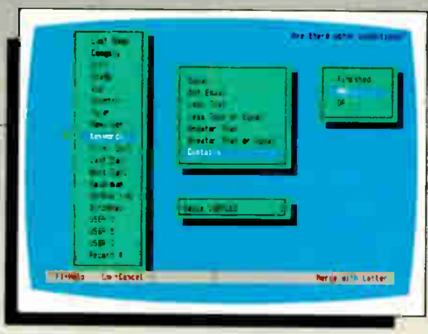
4:32 Mailing lists sorted.

Our new LetterMaster mailing software is a lifesaver. It sorts any list according to any criteria in its own internal database and our dBASE® III files.

4:33 Lists merged and purged.

LetterMaster merges lists and purges duplications in a matter of seconds. It's incredible! I can create instant custom mailing lists with a few keystrokes!

4:38 Personalized sales letters printed.

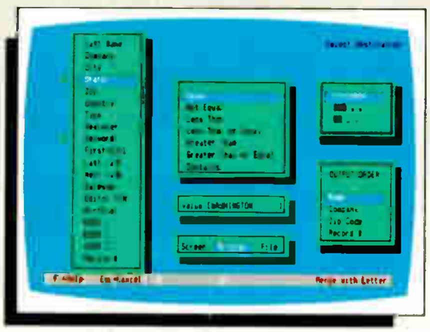


With LetterMaster, all I do is name the list, name the letter, activate the printer, and "go do." It's that simple!

4:41 Labels printed.

LetterMaster prints off any list onto leading brand address labels. It prints Rolodex cards and file folder labels, too.

4:45 Mailing complete and ready for pick-up.



LetterMaster operates with all the popular word processing programs. About the only thing it doesn't do is lick the envelopes!

System requirements for Single User: DOS 2.1 or higher. IBM PC or your IBM PS2, or 100% compatable. 512K RAM. System requirements for Network Work Station: DOS 3.1 or higher. 640K RAM, any combination of hard, floppy or no-disk drives. Trademark/Owners: LetterMaster/Dilg Properties, Inc., dBase III/Ashton-Tate Corp., IBM PC & IBM PS2/International Business Machines Corp. DOS/International Business Machines Corp. and Microsoft Corp.

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A Color Paint Application for the Mac II

SuperMac Software's **PixelPaint** does for color graphics on the Mac II what MacPaint did for the original 128K-byte Mac in black and white: It lets you draw in color using a simple user interface. The lasso, marquee, grabber, bucket, spray can, brush, pencil, and eraser tools that you used in MacPaint are included. You still have the ability to enter any style of text and draw lines of any thickness or direction, as well as rectangles, ovals, polygons, and freehand shapes.

However, these tools come with new capabilities, thanks to color. You can pick 256 colors out of a palette of 16 million for the bucket, spray can, brush, and pencil to use. You can draw the shapes in any color or have them filled with color as you draw them. PixelPaint also has two new tools: the eyedropper (click it on a particular color to use the same hue in a new spot—a lot simpler than trying to remember the color's RGB values) and the arc tool (handy for drawing arcs or Bézier curves).

PixelPaint's real power lies in this: Click on the box labeled Normal Tools and it becomes Special Effects, and these tools take a quantum leap in color capabilities. Now the bucket tool can do color blends, with the blend effect (e.g., top-to-bottom, left-to-right, sunburst, and venetian blinds) determined by selections in the option menu.

Spray can and brush operations cycle through the entire spectrum of colors as they work, or within a user-selected range of colors. With the brush, you can also perform shadow, charcoal, wash, smooth, shade, and smear effects. Lines can be drawn as fractals, radials, and neon (a line with colored edges that resembles a neon tube), as well as the cycle effects just described. Properly handled, these Special Effects yield color images whose appearance can only be described as breathtaking.

PixelPaint prints to PostScript devices like Apple's LaserWriter and the Linotronic 100 and 300. I successfully printed a color image to a networked LaserWriter and got the expected gray-scale image. Printing to the Imagewriter II is not supported because PixelPaint images can have up to 256 colors, which is beyond the ability of the Imagewriter II to reproduce accurately. PixelPaint can open MacPaint, PICT, and encapsulated PostScript files, letting you import graphics from Mac applications like MacDraw, Adobe Illustrator, and Cricket Draw.

At a price of $495, you'd expect copy protection on such a product. But in a bold move on SuperMac's part, PixelPaint was introduced without copy protection. The diligent user can produce publication-quality color graphics of great sophistication with PixelPaint. If you bought a Mac II to do professional graphics, you'll do well to make PixelPaint your first software purchase.

—Tom Thompson

Artwork by Bert Monroy

The Facts:

PixelPaint 1.0
$495

SuperMac Software
295 North Bernardo
Mountain View, CA 94043
(415) 964-9694
Inquiry 853.

Requirements:
Macintosh II with 256-color video board and 1 megabyte of RAM; color monitor and 2 megabytes of RAM recommended.

Don't Be Intimidated by OS/2

The Norton On Line Programmer's Guides: OS/2 API ease the task of learning and using OS/2 functions. The database of information is organized alphabetically and logically. While the alphabetic listing is valuable for experienced OS/2 programmers, the logical organization of the information is great for those of us who are trying to figure out what's going on with this new operating system. One of the most valuable features is a cross-referencing line that points you to information related to what's currently on the screen.

The program is menu-driven, and you can choose to start with an introduction to OS/2. It gives a brief summary of what OS/2 and DOS have in common and what's different, lists which OS/2 function calls correspond to which DOS interrupts, and includes a section discussing 15 areas of OS/2 (e.g., multitasking and semaphores). The related function calls are grouped for each of the 15 areas.

From the menu, you can choose system, file, mouse, and video calls. The first level in each group is an alphabetic list of the function calls, followed by a short description. The second level gives you a detailed discussion of the function, including what parameters it requires, what it returns, what include files it needs, and whether it works in DOS mode.

continued

This is followed by an actual example of using the call, both from C and assembly language.

Other useful information you can find under the reference menu includes a complete list of the IOCTL functions (functions for sending device-specific commands to a device driver), a discussion of OS/2 device drivers and related functions, and the error and return codes for DOS 2.x, DOS 3.x, and OS/2. There is also a menu item for the ANSI escape sequences, the CONFIG.SYS commands, and the OS/2 structures, which are the predefined C structures that OS/2 function calls use to pass data to and from functions.

The package includes a version of the program for OS/2 mode and for DOS mode.

In OS/2 mode, you can install the Norton Guides as a pop-up program that is available to all OS/2 screen groups or as a stand-alone application in one OS/2 screen group. When you run the Guides as a pop-up program, you activate them with a hot key (Shift-F1), and while the Guides are activated, the OS/2 hot keys for switching to another screen group are disabled until you leave the program.

The disabling of the screen group hot keys is a function of the OS/2 pop-up call; tasks continue to run in the background. If you want to be able to switch screen groups while the Guides are on the screen, you can install them as an application. The two methods of running the Guides let you have two databases open on the screen at the same time.

In DOS mode, you can have the Guides as a terminate-and-stay-resident (TSR) program that takes up about 65K bytes of RAM; you can easily remove it from memory if you need the space.

Other features include a compiler and a linker that let you create custom databases. There is a full-screen and a half-screen mode, and you can search for all or part of a keyword. An auto-lookup feature looks up the word under the cursor when you activate the Guides.

I highly recommend this program. Using it is an order of magnitude easier than thumbing through the OS/2 manual to get the information you need. The interface is intuitive, and the information is presented in a clear and even conversational manner.

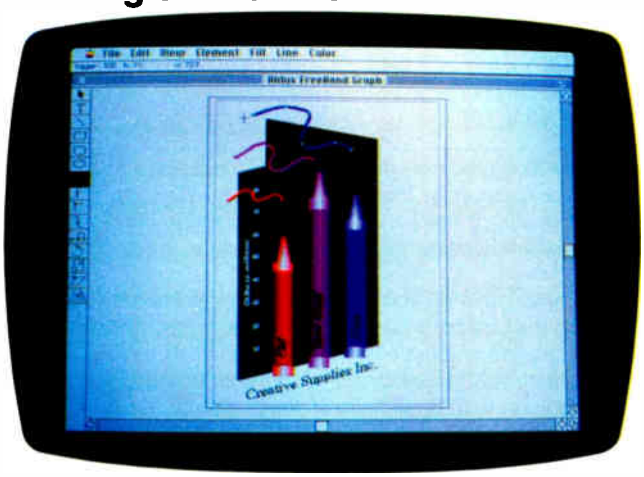
The Facts:

The Norton On Line Programmer's Guides: OS/2 API
$150 with Instant Access Engine; $100 without engine

Peter Norton Computing Inc.
2210 Wilshire Blvd., Suite 186
Santa Monica, CA 90403
(213) 453-2361
Inquiry 852.

Requirements:
IBM PC or compatible with DOS 2.0 or higher, or OS/2.

Drawing on the Mac



The Facts:

FreeHand 1.0
$495

Aldus Corp.
411 First Ave. S
Seattle, WA 98104
(206) 622-5500
Inquiry 851.

Requirements:
Macintosh Plus or 512Ke with at least 1 megabyte of RAM, two 800K-byte floppy disk drives, or a hard disk drive; Mac SE with two 800K-byte drives or a hard disk drive; or Mac II with two 800K-byte drives or a hard disk drive.

FreeHand. Sounds like a light, fun sort of drawing program, right? Well, don't let the name fool you. We're talking serious drawing here. This is a Macintosh package for people who need to produce clean art and copy that are ready to go to the print shop.

The folks at Aldus may not like this comparison, but FreeHand is similar to Adobe Illustrator in that it uses a connect-the-dots approach. This is great for working up a polished version of a rough sketch. You scan the sketch, bring it into FreeHand, and then trace it. The program is like a multidimensional tracing pad.

The tricky part is doing the tracing. You can put down points (dots) on the object you're tracing and then connect the points using various tools, or you can use the freehand tool that lets you draw by dragging the mouse. I found both methods to be awkward, but it's not Aldus's fault that the mouse is like drawing, as someone said, with a brick.

The FreeHand toolbox is geared toward building drawings using straight lines, curved lines, angles, diagonals, and shapes (squares, ellipses, and boxes with rounded corners). Transformation tools let you rotate, stretch or compress, slant, and reflect images. A text tool lets you add type to a drawing; it's a basic Mac-style editor that lets you change fonts, specs, and even colors.

The program's color capabilities make it a serious program for pre-press work. A print shop handles color in two ways: spots of one color here and there on an illustration, or process color, which basically breaks an image into tiny dots and colors them with a mix of four pigments that tricks the eye into thinking it's looking at one color. FreeHand will let you set up a drawing to use spot or process color. (Adobe Illustrator 88 is supposed to have some of these same capabilities that make FreeHand shine, but we're still waiting for it.)

There's no room here to describe how the program does

continued

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this, but it lets you mix basic colors on your screen to get the shades you want. (On a black-and-white screen, you get black, white, and gray instead of red, green, cyan, turquoise, or whatever.) The program comes with a chart that shows you how to mix basic colors to get not-so-basic colors. The folks who wrote the FreeHand manual do a good job of explaining this whole process, but if you're not familiar with how color printing works, you should talk with someone who is before you take your copy down to the print shop.

FreeHand can send output to a PostScript device or to QuickDraw printers like the Imagewriter. You can adjust the resolution so that a printer can make plates with the copy you provide. Setting up a drawing for printing is relatively easy.

As a way of converting a sketch into camera-ready copy, FreeHand is great. One of the things that's supposed to distinguish this package from, say, Adobe Illustrator, is its set of freehand drawing tools. In other words, you can use this software to draw (rather than just trace), edit, and enhance pieces of art done outside the program.

As far as drawing and painting ability goes, I think there are better stand-alone programs with these capabilities than FreeHand. In software heaven, you'd have both: a good graphics package—like MacPaint, SuperPaint, or GraphicWorks—to create your original art, and FreeHand to get the art ready for the printer. However, the real world is not software heaven, and we mortals must pay for programs.

If I needed a package for drawing and painting and didn't need to worry about sending multilayered illustrations to a print shop, I'd go with something else. But for serious stuff that's bound for the printing press, things like technical diagrams or ad copy, FreeHand wins hands down. If I needed both, I'd buy FreeHand and hope that Aldus adds some better freehand drawing tools next time around.

—*D. Barker*

A Hand-Held PC Compatible

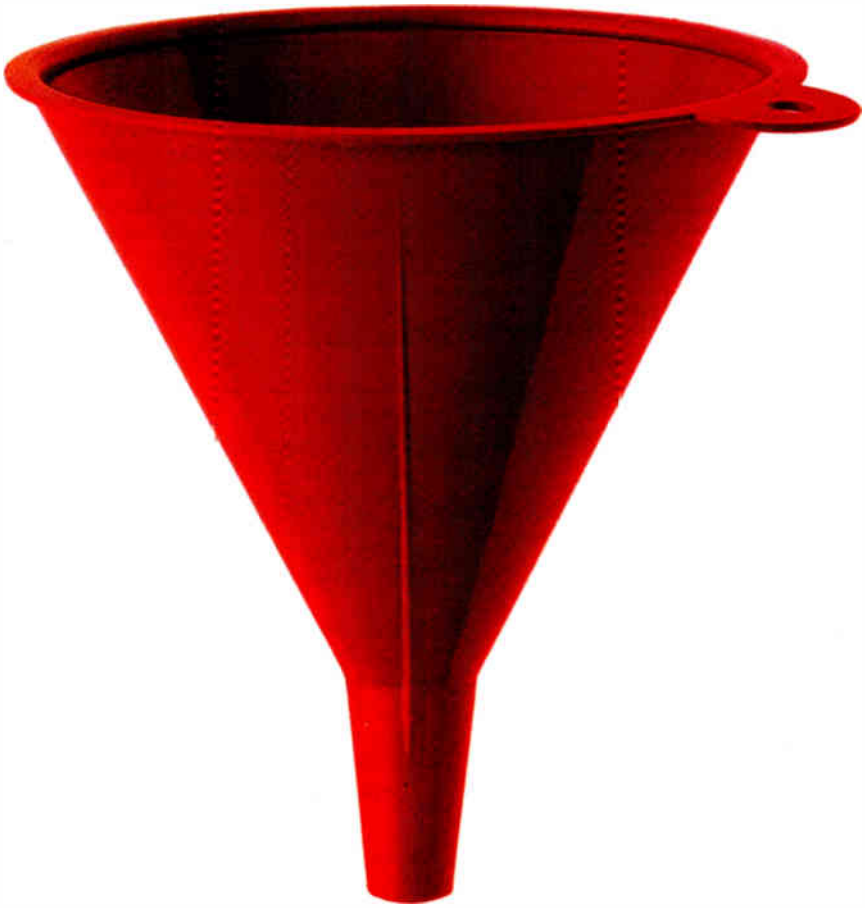
The **Datacomputer** is a portable computer designed for data collection and portable processing. It uses the same CPU as an IBM PC, so you can develop programs on the PC and download them to the Datacomputer. Its small size and ergonomic design make it a true hand-held computer.

Transferring programs to the Datacomputer is simple. I connected my AT to the Datacomputer with an RS-232C cable. Then I ran the data transfer program on the AT. Next I selected the Load Program function from the Datacomputer's on-screen menu. The NDCDL program can automatically download a program to the Datacomputer at 9600 bits per second (the default setting) using the XMODEM protocol. NDCDL also has an optional mode for interactive commands to change the COM port used, path names and filenames, and the data transfer rate. I could also connect one Datacomputer to another for a program transfer.

The computer uses an 80C88 microprocessor and a CMOS version of the 8088, and it has 128K bytes of RAM, expandable to 960K bytes with optional memory modules. The screen is a backlit 26-character by 8- or 10-line liquid crystal display. The keyboard includes a full-size numeric keypad and a small QWERTY keyboard. The unit measures 10 by 5 by 1½ inches and weighs 35 ounces. It is powered by either four or eight AA alkaline or nickel-cadmium batteries.

External connections to the computer include an 8-pin DIN serial printer port, a DB-25 RS-232C serial port, a DB-9 bar code scanner port, an optional RJ-11 modem jack, and a

continued



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coaxial connector for an external power supply. All the connectors are located behind a flip-down access cover that has a neoprene gasket to seal out the elements.

The standard system includes a utility software disk for the IBM PC, with programs for downloading and uploading files, memory-resident file management, an interactive data manager, and data space management. The computer can store and run .EXE files created in BASIC, C, Pascal, assembly language, or other programming languages.

The Datacomputer is also available as part of a Developer's Kit, which includes a software developer's manual, two 5¼-inch floppy disks containing communications software for downloading programs to the Datacomputer, software routines for data compression, screen and keyboard interfaces, peripheral drivers, and bar code decoding software. The kit also includes a PC-to-Datacomputer RS-232C cable and a nylon case for the computer.

The Datacomputer's small size, rugged construction (it can survive a drop to a concrete floor), and the gaskets that seal the access and battery compartment covers make this computer ideal for use in harsh environments like factories and warehouses. A variety of bar code scanners can be directly connected to the computer. Because it's programmable, the Datacomputer can be used for a variety of applications in locations where you wouldn't want to risk an ordinary computer.

—Stanley J. Wszola

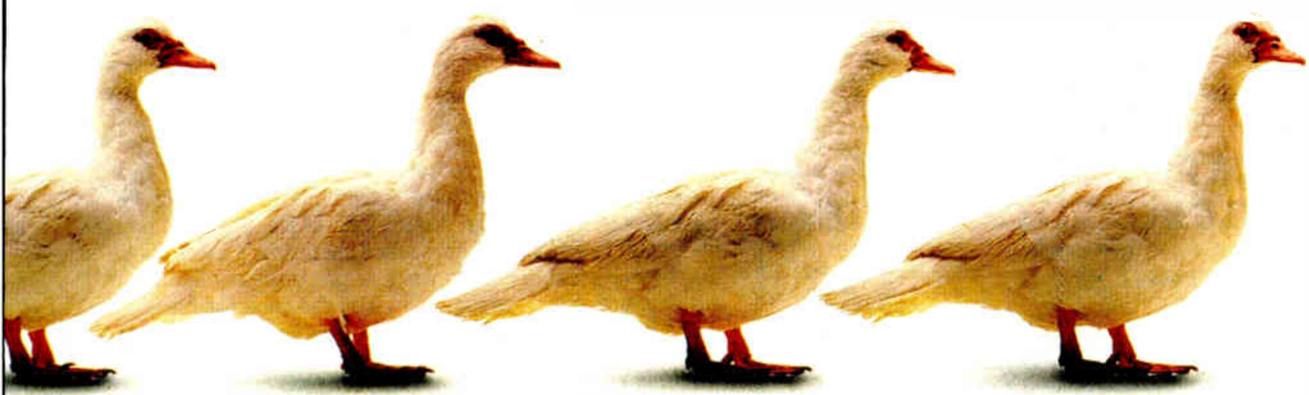
The Facts:

Datacomputer DC 3.0
128K bytes of RAM, $1995;
384K bytes, $2245;
640K bytes, $2495;
960K bytes, $2795;
Developer's Kit, $2245

National Datacomputer Inc.
Middlesex Technology Center
900 Middlesex Tnpk.
Building 5
Billerica, MA 01821
(617) 663-7677
Inquiry 856.

Options:
10 AA battery pack, $39; printer cable, $39; 300-/1200-bps internal modem, $199; bar code readers: pencil wand, $159; non-contact four-LED scanner, $429; fixed-beam infrared laser, $439; moving-beam laser scanner, $869.

continued



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Two TSRs to Help You Manage the RAM Traffic Jam

The Facts:

PopDrop 3.1
$49.95

InfoStructures Inc.
P.O. Box 32617
Tucson, AZ 85751
(602) 299-5962
Inquiry 854.

RAM Lord
$99.95

Waterworks Software Inc.
913 Electric Ave.
Seal Beach, CA 90740
(213) 594-4768
Inquiry 855.

Requirements:
IBM PC, XT, AT, or compatible, or IBM PS/2;
DOS 2.0 or higher.

Managing the gaggle of memory-resident programs that resides in a typical IBM PC's RAM is about as much fun as keeping tabs on a room full of kindergarten kids. TSR programs are often a badly behaved lot when you force them to work together. They stomp on each other's electronic toes, greedily grab for identical interrupts and precious memory space, and even throw tantrums by completely locking up your system.

OS/2 is supposed to eliminate all this so-called RAM cram. But in the meantime, you either have to live with it or take action. If you opt for action, remedies can come in the guise of two programs (themselves memory-resident) designed to deal with TSR discipline.

InfoStructures' **PopDrop** has been around for a few years, and version 3.1 is a completely new incarnation. It has developed into an effective and useful program with an elegantly simple user interface. Each time you run PopDrop, it generates a record of your system's RAM status (taking up about 600 bytes of RAM space the first time it's used; about 200 bytes thereafter). Then you load one or more of your resident programs "on top" of it. You can create layers of TSRs in your system RAM by simply rerunning PopDrop at any point. All the TSRs you've loaded between invoking the program become a *layer*.

But no matter how clever TSR programs like PopDrop are, the programs are still stymied by the way that MS-DOS was designed. If you need RAM space for other programs, you *must* unload the programs in the reverse order of how you loaded them in. Not unlike an onion, PopDrop lets you peel off the layers of TSRs that you built, in the event that you need to free up the RAM for other use. You can also tell PopDrop to deactivate TSRs without freeing the memory. And with a bit of planning, you can use PopDrop in batch files to load and unload TSRs with applications without making your RAM a completely scrambled mess of holes and unused code.

In contrast to PopDrop, **RAM Lord** from Waterworks Software takes a different and unique approach to managing TSRs. It lets you have access to up to 20 RAM-resident programs while taking up only the RAM space that the largest single TSR requires (plus 26K bytes for itself). For example, let's say you use a dozen TSRs regularly, and the largest takes up 50K bytes of memory. In this case, RAM Lord would keep a 76K-byte kernel in RAM. You use your TSRs just as you always have, but instead of their all being crammed into the RAM, RAM Lord keeps copies of the actual programs in a *swap area* on your disk.

RAM Lord works quietly and well. Its major disadvantage is speed. Because it's storing your RAM-resident programs on

continued

Coming from Lotus.

disk, there's a perceptible delay when you press a hot key. On a fast AT the delay isn't objectionable, but on my disk-based laptop it was uncomfortably slow. That disadvantage essentially disappears if you have extended or expanded memory available. Then RAM Lord keeps its swap area there, with no perceptible delay.

If you regularly use more than a few RAM-resident programs, you *need* one of these programs. At $49.95, PopDrop is reasonably priced, but it requires regular interaction. Although RAM Lord costs twice as much, it is well worth the extra bucks. Once you've installed it, you can forget about it as it quietly and firmly manages your RAM space.

—Stan Miastkowski

Delta's Mini Modem: A $99 Powerhouse

When I first looked in the **Delta Voyager**'s box, I didn't intend to review the tiny modem that sat inside. But after hooking it up to a Toshiba T1100 Plus, I knew this was a product I had to write about. The little powerhouse costs only $99, recently reduced from $149. It's about the size of a cigarette pack (2⅜ by 1 by 3⅓ inches) and runs on a 9-volt battery, off a car's cigarette lighter, or off an AC adapter. It weighs about half a pound.

Delta Voyager is a Hayes-compatible 300-/1200-bps modem that has 28 characters of nonvolatile configurable memory, remote ring, tone sensing, a low-battery light, and dial-tone monitoring. Also, it's compatible with Bell 103 and 212 and CCITT V.21 and V.22 standards. It operates in full- or half-duplex mode.

To install the modem, you hook it directly into the RS-232C port, with modular RJ-11 telephone cable connecting to the phone line. It's a little awkward, sticking straight off the back of the computer, and it seems like it might be too heavy to stay attached to the RS-232C port. At just 8 ounces, however, it stayed attached, and I had to allow just about 4 inches between my computer and the wall.

Delta reports that you can operate under battery power for up to 10 hours. I didn't try any marathon sessions, but I used it on a daily basis for 2 weeks with no trouble whatsoever. A shrink-wrapped 9-V alkaline battery is included, along with telephone cable and a DB-25-to-DB-9 adapter. Delta also offers an external 9-V AC adapter as an option, although you can use any standard adapter with an external plug (I used the one that came with the Toshiba). Procomm 2.4.2 also comes with the modem.

Used with a battery-powered portable computer, the Delta Voyager gives you complete flexibility in telecommunications. The only feature the Voyager lacked that I missed having was a speaker. But at $99, this modem is hard to beat.

—Anne Fischer Lent

The Facts:

Delta Voyager (DM-1200)
$99

Options:
AC adapter, $4.95

Delta Computer Corp.
260 Forbes Blvd.
Mansfield, MA 02048
(617) 339-5575
(800) 255-3358
Inquiry 857.

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High-Speed Modems

John H. Humphrey and Gary S. Smock

A new crop of modems take transmission rates to a blazing 9600 bps and beyond

We fly to Paris in 4 hours, seal deals by facsimile in minutes, and can't stand to wait more than 24 hours to get important mail. It's not surprising that high-speed modems, able to accurately send 3 megabytes across the country in less than an hour, are the fastest growing segment of personal computer communications.

The advantages of high-speed modems are clear: substantial savings in communications charges and in time. Until recently, these high-speed units have commanded premium prices, but prices have fallen sharply during the past year. The 13 modems we review here send data at a rate of at least 9600 bits per second and range in price from about $900 to over $2000.

But as in any field of rapid growth, standards and uniformity among high-speed modems have lagged behind in the rush to provide the most impressive performance for the most palatable price. Unlike the highly standardized 1200- and 2400-bps modems we're used to, most high-speed modems work at top speed only when communicating with another such modem. The incompatibility is due to the push for greater performance at a given price and to the use of several competing—and confusing—standards for high-speed data communications.

A Good but Shortsighted Start

The central force for standardization in the communications industry is the CCITT, headquartered in Geneva, Switzerland. In 1976, the CCITT drafted the first standard for 9600-bps modems. This recommendation (V.29) was designed to speak specifically to modems operating at 9600 bps over 4-wire, leased-line facilities with synchronous data.

In 1984, the CCITT adopted another standard (V.32), which provides for a 9600-bps modem to be used on dial links. V.32 includes avant-garde communications technology known as echo cancellation to achieve full-duplex operation over 2-wire facilities.

Echo cancellation makes extensive use of high-speed digital signal processors (DSPs). Both sending and receiving modems transmit simultaneously at identical carrier frequencies, and the inbound and outbound data signals clash and overlap, interfering with one another.

The modem knows what signals it just transmitted, transmitted 100 milliseconds ago, transmitted 2 seconds ago, and so on. It creates scaled and inverted copies of the waveforms that it transmitted and adds these into the received data stream to cancel the interference from its transmitter, leaving only the incoming signal for its receiver to process. This is an incredibly complicated task that typically requires the service of DSPs with performance in the range of 25 to 50 million instructions per second.

As published today, V.32 does not provide rules regarding the use of asynchronous data, which was left for "further study." Basically, the CCITT did not foresee the rapid buildup in end-user demand for a moderately priced, asynchronous, 9600-bps, dial-up modem. At the time V.32 was adopted, high-speed modems were predominantly the realm of corporate users, where physical size, price, and power consumption were of secondary importance to solid analog performance, consistent reliability, and growth flexibility.

But user demand for 9600-bps communication has been growing faster than the ink was drying on V.32. Modem manufacturers, struggling with the technical impact of designing reliable echo-canceling circuits, have chosen to offer stopgap alternatives to feed user demand during the interim period required to design and cast echo-canceling circuits into inexpensive silicon building blocks.

Today, V.32 modems are beginning to ship in increasing numbers. They are still bulky, power-consumptive, and expensive. Most manufacturers have jumped the gun, designing in isochronous (i.e., synchronous/asynchronous) converters to allow the modem to use asynchronous data. A number of smaller, lower-cost 9600-bps modems are also available, the product of stopgap design efforts.

Competing Modem Techniques

To achieve high-speed dial-up communications for personal computers, there are three core requirements: an asynchronous interface, full-duplex operation, and a reliable and inexpensive modem engine capable of working under dial-up line conditions.

V.32 achieves the first two objectives but falls down in the third area. To get around the R&D investment required to develop a true V.32 modem, many manufacturers have elected to produce high-speed modems that are not compatible with V.32 but that do provide 9600-bps operation. These manufacturers use one of four modulation approaches that provide alternatives to the V.32 standard. (For more information on the theory and technology of the competing techniques, see the text box "High-Speed Modem Modulation" on page 106.)

V.29 and V.32 Revisited

The first—and most popular—modulation approach involves changes to V.29 core engines, which are available in chip sets from several sources. V.29 chips were originally tooled to serve modem manufacturers' needs for conventional 4-wire, leased-line, synchronous modems and for fax machines.

Two techniques, *ping pong* and *statistical duplexing*, are used to build V.29-based 9600-bps microcomputer modems.

continued

Hayes V-Series Smartmodem 9600

Fastcomm Turbo 2496

Case 4696/VS

Ven-Tel EC18K-34

Microcom AX/9624c

USRobotics Courier HST

Racal-Vadic 9600VP

Data Race Race BMX-VM

Telcor Accelerator 2496MA

Data Race Race VM I

Telebit TrailBlazer Plus

Telenetics 9600E/V.32

Concord 296 Trellis

Photography by Paul Avis © 1988

Table 1: *The modems reviewed use a variety of techniques to achieve high-speed data transfer. Prices vary as well, from a low of $895 to a high of $2295.*

	Case 4696/VS	Concord 296 Trellis	Data Race Race BMX-VM	Data Race Race VM I	Fastcomm Turbo 2496	Hayes V-Series Smart-modem 9600
Chip set	Rockwell sets	Custom TMS32010	Rockwell sets	Rockwell sets	Rockwell sets	Custom TMS32010
Maximum input speed (bps)	19,200	19,200	19,200	19,200	19,200	19,200
Error correction	Yes (MNP class 6)	Yes	Yes	Yes	Yes	Yes
Data compression	Yes	Optional	Yes	Yes	No	Yes
Duplexing technology	Statistical	Echo cancellation	V.29 ping pong	V.27 asymmetric	Dynamic	V.32 HDX ping pong
Compatibility	V.29 and V.27 with statistical duplexing, V.22bis, V.22, 212A, and 103	V.32	Data Race BMX units, V.29 (V.22bis, V.22, 212A, and 103 optional)	Data Race Race units, V.29 (V.22bis, V.22, 212A, and 103 optional)	Fastcomm units (speeds above 2400 bps), V.22bis, V.22, 212A, 103, and V.29	Hayes V-Series Smartmodem 9600, V.22bis, V.22, 212A, and 103
Price	$1395	$1795; $1995 w/data compression	$995; $1245 w/options	$1195; $1345 w/options	$1099	$1299

Both start with a core V.29 engine and build an isochronous converter onto it. V.29 is intrinsically half-duplex, however, and a method to simulate full-duplex operation is needed. This is where the two V.29 approaches differ.

In the ping pong approach, data you send to the modem is buffered. The two modems automatically switch their carriers on and off rapidly, exchanging data each time they have the link for transmission. A form of ready/busy flow control is used between the modem and your computer to prevent you from losing data.

Statistical duplexing uses a low-speed reverse channel, which is added at frequencies above or below the V.29 engine's pass band. The reverse channel is intended to handle data at up to 300 bps and is there to service data at keyboard rates. Should a conversation change dynamically (i.e., you were inputting and receiving file data, but now your partner is inputting and receiving file data), the modems sense this change by watching the relative queue length of their I/O buffers. The modems exchange control information to swap the assignment of their high-/low-speed channels.

A second approach used by a few firms makes use of the technically easier to design portions of V.32's modulation. The key technical problem with V.32 is echo cancellation, which is required for full-duplex operation. One modification uses V.32 without echo cancellation and employs the ping pong approach to simulate full-duplex operation. The other method grafts a low-speed reverse channel onto the core V.32 high-speed center channel to handle keyboard input.

Please Squeeze the Data

The third approach involves data compression. Although a number of the modems we tested offer some form of data compression, what if we can get a really big "squish"? Data compressors find clever ways to shrink 10-bit ASCII data to, say, 4 or 5 bits for transmission, then convert back to 10 bits at the other end. They look for repeated strings in the data, convert them into unique control characters, and explode them back to the original string when received.

If the compression algorithm is efficient enough to absolutely guarantee a four-to-one advantage, modem makers don't have to use fancy high-speed modem engines at all. With a guaranteed 4-to-1 compression, they can get by with low-cost V.22bis (standard 2400-bps) technology that now exists. The drawback to this is that you need a similar modem at the other end of the link to achieve 9600-bps speeds. An unexpected benefit is built-in compatibility with existing 2400-bps modems operating without compression.

Multicarrier Technology

The fourth approach borrows from spread spectrum communications technology used by the military in secure communications systems. This technology breaks the data into discrete pieces and spreads them across the available bandwidth on separate carrier frequencies, keyed at different time intervals. This requires the enemy to know which spreading algorithm is being used to recover the individual pieces of the communiqué. Without the correct algorithm, the transmission looks like random noise.

Modems using multicarrier technology spread the telephone bandwidth with hundreds of individual carrier tones, each of which is modulated quite slowly. Digital data is fed to the modem and buffered. Individual bits are fed to the multiple carriers and data is passed over the link in *n*-length, bit-parallel fashion.

The advantage of this approach is its ability to "map around" bad spots in telephone lines. If discrete portions of the telephone line are of poor quality, the modems recognize this and simply do not place carrier tones in those areas. In theory, this lets the modems operate at full speed under good line conditions and slowly fall back under poorer line condi-

Microcom AX/9624c	**Racal-Vadic 9600VP**	**Telcor Accelerator 2496MA**	**Telebit TrailBlazer Plus**	**Telenetics 9600E/V.32**	**USRobotics Courier HST**	**Ven-Tel EC18K-34**
Rockwell sets	Rockwell sets	Rockwell sets	Custom TMS32010	Custom TMS32010 and TMS32025	Custom TMS32020	Custom TMS32010
19,200	9600	9600	19,200	9600	19,200	19,200
Yes (MNP classes 1-6)	Yes	Yes (MNP classes 4&5)	Yes (MNP classes 1-3)	Yes	Yes (MNP classes 1-5)	PEP (19,200 to 2400) MNP below 2400
Yes	Yes	Yes	Yes	No	Yes	Yes
Statistical	Dynamic	V.22bis with compression	PEP	Echo cancellation	Asymmetric TCM QAM	PEP
V.29 with statistical duplexing V.22bis, V.22, 212A, 103, V.27, and V.29FT (synchronous only)	V.29 with dynamic duplex (Vadic), 212A, 103, and V.29 (synchronous half-duplex)	Telcor Accelerator, V.22bis, V.22, 212A, and 103	PEP modems, V.22bis, V.22, 212A, and 103	V.32	USRobotics HST, V.22bis, V.22, 212A, and 103	PEP modems, V.22bis, V.22, 212A, and 103
$1399	$995	$895	$1345	$2295	$995	$1399

tions. The modems automatically seek and find the maximum operating speed achievable under constantly changing line conditions.

A Fast Field of Contenders

The 13 modems we tested for this review all use at least one of the modulation approaches discussed above. When you look at the features for each modem in table 1 and the results of the tests we ran, remember that high-speed data communications must be tailored to individual situations. Before you purchase a high-speed modem (or a set of modems), take a careful look at precisely how the features and performance of a system will match your needs. That said, let's look at the modems.

Case 4696/VS: The Case 4696/VS is a full- or half-duplex V.29 modem with statistical duplexing that operates at speeds of 300, 1200, 2400, and 9600 bps. Data compression and error correction are provided through the six classes of MNP (Microcom Networking Protocol) that this product supports. This unit provides the Microcom SX and the AT command sets, and it is compatible with Microcom's AX/9624c and other conventional V.22bis, V.22, Bell 212A, and Bell 103 modems.

Concord 296 Trellis: This is a true full-duplex V.32 product with MNP class 4. It features an AT command set, a Concord command set, and operates either asynchronously or synchronously at 4800 or 9600 bps. It supports 2-wire dial or leased-line operation.

Data Race Race BMX-VM: The BMX-VM operates in half-duplex V.29 mode and uses a high-speed line-turnaround technique to simulate full-duplex operation. The modem has an AT command set, a BMX command set, error detection/correction, data compression, and flow control. It supports V.29 and V.27, and an option adds V.22bis, V.22, Bell 212A, and Bell 103 compatibility.

Data Race Race VM I: The Race VM I employs error detection/correction, data compression, and flow control to offer full-duplex asynchronous communication. It features an AT command set, a Race command set, and supports connection to either dial or leased 2-wire lines. An option is available for V.22bis, V.22, Bell 212A, and Bell 103 compatibility. Half-duplex synchronous operation is possible when the modem is operating in its V.29 mode at 4800, 7200, and 9600 bps.

Fastcomm Turbo 2496: The Turbo 2496 uses a design based upon the V.29 recommendation and simulates a full-duplex asynchronous channel by using a proprietary modem-to-modem protocol with error detection and correction when operating at speeds greater than 2400 bps. The unit features an AT command set with some additional extensions, flow control, and compatibility with other modems at 0 to 300, 1200, and 2400 bps.

Hayes V-Series Smartmodem 9600: This Hayes modem uses a modified V.32 design that provides full-duplex transmission at 0 to 300, 1200, and 2400 bps, plus half-duplex transmission at 4800 and 9600 bps. At the higher speeds, a ping pong protocol is used to simulate full-duplex operation. This product is compatible with all earlier Hayes products and with modems that support the V.22bis, V.22, Bell 212A, and Bell 103 modulation. In addition to having true Hayes AT commands, the modem features error control, flow control, and adaptive data compression.

Microcom AX/9624c: The Microcom AX/9624c supports the V.22bis, V.22, Bell 212A, Bell 103, V.27, and V.29FT (fast train) modulation standards and provides its own SX command set, as well as an AT command set. Fast train is a technique within the V.29 standard that provides for an abbreviated handshaking between sending and receiving modems. This modem supports MNP classes 1 through 6 and provides data compression and error correction. The AX/9624c is compatible with the Case 4696/VS.

continued

High-Speed Modem Modulation

How high-speed modems work is a complete mystery to many people. The electrical fundamentals are straightforward. The real tricks involved lie in consistently and reliably demodulating the signal over a broad range of receiver conditions caused by telephone line conditions that can vary in real time on a given call.

Envision a sinusoid of fixed frequency whose phase is changed at discrete time intervals (the baud rate). If we are careful to sample the waveform at these periodic and discrete baud intervals, we can measure the phase changes that represent the data.

Figure A shows a sinusoidal signal that has been phase-modulated to produce +90, +180, and +270 degree relative phase shifts over three successive baud intervals. If we preassign digital meanings to the relative phase changes (0 = 0,0; +90 = 0,1; +180 = 1,1; and +270 = 1,0), we have encoded digital information and are sending data faster than the fundamental data transfer rate. Here, 2 bits of information (a dibit) is exchanged on each baud interval.

If we increase the encoding density (tribits and quadbits), we can send even more information per baud interval. The baud rate is restricted by the fixed bandwidth of the telephone line; the rate of information exchange is not. The price we pay for higher encoding densities is the complexity of the modem's hardware—being able to differentiate between smaller discrete signal differences.

In the example shown, the modem need only differentiate between 90-degree shifts. If we carried the example one step further (tribit encoding), the modem would have to slice the phase domain into eight pieces ($2^3 = 8$). Such a modem would need to be able to distinguish between 45-degree phase differences.

Modems don't actually shift a single sinusoid. They make use of vector algebra by summing quadrature components. Suppose we have two signals (A and B) of identical frequency that are 90 degrees out of phase with each other (a sine wave and a cosine wave). We say these signals are orthogonal or in quadrature to each other.

Vector algebra (remember physics?) tells us that the sum of the two (signal C) is another sinusoid of the same frequency at 45 degrees (see figure B1). Also note that if we scale the two orthogonal signals with discrete multipliers (+1 or −1) before summing the two, we can place the resultant vector at any one of four discrete positions, each of which differs from the other by even 90-degree multiples (see figure B2).

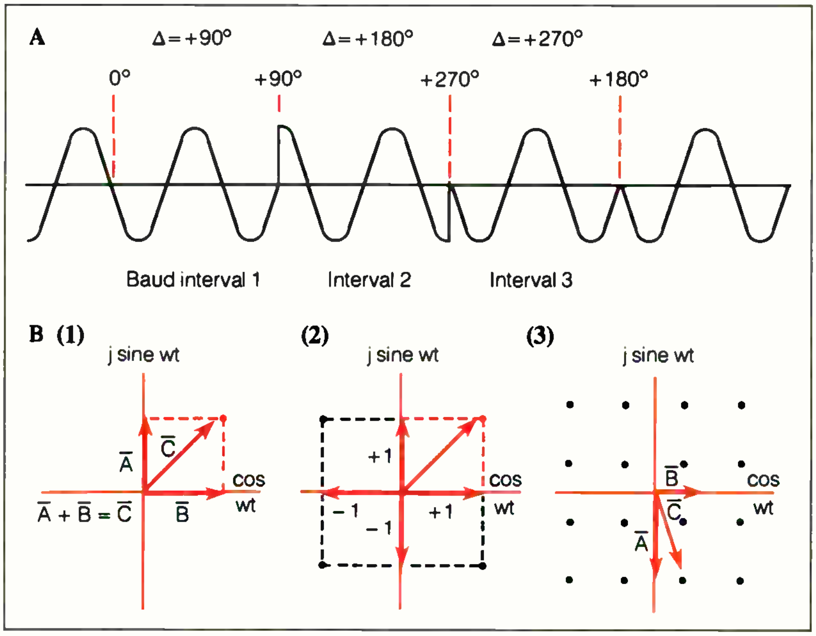


Figure A: *A phase-modulated sinusoid.* **Figure B: (1)** *The sum of two vectors.* **(2)** *The sum of integer orthogonal components.* **(3)** *Amplitude scaling of orthogonal components.*

Hence, we have taken a complicated modulation problem (changing the phase of a single sinusoid) and reduced it to electrical functions that are easy to perform (inverting a signal and summing two signals). Figure B2 represents precisely what takes place inside the familiar Bell 212A 1200-bps modem—differential phase shift keying (DPSK).

Although higher-speed modems operate similarly, the encoding density is greater. In the DPSK example shown, we restricted the amplitude values placed upon our orthogonal components to integer values (+1 and −1). If we allow the quadrature components to be scaled by fractional values before summing the two signals, we can combine amplitude modulation with phase modulation and achieve an even greater encoding density.

Another form of DPSK modulation that is used commonly offers 4800-bps communication. There are two popular (and similar) schemes. One used in the U.S. is called the Bell 208 discipline; its counterpart in Europe is the CCITT V.27 discipline.

Instead of a simple 4-point constellation like that shown in figure B2, the V.27 discipline offers an 8-point constellation, where the individual points of the constellation form a circle about the origin separated by 45-degree angles. V.27 is a half-duplex technique using a single-carrier frequency centered at 1800 Hz that is modulated at 1600 baud using tribit encoding. Thus, we get 4800-bps communication in one direction at a time (1600 baud × 3 bits/baud).

Figure B3 shows the constellation pattern associated with newer 2400-bps dial-up modems that utilize quadrature-amplitude-modulation (QAM) technology to achieve full-duplex communication according to the CCITT V.22bis recommendation. This is a 16-point constellation, which implies that the modems exchange quadbits ($2^4 = 16$) of information at each baud interval.

V.22bis technology is full-duplex.

Each modem transmits its own carrier, and they are separated in frequency by prearrangement. The originating modem transmits at 1200 Hz; the answering modem transmits at 2400 Hz. The carriers are modulated at 600 baud using the 16-point constellation shown and provide 2400-bps (600 baud × 4 bits/baud) information interchange.

To achieve 9600-bps communication rates, several techniques are in use today. The oldest one stems from the CCITT V.29 recommendation. V.29 was originally written to provide 9600-bps communications over 4-wire leased lines using a synchronous data format. There is no reason why the core technology cannot be used in asynchronous dial-up environments, and a number of manufacturers have elected to do so.

V.29 uses the same generic 16-point QAM constellation shown for V.22bis in figure B3. However, the carrier assignment is changed. Instead of using two discrete carrier frequencies, V.29 places a single carrier frequency in the center of the voice band at 1700 Hz. The modulation rate is increased from 600 baud to 2400 baud, which causes the modem to take up virtually all the available bandwidth the telephone line has to offer. This means that only one of the two modems can send data at a given time, but they operate much faster—9600 bps (2400 baud × 4 bits/baud).

The newest modulation technique (V.32) is quite similar to V.29 in many respects. It uses a single carrier frequency at 1800 Hz instead of 1700 Hz, a 2400-baud modulation rate, and a core 16-point constellation. V.32 differs from V.29 by offering an optional 32-point constellation (quintbit encoding), which is trellis-encoded.

The fifth bit is a logical derivative of the other four. It represents an integrity check similar to the ninth bit that is used in IBM PC and PC XT machines for memory-parity purposes or hamming-code techniques used in more advanced error-correction-coding memory storage systems. Trellis encoding gives the modem superior signal-to-noise performance. V.32 is true full-duplex 2-wire modem technology. Echo cancellation is used to separate the transmitted and received data streams of analog waveforms that are propagating simultaneously through the 2-wire link.

Racal-Vadic 9600VP: The 9600VP offers full-duplex asynchronous operation at 300, 1200, and 9600 bps. Its modified V.29 design offers error control, selective retransmission, and data compression, and it adjusts its speed dynamically to optimize to current line conditions. The unit provides an AT-compatible command set, nonvolatile telephone number storage, and compatibility with the standard communication protocols when operating in the Bell 212A or Bell 103 modes. Speed conversion and five types of flow control are available.

This modem offers true full-duplex data transmission during interactive sessions that have relatively low data-throughput requirements and a half-duplex link while transferring large amounts of data in one direction. The dynamic duplex technology will automatically select the appropriate duplexing method based on data traffic patterns.

Telcor Accelerator 2496MA: The Accelerator uses a proprietary data-compression and error-detection technique with its V.22bis design to increase data throughput. It supports full-duplex interface speeds of 1200, 2400, 4800, and 9600 bps, along with several interface and flow-control protocols. The unit is configured by an AT command set with some unique extensions. When not communicating with another Accelerator, this modem will communicate with V.22bis, V.22, Bell 212A, and Bell 103 modems.

Telebit TrailBlazer Plus: The TrailBlazer Plus features compatibility with modems that support the V.22bis, V.22, Bell 212A, and Bell 103 standards, plus its own Packetized Ensemble Protocol (PEP). Supported interface speeds are 300, 1200, 2400, 4800, 9600, and 19,200 bps. This unit features automatic error detection and correction, flow control, an AT command set, and support of MNP classes 1 through 3.

Telenetics 9600E/V.32: This is a V.32 modem with an AT command set and error control. It offers full-duplex asynchronous or synchronous operation at 4800 and 9600 bps. An option switch lets you enable/disable its trellis-encoded modulation at 9600 bps. The modem can monitor call progress electronically with terse or verbose responses or via a built-in speaker. Front-panel controls provide the ability to manually answer, originate, and disconnect calls, as well as force 4800-bps operation and select error control. The unit also provides nonvolatile storage for ten 40-character telephone numbers.

USRobotics Courier HST: The Courier HST is compatible with V.22bis, V.22, Bell 212A, and Bell 103 modems, plus those that support the USRobotics high-speed technology (HST). When operating at interface speeds of 4800 bps to 19,200 bps, the Courier HST operates in the HST mode with error control and will either fall back or spring forward as line conditions permit. The unit supports MNP classes 1 through 5, data compression, flow control, and has an AT command set with extensions.

Ven-Tel EC18K-34: This modem is also known as the Pathfinder 18K and features a high-speed mode that supports interface speeds to 19,200 bps. The unit uses PEP at the higher speeds, making it compatible with the TrailBlazer Plus and other PEP modems. It is also compatible with modems that support the V.22bis, V.22, Bell 212A, and Bell 103 standards. In the high-speed mode, the modem uses data compression, error detection, and error correction, and it adjusts its operating characteristics to compensate for line changes. An AT command set with extensions is supported, as is MNP at speeds of 2400 bps and below.

[Editor's note: *Cermetek, NEC, and Universal Data Systems also make 9600-bps modems. Although none could supply us with units in time for this review, we will evaluate them in an upcoming issue.*]

Measuring Modem Performance

We used Telequality Associates' SNR (signal-to-noise ratio) Map technology to measure the performance of the modems. (For more information on SNR Map technology, see the text box "How Testing Was Conducted" on page 108.) The performance parameter we collected was throughput efficiency as a percentage of the data rate driving the modem. For purposes of comparison, our test setup drove all modems at 9600 bps, although many of the units tested offer higher nominal I/O speeds.

Figures 1a and 1b provide raw test data in graphical form for two modems. We annotated the graphs to show the peak or maximum throughput efficiency measured, the mean or average efficiency recorded, the range, and the standard deviation of the test data.

Ideally, we like to see performance where both the peak and average efficiencies are high and close to one another. We also desire a value approaching 40 for the range, indicative of a low headroom demand. (*Headroom* is a term used in conventional modem engine testing that describes the margin between signal strength and line noise required to operate properly.) Last, we like to see small values of standard deviation, indicating a very consistent modem.

Let's look at figure 1a, which shows

continued

How Testing Was Conducted

Figure A provides a simplified block diagram of our test system. Modem #1 and modem #2 represent the target modems under test. In each case, the target modems were a pair of identical models from one manufacturer.

The central office (CO) simulator provides operating loop current to simulate the DC conditions of a typical connection to the telephone network. The CO simulator also provides conventional ringing voltage to trigger the modem's automatic answer function.

Additionally, the CO simulator is connected to a hybrid (2-/4-wire converter) that separates the transmitted signal from the received signal, as telephone lines do. The isolated transmit signal is then impaired by the telephone channel simulator, which has programmable frequency response, group delay, and gain characteristics that can simulate varying telephone line conditions.

A programmable amount of noise is then summed with the signal to establish the desired SNR. The hybrid and CO simulator deliver this signal (i.e., scaled signal summed with the appropriate level of noise) to the other modem.

The RS-232C ports of the modems are connected to data-pattern generators and checkers. Serial data is given to, say, modem #1 for transmission, and the 8-bit binary data stream output from modem #2 is checked. The tester is capable of both one-way data flow or two-way simultaneous data flow.

Some of the modems evaluated were true full-duplex devices; others merely simulated full-duplex operation. We decided to test the modems by sending data in only one direction for the simulated full-duplex modems and in both directions for the true full-duplex units.

Testing in one direction corresponds only to the conditions of a file transfer where one modem has nothing to transmit while it receives a large amount of data. We noted that the throughput of the simulated full-duplex modems suffered dramatically if asked to traffic two-way 9600-bps full-duplex data.

We tested the modems under two different operating environments. One provided −26-dBm received signal strength over a C2 line simulator, providing typical phone line conditions. The other presented 40-dBm signal strength over a 3002 simulator, providing poor phone line conditions.

At each signal level, we decreased the SNR by adding noise to the received signal until the modem's throughput efficiency dropped to less than 10 percent of the tester's nominal 9600-bps feed rate.

At each point in SNR space, the modems exchanged a minimum of 81,920 bytes. We used proprietary methods to ensure that the resulting data was within a 4 percent accuracy band with a 90 percent confidence level. We determined throughput efficiency by measuring the total time required to transmit and receive data. Time used by the modems to correct errors was included in the elapsed time for that particular block.

Since we knew the number of data bits received and the total time required to receive the error-free data, we calculated and expressed the number of bits per second as a percentage of the nominal rate. We constructed a special precision timer for the test to ensure the accuracy of data clocking to within 1-millisecond increments.

We configured the modems with factory default options and then programmed them for testing with as few changes as possible. Since binary data was being transmitted, we disabled XON/XOFF flow control in favor of hardware flow control. We fixed the interface speed of the test system at 9600 bps, the minimum common denominator between all the modems tested.

Due to variations in data-compression techniques used in the modems, we followed the manufacturers' recommendations regarding the transfer of 8-bit binary data. Some modems actually had lower throughput when data compression was used to transfer our pseudorandom data than without compression.

If the manufacturer failed to make recommendations for handling pseudorandom data, we ran a pilot test to determine the optimum setting for the compression feature. All modems employed some form of error correction.

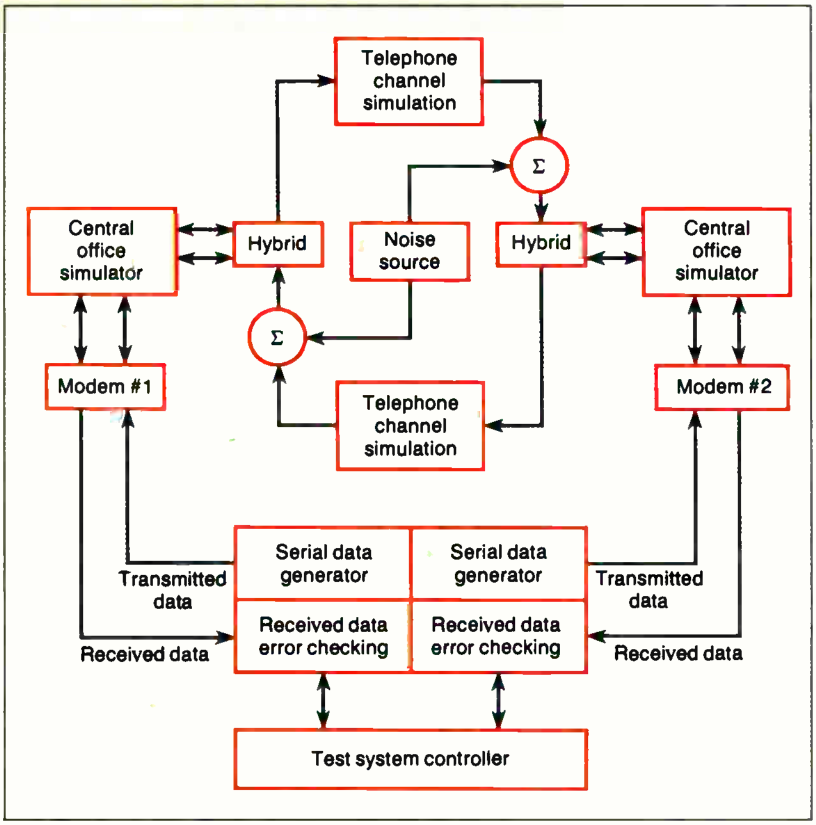


Figure A: *This simplified block diagram shows the setup for testing each pair of modems.*

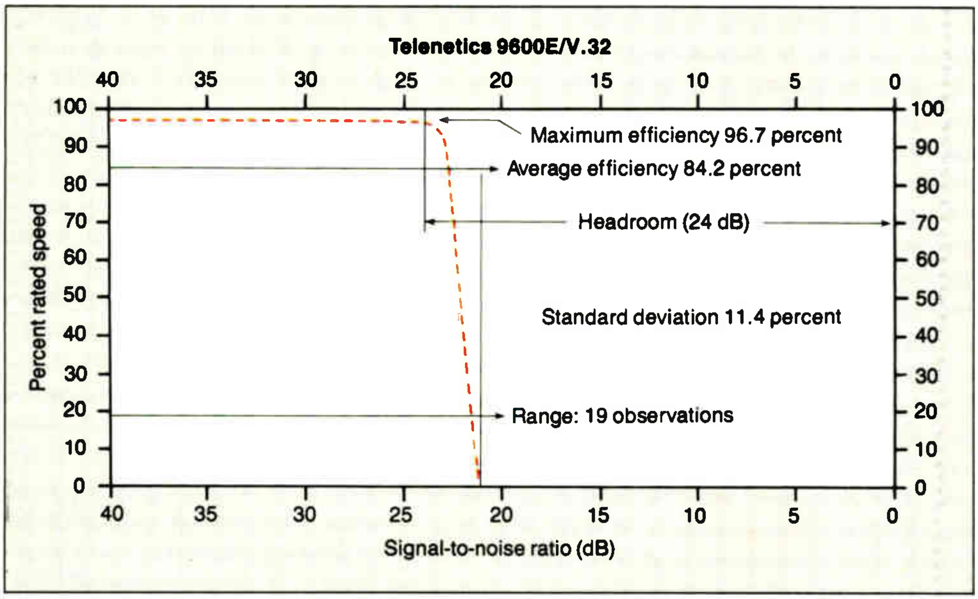


Figure 1a: *The SNR Maps here and in figure 1b show that the Telenetics modem ran with greater efficiency than the Ven-Tel modem under typical line conditions. The Telenetics modem, though, showed a much narrower range of operation. Shown here are the raw test results for the Telenetics 9600E/V.32, a true V.32 modem. (In ideal performance, maximum and average efficiencies are high and close to one another, the standard deviation is a small value, and the range is a large value.)*

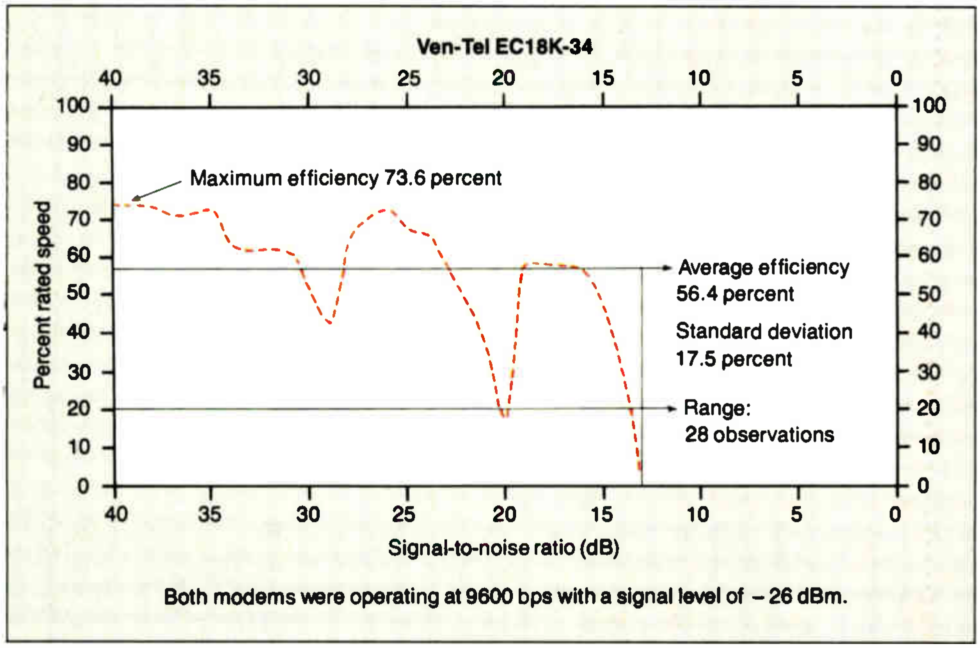


Figure 1b: *The raw test results for the Ven-Tel EC18K-34 modem, a multicarrier unit, show that it operated with less efficiency but over a broader range than the Telenetics modem.*

the resulting test data taken from the Telenetics 9600E/V.32 modem (a true V.32 unit) operating under typical line conditions (simulated C2 channel with a received signal level of −26 decibels below 1 milliwatt [dBm]). The modem was almost 100 percent efficient in transferring data at 9600 bps as long as the SNR accompanying the received signal was above the modem's native headroom needs of 24 dB.

In this example, the 9600E/V.32 needed operating conditions where the received signal level was 24 dB greater than channel noise. As long as these conditions were met, the modem's receiver operated flawlessly. Once the modem's headroom needs were violated, its receiver performance fell dramatically.

If you operate a conventional modem below its native headroom needs, data errors result. Modems that have error correction don't make data errors. Their throughput degrades, due to the extra time they spend in retransmission to correct the flawed data.

From the shape of the curve, you can see that error correction is not a panacea, since modems exhibit extremely sharp roll-off characteristics. By forcing the modems to operate just a few decibels below their headroom needs, they make a fast transition from perfect throughput to no throughput at all.

Figure 1b shows test data for the Ven-Tel EC18K-34 modem, which employs multicarrier modulation technology. The Ven-Tel modem is also operating under typical line conditions. There are a number of differences between the operating characteristics of these two modems. First, both the peak and average throughput efficiencies measured for the Ven-Tel modem are lower than for the Telenetics modem. With a maximum efficiency of 73.6 percent, the Ven-Tel modem delivered a peak communications speed of 7066 bps under 9600-bps feed-rate conditions.

The Ven-Tel modem showed a much broader range of operation than the Telenetics modem, meaning that its headroom needs are smaller. This confirms the advertised benefits of multicarrier modulation. The modem can brown out instead of black out under poor line

continued

Table 2: *When fed data at a rate of 9600 bps, the true full-duplex modems from Concord, Telcor, and Telenetics consistently showed better throughput than the pseudo-duplex models. With the exception of the Telenetics modem, the true full-duplex modems operated at about the same rate over typical and poor phone lines. This table shows only throughput, not efficiency, and some of the modems can accept data at higher speeds (up to 19,200 bps).*

	Typical line throughput (bps) (C2, −26 dBm)		Poor line throughput (bps) (3002, −40 dBm)	
	Maximum	Average	Maximum	Average
Case 4696/VS	8429	6422	4925	3274
Concord 296 Trellis	8842	8448	8861	8237
Data Race Race BMX-VM	4963	4704	4829	4339
Data Race Race VM I	5520	5136	0	0
Fastcomm Turbo 2496	3475	2486	3341	2102
Hayes V-Series Smartmodem 9600	5002	4742	4973	4435
Microcom AX/9624c	8304	6115	3926	2592
Racal-Vadic 9600VP	6442	5798	6461	5002
Telcor Accelerator 2496MA	9091	8256	9082	8362
Telebit TrailBlazer Plus	7152	5568	7229	5078
Telenetics 9600E/V.32	9283	8995	0	0
USRobotics Courier HST	8678	8083	0	0
Ven-Tel EC18K-34	7066	5414	7190	4704

conditions.

The other modems we tested performed similarly. These V.29- and V.32-based modems employed conventional fallback techniques to contend with deteriorated line conditions. Although the digital feed rate to and from the modem was fixed at 9600 bps, the modem saw line conditions degrading and ordered its engine to initiate speed fallback from 9600 bps to 7200 bps to 4800 bps.

Figure 1b also shows that the Ven-Tel modem recorded a larger standard deviation. This indicates that its throughput efficiency varied more than the Telenetics modem. You can see the effects of this in the shape of the curve trace. A number of dips are found in the modem's efficiency curve.

These dips represent decision points where the modem elected to change the configuration of its multicarrier assignment to deal with signal quality degradation. A trade-off was executed. Ven-Tel purchased a greater operating range at the expense of consistency in throughput.

Comparing Efficiencies

Now that we have a handle on how the data was analyzed, we can proceed to a side-by-side comparison of the modems. Table 2 shows performance in terms of raw bps numbers. To consolidate the data in a meaningful fashion, we used statistics to represent key aspects of performance. Figure 2 shows the group's performance on typical lines and poor lines by graphing the differences in their efficiencies. We think that figure 2 offers a more complete basis than the raw bps rates for comparing the modems.

All the true full-duplex machines (Concord, Telcor, and Telenetics) had consistently better throughput than their pseudo-duplex cousins. Among the latter, the USRobotics, Microcom, and Case modems turned in performances approaching those of the true full-duplex modems.

With the exception of the Telenetics modem, which refused to operate over our poor line conditions, the true full-duplex modems showed virtually no operating distinction between running over good or bad lines. The Race BMX-VM, Fastcomm, Hayes, Racal-Vadic, Telebit, and Ven-Tel modems were resistant to channel differences, however, they were still not as efficient as the full-duplex units.

The Case and Microcom modems both ran over our poor line but exhibited a significant loss of throughput efficiency. The Race VM I, Telenetics, and USRobotics modems simply failed to exchange data under our poor line conditions. These are, indeed, grueling operating conditions rarely encountered in dial-up America. However, other modems tested were able to handle the poor line conditions successfully.

The surprise among the lot was Telcor's Accelerator 2496MA. This modem used conventional 2400-bps V.22bis engine technology and was robust and efficient in handling our 9600-bps stream of pseudorandom data. While a number of other modems tested offered data-compression technology, the Telcor modem showed outstanding consistency in crunching 10-bit ASCII data.

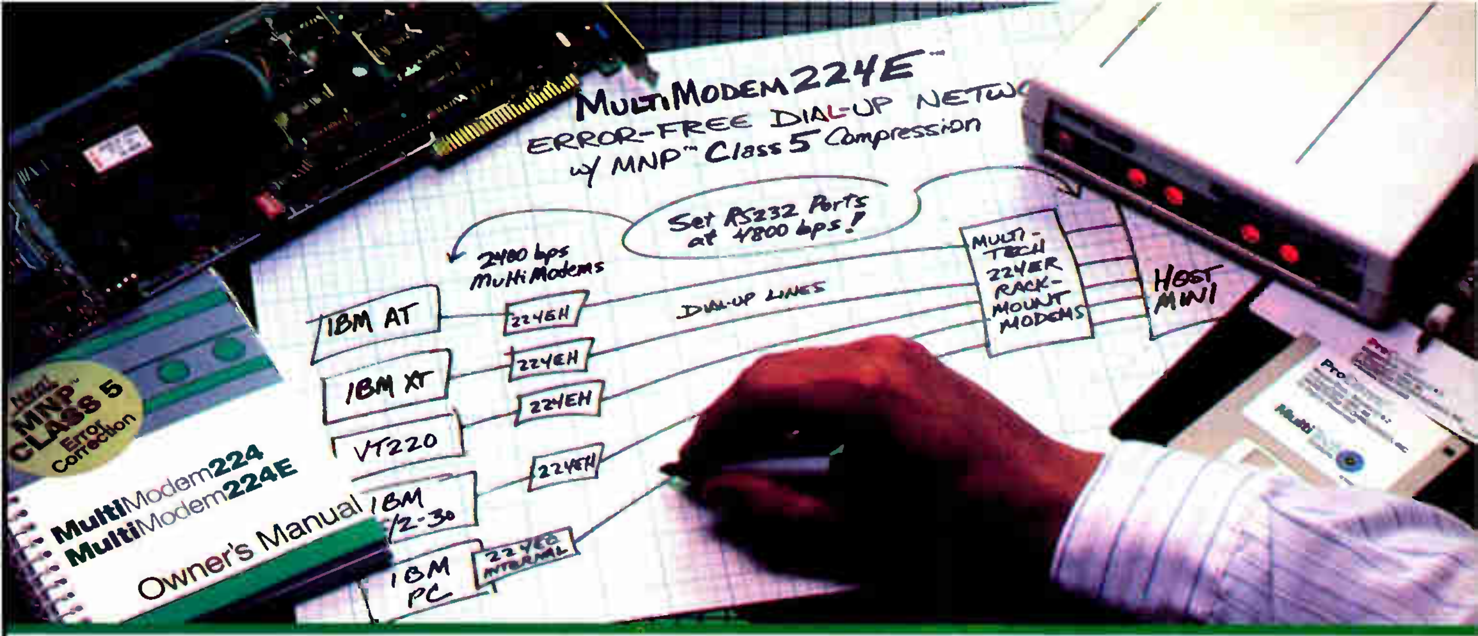
Some Caveats

Overall, these modems are complicated. They have extensive hardware and software options that can have a serious impact on performance. To achieve top performance, you must carefully control the following three parameters: error correction, data compression, and raw data transfer rate.

Almost all these modems offer built-in error correction. If you work with a terminal emulator that employs data blocking and error correction, you can choke one of these modems to death by setting the size of your feed blocks too small and starving the modem's built-in buffer.

We sent pseudorandom data, which is hard to compress. Some of the modems offered options to engage or disengage the compression function so they wouldn't choke when fed incompressible data. One modem (Hayes) used data compression that was not user-defeatable. Perhaps, had we sent spreadsheet or text files, we would have observed significantly better throughput with the Hayes

continued



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>
> In the May 12, 1987 edition of PC Magazine where 87 modems were reviewed, only three were awarded *Editors Choice*: "For a high-performing 2,400-bps modem with a slew of extras, check out Multi-Tech Systems' MultiModem224E . . . with [its] high immunity to line noise and the extra advantage of MNP error correction, [this modem] should do a fine job of managing fast, error-free data communications."

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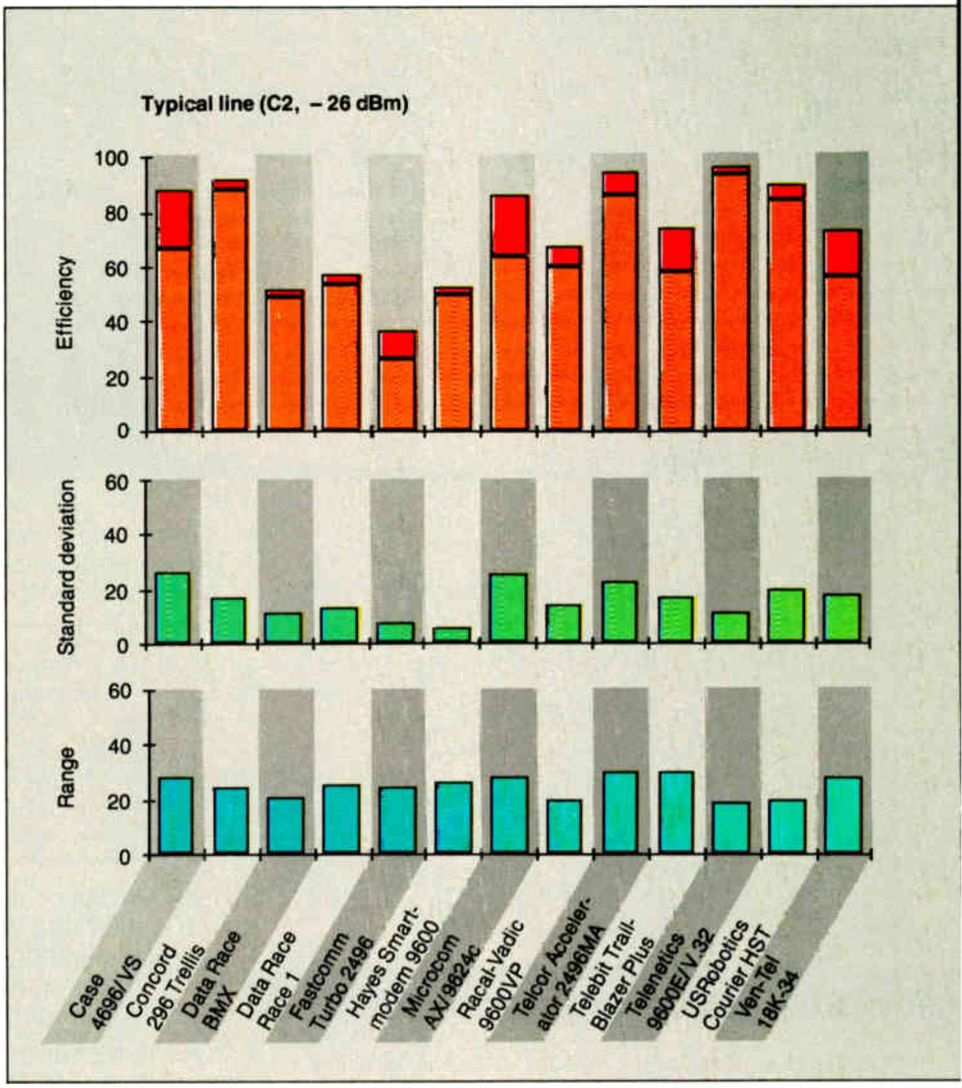

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modem. However, the Telcor unit provided an intelligent compression algorithm that simply ate up our data.

Many of the modems allow data I/O rates in excess of the 9600-bps speed we used for our comparison. For those of you who can crank up the feed rate (not all computers and/or communications packages will support faster data rates), you can expect higher gross throughput. But for this review we wanted to measure both throughput and efficiency.

What the Future Holds

The outlook for the future seems clear. The utility of error detection/correction features is quite apparent, and the CCITT is working on a new recommendation in this area (V.42). As currently drafted, this provides a smooth transition from the past to the future.

V.42's main impetus revolves around a new protocol, LAP M, which is similar to the byte-independent, bit-oriented, packet-switching protocols used in X.25

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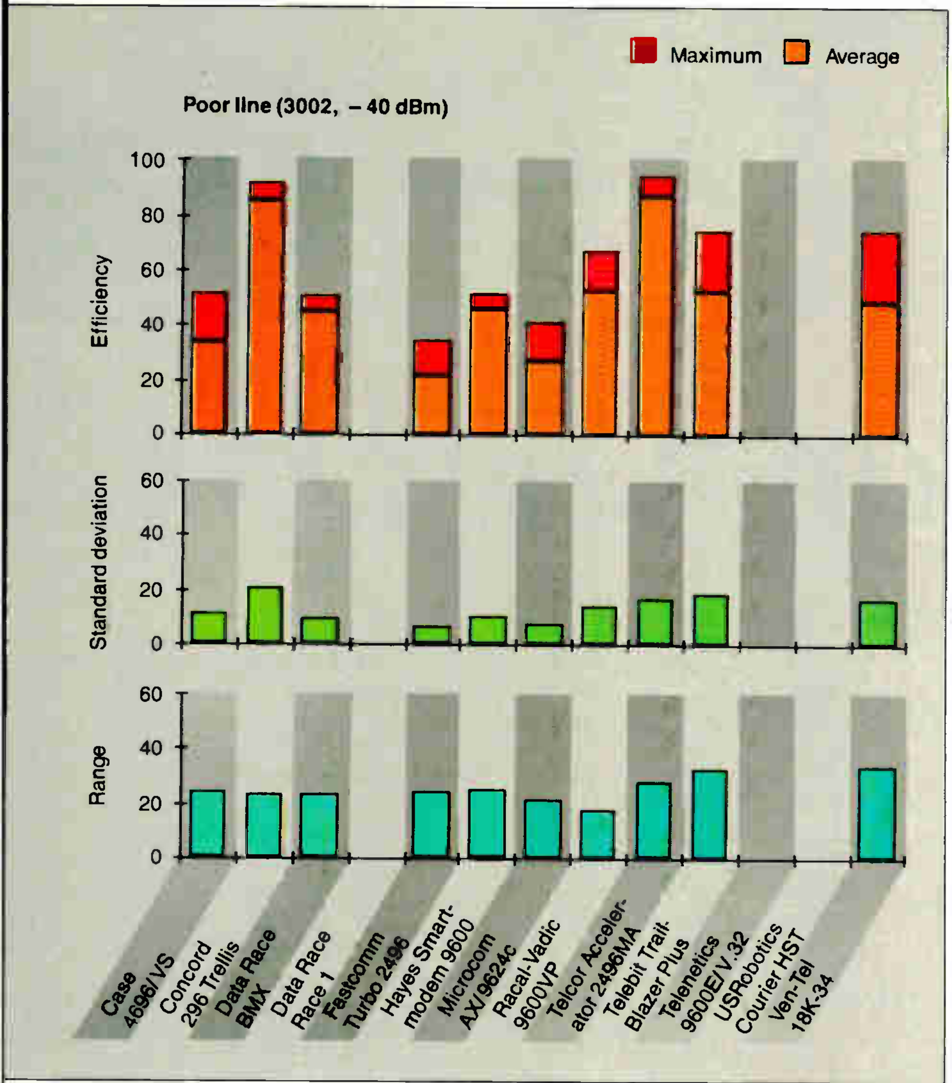
Inquiry 896.



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Natick, MA 01760
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(312) 982-5001
Inquiry 901.

Ven-Tel Inc.
2121 Zanker Rd.
San Jose, CA 95131
(408) 436-7400
Inquiry 902.

and ISDN (Integrated Services Digital Network) communications links. V.42 doesn't neglect current modems, however; during initial handshaking, a V.42 device will query the other modem and use LAP M only if it is appropriate to do so.

If one of the modems is not equipped with LAP M but has MNP capability, both modems will begin to exchange data under MNP. Therefore, current users of modems equipped with MNP can take comfort in the knowledge that their hardware is not likely to become obsolete.

It's also clear that intelligent data-compression algorithms will be increasingly important in data communications. If a lowly 2400-bps V.22bis modem can be souped up to consistently pass data at 9600 bps, combining data-compression technology with a good V.32 engine offers the possibility of reliable and cost-effective dial-up communication at effective rates of 38,400 bps.

The wild card in the data communications picture is ISDN. There are those in the telecommunications and data communications industries who predict that the increased bandwidth and line quality of ISDN will provide their own solutions to the data rate problem. These experts tell us that ISDN is an inevitable part of our communications future and that any present plans should be built around the features offered by ISDN.

ISDN holds a tremendous promise for corporate users shuttling mixed voice and data signals between plant sites. But ISDN is not the only logical alternative, and it won't be implemented overnight. It took 100 years to wire America with copper, put a telephone in virtually every household, and train us to say "Hello" in response to a ringing bell. In the 1960s we started to replace rotary dialing with tone dialing, and as we enter the 1990s, manufacturers are still churning out equipment with pulse-dial fallback.

While we look to V.42, ISDN, and beyond, V.32 and other modems are here, and their price and availability can only get better. Semiconductor manufacturer Rockwell International has announced a CMOS chip set for V.32. Others in the industry (TRT from France and Atlantic Network Systems from England) are shipping highly integrated V.32 modems with proprietary chips. The 9600-bps and faster modems reviewed here are just the beginning of the push to make dial-up modems even faster and better. ■

John H. Humphrey and Gary S. Smock are general partners of Telequality Associates in Golden, Colorado, providing engineering consultation and design and product testing in telecommunications.

One Language For V

BBX® Specifications:

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- 14 place precision and computational accuracy
- Floating point conversion
- Task specified rounding precision
- Binary to decimal conversion
- Long function names
- Dynamic arrays

String Functions

- Numeric to string conversion
- String manipulation
- No string length restriction

I/O Functions

- Windowing
- I/O mnemonics
- Device independent verbs
- X,Y cursor addressing
- Masking
- Soft key loads
- No record length restrictions
- BB^x file sizes are limited only to the size of the available media

File Structures

- INDEX
- KEYED
- MKEYED
- SERIAL
- SORT
- PROGRAM
- STRING

System Structure

- Multi-tasking - which provides record and file level locking
- Program overlay
- Public programming which provides:
  - Local variables
  - Dynamically called sub-programs
  - Argument passing
  - Automatic public program drop from memory at exit
  - Public program in memory lock option

Language Structure

- Interactive program development
- Online syntax checking
- Compound statements
- User defined functions
- Unlimited nesting
- Remote I/O lists
- Program self modification
- Case Insensitive console mode
- Various debugging tools

BB^x Utility Set

- File Browse
- Create Data Bundle
- Calculator
- Clear Workspace
- Program Compare
- Copy File
- Define/Redefine File
- Directory Listing
- Erase File
- Generate Filelist
- Program List/Cross Reference
- Move File
- Program Renumbered
- Rename File
- File Resizer
- Execute O/S Shell Command
- Search and Replace Program
- Color & FUNC Key Setup
- Time/Date Examine/Set
- Utility Menu
- Visual Utility Interface
- BXSND BXRCV conversion utilities

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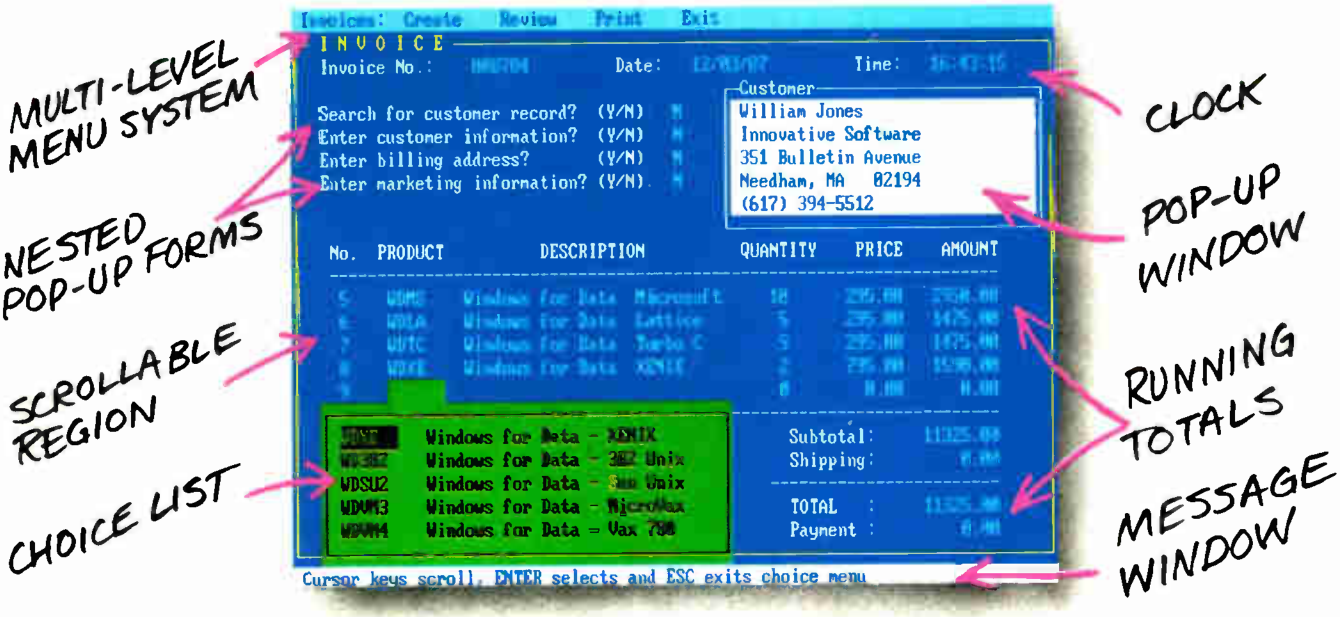

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ALR's FlexCache 20386 Catches Compaq

Mark L. Van Name

The 20386's dual buses and cache controller make it the Compaq 386/20's peer

In the race for the world's fastest 80386-based personal computer, the list of top contenders is growing. If the standard BYTE benchmarks are any indication, Advanced Logic Research's FlexCache 20386 is in a dead heat with the reigning speed champion, the Compaq Deskpro 386/20.

The 20386 achieves its speed by using a FlexCache architecture that is much like Compaq's Flex architecture. It uses two concurrent buses, an Intel 82385 cache controller, and a cache of 32K bytes of very high-speed (35-nanosecond) static RAM (SRAM). It is in the over-five-digit cost class, although it is still considerably cheaper than the Compaq Deskpro 386/20.

There are four basic 20386 systems: the Model 60 ($5990), the Model 100 ($6490), the Model 150 ($7490), and the Model 300 ($9990). All four include a 20-MHz 80386 processor, 1 megabyte of 80-ns dynamic RAM (DRAM), 32K bytes of cache memory, a socket for a 20-MHz Intel 80387 math coprocessor, a 1.2-megabyte 5¼-inch floppy disk drive, an enhanced-small-device-interface (ESDI) based hard disk drive (in Models 150 and 300) or a run-length-limited (RLL) based hard disk drive (in Models 60 and 100), one RS-232C communications port, one parallel port, and a keyboard that follows the style of the IBM Enhanced AT keyboard. ALR also throws in a Setup Utilities disk and Phoenix Technologies' Control/386 software. The units differ only in the size (60, 100, 150, or 300 megabytes, respectively) and speed of their hard disk drives. Any machine this powerful could function well as a multiuser system or a network file server.

The system also needs a monitor, a video card, and operating system software. ALR's EGA-compatible monitor costs $699, while its EGA card adds $399. MS-DOS/GWBASIC 3.3 tacks on another $149. My evaluation unit also came with a second megabyte of DRAM ($899), an 80387 ($1195), and a 1.44-megabyte 3½-inch floppy disk drive ($349). This package, which includes what many Model 150 users are likely to want, totals $11,180. For those whose pockets are not quite so deep, ALR also has a 16-MHz 80386-based system, the FlexCache 16386: The Model 60 sells for $4690, and the Model 100 costs $5690.

Tying the Performance Race

Because the Compaq Deskpro 386/20 was the previous performance leader, I compared the 20386's test results to that machine's times. (The performance table compares it to several other systems as well.) Using the new BYTE benchmarks, the 20386 beat the Deskpro 386/20 in the CPU tests by a small margin. Clearly, there is not much of a difference between the computational power of the two systems, but the 20386 holds a slight advantage. Since both machines use the same CPU and cache controller chips, and both have the same size and speed cache, the performance differences probably stem from the 80-ns DRAM memory of the 20386, as opposed to the Deskpro 386/20's 100-ns DRAM.

Many of the newer 80386-based machines include a disk-caching utility that can often improve performance. The 20386 does not include a disk-cache utility with its version of MS-DOS, but there is one in the Control/386 program that is bundled with the system. However, because Control/386 puts the 80386 in virtual 8086 mode, you cannot run any protected-mode programs while using it—and BYTE's C benchmarks run in protected mode. I did run the BASIC and Spreadsheet tests with Control/386's disk cache enabled, but it made no measurable difference.

The 20386 lost the FPU benchmark tests. The 80387 coprocessor in my machine was a 16-MHz chip, not the advertised 20-MHz version. This chip was supported by a special 32-MHz oscillator that ALR attached to the motherboard as an obvious patch. An ALR spokesperson said that the company had to use the slower 80387 and the slower oscillator because it could not get a 20-MHz 80387 from Intel. The spokesperson said that later versions of the 20386 will use a 20-MHz 80387 and will not include the slower oscillator.

The hard disk drive benchmarks also

continued

FlexCache 20386

Company
Advanced Logic Research Inc.
10 Chrysler Ave.
Irvine, CA 92718
(714) 581-6770

Components
Processor: 20-MHz 32-bit Intel 80386; socket for 16-MHz Intel 80387 coprocessor
Memory: 1 megabyte of 32-bit 80-ns DRAM on motherboard, expandable on motherboard to 2 megabytes and expandable on a two-card memory card set to 10 megabytes; 32K bytes of 35-ns static RAM for the cache; 128K bytes of BIOS ROM
Mass storage: 1.2-megabyte 5¼-inch floppy disk drive; optional 1.44-megabyte 3½-inch floppy disk drive; 100-, 150-, or 300-megabyte hard disk drive
Display: Optional Casper TE 5154 EGA monitor; optional ALR EGA board
Keyboard: 101 keys in IBM Enhanced keyboard layout
I/O interfaces: One RS-232C serial port with DB-9 connector; one DB-25 parallel port; one RGB-intensity monitor port with DB-9 connector; two 32-bit slots for memory-expansion cards; two 8-bit and four 16-bit expansion slots

Size
7½ by 17 by 26 inches; 75 pounds (100 pounds maximum)

Software
Setup Utilities disk with diagnostics tests and system setup; Control/386

Options
1-megabyte upgrade: $799
1-megabyte memory card set: $899
4-megabyte RAMpack set: $2100
1.2-megabyte 5¼-inch floppy disk drive: $179
1.44-megabyte 3½-inch floppy disk drive: $349
20-MHz 80387 coprocessor: $1195
150-megabyte hard disk drive: $2999
300-megabyte hard disk drive: $4595
ALR EGA card: $399
EGA monitor: $699
MS-DOS/GWBASIC 3.3: $149

Documentation
Quick Installation Reference Guide FlexCache 16386/20386 Series; FlexCache 16386/20386 User's Manual; Operating Manual—High-Resolution Color Display Monitors; User Guide—Control/386 Version 1.1

Price
Model 60: $5990
Model 100: $6490
Model 150: $7490
Model 300: $9990
System as reviewed: $11,180

Inquiry 883.

reflect the even match between the two machines. Both hard disk systems had comparable performances, with the 20386 winning the Full Platter and 1-megabyte Write tests. An older test, the Coretest (version 2.7), rates the 20386's hard disk as marginally faster on seeks but slightly slower on data transfers than the Deskpro 386/20's hard disk.

The ALR EGA card was substantially slower than the Compaq EGA card. The speed difference was apparent in the text-mode tests, where the Deskpro offered a 2- to 3-second advantage. That advantage was less in the graphics-mode tests, where the results were more evenly divided.

The Livermore Loops, LINPACK, and Dhrystone tests went decisively to the 20386, but not by a substantial margin.

Finally, the Applications benchmarks were a split decision. The computers traded wins in the Word Processing tests, although the FlexCache came out slightly ahead. The Spreadsheet tests gave similar results, but the Compaq took a slim lead here. The Database tests went to the Deskpro, but, again, not by much. The Scientific and Engineering tests gave a slight edge to the FlexCache, and the Compiler test showed once more that the computers were evenly matched.

Neither computer scored a knockout in any of the test categories. Like two evenly matched prizefighters, the FlexCache 20386 and the Deskpro 386/20 stand bloodied but unbowed.

Of course, the 20386's great performance would be useless if it could not run AT-compatible software or use standard hardware options. Fortunately, everything that I tested worked. I ran the following programs: Lotus 1-2-3 version 2.0; Quarterdeck Office Systems' DESQview 2.0, with its Quarterdeck Expanded Memory Manager 386 version 1.10; Kermit 2.30; The Norton Utilities 3.00; Symantec Q&A 1.1; Borland's Reflex 1.14, SideKick 1.56A, SuperKey 1.16A, Turbo C 1.0, Turbo Pascal 4.0, and Quattro 1.0; Digitalk's Smalltalk/V 1.2; MicroPro's WordStar 3.3 and 4.0; and Microsoft's PC Paintbrush 2.0, Word 4.0, and Windows/386 2.0. I also successfully installed a fully populated Intel Above Board/AT, an Everex Evercom II 2400-bit-per-second internal modem, and a Microsoft Serial Mouse.

In the course of my compatibility tests, I ran into a few minor but annoying problems. First, for 1-2-3's copy-protection scheme to work, I had to set the 20386 to its slower speed while 1-2-3 read the key disk. Once 1-2-3 was done with the key disk, I returned the 20386 to its normal high speed and ran 1-2-3 with no difficulties. Since you can control the system's speed from the keyboard, this is no real hardship.

A second problem occurred any time a program, such as Setup or the Above Board/AT configuration and test software, rebooted the system. When this happened, I got the error message `No timer tick interrupt`. The unit ran fine, but the message was disturbing. The company said that this problem occurred because my evaluation unit included an older BIOS version, and that the production 20386s use a newer BIOS that fixes this problem.

I also tried booting up OS/2. The 20386 couldn't load OS/2 while running at 20 MHz, and ALR suggested that I slow the machine to 10 MHz. At that speed, OS/2 did load and run, and then I changed the speed to 20 MHz. The ALR spokesperson said that a new version of the ROM BIOS would eliminate that problem in future versions of the machine.

One Big Box

The very first thing that strikes you about the 20386 is its size. It is over an inch thicker, 1 inch deeper, and about 5 inches longer than a standard IBM PC AT. It is also heavier; my unit weighed in at around 75 pounds, and a fully configured system can approach 100 pounds. ALR designed the unit to stand upright on the floor, supported by a stand that you can attach to its bottom with four screws.

The biggest benefit of the large chassis is the addition of two extra half-height floppy disk drive bays at the top of the unit. The standard 1.2-megabyte floppy disk drive fills one of these new openings. There are two more typical bays below these new areas. With all these drive bays, you can fit up to one full-height hard disk drive and five half-height devices in the 20386. To help support these many devices, the power supply has a steady-state rating of 220 watts, with peaks up to 300 watts. You could take full advantage of the 20386's drive capacity by putting two of ALR's 300-megabyte hard disk drives into a Model 300 and placing its tape unit below the standard floppy disk drive; this would give you a system with 600 megabytes of disk storage and a tape drive.

To get a peek inside the unit, you only have to loosen the two thumbscrews on the rear of the unit that attach a side panel to the body, and then remove that panel. Once you are inside, the way ALR arrived at this design becomes obvious (see photo 1). The chassis surrounds an inner, coverless chassis that is the standard AT size and is bolted to the sides of the new container—as if the company took the

continued

ALR FlexCache 20386 Model 150

BYTE LAB

APPLICATION-LEVEL PERFORMANCE (in minutes and seconds)

ALR FlexCache **19.7**

WORD PROCESSING

XyWrite III + 3.52	Med.	Large
Load document	N/A	:12
Word count	:02	:16
Search/replace	:04	:17
End of document	:02	:10
Block move	:10	:10
Spelling check	:06	:47

Microsoft Word 4.0	
Cursor move	:14
Forward delete	:12
Aldus PageMaker 1.0a	
Load document	:03
Change/bold	:16
Align right	:16
Cut 10 pages	:13
Place graphic	:03
Print to file	1:27
Index:	**4.3**

SPREADSHEET

Lotus 1-2-3 2.01	
Block copy	:03
Recalc	:01
Load Monte Carlo	:09
Recalc Monte Carlo	:03
Load rlarge3	:02
Recalc rlarge3	:01
Recalc Goal-seek	:03
Microsoft Excel 2.0	
Fill right	:04
Undo fill	1:30
Recalc	01
Load rlarge3	:17
Recalc rlarge3	:01
Index:	**3.6**

DATABASE

dBASE III + 1.1	
Copy	:46
Index	:05
List	1:07
Append	1:28
Delete	:01
Pack	1:16
Count	:03
Sort	:49
Index:	**3.2**

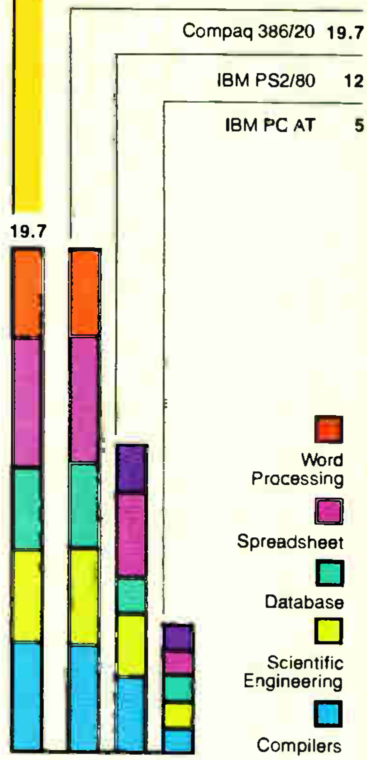
ENGINEERING/SCIENTIFIC

AutoCAD 2.52	
Load SoftWest	:35
Regen SoftWest	:27
Load St. Pauls	:07
Regen St. Pauls	:05
Hide/redraw	8:48
STATA 1.5	
Graphics	:23
ANOVA	:12
MathCAD 2.0	
IFS 800 pts.	:11
FFT/IFFT 1024 pts.	:11
Index:	**5.1**

COMPILERS

Microsoft C 5.0	
XLisp compile	3:01
Turbo Pascal 4.0	
Pascal S compile	:03
Index:	**3.5**

Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT = 1.



Graphs are based on indexes at left and show relative performance compared to an 8-MHz IBM PC AT.

LOW-LEVEL PERFORMANCE[1] (in seconds)

ALR FlexCache

CPU

Matrix	3.1
String Move	
Byte-wide	21.18
Word-wide:	
Odd-bnd.	28.84
Even-bnd.	10.60
Sieve	19.6
Sort	20.73
Index:	**3.8**

FLOATING POINT[2]

Math	16.27
Error[3]	0.0
Sine(x)	5.9
Error	2.0E-9
e^x	5.93
Error	1.77E-2
Index:	**3.1**

DISK I/O

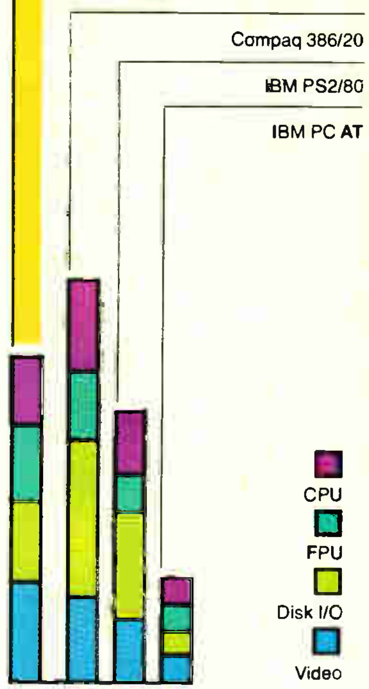
Hard Seek[4]	
Outer track	3.33
Inner track	3.33
Half platter	6.65
Full platter	6.68
Average	5.0
DOS Seek	
1-sector	1.44
8-sector	11.02
File I/O[5]	
Seek	.27
Read	007
Write	012
1-megabyte	
Write	2.87
Read	2.89
Index:	**2.9**

VIDEO

Text	
Mode 0	5.84
Mode 1	5.83
Mode 2	6.87
Mode 3	6.88
Mode 7	4.87
Graphics	
Mode 4	1.48
Mode 5	1.48
Mode 6	1.65
Mode 13	3.19
Mode 14	3.46
Mode 16	3.23
Index:	**2.6**

CONVENTIONAL BENCHMARKS

LINPACK	170.81
Livermore Loops[6] (MFLOPS)	.1742
Dhrystone (MS C 5.0) (Dhry/sec)	6518



[1] All figures were generated using the 8088/8086 version of Small-C (16-bit integers). Figures for the 80386 machines shown here do not use 80386-specific instructions.
[2] The floating-point benchmarks use 8087-compatible instructions only.
[3] The errors reported for the floating-point benchmarks indicate the difference between expected and actual values.
[4] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100.)
[5] Read and write times for the File I/O benchmarks are in seconds per Kbyte.
[6] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks" on page 239.

cover off one of its older machines and then dropped it into this newer chassis. The older chassis sits at the bottom of the new one, leaving room at the top for the two additional half-height devices.

This design leaves the power switch in an interesting spot. It is a large red rocker switch on the right side of the inner chassis—but that side is now in a cavity at the top of the taller, floor-standing unit. ALR solved this problem by putting a small (4-inch by 2¾-inch) metal door on the back of the system near the top. To turn on the unit, you loosen the restraining thumbscrew, open the door, and reach in and flip the power switch. The company defended this design by pointing out that, while this procedure is certainly awkward, it makes it difficult for anyone to turn off the unit accidentally.

Both the inner and outer chassis, as well as nearly all of the system, are metal, so I expected an FCC Class B approval. Instead, the 20386 has only FCC Class A certification. An ALR spokesperson said the company could get Class B approval easily but had not filed for it because it expects this system to be used primarily in the office and only rarely in a home.

When you poke around inside a bit more, you find that ALR reused more than just the old chassis: The motherboard appears to be the same one that ALR used in its previous 80386-based systems—the ALR 386/2. It is even labeled "386/2." If you take it out, however, you find that ALR has changed it in several important ways.

The most obvious change is the addition of a 6⅓-inch by 5⅞-inch daughterboard that connects to the motherboard by plugging into its 80386 socket. There are also about a dozen wires on the back of the motherboard that ALR uses to make signal corrections to support the daughterboard.

The daughterboard contains the heart of the 20386: the 80386 CPU, the 80387 math coprocessor, the 82385 cache controller chip, four SRAM modules that provide the cache memory, and 21 support chips. All three of the Intel chips are socketed. The current 80387 socket cannot support a Weitek coprocessor. A spokesperson said that ALR was planning to design a new motherboard that would combine the functions of the current daughterboard and motherboard on one board, and that the new board would support a Weitek board or an 80387.

The daughterboard actually connects to an extender that is plugged into the 80386 socket on the motherboard. It is mounted on three standoffs that are glued to the motherboard to prevent contact with the chips on the motherboard.

The motherboard itself is about 13¾ inches by 12 inches. It contains all the standard AT circuitry, such as the clock and the AT bus, as well as up to 2 megabytes of 80-ns DRAM. It is a very busy board, however, with almost 120 chips—not counting the DRAM chips. My unit had 72 DRAM chips on the motherboard, giving it 2 megabytes of memory.

The system has eight full-length expansion slots. On the bottom are two special 32-bit slots. Even though they look exactly like standard AT slots, you can use them only for the ALR 32-bit memory card set. These two cards are installed together and hold, in 1-megabyte increments, from 1 to 4 megabytes of 80-ns DRAM. ALR also offers a 4-megabyte daughtercard that attaches to the memory card set. This gives you 8 megabytes of additional memory on this two-card set, for a maximum configuration of 10 megabytes.

There are also two 8-bit expansion slots and four 16-bit slots. In my evaluation unit, ALR's EGA card occupied one of the 8-bit slots, and the ESDI disk controller card and the serial/parallel/floppy disk controller card filled two of the 16-bit slots. Two 16-bit slots and one 8-bit slot were empty.

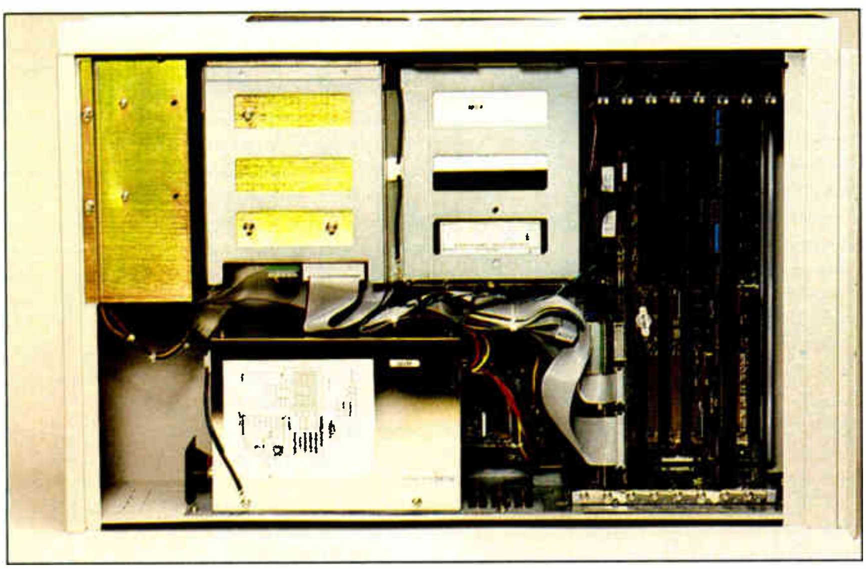


Photo 1: *The internal view of the 20386 clearly shows the case-within-a-case construction that allows extra space for additional disk drives.*

The FlexCache Architecture

The 20386's FlexCache architecture works much like the Compaq Flex architecture that I described in my review "Compaq Flexes Its Muscles" (February BYTE), but it is a different hardware design. There are two different buses that operate concurrently. One is the standard 16-bit AT bus that the system uses for peripherals. The other is a 32-bit local bus that is connected to the 82385 cache controller and the cache. The 80386 and 80387 use this 32-bit bus to retrieve data from memory.

A cache controller tries to satisfy any CPU memory request with data already in the cache. When it can (a hit), the CPU can keep working without waiting on the slower memory. When the desired data is not in the cache (a miss), the CPU waits while the cache controller gets the data from the slower DRAM system memory. ALR claims a cache hit rate of 95 percent. The 82385 also handles all the cache management chores required to ensure that data in the cache is valid.

The BIOS (Phoenix Technologies version 1.00 04 on my evaluation unit, version 1.10 001F on future units) is stored in slow ROM chips that sit on the AT-compatible bus. To speed up access to the ROM BIOS, the system copies it to the 128K-byte area just below the 16-megabyte memory line. If the computer contains an ALR EGA card, it also copies the EGA ROM BIOS to that area. The 20386 then protects that memory so no program can write on the BIOS.

Whole Lotta Storage

My unit contained a Toshiba 1.2-megabyte 5¼-inch floppy disk drive and a TEAC 1.44-megabyte 3½-inch floppy disk drive. ALR also offers a 360K-byte 5¼-inch floppy disk drive.

My hard disk drive was a 151.2-megabyte Control Data Corp. Model #94166-182 drive. It was controlled by a Western Digital ESDI controller that runs with 1-to-1 interleaving. The Core Disk Performance Test Program indicated that the drive system had a data transfer rate of

continued

780.9K bytes per second, an average seek time of 18 milliseconds, and a track-to-track time of 4.8 ms.

The EGA-compatible card in the review unit was made by ALR. It was driving a 13-inch Casper Model TE 5154 enhanced color monitor, which comes with a tilt-and-swivel base.

The keyboard was made by Maxi-Switch. It follows the IBM Enhanced keyboard layout and has two legs that you can tilt. The key action was good and produced a mechanical click. You can use a DIP switch on the back of the keyboard to swap the functions of the Caps Lock and Control keys.

Documentation and Software

The 20386 came with the ALR 386/2 version 4.0 Setup Utilities disk. The disk contains a Setup program, a program for doing a low-level disk format, an expanded memory manager (QEMM.SYS), a driver for 3½-inch floppy disk drives (in case you are not running MS-DOS 3.3), an ESDI driver, system diagnostics, a program to patch the disk-related bugs in MS-DOS 3.2, and the SETSPEED.EXE program. With SETSPEED, you can set the system to its normal high speed (20 MHz), or you can have it run at its low speed and emulate a 10-MHz system.

ALR also bundles Control/386 version 1.15 from Phoenix Technologies with the 20386. This package contains many programs that can help you run an 80386-based system, including an Enhanced Expanded Memory Specification (EEMS) driver, a disk-cache program, and hard disk utility programs.

Four manuals accompanied my system: a quick installation and reference guide, a user's guide, an operating manual for the high-resolution color display monitor, and a user's guide for the Control/386 programs. The main manual, entitled FlexCache 16386/20386 User's Manual, is reasonably well written and clear. It contains many useful technical charts and explanations.

After the Sale

The 20386 comes with a one-year parts and labor warranty. You have to pay to ship your system to ALR, but the company pays return shipping. This warranty, however, does not cover any options that your dealer installs.

You also get unlimited telephone support with the 20386. The support staff seemed generally knowledgeable and pleasant. They were able to answer all my questions about operating the machine and adding options to it.

You also can extend your service warranty for one, two, or three additional years with the ALR Extended Warranty Program. A one-year extension costs $579 for the Models 100 and 150, and $749 for the Model 300.

Tops in Price and Performance

Because of the 20386's 20-MHz CPU and FlexCache architecture, currently only the Deskpro 386/20 is in its performance class. On the down side, the 20386 is big, and some of the engineering (at least on my evaluation unit) could be more polished. The Deskpro 386/20, while more crowded and difficult to take apart, is a more finished product. On the other hand, a Deskpro 386/20 Model 130, equipped comparably to my evaluation unit but with 20 megabytes less disk storage, costs $1730 more.

The FlexCache 20386 has power to burn. But you should plan to spend over $10,000 for most ready-to-use configurations. If you can afford it, the FlexCache 20386 is (at least for the moment) tied for tops in PC performance. ■

Mark L. Van Name is a freelance writer and computer consultant living in Durham, North Carolina.

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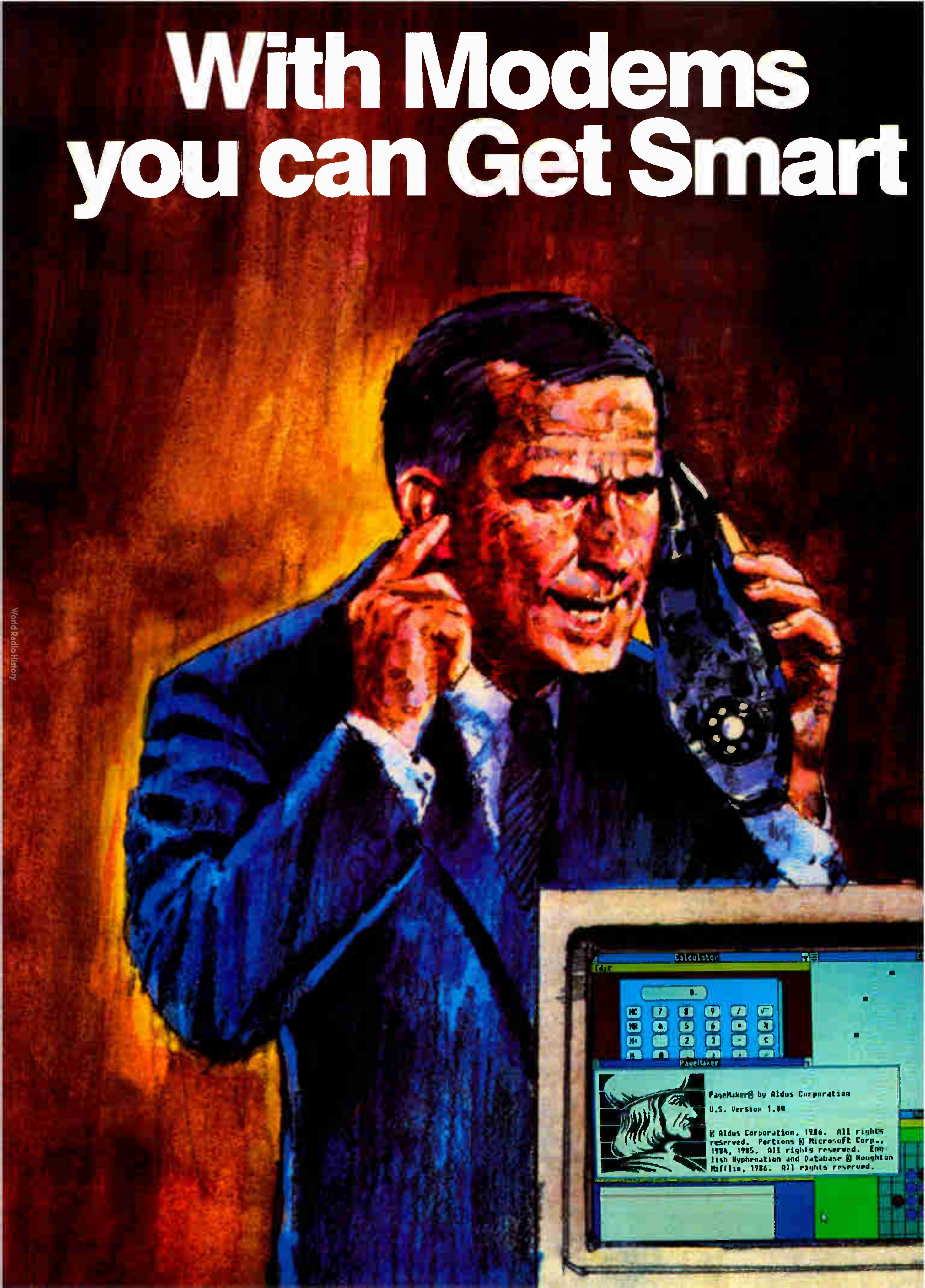

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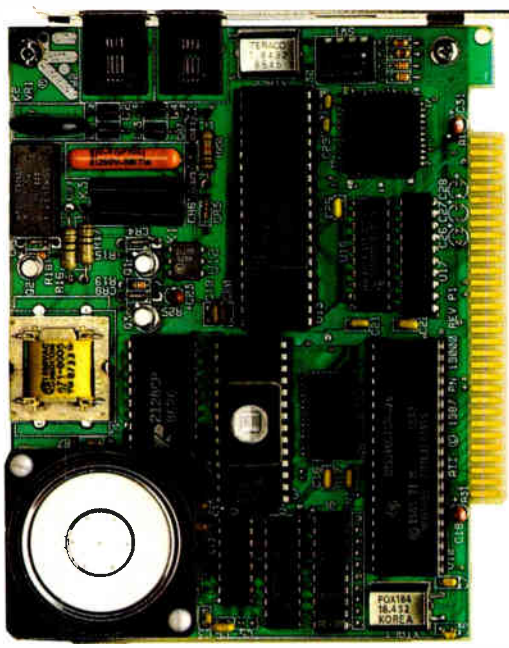

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CLEO

A Tale of Two Laptops

Wayne Rash Jr.

NEC's MultiSpeed HD and HP's Vectra CS Model 20 take very different approaches to portability

Cramming the functionality of a complete desktop computer, including monitor, power supply, and hard disk drive, into a briefcase-size package is no small task. Although we're now seeing laptops with far more power than a year ago, design problems still mean compromises.

That's the case with NEC's and Hewlett-Packard's latest laptops. While the MultiSpeed HD and Vectra CS Model 20 are both MS-DOS machines with hard disk drives and liquid crystal displays (LCDs), they are as unlike each other as two such computers can be. Both have solid strengths, and both have significant weaknesses.

The HP Vectra CS Model 20 ($3595) is designed for long battery life and to function well as a desktop computer. It has a full-size keyboard and a screen that maintains the normal aspect ratio of an 80-column monitor. Typing on the Vectra is easy. In fact, the Vectra may have the best keyboard of any laptop computer available.

However, the long battery life and the large screen and keyboard create problems with size and weight. In addition, because of the emphasis on long battery life, HP has outfitted the machine with a display that is not backlit. In short, the Vectra is large, heavy, and difficult to use as a portable.

NEC, on the other hand, has opted for convenience in the MultiSpeed HD ($3695). The computer is smaller and lighter than the Vectra, and it has one of the best screens I've used. Along with the small, light computer comes a small, light battery that tends to run out of steam pretty quickly: The MultiSpeed runs for only an hour or two on internal power.

Like the Vectra, the MultiSpeed has an excellent keyboard, although it is less like that of a desktop IBM PC. In addition, the screen does not preserve the aspect ratio of the PC, so your pie charts may look like egg charts.

The differences between the MultiSpeed (left) and Vectra (right) go beyond appearance.

Hewlett-Packard's Approach

HP seems to have placed its emphasis on building a machine that would do well as an office desktop computer that could occasionally be taken into the field. HP claims that the Vectra has exceptionally long battery life for a hard disk drive computer—up to 10 hours. But this machine is unlikely to gain much favor while traveling: Its 19½-pound weight and great size conspire against it. In addition, I was unable to get it to run longer than 6 hours before the battery died.

As a desktop machine, it performs better than other laptops. The full-size keyboard with separate numeric keypad is about the same size as keyboards on traditional desktops. It has 12 function keys along the top of the keyboard, and the Control and Alt keys are arranged as they are on the IBM Enhanced keyboard. You do not need to learn those mysterious triple-key combinations that plague other laptops.

In the office, you can remove the 7-inch by 9¼-inch, 80-column by 25-row LCD screen and plug in a standard monitor. The video controller lets you use either a CGA or an EGA monitor; a switch beneath the battery lets you select the one you want to use. To get to the switch, you have to remove the battery—a step that also erases the setup information for the computer.

The monitor plugs into a 9-pin connector on the rear of the computer, next to the parallel printer port. Also on the rear are covers for expansion slots for Expanded Memory Specification (EMS) memory, serial ports, and modems. The 3½-inch floppy disk drive and the 20-megabyte hard disk drive emerge from the top of the computer. Also on the top is a bar graph, resembling a fuel gauge, that shows the life remaining in the lead-acid battery.

The Vectra laptop uses an 8086-compatible NEC V30 processor running at 7.16 MHz. It has 640K bytes of 120-nanosecond (ns) RAM, room for an 8087 math coprocessor, and a high-density 1.44-megabyte 3½-inch floppy disk drive. The computer supports the use of proprietary-bus expansion cards that let you add memory, I/O ports, or modems; this lets you set up the machine for your specific use more easily than with other laptops. You can add an HP-422 serial

continued

Vectra CS Model 20

Company
Hewlett-Packard
Customer Information Center
19310 Pruneridge Ave.
Cupertino, CA 95014
(800) 367-4772
(415) 857-1501

Components
Processor: 7.16-MHz NEC V30; socket for optional 8087 math coprocessor
Memory: 640K bytes, expandable to 4 megabytes of EMS memory
Mass storage: 1.44-megabyte 3½-inch floppy disk drive; 20-megabyte hard disk drive
Display: CGA on internal LCD screen; CGA and EGA for external monitor
Keyboard: 92 keys, including separate numeric keypad
I/O interfaces: Parallel printer port; four internal proprietary-bus expansion slots

Size
16½ by 14 by 3½ inches; 19½ pounds

Software
HP Personal Applications Manager

Options
Dual serial adapter with 0 to 2 megabytes of RAM: $220 to $1415
2400-bps synchronous/asynchronous modem: $695
1200-bps asynchronous modem: $450
HP Vectra DOS 3.2: $95
12-inch monochrome monitor: $325
13-inch enhanced monitor: $845
Battery module: $250
Recharger: $155
Soft case: $150
Technical Reference Manual: $125

Documentation
62-page Setting Up the Portable Vectra CS; MS-DOS manual; pamphlets for disk-cache program; support guide

Price
$3595

Inquiry 884.

MultiSpeed HD

Company
NEC Home Electronics (U.S.A.) Inc.
1255 Michael Dr.
Wood Dale, IL 60191
(800) 447-4700

Components
Processor: NEC V30 running at 4.77 MHz and 9.54 MHz
Memory: 640K bytes of RAM (first 126K bytes is CMOS, battery-backed-up for RAM disk); 512K-byte ROM
Mass storage: 720K-byte 3½-inch floppy disk drive; 20-megabyte hard disk drive
Display: CGA on internal backlit LCD screen or external monitor
Keyboard: 85 keys, including separate numeric keypad
I/O interfaces: Bidirectional parallel printer port; RS-232C (25-pin) serial port; CGA monitor port; floppy disk drive controller/expansion port

Size
13¾ by 12½ by 3½ inches; 14 pounds

Software
MS-DOS 3.2; in ROM: Telcom, Outliner, Filer, Dialer, Notepad, Setup

Options
300-/1200-bps modem: $399
300-/1200-/2400-bps modem: $499
Leather carrying case: $249
Semi-rigid carrying case: $129
Car DC cable: $20

Documentation
241-page MultiSpeed HD User's Guide; 120-page Introduction to MS-DOS; 280-page Outliner-Filer-Notepad User's Manual; 147-page Telcom-Dialer User's Manual

Price
$3695

Inquiry 885.

port for instrumentation, for example, or up to 4 megabytes of EMS 3.2 memory for handling large spreadsheets.

The Vectra is quite compatible with the IBM PC. While I do not have the range of software on 3½-inch disks that I do on 5¼-inch disks, I was able to confirm that WordStar 4.0, dBASE III Plus, Multiplan 2.1, HyperACCESS 3.2, and Procomm 2.4.2 all work fine. HP says all business-related IBM software runs on the Vectra.

Travel Pains

Clearly, HP did not design the Vectra laptop for air travel. Its weight and size make it inconvenient to carry onboard an aircraft, but this is insignificant compared to the inconvenience of actually using it on one.

I carried the Vectra on a cross-country flight in a United Airlines DC-10. Even though I was traveling First Class, the Vectra was simply too large to use comfortably; using it in Coach would have been out of the question. The computer's weight even bent the table attached to my seat. (These travel pains were eased somewhat by a roomy and attractive vinyl carrying case that looked like leather and was comfortable to carry.)

To make matters worse, the Vectra's LCD screen was essentially illegible in the well-lit aircraft cabin. It remained hard to read in reasonably well lit hotel rooms. The lack of backlighting was a serious handicap under many of the conditions where a laptop computer would be the logical choice. The brightness and contrast controls varied the display, but they could not raise the screen brightness to readable levels.

Using the Vectra is complicated by the minimal documentation that HP provides with the machine. All you get is a slim setup guide, an MS-DOS manual, and some pamphlets that accompany the software and accessories. Additional manuals are available at extra cost.

NEC's Approach

The NEC MultiSpeed computer has earned praise since the floppy disk version was introduced last year—and it deserves the praise. Like its floppy disk-based sibling, the hard disk drive version of the MultiSpeed is well designed and easy to use. Unlike the Vectra, it is light, relatively small, and convenient to use out of the office.

It is also nearly as convenient to use as a desktop machine as the Vectra is. The backlit LCD screen removes in seconds to allow the MultiSpeed to support a standard CGA monitor. The keyboard is excellent, and, like the Vectra, the MultiSpeed supports a separate numeric keypad, although its location is slightly less convenient—above the keyboard rather than next to it.

The external monitor plugs into a 9-pin connector on the rear of the computer. Also located on the rear are a standard parallel printer port, a 25-pin serial port, and a floppy disk drive expansion connector. The rear panel also has a switch that controls the speed of the processor so you can switch between 4.77 MHz (for compatibility with the original IBM PC) and 9.54 MHz. There is also a reset switch on the rear. The connectors are protected by small plastic covers that look like they would get lost easily.

Included with the MultiSpeed are cables that allow the use of Zenith and Toshiba external 5¼-inch floppy disk drives, and a cable that lets you connect the machine to an IBM PC so the PC can use the MultiSpeed's disks. This permits considerable flexibility in transferring information to and from the MultiSpeed.

The MultiSpeed's 3½-inch floppy disk drive is located on the right side of the machine. This drive supports the standard 720K-byte MS-DOS format for 3½-inch drives—the same format that Data General, Zenith, and Toshiba use

continued

NEC MultiSpeed HD
HP Vectra CS Model 20

APPLICATION-LEVEL PERFORMANCE (in minutes and seconds)

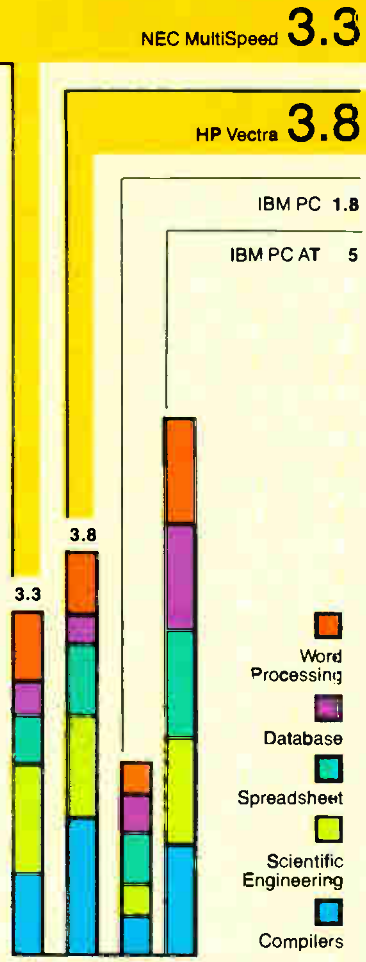
WORD PROCESSING	NEC Med.	NEC Large	HP Med.	HP Large
XyWrite III + 3.52				
Load	N/A	:25	N/A	:28
Word count	:10	1:17	:10	1:19
Search/replace	:17	1:10	:19	1:15
End of document	:05	:44	:05	:47
Block move	:33	:33	:24	:24
Spelling check	:31	3:54	:34	4:17
Microsoft Word 4.0				
Cursor move	5:41		:31	
Forward delete	1:27		:57	
Aldus PageMaker 1.0a				
Load	N/A[1]		N/A[1]	
Change/bold	N/A		N/A	
Align right	N/A		N/A	
Cut 10 pages	N/A		N/A	
Place graphic	N/A		N/A	
Print to file	N/A		N/A	
Index:	.73		1.26[2]	

SPREADSHEET	NEC	HP
Lotus 1-2-3 2.01		
Block copy	:12	:14
Recalc	:05	:05
Load Monte Carlo	:56	:59
Recalc Monte Carlo	:24	:27
Load rlarge3	:14	:15
Recalc rlarge3	:04	:04
Recalc Goal-seek	:12	:13
Microsoft Excel 2.0		
Fill right	:15	:19
Undo fill	6:16	6:58
Recalc	<:01	<:01
Load rlarge3	1:25	1:20
Recalc rlarge3	:05	:05
Index:	1.01	.97

DATABASE	NEC	HP
dBASE III + 1.1		
Copy	3:51	3:06
Index	:32	:29
List	4:27	3:18
Append	6:49	5:31
Delete	:08	:06
Pack	4:12	3:30
Count	:24	:24
Sort	3:06	2:36
Index:	.58	.69

ENGINEERING/SCIENTIFIC	NEC	HP
AutoCAD 2.52		
Load SoftWest	9:30	9:41
Regen SoftWest	8:01	9:01
Load St. Pauls	2:37	2:40
Regen St. Pauls	2:07	2:25
Hide/redraw	1:41:15	1:53:57
STATA 1.5		
Graphics	3:21	3:36
ANOVA	2:21	2:30
MathCAD 2.0		
IFS 800 pts.	4:22	4:49
FFT/IFFT 1024 pts.	5:14	5:45
Index:	.32	.29

COMPILERS	NEC	HP
Microsoft C 5.0		
XLisp compile	14:03	15.02
Turbo Pascal 4.0		
Pascal S compile	:19	:17
Index:	.65	.6



[1] No mouse.
[2] The result for the Word cursor move test gives the Vectra a higher overall index than the IBM PC AT for word processing.

Indexes show relative performances; for all indexes, an 8-MHz IBM PC AT = 1; graphs are based on indexes.

LOW-LEVEL PERFORMANCE[1] (in seconds)

CPU	NEC	HP
Matrix	18.71	21.53
String Move		
Byte-wide	116.54	118.67
Word-wide:		
Odd-bnd.	116.54	118.69
Even-bnd.	58.27	59.38
Sieve	104.32	113.86
Sort	121.66	132.62
Index:	.68	.6

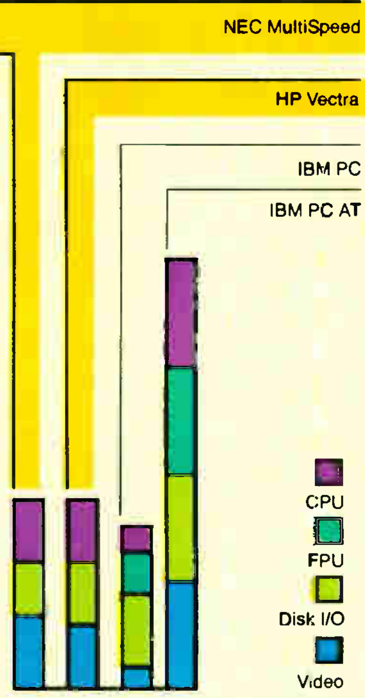
FLOATING POINT[2]	NEC	HP
Math	N/A	N/A
Error[3]	N/A	N/A
Sine(*x*)	N/A	N/A
Error	N/A	N/A
e^x	N/A	N/A
Error	N/A	N/A

DISK I/O	NEC	HP
Hard Seek[4]		
Outer track	9.18	9.16
Inner track	9.20	9.22
Half platter	23.10	23.05
Full platter	27.68	27.72
Average	17.29	17.29
DOS Seek		
1-sector	16.84	17.33
8-sector	47.94	49.42
File I/O[5]		
Seek	.49	.37
Read	.060	.058
Write	.061	.054
1-megabyte		
Write	16.79	13.47
Read	13.97	10.05
Index:	.5	.58

VIDEO	NEC	HP
Text		
Mode 0	23.34	19.61
Mode 1	23.38	19.61
Mode 2	25.54	21.09
Mode 3	25.52	21.07
Mode 7	23.45	18.78
Graphics		
Mode 4	6.88	7.52
Mode 5	6.88	7.52
Mode 6	7.45	8.13
Mode 13	N/A	N/A
Mode 14	N/A	N/A
Mode 16	N/A	N/A
Index:	.6	.6

CONVENTIONAL BENCHMARKS

	NEC	HP
LINPACK	8846	9739
Livermore Loops[6] (MFLOPS)	.0024	.0022
Dhrystone (MS C 5.0) (Dhry/sec)	1164	1066



[1] All figures were generated using the 8088/8086 version of Small-C (16-bit integers).
[2] The floating-point benchmarks used 8087-compatible instructions only.
[3] The errors reported for the floating-point benchmarks indicate the difference between expected and actual values.
[4] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).
[5] Read and write times for the File I/O benchmarks are in seconds per Kbyte.
[6] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

For a full description of the benchmarks, see "Introducing the New BYTE Benchmarks" on page 239.

for their laptops. The 20-megabyte hard disk drive is hidden deep in the machine.

The MultiSpeed's computing power comes from NEC's 9.54-MHz V30 microprocessor. There is no provision for an 8087 math coprocessor. The first 126K bytes of the 640K-byte memory is low-power CMOS RAM that stays powered up by the battery and can be used as a nonvolatile RAM disk. The RAM disk software is included with the system.

The 2200-milliampere nickel-cadmium battery that powers the MultiSpeed when it's being used as a portable is beneath an easily removed cover just behind the screen. It is designed for quick replacement, making its short life somewhat less of a problem. Still, you can expect only an hour or two of operation using both the hard disk drive and the screen backlighting.

The MultiSpeed gets its name from its ability to operate at two different speeds. This function is controlled by a DIP switch on the rear panel of the machine. While there was once a need for the slower speed to satisfy some copy-protection schemes, the problem seems to have disappeared; although a few games still operate properly only at the slower speed, the multiple-speed capability seems to be of questionable value.

Included with the MultiSpeed is a collection of ROM-based applications. The machine's 512K-byte ROM contains Telcom, Outliner, Filer, Dialer, Notepad, and Setup. The machine has sockets for four additional ROMs beyond the two that contain the applications.

A dedicated key, labeled "Pop-up" on the keyboard, invokes these applications. When the key is pressed, a menu appears, and you select the program you want. The machine normally has these applications enabled, along with the RAM disk, but you can clear them out of memory if you need the space. In addition to the ROM software, the MultiSpeed also includes MS-DOS 3.2, and there is a help key that produces ROM-resident help screens for the built-in applications.

On the Road with the MultiSpeed

The MultiSpeed HD is built for the convenience of the person who must use it while traveling. This machine fits well on the tables in First Class on a DC-10, and its weight is within their capabilities. The screen was easily visible under any lighting conditions I encountered while traveling. Unfortunately, the short battery life limits your productivity on a long flight.

The MultiSpeed also works well in hotels and offices. The external power supply can use 50- or 60-Hz power from 100 to 220 volts. In short, you can use it anywhere. Its relatively small size and light weight make it easy to carry while traveling, and its rugged fabric case is well designed.

The machine's use is enhanced by the excellent manuals that have become one of NEC's strong points. The four manuals are clearly written, well illustrated, and very helpful to users who find themselves with questions in places where they can't ask for help.

Similar Performance

A quick look at the benchmarks (see the graphs on page 128A) shows that these two machines perform similarly, despite the difference in CPU speeds. It's clear that the Vectra operates without wait states, negating much of the MultiSpeed's potential speed advantage. Still, the MultiSpeed is slightly faster in all the standard CPU benchmarks. This can be attributed primarily to its slightly higher clock speed.

continued

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1-800-4 CORVUS

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Circle 306 on Reader Service Card

The two machines split wins in the hard disk tests, with the Vectra coming out slightly ahead in the tests that go through the operating system for disk access. The screen display tests came through with another split, with the MultiSpeed a bit faster in graphics and the Vectra much faster at displaying text.

Although the Vectra turned in a slightly higher overall score in the applications benchmarks, these tests also failed to deliver a strong winner. Some of the applications, such as Excel, Lotus 1-2-3, and AutoCAD, showed the MultiSpeed to be the faster machine. Others, notably dBASE III Plus and Word, favored the Vectra. It is important to note that the results of the Vectra running Word show a level of performance not supported by other tests. It looks like the Vectra's key-repeat rate and graphics display connected perfectly with Word to make the HP computer a real screamer on this application.

While the benchmarks didn't show either computer to be clearly superior to the other, they did show that both computers perform well. Both machines consistently ranked closer to the IBM PC AT than to the IBM PC.

A Winner on Convenience

In terms of convenience, there is a significant difference between the machines. On one hand, there is the massive Vectra with its full-size keyboard and long battery life. On the other hand is the convenience of the MultiSpeed, tempered by its short battery life.

The Vectra's strengths make it a good solution if you need a machine that works well as a desktop computer but must occasionally be taken out of the office. The key word here is "occasionally." The lack of backlighting makes using the Vectra a chore in the field.

The Vectra's size and weight also conspire against its usefulness. The battery is again partly the culprit, but so is the placement of the numeric keypad, which is located in the same place as the keypad on desktop machines. Nice, but I'm not convinced it's worth the cost in space and weight. The MultiSpeed's keypad works quite well located above the letter keys, and it allows for a much more compact machine.

The MultiSpeed performs nearly all the functions that the Vectra does, and it works equally well as a desktop machine, except that it does not support an EGA monitor. In addition, unlike the Vectra, the MultiSpeed is a willing traveler. It can be used conveniently out of the office, although, because of the short battery life, it cannot be used for long.

In spite of the battery-life problem, the MultiSpeed's usability and portability make it one of the best laptops available. Clearly, a great deal of thought went into meeting the needs of laptop users. If I had to make a choice between the MultiSpeed and Vectra, I'd choose the MultiSpeed.

There are other choices, however. If you're willing to live with a couple of extra pounds, the highly regarded Zenith Z-183 provides the best of both worlds. It has a screen the size of the Vectra's that's as easy to read as the MultiSpeed's. Its keyboard is not as good as the Vectra's or the MultiSpeed's, but its battery life is nearly as good as the Vectra's, lasting nearly 5 hours in the latest tests I performed. There's also the T3100/20 from Toshiba, which gives you all the performance of the IBM PC AT, with an 80286 and a fast hard disk drive, but which has no battery. For me, it's a toss-up between the MultiSpeed and the Zenith. ■

Wayne Rash Jr. is a member of the professional staff of American Management Systems, Arlington, Virginia. He consults with the federal government on microcomputers and communications.

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Revitalize Your Old AT

Don Crabb

Four 80386 replacement motherboards significantly improve your AT's performance

The dream of every computer owner is to take the old machine and make it run faster, give it more versatility, keep it compatible with current software, and do all that for very little money. Most owners, however, just replace the old machine with a newer model. While the price of 80386-based machines has dropped over the last year, you can still expect to pay $3000 and up for the privilege of owning one. And if you've set your sights on the high end of the market (such as the Compaq Deskpro 386/20 or the IBM PS/2 Model 80), you can expect to pay over $10,000. Equip these high-end models with big, fast hard disk drives and lots of memory, and the price reaches the $20,000 range. In addition, you absorb the cost of your old AT, which just languishes in the background once you've bought an 80386 machine.

There is an alternative. You can replace the original motherboard in your computer with a newer 80386 motherboard. With a 32-bit processor and 32-bit data and address paths, an 80386 machine can give you a tremendous performance advantage over an 80286-based system. These motherboards typically cost about $1500 and up—less than a full 80386 system but more than an 80386 accelerator card. They offer better performance than accelerator cards, however, because combining an accelerator card and an older AT motherboard can create an I/O bottleneck.

Many of the early 80386 boards (such as the Intel iSBC 386 AT) did not take advantage of very-large-scale-integration (VLSI) custom chips; consequently, they were crowded designs whose performance was far below the predicted level. That has all changed in the last several months: A whole slew of 80386 replacement motherboards for PC XT and PC AT chassis has appeared.

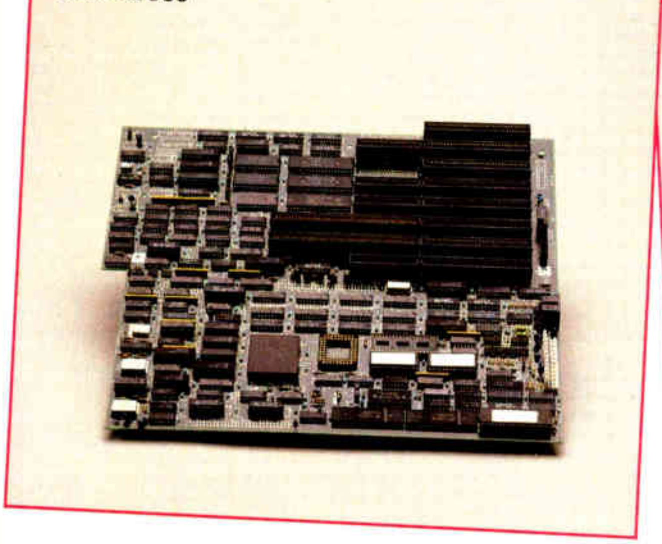
For this review, I looked at four 80386 motherboards made for AT-style chassis: the Fortron 386, the Micronics 386, the Turnpoint 386, and the Whole Earth Electronics (Mylex) 386. These boards are designed to improve the overall performance of your AT by 2 to 4 times by executing instructions on a faster 16- or 20-MHz 80386 chip. They also supply additional fast 32-bit RAM that can be used to further increase system performance while maintaining compatibility with DOS 3.x and your applications software.

These boards replace the existing motherboard in your AT. Basically, you must disembowel your AT to install one of the boards. They have the usual complement of slots (32-bit, 16-bit, and 8-bit), plus keyboard connectors, a keylock, LED connectors, jumpers, a battery-powered clock/calendar, coprocessor sockets (for 80387 or 80287 chips), and a power supply connector that you'd expect to find in any AT-style motherboard.

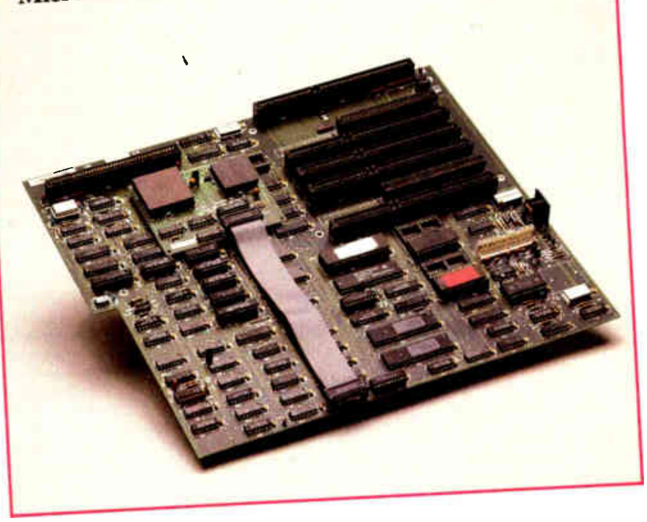
AT Chassis Required

Besides upgrading an AT, you can easily build your own 80386 machine around

Fortron 386



Micronics 386



one of these boards by adding a power supply (185 watts or greater), a generic AT chassis, an AT-style keyboard and cable, a combination floppy disk drive/hard disk drive controller, a floppy disk drive, a hard disk drive, a speaker, a keylock, a turbo switch, and status LEDs, plus a monitor and an EGA or VGA video card. All you'd have to add to this mix is DOS 3.1 or higher, and you'd have a fast, inexpensive 80386 machine.

Some of the boards come with 32-bit memory standard on the board itself, while others come with their standard RAM on a 32-bit plug-in card. In any case, each board I tested came with a minimum of 1 megabyte of 32-bit RAM.

But if you're not up to building a new system from scratch, these boards will function nicely in most AT-style computers. As long as your machine's motherboard conforms to the AT's motherboard form factor (roughly 12 inches by 13 inches), you should be able to install any of these boards as an upgrade replacement. Your only other consideration is your keyboard; if it's not AT-compatible, it may not work with the particular keyboard ROM BIOS installed in the motherboard you buy. Other hardware compatibility issues are minor, since you are giving up your existing AT motherboard in favor of a new system with new ROM BIOS, a new processor, new RAM, and so on.

Not for the Novice

Replacement motherboards are not for the timid or the novice, or even the casual board twiddler, and don't let anyone try to tell you otherwise. While these boards can boost your AT's performance, they can be very tricky to install and configure. I've been building and using computers for 20 years, and I can't imagine anyone thinking that the complete dismantling of an AT and installation of a new motherboard is "simple." The manufacturers of all the boards I tested caution against inexperienced people installing these boards. Indeed, many of the 80386 motherboards now on the market were originally sold only to OEMs because of the difficulty of installing them.

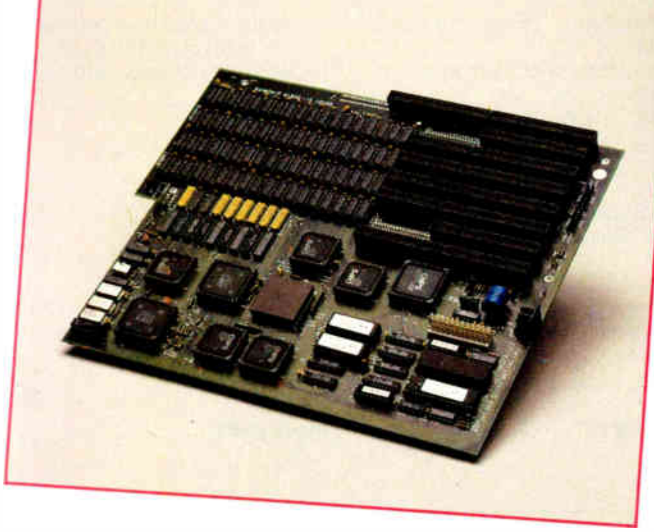
Typically, you have to ground the AT's chassis (with a grounded antistatic mat), yourself (using a wrist grounding strap), and the replacement motherboard (using an alligator clip wired to a separate ground) before you begin. Then you have to dismantle your current AT, noting where all the board connectors are located and how they're connected.

The grounding process also has to be done carefully to avoid a ground loop that would reinforce any static problems. A ground loop is what occurs when you have more than one common ground for any electrical potential. You want only one true ground for any such potential. Ground loops tend to reinforce static effects rather than dissipate them. The best situation is to run one true earth ground to each electrical surface you want to ground; such grounding is called an *isolated ground*. By definition, isolated grounds cannot result in ground loops.

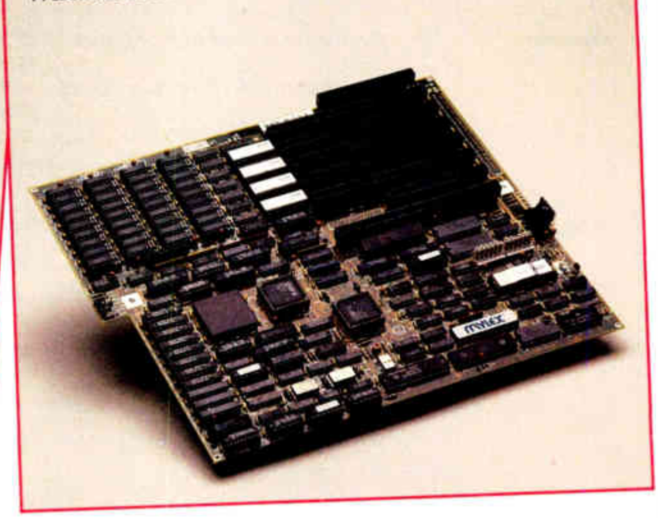
After dismantling your AT, you have to install the new 80386 motherboard in the chassis. Then you reconnect the power supply, install the disk controller, and reinstall the disk drives, keyboard, keylock, status LEDs, turbo switch and LED

continued

Turnpoint 386



Whole Earth Electronics (Mylex) 386



	Fortron 386	Micronics 386	Turnpoint 386
Type	80386 replacement motherboard	80386 replacement motherboard	80386 replacement motherboard
Company	Fortron Corp. 2380 Qume Dr., Suite F San Jose, CA 95131 (408) 432-1191	Micronics Computers Inc. 935 Benecia Ave. Sunnyvale, CA 94086 (408) 732-0940	Turnpoint America 150 North Center St., Suite 224 P.O. Box 41334 Reno, NV 89504 (702) 786-4484
Design Topology	Not specified	Not specified	Not specified
Components	Processor: 80386 running at 16 MHz with one wait state; socket for optional 80387 or 80287 math coprocessor Memory: 2 megabytes of RAM standard on 32-bit plug-in memory card (no RAM on motherboard); optional 2- or 8-megabyte accessory memory card; Award Software or Phoenix Technologies 386 ROM BIOS and keyboard BIOS Slots: Four AT-style 16-bit slots; two proprietary 32-bit slots for system memory; two XT-style 8-bit slots Other: Speaker, turbo switch, and LED connectors; keylock; AT-style keyboard jack supplied; standard AT-style power connectors supplied; two serial ports and one parallel port; real-time clock/ calendar with battery backup for system configuration CMOS RAM Warranty: One year	Processor: 80386-20 running at 20 MHz with zero wait states; compatibility speed operation at 16, 8, 6, and 4.77 MHz; optional Intel 80287-8, 80287-10, 80387-16, or 80387-20 math coprocessor (test unit included an 80387-20 on a special daughterboard that also held the 80386-20) Memory: 1 megabyte of RAM on motherboard; optional 2-megabyte 32-bit memory board; expandable to 10 megabytes with optional 8-megabyte 32-bit memory board; Phoenix 386 ROM BIOS; Award keyboard ROM BIOS; Award ROM BIOS and Phoenix keyboard ROM BIOS also available at no extra cost (board has sockets for both ROM BIOS and can be software-selectable as desired) Slots: Five AT-style 16-bit slots; two XT-style 8-bit slots; one 32-bit slot for proprietary RAM board Other: Speaker, turbo switch, and LED connectors; keylock; AT-style keyboard jack supplied; standard AT-style power connectors supplied; battery backup for CMOS configuration table and real-time clock Warranty: One year parts and labor	Processor: 80386-16 running at 16 MHz with zero wait states; optional 80287-10 math coprocessor Memory: Optional 2-megabyte 32-bit RAM board; AMI 386 ROM BIOS; optional Award or Phoenix BIOS; AMI keyboard BIOS Other: Speaker, turbo switch, and LED connectors; keylock; AT-style keyboard jack supplied; standard AT-style power connectors supplied; system support functions include seven-channel DMA, 16-level interrupt, three programmable timers, and a real-time clock; CMOS RAM to maintain system configuration parameters; battery backup for CMOS configuration table and real-time clock Slots: Five AT-style 16-bit slots; two XT-style 8-bit slots; one 32-bit slot for proprietarty RAM board Warranty: One year parts and labor
Size	12 by 13 inches; conforms to AT motherboard form factor	12 by 13 inches; conforms to AT motherboard form factor	12 by 13 inches; conforms to AT motherboard form factor
Software	ROMBIOS utility for running ROM in 32-bit RAM	RAM BIOS and EGA BIOS utilities for relocating BIOS into 32-bit RAM; MICEMM (LIM/EMS) software	None supplied
Options	2-megabyte DRAM memory board: $850 8-megabyte DRAM memory board: $2650 80287-8 coprocessor: $250 80287-10 coprocessor: $289 80387-16 coprocessor: $485	2-megabyte 32-bit memory board: $995 8-megabyte 32-bit memory board: $4995 80387 adapter: $99	2-megabyte 32-bit memory board with 0K bytes of DRAM: $149 80287-10 coprocessor: $300
Documentation	The Complete Computer Companion; Motherboard Jumper Settings and Hard Disk Installation Guide	386 System and Memory Board User Manual	80386 Motherboard User's Manual
Price	With 2-megabyte DRAM card: $2250	With 2 megabytes of DRAM: $2950	With 0K bytes of DRAM: $1495
	Inquiry 886.	**Inquiry 887.**	**Inquiry 888.**

Whole Earth Electronics (Mylex) 386

80386 replacement motherboard

Whole Earth Electronics
1321 67th St.
Emeryville, CA 94608
(415) 653-7758
(800) 323-8080

Eight-layer

Processor: 80386-16 running at 6 MHz or 16 MHz with zero wait states; optional Intel 80287-8 math coprocessor, running at 8 MHz or 10 MHz (can be externally clocked to run at 10 MHz)
Memory: 1 or 4 megabytes of RAM (must be specified when ordering, since the board RAM is not field-upgradable); 64K bytes of 40-ns 32-bit SRAM cache; AMI 386 ROM BIOS, rev. 09/03/87, with firmware setup and diagnostics, including real-time clock setup; AMI keyboard BIOS, version 6
Slots: Six AT-style 16-bit slots; two XT-style 8-bit slots
Other: Speaker, turbo switch, and LED connectors; keylock; AT-style keyboard jack supplied; standard AT-style power connectors supplied; system support functions include seven-channel DMA, 16-level interrupt, three programmable timers, and a real-time clock; CMOS RAM to maintain system configuration parameters; battery backup for CMOS configuration table and real-time clock
Warranty: 30-day unconditional money-back guarantee; one year parts and labor; extended warranty available

12 by 13 inches; conforms to AT motherboard form factor

None supplied

80287-10 coprocessor: $309
80387-16 coprocessor (requires daughterboard): $549
80387-20 coprocessor (requires daughterboard): Call for price
Daughterboard: $179

Mylex 386 Manual

With 1 megabyte of DRAM: $1595
With 4 megabytes of DRAM: $3095

Inquiry 889.

(if you have a hardware turbo speed switch), speaker, external battery backup, adapter cards, and so on before you can start the configuration process (i.e., setting DIP switches and jumpers, running the ROM BIOS configuration routines, and running any supplied utility programs). Plus, you may have to partition and reformat your hard disk drive and reload your existing software and data from backups, since you may encounter problems when using a hard disk drive formatted by your old system.

Even with all these precautions, and with my experience, the Mylex board sold by Whole Earth Electronics managed to die a static-induced death and had to be replaced for this review.

Minimal Instructions

None of the documentation supplied with these boards will win any awards for information or appearance. The manuals are for competent hardware jockeys who know all about address lines, dynamic versus static RAM (SRAM), and memory interleaving. At that level, they are a minimal success. Still, as a card-carrying member of the Hardware Jockeys of America, I wished for even more technical information in the manuals. All of them could have used complete board schematics instead of the paltry drawings of gross topology that were included.

The best of a mediocre lot was the Turnpoint manual. The worst was the Fortron, since it lacked any visual aids. Still, I'd rate none of the manuals above a minimally satisfactory level. For novices, these manuals represent a disaster waiting to happen: one more reason why inexperienced people should not be turned loose with these boards. A dead AT will likely be the result.

Looking at the Hardware

All the boards are approximately 12 by 13 inches, the AT motherboard form factor, so they all should fit into a standard AT-style case. Each board is predrilled for mounting according to the AT standard mounting stanchions. Each comes with an 80386 CPU chip, a number of 8- and 16-bit slots, connectors for a keyboard and a speaker, a keylock, an external battery (for the on-board clock/calendar), a power-on LED, and supporting circuitry. All the boards can support a floating-point coprocessor (80287 or 80387), but none of the tested boards supports the Weitek WTL 1167 chip.

The Micronics board came with an 80386 running at 20 MHz and included an optional 20-MHz 80387 math coprocessor. The rest used 80386 chips running at 16 MHz. The Fortron board has a socket for an 80287 or 80387. The Mylex board uses an 8-MHz 80287, while the Turnpoint uses a 10-MHz 80287.

All the boards included at least one 32-bit expansion slot, except the Mylex board. Its 32-bit RAM cannot be expanded with external cards, so it is limited to on-board RAM (1 or 4 megabytes)—a significant disadvantage. Each board supported the 8-MHz I/O bus timing common for ATs.

The Mylex memory was composed of 36 256K- by 1-bit dynamic RAM (DRAM) chips (including parity chips), for a total of 1 megabyte of DRAM, using 120-nanosecond (ns) chips. Mylex also includes 64K bytes of 40-ns 32-bit high-speed SRAM that caches the entire 16-megabyte memory-address space, with no-wait-state caching, improving performance over an uncached processor. It is implemented with a write-through algorithm. The board comes with the 386 ROM BIOS and keyboard BIOS manufactured by American Megatrends International (AMI). Mylex does not include any software to relocate the BIOS or EGA BIOS to RAM. With 1 megabyte of DRAM, the board lists for $1595.

System support functions of the Mylex board include seven-channel direct memory access (DMA), 16 levels of hardware interrupt, three programmable timers, and a real-time clock. CMOS RAM is used to maintain system configuration parameters. A battery backup for the CMOS configuration table and the real-time clock/calendar is included.

The Fortron board ($2250) includes no RAM on the motherboard, but it has 2 megabytes standard on a proprietary 32-bit plug-in memory card. I also received an extra 2 megabytes on a second memory card. Each memory card has 72 120-ns 256K- by 1-bit DRAM chips (including parity chips). Each card arranged the chips into 1-megabyte RAM banks, with two-way interleaving between the banks. The Fortron board did not include any SRAM cache, and this lack affected its performance rating: It was the slowest of the boards running the benchmarks.

Fortron equips its 386 motherboard with the Award 386 ROM BIOS and keyboard BIOS. Fortron also includes a ROM BIOS utility that copies the slow system ROM onto the fast 32-bit RAM. The Fortron board comes with a real-time clock/calendar and a battery backup that also powers the system configuration CMOS RAM.

The Micronics board came with 2 megabytes of RAM on the motherboard. In this configuration, the board sells for $2950. The memory is composed of 72 100-ns 256K- by 1-bit static-column DRAM chips (including parity chips).

continued

Table 1: *The Micronics 386, with its 20-MHz 80386, was the speed champ, comparing favorably to the Compaq Deskpro 386/20. The Whole Earth (Mylex) 386, Fortron 386, and Turnpoint 386, all with 16-MHz 80386s, had performances comparable to the IBM PS/2 Model 80.*

	Fortron 386 80287-10	Micronics 386 80387-20	Turnpoint 386 80287-10	Whole Earth (Mylex) 386 80287-10	Compaq 386/20 80387-20	IBM PS/2 Model 80 80387-16
Dhrystone*	3302	5120	3720	3610	5705	3626
Fibonacci	59.49	41.2	54.5	56.1	38.27	57.26
Float	7.01	1.25	5.3	5.65	1.10	1.62
Savage	24.51	7.05	20.18	22.1	6.53	9.49
Sieve	6.9	3.75	6.0	5.59	3.88	6.45
Sort	6.98	4.85	5.71	5.93	4.89	7.74
Disk access in BASIC						
Write	6.4	4.8	5.4	5.5	4.8	7.1
Read	5.9	4.7	4.9	4.9	2.5	4.6
BASIC performance						
Sieve	30	16	27	28	15	27
Calculations	11	5.1	8.9	9.2	4.6	9.2
Spreadsheet						
Load	2.2	0.8	1.8	1.8	0.7	1.8
Recalculate	4.5	3.0	4.3	4.3	2.8	4.9
System utilities						
40K File Copy	2.2	0.9	1.7	1.8	0.5	0.7

For a description 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. The BASIC benchmark programs were run with MS-DOS 3.2 and GWBASIC 3.3 on all the motherboards. The Compaq Deskpro 386/20 ran MS-DOS 3.31 and GWBASIC 3.3. The IBM PS/2 Model 80 ran PC-DOS 3.3 and BASICA 3.3.

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

Included with the reviewed board was an additional 2 megabytes of 32-bit RAM on a proprietary plug-in card. The maximum memory you can load on the accessory card, using 1-megabit chips, is 8 megabytes, giving the Micronics board a maximum of 10 megabytes of 32-bit RAM. The Micronics board is the only one of the four I tested that uses static-column DRAM, like the Compaq Deskpro 386/20, rather than two-way interleaved DRAM.

Micronics includes a real-time clock and configuration CMOS RAM that are both backed up by a battery. The Micronics board supports operation at five processor speeds: 4.77, 6, 8, 16, and 20 MHz. You can specify either the Phoenix or the Award ROM BIOS and keyboard BIOS when you order this board. For $50 over the list price, Micronics will supply you with two sets of ROM BIOS chips: one from Phoenix, the other from Award. A nice touch.

Micronics also includes both a BIOS and EGA BIOS relocation utility for moving this code from the slower ROM to the faster 32-bit RAM. The Micronics board is also the only one I tested that includes a software assist for supporting the Lotus/Intel/Microsoft Expanded Memory Specification (LIM/EMS) 2.0 using its 32-bit extended memory. If you are planning to use OS/2, however, be advised that Intel hasn't yet written a driver that will allow the proper operation of LIM/EMS software under OS/2.

Turnpoint America's 386 motherboard included 2 megabytes of 32-bit DRAM on the board, composed of 72 120-ns 256K- by 1-bit DRAM chips, with a two-way interleave. An additional 8 megabytes of 32-bit RAM can be plugged into the 32-bit expansion slot using proprietary cards. With 0K bytes of DRAM, the board sells for $1495; a 2-megabyte memory board with 0K bytes is $149.

The Turnpoint board also provides the usual seven-channel DMA, 16 levels of hardware interrupts, three programmable timers, and a real-time clock/calendar. Both the clock and its CMOS configuration RAM come with a battery backup. The Turnpoint board comes with the AMI ROM BIOS and keyboard ROM. Turnpoint does not include any BIOS relocation software.

Other than design discrepancies (including the use of some custom VLSI chips) and the inclusion or absence of on-board RAM, these boards were remarkably similar in appearance, location of connectors, and ease of installation. The Micronics board follows the design and layout of the Compaq 386/20 board (with the exception of Micronics' 387 daughterboard), while the Fortron and Turnpoint boards follow the Intel iSBC 386 board layout. The Mylex board conforms to the design of the AMI 386 board.

Although speed differences surfaced during testing, all these boards juice up the performance of a tired PC AT quite nicely. None showed excessive post-production engineering modifications, although the Mylex board did have a few new traces added after the substrate had been cast. Overall, each board has a solid, quality-built appearance.

Compatibility Testing

I tried every DOS-compatible application I could lay my hands on with these boards. That included all categories of applications: integrated programs such as Framework II version 1.1, Symphony 2.0, SuperCalc 3 version 1, Lotus 1-2-3 version 2.01A, Smart Software 3.10, Enable 2.0, and Open Access II version 2.05; project management programs like Time Line 1.0, ABT Project Manager 1.0, and Harvard Total Project Manager 1.0; database programs like dBASE III Plus 1.1, Paradox 2.0, Unify 1.1, Informix-SQL 1.1, Revelation 1.0, and DataFlex 2.2; financial programs like Managing Your Money 2.0 and Financial Independence 1.0; the CAD program

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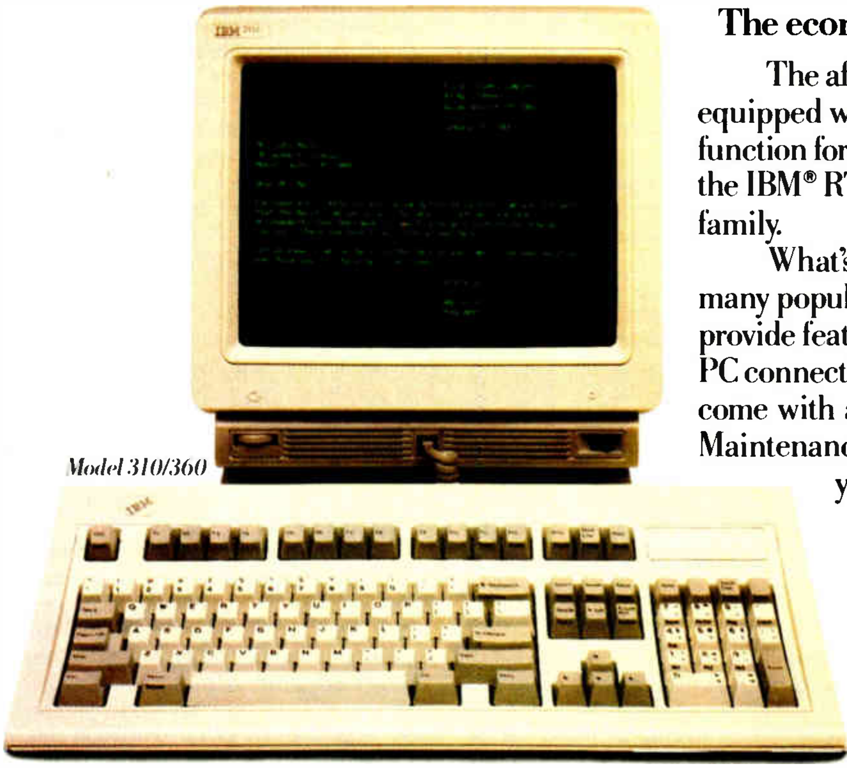

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Without exception, each board ran these applications at the full rated 80386 speeds of 16 or 20 MHz. AMI, Phoenix, and Award Software's 386 BIOS provide complete compatibility. A few old games and some custom programs, including Flight Simulator 1.0, wouldn't work on these boards at the full rated speeds.

I also briefly tested each board's ability to boot a Microsoft OS/2 system disk (version 1.02). Each booted the disk properly, except the Mylex board (OS/2 needs 2 megabytes to operate, and more to run multiple applications). I also tried a beta version of database software for OS/2 on all but the Mylex board. It crashed frequently on the other boards. Since this beta software also crashed repeatedly on an IBM PS/2 Model 80, it's not a fair test of OS/2 compatibility. Based on my testing and the availability of different ROM BIOS for each board, I'd say that each of these boards, given sufficient memory, will handle OS/2 and multitasking applications properly.

I also had the chance to test each board with Microsoft Windows/386. Each board did the job properly, although I ran out of memory when I tried to open applications on the Mylex board.

Performance Results

All benchmarks (see table 1) were run with the replacement motherboards installed in the chassis of an 8-MHz IBM AT configured with a 30-megabyte hard disk drive (40-millisecond average access time), an IBM EGA card and enhanced color monitor, one 1.2-megabyte floppy disk drive, the combined IBM hard disk drive/floppy disk drive controller, and the standard AT keyboard. I used MS-DOS 3.2, GWBASIC 3.3, and Multiplan 1.06 to run the benchmarks.

I took advantage of every hardware and software performance assist available on each board when testing: If a board had an 80287 or 80387 coprocessor, it was installed and used. If a board came with utility software to move ROM and EGA BIOS code out of slow ROM chips onto the fast 32-bit RAM, I used it. In short, I tested these boards under their best possible performance configurations, given the equipment I was supplied. I tested the Fortron board using an 80287-10 math coprocessor, since it did not come supplied with one; I used the same 80287-10 in testing the Mylex board, instead of the 80287-8 supplied. Finally, I tested the Turnpoint board with its own 80287-10.

The Micronics board was the fastest of the reviewed boards during benchmark testing. It ran away from the others, which is not too surprising considering its 20-MHz clock speed, 80387-20 chip, and 100-ns static-column DRAM. It also effectively relocated ROM and EGA BIOS into the 32-bit speed RAM, using a special utility, `RELOCATE.EXE`. The EGA BIOS relocation was effective; it really helped EGA I/O performance. The ROM relocation speedup was not noticeable in my tests.

The Turnpoint board was faster than the Mylex board, although not by a significant percentage, despite the Mylex board's 64K-byte RAM cache. The Fortron board proved to be the slowest of the group, although it still provided a sizable performance jolt to my test AT. The `ROMBIOS` Fortron utility, for pulling the ROM BIOS into 32-bit RAM, had no effect on my benchmarks. Neither the Turnpoint board nor the Mylex board included a ROM BIOS copying utility aimed at improving performance.

Recommendations

If speed and raw horsepower were the only considerations, the choice would be Micronics. But making a choice purely on speed is a mistake because it ignores other buying concerns, the most important of which is value. If a replacement motherboard costs too much to buy, then all the performance in the world won't benefit you. For me, value is just as important as performance, especially since the four boards I tested all made my tired old AT come to life.

With these biases in mind, I picked the Turnpoint 386 board as my first choice in this group. The Turnpoint has the best manual, as well as the second best benchmark times. It was about equally troublesome to install as the other boards. Turnpoint's technical staff was hard to reach, but knowledgeable the one time I got through. The Turnpoint board combines speed, RAM expandability (up to 10 megabytes), and an attractive price ($1495 with for a board with 0K bytes of DRAM). Overall, it was the best buy of the lot, combining solid performance with a good price.

At $2950 with 2 megabytes of DRAM, the Micronics board was the most expensive one I tested, although that $2950 buys a lot: an 80386-20 and an 80387-20, a choice of the Phoenix or Award ROM BIOS, and memory expandability to 10 megabytes. The Micronics board performed much like the Compaq Deskpro 386/20 in my benchmarks, and the technical-support staff was reliable over the phone. The board also supports LIM/EMS through a software assist—a feature the other boards lack. The Micronics board performed flawlessly during my tests.

Although the Micronics 386 has outstanding performance, it's just too pricey compared to the other boards I tested. If Micronics could get the single-unit price down to under $2000, it would easily be the pick of this litter. As pricing currently stands, the Micronics board checks into the number two spot on my preference list.

The Whole Earth Electronics (Mylex) board was a decent buy in its 1-megabyte version at $1595, but the 4-megabyte version (the only other choice) was an expensive $3095. The Mylex board was a fine performer, even though it ended up third in my benchmark tests. It comes with a 64K-byte processor cache—a performance plus that didn't shine during testing but might make an important difference in day-to-day software use.

The big advantage of the Mylex board is the company selling it. Whole Earth Electronics is an established company with a good reputation, and you can feel comfortable buying from it. Still, the Mylex 386 suffers from some performance compromises. The most important is the lack of a 32-bit expansion slot. You order the board with either 1 or 4 megabytes of 32-bit RAM. In these days of OS/2 and expanded and extended memory support, 4 megabytes is often not enough. Since I'm a memory junkie even more than I'm a CPU speed freak, I already have some custom applications that can easily use more than 4 megabytes of memory, so the Mylex board is third on my list.

The Fortron board was the second most expensive of the lot ($2250 with 2 megabytes of DRAM), sported the most conservative board design, and afforded the slowest performance in this fast company. Its conservative design will likely reward its purchasers by reliable performance and long life. Fortron also has the best technical support—which you may need, given the poor manual. I'd buy the Fortron board only if I was nervous about the long-term reliability of other boards; it ranked last on my personal preference scale. ■

Don Crabb is the director of instructional laboratories for the computer science department of the University of Chicago and is a lecturer in the department and the college. His articles and reviews have appeared in industry magazines, newspapers, and journals.

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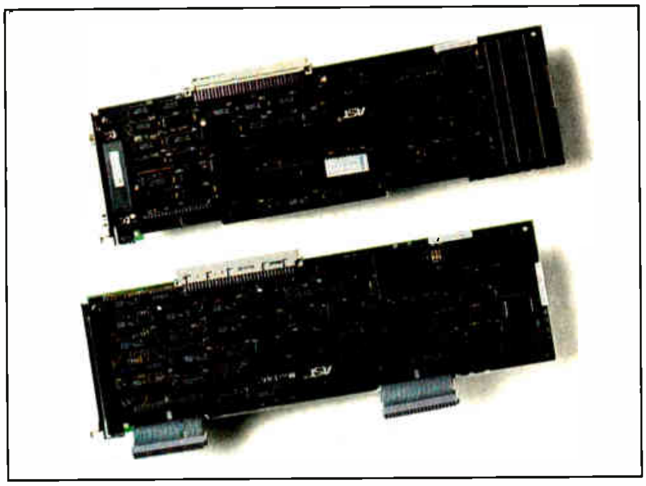
An AT in a Mac II?

Naor Wallach

AST's Mac286 board runs DOS on a Macintosh II—but not without problems

It's high noon at the job, and you and a coworker are frantically preparing a crucial report for that big 1:00 meeting. You've been breaking records laying out graphics for the report, thanks to the Macintosh II on your desk, and you can hear your cohort pounding away at the keyboard in the other room, computing spreadsheet numbers. You'll drop these numbers into tables that you've laid out inside the report. Finally, with 10 minutes to spare, in rushes your collaborator with that spreadsheet data—on a 5¼-inch DOS disk.

Is this simply a high-tech office nightmare? Unfortunately, no. With today's mix of PC and Macintosh computers, there's a growing problem of sharing data between workers who use incompatible microcomputers.



AST Research's solution to this problem is the Mac286, an AT-on-a-board that costs $1599. Equivalent to a complete AT motherboard, the Mac286 shares a Mac II's hard disk drive, keyboard, and video display. This lets Mac owners not only share data with PC users but actually run MS-DOS programs (say, to correct a minor error in those spreadsheet numbers mentioned earlier). Most AT-compatible software runs unchanged on the Mac286, with the exception of programs that require an EGA board or other PC expansion cards, or programs that need expanded memory beyond MS-DOS's standard 640K bytes.

I reviewed the Mac286 on a Mac II with 5 megabytes of RAM, a 40-megabyte hard disk drive, the Apple Macintosh II Video Card with memory expansion installed, and an AppleColor video monitor. I used Apple's 5¼-inch PC floppy disk drive with the Mac286. The Mac II ran either MultiFinder 1.0 or System 4.2 and Finder 6.0.

The PC Within the PC

The Mac286 consists of a set of two printed circuit boards (shown above) joined by two short ribbon cables. Each board occupies a slot in the Mac II. The first board is a processor card with an 8-MHz Intel 80286 CPU and a socket for an 80287 math coprocessor. The second board contains the system's RAM. This RAM consists of four 256K-byte-density single in-line memory modules (SIMMs), providing 1 megabyte of parity-checked RAM. The first 640K bytes of RAM is MS-DOS user memory, and AST uses the remaining 360K bytes to house the PC ROM BIOS routines.

The memory board also contains support electronics, such as the direct-memory-access (DMA) controller, the interrupt controller, timers, and a floppy disk controller. A floppy disk connector is located to the rear of the memory card. You must supply your own 5¼-inch floppy disk drive.

These boards operate as a NuBus slave under the control of a Macintosh application. This application emulates several popular PC displays, manages a file that emulates a hard disk drive for the Mac286, and sets certain AT system configuration parameters.

On the Mac286 card, calls to ROM BIOS routines are either handled by the Mac286's support hardware (e.g., calls to the floppy disk controller), or intercepted and processed by the Mac II's 68020 (e.g., calls to the hard disk drive, printer, or video display). Process synchronization between the two computers is maintained by holding the Mac286's 80286 in a wait state until the request is completed.

Installing the Computer

The Mac286 came packed in a large box that held the two boards, three manuals, and three floppy disks. I was dismayed to find that the boards were sandwiched between three flimsy pieces of white foam and that they weren't wrapped in any nonconductive plastic sleeves. This packaging provides no protection against electrostatic discharge (ESD), which means the chances are good that you could damage the Mac286 before you even install it.

One of the three manuals contains installation procedures that tell you how to open the Mac II, remove the back panels, and mount the two boards in the NuBus slots. You must locate the boards in the NuBus slots farthest away from the Mac II power supply when you install them. If they're placed in any other slots, the weight on the monitor atop the Mac II might push the boards together and short them out. Finally, you connect the PC floppy disk drive, close the hood, and prepare to start the Mac II.

The three floppy disks contain all the software necessary to install and operate the Mac286 system. Two 5¼-inch floppy disks, labeled MS-DOS 3.2 System Disk and MS-DOS 3.2 Supplemental Disk, supply the MS-DOS operating system and software. The MS-DOS system disk contains the standard PC system programs, such as `ATTRIB.EXE` and `FORMAT.COM`. The second disk includes GW-BASIC, an assortment of drivers, and an installation batch file. Those familiar with MS-DOS will recognize these two disks as the standard disk set that comes with every IBM PC-compatible microcomputer.

One 3½-inch Macintosh disk contains version 1.0 of the Mac286's Macintosh application, which manages communications between the Mac286 system and the

continued

Table 1: *In most of the benchmark tests, the Mac286 outperformed the IBM PC AT. The Disk Write and Read times are good, considering that the Mac286 must interrupt the host 68020 processor to perform hard disk I/O. There is no apparent degradation of the Mac II's performance with the Mac286 idle in the system.*

	Disk Write	Disk Read	Calcu-lations	Sieve	40K File copy	Spreadsheet Load	Spreadsheet Recalculate
8-MHz Mac286	15	9	15	48	8	2	3
8-MHz IBM PC AT	14	9.3	20	61	20	1.2	3.0
Mac II with Mac286	6	5	7	24	6	1	3
Mac II	8	6	6.7	24	6	2.4	2.7

Note: The Disk benchmarks write and then read a 64K-byte sequential text file to the hard disk. Calculations performs 10,000 multiplication and division operations. Sieve runs one iteration of the Sieve of Eratosthenes. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The Spreadsheet tests load and recalculate a 25-row by 25-column Multiplan (1.06) spreadsheet. All BASIC benchmark programs were run with MS-DOS 3.20 and GWBASIC 3.20. For the Mac II, Microsoft BASIC 2.1(b) was used for the system benchmarks. Multiplan 1.02 was used for the spreadsheet tests, and a 25- by 25-cell spreadsheet was used. System 4.2 and Finder 6.0 were used.

dendum indicates that you get better performance running the Mac II monitor in the two-color (black-and-white) mode. This helps performance a little, but it causes problems running some programs that expect to have a CGA monitor with more than two colors present.

A serious problem showed up when I issued the XyWrite `print` command. When the Mac286 application attempted to print to the networked LaserWriter, the system crashed spectacularly, without even the courtesy of a bomb box. I traced this problem to my having supplied XyWrite with the wrong `.PRN` printer file. When I copied the file `3EPSONFX.PRN` into the XyWrite directory and modified XyWrite's `STARTUP.INT` file to use this Epson printer file, the printing problem with XyWrite disappeared.

I also experimented with Lotus 1-2-3 version 2.01, Turbo Pascal 3.0, Multiplan 1.06, and Wizard's Crown, a game sold by Strategic Simulations, and I had no problems beyond the extremely slow screen refresh rate.

One of the major concerns of anyone contemplating buying a PC emulator is performance. To address this concern, I compared the Mac286 to an 8-MHz PC AT. Table 1 compares the Mac286 to the IBM PC AT using BYTE's standard BASIC benchmarks. I also ran the standard system benchmarks on the Mac II to see if the presence of the Mac286 might degrade the Mac II's performance, and these numbers are also given in table 1. As the results show, the Mac286's performance is better than or similar to that of an 8-MHz PC AT.

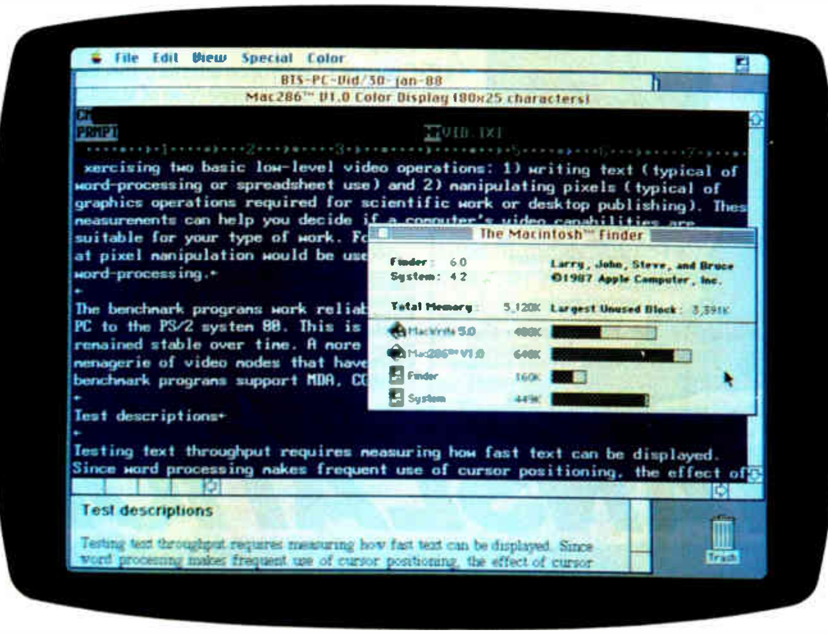


Photo 1: *The Mac286 runs under MultiFinder on a Mac II with a 256-color display. The MacWrite document shown was just converted to a text-only file called* `VID.TXT` *and was copied to Mac286's drive C using the DOS command* `COPY D:VID.TXT C:`. *The document was then opened as it would be with XyWrite.*

Getting It from There to Here

There are two ways to transfer text information between the Mac286 and the Mac II. You can select text from a Macintosh word processor, such as MacWrite 5.0, and paste it into a PC word processor—in this case, XyWrite. This works, but only for short pieces of text. I selected and copied 10K bytes of text from a MacWrite document into the Clipboard and then pasted it into XyWrite. The transfer was painful to watch. The text was placed into XyWrite a character at a time, and the transfer took 53 minutes to complete—with the Mac II in the two-color mode. This process doesn't work very well in the other direction: You get all sorts of escape characters from the XyWrite display buffer pasted into MacWrite. You cannot cut and paste graphics from one computer to another.

Fortunately, AST has provided another method for transferring text files between the two computers. At start-up, the `AUTOEXEC.BAT` file runs three drivers—`DSTEP1.SYS`, `DSTEP2.EXE`, and `DSTEP3.EXE`—that let the Mac286 see the Mac II hard disk drive as a D drive. Folders and filenames that follow MS-DOS conventions appear in a `DIR D:` command. The only file types that appear in this directory scan are files of type `TEXT`, `crlf` (MS-DOS text with carriage return/linefeed combinations at the end of lines), and `BINA` (an MS-DOS executable file). Transferring a file from the Mac II hard disk to the Mac286 emulated hard disk is simply a matter of issuing the command `COPY D:DOCUMENT C:` (see photo 1). Unlike the copy-and-paste procedure, this transfer works both ways.

A File Type item under the File menu lets you specify the default file type when you copy a file to D or prompts you for the file type when you do the copy. Files

continued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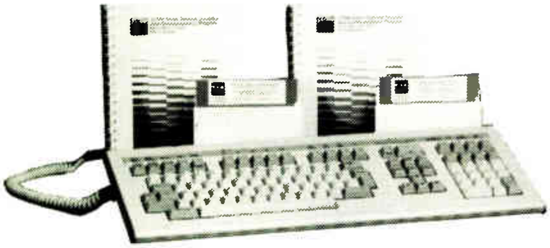

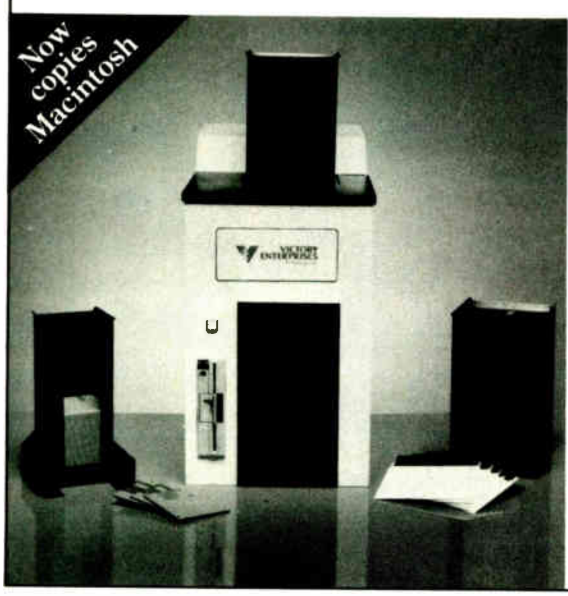

copied this way to the Mac II's hard disk show up on the Mac Desktop with their own distinctive icons.

To Have or to Have Not

Having a PC-compatible machine reside within your Mac II is a good idea. It solves many problems for people who have to deal with the tons of software developed for the PC but prefer to work on the Mac. The Mac286 provides this capability without robbing you of the desktop space that another computer would require.

However, I have several concerns about the current usability of this product. First, if you simply need to transfer text from MS-DOS to the Mac and back, there are less expensive ways to do this. For example, you can use the Apple PC Drive Card ($129) and the Apple PC 5¼-inch floppy disk drive ($399) to move files from a 360K-byte 5¼-inch floppy disk to your Mac II's hard disk. Networking solutions are also available. By contrast, the Mac286 costs $1599, and you still have to purchase the external 5¼-inch PC floppy disk drive.

The second, and probably the most severe, problem concerns the slowness of the screen refresh. Using the two-color mode on the Mac II helps, but this creates problems for some PC programs and denies you the use of the Mac II's color capabilities. AST is aware of this problem and promises that version 1.1 of its software will have faster video performance.

The third major area of concern is with ESD protection, or rather the lack of it. These two boards contain a whole host of highly sensitive chips, yet the packaging does nothing to protect the boards from static. I went through three sets of Mac286 boards before I got a set that worked reliably, and I suspect most of my problems were caused by static damage.

If you need PC processing capability beyond simply moving files between incompatible microcomputers, and if you can live with the sluggish video display, the Mac286 works well. The Mac286 application operates under the latest versions of MultiFinder and Finder, and the AT boards run XyWrite and Lotus 1-2-3—two of the most finicky PC programs—without problems. Nevertheless, the lack of ESD protection is alarming, and it's likely to cause grief for the less technically experienced user. I can't recommend the Mac286 until AST improves the video performance and does something about the ESD problem. At least the last problem has an easy fix. ■

Naor Wallach is a senior development engineer at Eastman Kodak Co. in Rochester, New York. He uses a Macintosh II at work and at home.

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IBM's OS/2 Standard Edition 1.0 is an 80286-based multitasking operating system that implements virtual memory on a segment basis. When you buy IBM's OS/2 Standard Edition, you get a dual-mode operating system: In DOS mode, you can run only one application, and in OS/2 mode you can run multitasking applications in each of 12 sessions. The system comes on four 1.44-megabyte 3½-inch floppy disks—one installation disk and three system disks. The documentation consists of a 310-page user's reference in a three-ring binder and a 51-page spiral-bound user's guide.

IBM OS/2's Standard Edition runs on the IBM PC AT, XT 286, and PS/2 Models 50, 60, and 80. It requires a minimum of 2 megabytes of memory, or, if you give up the DOS compatibility box, you can get by on 1.5 megabytes. I ran OS/2 on a PS/2 Model 50 with 3 megabytes of memory (using the Intel Above Board) and a 20-megabyte hard disk drive. The installed system took up approximately 3.4 megabytes of hard disk storage. OS/2 can support up to 16 megabytes of physical memory. In theory, the Intel 80286 is capable of addressing a gigabyte of virtual memory. OS/2, however, constrained by the 32-megabyte limit on the size of a hard disk drive, provides only a 48-megabyte virtual address space.

OS/2 Standard Edition ($325) does not include the graphical user interface, the Presentation Manager. According to IBM, the Presentation Manager won't be available until the end of the year (see the text box "Future Versions of OS/2" on page 147).

The command interface of OS/2 is very similar to DOS (see table 1). Most commands work in both modes; only a handful are specific to DOS mode or OS/2 mode. This allows users already comfortable with DOS to ease themselves slowly into OS/2 and its advanced features. Upon closer examination, though, it takes a little mental mode-switching to keep straight which commands work in which mode and in what form. Some commands work in both modes identically, but some have features that are specific to only one mode. According to IBM, when the Presentation Manager becomes available, you will have the option of replacing the command prompt with windows and menus.

There are some caveats to be aware of when using DOS programs in the DOS-compatibility mode. For example, for those DOS programs that access a serial port directly, you'll need to run a specific program (`Setcom40`) that lets the DOS program access the target port addresses. Also, the number of device drivers you have installed at system start-up nibbles away at the memory pool allocated to the DOS mode.

You can install OS/2 over your current DOS system without reformatting your hard disk. There are two factors that allow you to do this. First, OS/2's directory structure is identical to DOS's, allowing both types of programs to share the same hard disk and access the same files. Second, OS/2's hidden system files, `IBMBIO.COM` and `IBMDOS.COM`, are smaller than DOS's, allowing these files to overwrite the old ones.

A Familiar Feeling

If you are familiar with DOS, then you will be immediately comfortable with OS/2. Choosing the DOS or OS/2 command prompt puts you in a screen group (a virtual display of the computer screen) with a DOS-like command prompt (`C:`).

The Standard Edition of OS/2 comes with a full-screen user shell called the Program Selector (as shown in the photo above). The Program Selector is a rudimentary graphical user interface that gives you windows with a start list on the left side of your screen, a switch list on the right side, and a pop-down menu. The start list (left window) shows the applications you can initiate. The switch list (right window) shows currently running applications that you can choose to run specifically or hop between. From the pop-down menu, you can update the start list by adding or deleting programs. All have context-sensitive help along the way.

In OS/2, certain key combinations are special "hot keys." The Alt-Esc combination cycles you through the screen groups; Ctrl-Esc brings you back to the Program Selector. The only way to move between DOS and OS/2 mode is with one of these hot keys. A comforting help line

continued

Table 1: *Because IBM OS/2 Standard Edition is a dual-mode operating system, you have to keep straight which system utilities, configuration commands, and batch commands work in which modes. Some commands work only in OS/2 mode and are mainly concerned with multitasking issues; some commands work only in DOS mode and are there for compatibility. The majority, however, are dual-mode commands that you can use from either DOS mode or OS/2 mode.*

	OS/2 mode only	DOS mode only	OS/2 and DOS dual mode	
Internal commands:	Detach[1]	Break	Chcp	Chdir[2]
	Dpath[1]		Cls	Prompt
	Start[1]		Copy	Rename
			Date	Rmdir[2]
			Dir[2]	Sys
			Erase (Del)[2]	Time
			Exit	Type[2]
			Label	Ver
			Mkdir[2]	Verify
			Path	Vol[2]
External commands:	Ansi[1]	Append	Attrib	More
	Cmd[1]	Assign	Backup	Patch[1]
	Createdd[1]	Command	Chkdsk	Print
	Fdisk	Graftabl	Comp	Recover
	Keyb	Join	Diskcomp	Replace
	Spool[1]	Setcom40[1]	Diskcopy	Restore
	Trace[1]	Subst	Find	Set
	Tracefmt[1]		Format	Sort
			Help[1]	Tree
			Mode	Xcopy
CONFIG.SYS commands:	Iopl[1]	Break	Codepage[1]	
	LibPath[1]	Fcbs	Country[1]	
	Maxwait[1]	Rmsize[1]	Device	
	Memman[1]	Shell	Devinfo[1]	
	Priority[1]	Buffers	Diskcache[1]	
	Protshell[1]		Pauseonerror[1]	
	Swappath[1]		Protectonly[1]	
	Threads[1]		Rem	
	Timeslice[1]		Run	
			Trace[1]	
			Tracebuf[1]	
Batch commands:	Endlocal[1]		Call	If
	Extproc[1]		Echo	Pause
	Setlocal[1]		For	Rem
			Goto	Shift

[1] These commands are new with IBM OS/2 Standard Edition.
[2] In OS/2 mode, these commands will accept multiple filenames.

across the top of the screen reminds you of the Program Selector key. With the help command, you can get an explanation of an error message and a recommended action to take by typing `Help` followed by the error message number. Most error messages are available online, but you can turn to the back of the manual to find those that aren't. You can also use `Help` to turn the help-line display on and off.

I didn't find OS/2's power readily apparent because its commands look so much like DOS's. The power is there, nonetheless.

OS/2 provides an environment where applications are protected from one another. Because of its multitasking nature, OS/2 has to assume more responsibility for resource management. In OS/2, a process consists of one or more threads (a dispatchable unit of work) and the associated system resources (i.e., memory, disk files, pipes, queues, and so on). A session is a collection of one or more processes associated with a screen group. OS/2's tasking model is a multilevel priority scheme with four priority classes (listed in order of decreasing priority): time critical, foreground, regular, and idle. The time-critical, regular, and idle priority classes each have 31 priority levels; OS/2 gives the foreground process a boost over other regular class threads when the `Priority` command in `CONFIG.SYS` is set to dynamic.

The time-critical class is for threads doing communications or real-time operations. The foreground class is the screen group that is currently using the display. Regular-class threads are those processes operating in screen groups that are not currently using the screen and keyboard. Idle-class threads are noninteractive processes initiated with the `Detach` or `Run` commands. OS/2 uses a preemptive time-slicing dispatcher to switch the processor among the threads. This means that all threads get a fixed period of time to use the CPU before OS/2 interrupts their execution and moves on to the next thread.

Flexible System Configuration

At boot time, the `CONFIG.SYS` file determines whether or not you will have both DOS and OS/2 modes and then sets many of the attributes of each mode. The number of commands that you can put in the `CONFIG.SYS` file has increased dramatically. Some commands affect only the DOS compatibility box, some affect only the OS/2 box, and some work in both modes. Leaving a command out of the `CONFIG.SYS` file causes the system to take the default value for that command. For example, if I booted the PS/2 Model 50 without a `CONFIG.SYS` file, the system would configure itself automatically with a DOS compatibility box.

Thankfully, the package comes with an automated installation program that, in about 10 minutes, creates the desired `CONFIG.SYS` file and the directories, and copies the files from the supplied disks to their proper places. The directories thus created are `C:\`, `C:\OS2`, `C:\OS2\INSTALL`, `C:\OS2\INTRO`, and `C:\SPOOL`. The system files go into `C:\`; system utilities and installable device drivers go into `C:\OS2`. Temporary files waiting for the printer go to `C:\SPOOL`. `C:\OS2\INSTALL` and `C:\OS2\INTRO` contain the installation programs and a program called "Introduction to OS/2," respectively.

Listing 1 shows the `CONFIG.SYS` file created for installation on the PS/2 Model 50. `PROTSHELL` loads the user-interface program (in this case, the Program Selector) and `CMD.EXE`, the OS/2 command processor. `CMD.EXE` is equivalent to DOS's `COMMAND.COM`. `CMD.EXE` has a `/C` switch that is similar to `COMMAND.COM`'s `/C` option in that you can pass a command to a copy of the command processor. An additional switch, `/K`, lets you pass a command to a copy of the command processor, but it does not return to the previous command processor.

When the Presentation Manager becomes available, it will take the place of the Program Selector. It will also take up its own session and have windowed applications. The Program Selector will be one of the applications.

The command PROTECTONLY determines if the DOS compatibility box is present. If it is, RMSIZE sets the upper limit of the real-mode memory (anywhere from 100K bytes to 640K bytes). You can configure the system to run without the DOS-mode box by setting PROTECTONLY to yes. But be careful: If you do this, you wind up with a protected-mode system that won't let you use the DOS-mode editor, EDLIN, to edit CONFIG.SYS to reinstall the DOS-mode box.

On the PS/2 Model 50, Chkdsk showed that there were 644,304 bytes available to the DOS mode, with 492,032 bytes free. Commenting out all device commands in the CONFIG.SYS gave me another 34,976 bytes free for the DOS mode. Chkdsk does not give a figure for memory available or free in OS/2 mode. However, you don't have to worry too much about space constraints in OS/2 mode because of the virtual memory scheme.

You can use some special batch files to further customize the system. Batch files in OS/2 mode must have a .CMD file extension, instead of the .BAT file extension in DOS. For example, STARTUP.CMD is the protected-mode counterpart to AUTOEXEC.BAT. OS2INIT.CMD is another special batch file that sets the environment for each OS/2 screen group that you start from the Program Selector's OS/2 Command Prompt. AUTOEXEC.BAT executes the first time you select the DOS Command Prompt.

OS/2 requires numerous system files (between 50 and 60), in addition to the two hidden ones (IBMBIO.COM and IBMDOS.COM), and the protected-mode command processor, CMD.EXE. You will need a high-density disk (either 1.44 or 1.2 megabytes) to create a boot disk. The exact number of these files varies, depending on whether you are installing OS/2 on a PS/2 machine or an AT-class machine. These additional files contain system components such as dynamic link libraries (DLLs) and standard default device drivers, message files, code pages, information files, and so forth. Some of the files are required only for PS/2 machines. In general, those files with 01 in the filename are for AT-class machines, and those with 02 in the filename are for PS/2 machines.

Some environment variables are system-wide and must be set in the CONFIG.SYS file; some are specific to each screen group. Swappath is a system-wide variable that sets the path for segment swapping to the disk. Memman dictates whether segments will be swapped or moved (i.e., relocated in memory to eliminate memory fragmentation). Libpath is another system-wide variable and sets the path for the system to search for DLLs. A DLL contains reentrant code that all processes share at run time. DLLs are global resources, and you must define the search path globally rather than on a per process basis as Path does. Dpath is an OS/2-mode environment variable that specifies paths to data files for each session.

The Diskcache command is supported only for the IBM PS/2 Models 50, 60, or 80. A number anywhere from 64 to 7200 specifies how many 1024-byte memory blocks the disk cache uses.

Four statements in the CONFIG.SYS file give you some control over the threads in the system. The default number of threads is 64: OS/2 allocates 24 threads, and applications programs allocate 40 threads. To set the minimum and maximum amount of time used for round-robin scheduling among threads of equal priority, you use Timeslice. Setting Timeslice to a maximum value of 248 milliseconds is good for most programs.

A couple of commands give you some control over how the multitasking scheduler handles regular-class threads. With

continued

Future Versions of OS/2

IBM's OS/2 Standard Edition 1.0 is but the first of several versions of OS/2 that will become available in the next year or two.

The next new version, which IBM says will be ready in July, will be IBM's OS/2 Extended Edition 1.0. This version will be similar to the Standard Edition, but will include two built-in applications: a communications manager and a database manager. It will sell at a list price of $795. Whereas several computer manufacturers may offer versions of the Standard Edition of OS/2 for their customers, the Extended Edition will be offered only by IBM.

In October, IBM will reportedly begin shipping 1.1 of the Standard Edition. This version will include OS/2's graphical user interface called the Presentation Manager. Owners of 1.0 will be able to upgrade to 1.1 for free.

In November, we should see 1.1 of IBM's Extended Edition. Again, this version will include the Presentation Manager, and previous owners will receive a free upgrade.

IBM has said it has plans to offer a 32-bit version of OS/2 designed for the 80386 processor sometime in 1989. The company may also offer an enhanced version of the Extended Edition, called Extended Edition Plus. No further details on these versions are available at this time.

—Rich Malloy

Listing 1: *The* CONFIG.SYS *file created for the Model 50 by the installation program.*

```
PROTSHELL=DMPC.EXE SHELL11F.CNF SHELL11F.EXE CMD.EXE /K
                                                  OS2INIT.CMD
LIBPATH=C:\;C:\OS2;C:\OS2\INSTALL;
BUFFERS=30
DISKCACHE=64
MAXWAIT=3
MEMMAN=SWAP,MOVE
PRIORITY=DYNAMIC
PROTECTONLY=NO
SWAPPATH=C:\
THREADS=64
SHELL=CCOMMAND.COM /P
BREAK=OFF
FCBS=16,8
RMSIZE=640
DEVICE=C:\OS2\POINTDD.SYS
DEVICE=C:\OS2\MOUSEB05.SYS
RUN=C:\OS2\SPOOL.EXE /D:LPT1 /O:LPT1
DEVICE=C:\OS2\COM02.SYS
DEVINFO=SCR,VGA,C:\VIOTBL.DCP
DEVICE=C:\OS2\EGA.SYS
```

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C and assembly

Hardware Needed
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Documentation
310-page user's reference
51-page user's guide

Price
$325

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the Priority command, you can choose to have the system dynamically vary the priority level of the threads based on the amount of I/O and CPU usage. The system also gives any foreground threads a boost in priority over any background threads. When you choose dynamic priority, Maxwait is the number of seconds that can pass before a thread waiting for the processor gets a boost in priority. With absolute priority, there is no foreground boost, and the system doesn't adjust the priority of the regular-class threads.

Unlike DOS, the asynchronous communication support in OS/2 is an installable device driver: COM01.SYS for IBM PC ATs and COM02.SYS for PS/2 machines. COM0x.SYS supports COM1 through COM3 for full-duplex interrupt-driven communication. The functions it provides are transmission and reception queues, automatic control modes for modem control signals, and XON/XOFF for transmit and receive. COM0x.SYS uses about 9K bytes of DOS-mode memory, so if you don't need its capabilities, you can leave it out of your CONFIG.SYS file. Also, if you do install the communications device driver, some DOS programs require you to execute the Setcom40 command before they can find the COM port (more about this later).

According to the company, COM0x.SYS is guaranteed to support 4800-bit-per-second communications on a 6-MHz AT while running a DOS-mode application in the foreground. I didn't have an OS/2 communications program with which to test this, however.

For PC ATs and XT 286s, OS/2 includes mouse drivers for Mouse Systems' PC Mouse, Visi-On's Serial Mouse, and Microsoft's Serial, parallel, and In-Port Mouse. On the PS/2 side, it includes drivers for the first two mice plus the Microsoft Serial and IBM PS/2 in-board Mouse. The POINTDD.SYS device driver works in conjunction with the mouse driver to provide mouse-pointer drawing support.

In OS/2 mode, the base system contains the ANSI support that lets you redefine keys, manipulate the cursor, and change screen-display colors. In DOS mode, however, you still need to install ANSI.SYS; this device driver has no effect on OS/2 mode. Another device driver used only for DOS mode is EGA.SYS. It provides support for the EGA register interface.

Other device drivers include VDISK.SYS, which installs a virtual disk, and EXTDSKDD.SYS, which lets you access an external disk using a logical drive letter. You should install virtual disks after any external drives so you won't affect their drive-letter assignments. OS/2 takes care of loading the standard default device drivers for the keyboard, display, printer, disk, fixed disk, and clock; don't put them in your CONFIG.SYS file.

Batch Commands and CMD.EXE

Batch commands and the internal commands supported by CMD.EXE are a superset of the DOS-mode commands, necessitating the different batch-file extensions between OS/2 and DOS. SetLocal and EndLocal work together to let you change and restore the drive, directory, and environment setting during batch-file execution. The ExtProc command lets you use your own batch processor instead of CMD.EXE. To use ExtProc, you have to put it on the first line of the OS/2-mode batch file that you want your external batch processor to execute.

In OS/2 mode, if you interrupt a batch file, you don't get the option of continuing. Continuation can't take place in a multitasking environment because it's impossible to predict what state the system will be in when the batch file recommences.

The OS/2-mode command processor, CMD.EXE, embellishes some of the dual-mode internal commands. For example, you can Type or call a directory (Dir) of multiple filenames. You can put multiple commands on the same line by separating them with the & character. Also, you can use the ^ symbol to precede special characters (such as & and |) and have them considered as text.

OS/2 expands nicely on the redirection capabilities of DOS. CMD.EXE uses the digits 0 through 9 as internal file identification numbers to which you can redirect a program's input or output. Digits 0, 1, and 2 are the file numbers for standard input, output, and error, respectively. In DOS, you could redirect standard input and output, but not standard error. Also, with OS/2 you can use digits 4 through 9 to stand for files of your choosing, to which any output of a process will be written.

OS/2 lets you process commands conditionally. Separating two commands with an && causes the second command to be processed only if the first was successful. If you separate commands with a ||, the second command executes only if the first was not successful.

Pipes in OS/2 mode are true pipes. That is, OS/2 uses a storage buffer to hold the data being piped between processes rather than a temporary file, as in DOS and DOS mode.

System Utilities

Both the DOS mode and the OS/2 mode share many of the system utilities. While some of the dual-mode commands will be familiar to DOS users, some will be new. The Help command mentioned earlier is a new dual-mode command, and so is Patch, which lets you apply IBM-supplied corrections to fix faulty code.

Some of the dual-mode commands act a little differently from their DOS 3.x counterparts. When you specify Format/s, for example, the hidden system files IBMBIO.COM and IBMDOS.COM are transferred to the target disk, as you would expect. But Format also uses a text file in the root directory, called FORMATS.TBL, to specify it to the other 50 or so system files required to make a boot disk. One slight problem with creating a bootable disk with the /s option is that Format can't find any files that are outside the root directory (e.g., it can't find an installable device driver in C:\OS2). The FORMAT command tells you which files it cannot copy so that you can copy them manually.

Unlike DOS, you cannot use Chkdsk's /F (fix) parameter on the drive from which you started the system; you must boot up from the floppy to restore any

continued

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lost clusters on the hard disk. The /F option requires that you cease all activity on the disk you want to fix. However, because of OS/2's virtual memory, there's always the possibility of disk activity if OS/2 needs to move a segment in memory or swap a segment out to disk.

Some dual-mode commands have more functions in OS/2 mode. The Mode command lets you set the operational mode of devices, such as the communications port, the display, the parallel printer, and system-wide disk I/O write verification (as opposed to a per process basis with Verify). You must have COMOx.SYS installed to use Mode to set the communications ports.

While Mode is a dual-mode command, the manual recommends you set the COM port from the OS/2 mode because some parameters are available only in OS/2 mode. You can also query the setting of the COM port from OS/2 mode and use this output as input to another mode command. Mode no longer has an option to send the output from the parallel port to a serial device; the Spool command supplies this function and requires COMOx.SYS to do it.

The more interesting commands are those intended for OS/2 mode only. The Start command lets you start an OS/2 session from another session. Using Start in the autostart batch file gives you another way, in addition to the Program Selector, to configure the system to automatically load whatever applications you normally use. Detach lets you initiate a noninteractive background process. Using a Run command in the CONFIG.SYS file has the same effect as issuing a Detach command from the system prompt.

A print spooler is necessary in a multitasking system where multiple applications share one printer. In OS/2, the print spooler, Spool, is separate from the Print command. Spool is an exclusively OS/2 function that intercepts files sent to the printer from multiple sources. You can start it with a Run command from the CONFIG.SYS file or with a Detach command at the command prompt. Either way, it is a process that runs at idle priority (i.e., when nothing else is going on).

Spool gives the data it receives temporary filenames and keeps them in the subdirectory, C:\SPOOL. Spool accepts only parallel devices for input, but it will send its output to either parallel or serial devices. You can have up to three print spoolers active, servicing three printers.

The spooler works fine in conjunction with the Print command, but there is a problem with using DOS editors with the spooler. Because most DOS programs do not contain code to inform the print spooler when to close and print the file, the output is not printed until you exit the application. You can press Ctrl-Alt-PrtSc to force the spooler to start without leaving the application. This key combination successfully forced output to the printer from XyWrite III Plus. However, it's important to wait until the application has sent the entire file to the queue before forcing the output, or else the spooler will split the output into two files.

The Print command can send output to the printer or cancel the printing of one or more files, but it doesn't have an option for listing the files waiting in the queue as it did in DOS 3.3.

OS/2 has the same 32-megabyte size limit for hard disk drives as DOS 3.3 and, like DOS 3.3, gets around the barrier by letting you partition your hard disk into a primary and extended partition. Fdisk has an option to then create a logical drive in the extended partition.

I found the manual's description of Fdisk awfully vague. When I first saw the second selection on the Fdisk menu, "Change the Active Partition," I thought I could install DOS 3.3 in one partition and OS/2 in another, and use `Fdisk` to change which operating-system partition was active. This wasn't the case. You can use this option only if you install another operating system (such as Xenix) on the primary partition.

Serviceability Aids

In a multitasking system a lot of things can go wrong, and it can be difficult to track the problem down. In OS/2 mode, however, because programs run in protected mode, certain components of the system continue to run even if the system is partially disabled. OS/2 has a system trace and memory dump facility. Both of these functions are not for the faint of heart: They're intended for use with aid from an IBM service representative.

You can use the `Trace` command to turn event tracing on or off, and you can invoke this command either at the OS/2 prompt or at boot time by placing a statement in your `CONFIG.SYS` file. If you don't want to turn tracing on at boot time, you must place a `Tracebuf` command in the `CONFIG.SYS` file to set the size of a circular trace buffer. `Tracefmt` takes the contents of the trace buffer, analyzes each record, and sends the output to the standard output device.

To use the memory dump facility, you should have one formatted disk holding the `Createdd` command file on hand to start the dump. Because `Createdd` uses the `Format` command, `Format` should be accessible from the current directory or from the search path. `Createdd` dumps all memory beginning at address 0 until the entire memory contents have been placed on the disk. To initiate the dump, you hold down the Control and Alt keys and press the Num Lock key twice. (Don't press this until you're absolutely ready, because the system will cease all current activities without flushing the buffers or other system cleanup operations.) A memory dump can take several disks, but one 1.44-megabyte floppy disk was enough to hold the contents of the 3 megabytes of RAM on my system. You can stop the procedure each time you are prompted to put in another disk.

DOS Compatibility

Most programs run in the DOS compatibility box without problems. The manual warns that programs with copy-protection schemes that depend on timing or the operating system may not work. Those programs that are timing-dependent or hardware-specific, such as device drivers, may give problems. I ran SideKick 1.52A, XyWrite III Plus, HyperACCESS 3.32, Lotus 1-2-3 version 2.01, AutoCAD 2.52, MathCAD 2.0, STATA 1.5, DIAL (Microsoft's bulletin board system), and dBASE III Plus 1.1 in the DOS-mode box, and they operated much as they do in DOS.

There were some differences, though. XyWrite usually caught the hot keys and put one of its own help screens up just before OS/2 switched me to another screen group. Although initially confusing, this was not a functional problem.

Because DOS programs that access a COM port were not written for a multitasking environment, many of them go directly to the port without bothering to see if another application is currently using it. `Setcom40` makes the address of the COM port available to a DOS-mode application so it can access the port when the `COM0x.SYS` device driver is installed. After the DOS-mode program is through, `Setcom40` also removes the address so an OS/2 application can use the port. It's important not to issue this command while a running OS/2 application is using the port. I had to turn on `Setcom40` before using DIAL from the DOS-mode box, but not before using HyperACCESS.

continued

I ran into a problem with an incompatible device driver. The Sysgen Bridgefile, an external 5¼-inch floppy disk drive, would not run in the compatibility box. According to the company, it is working on a new driver. For the time being, I installed the Sysgen driver onto my DOS 3.3 boot disk and rebooted from that whenever I wanted to transfer files from the 5¼-inch format to the PS/2 Model 50.

Some of the old, little-used command options have been weeded out of the DOS mode. `Format` no longer formats eight sectors per track, or a single-sided disk. `Exe2bin`, `Ctty`, and `Graphics` are no longer supported. The `Label` command does not delete a label from a disk. `Files` is ignored in the `CONFIG.SYS` file. `Print` doesn't support the `/B`, `/U`, `/M`, and `/Q` parameters, which deal with buffer size, scheduling of the print spooler, and the queue size of the spooler. You no longer have to specify the path name for the code page file with `Country`, change the code page with the `Mode` command, or load the `Nlsfunc` command to use `Chcp` to change code pages.

Improved Documentation

The OS/2 user's reference is much easier to navigate through than the DOS 3.3 manual. It is smaller and better organized. As with the DOS user reference, the OS/2 user reference lists the system utilities and batch commands alphabetically, with cross-references to other related commands. There is a large section on the `CONFIG.SYS` file commands. IBM has adopted a command diagram using lines and arrows that is clearer than the command format using brackets, capitals, and small letters.

The manual does a great job of showing which commands work in which modes through the use of a box icon. If the upper three-quarters of the box is filled in with black, it indicates that the command works only in OS/2 mode. If the lower left one-quarter of the box is filled in, the command works only in DOS. However, if the box is absent, it's a dual-mode command. Appendix A lists all commands in a table and indicates the mode each one operates in. The appendix also includes a useful section on DOS compatibility.

Test Results

To get some idea of how the scheduler works, I created a dual-mode version of BYTE's Sieve benchmark program in C and a compute-bound infinite loop and ran them together in various combinations. I used these programs on an IBM PS/2 Model 50 to find out how the `CONFIG.SYS` commands work together and how the DOS mode fits into the scheme of things. For these tests, I considered only regular- and foreground-class threads. Time-critical and idle-class threads do not have their priority dynamically adjusted by the system.

The way the scheduler works is that any higher-priority thread that is ready to run gets the CPU before any lower-priority thread. A CPU-intensive process at a higher priority could starve out processes at a lower priority. In `CONFIG.SYS`, if you set the priority to dynamic, the system will adjust the priority of lower-priority threads by boosting the priority of these processes by 1 after the number of seconds specified by `Maxwait` passes. It will also give any threads running in the foreground a boost over regular-class threads running in the background.

To see how this works, I started a CPU-intensive infinite loop in the foreground and ran 100 iterations of the Sieve in the background. When it was the only process running, the Sieve took 22 seconds; the contents of the foreground loop took approximately 47 seconds running alone. I ran these programs with both

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Table 2: *To show the difference between dynamic and absolute priority, I ran a compute-bound infinite loop in a foreground screen group and 100 iterations of the Sieve of Eratosthenes in a background, OS/2 screen group. Under dynamic priority, the smaller the value of* `Maxwait`*, the more often the background process gets to run. Under absolute priority,* `Maxwait`*'s value has no effect on the scheduling of the foreground and background processes; while the Sieve and foreground process are both running, they appear to be competing equally for the processor. It is interesting to note that in these tests, the performance of the DOS-mode foreground process is comparable to the OS/2 mode foreground process. (Times are in minutes:seconds.)*

Foreground	Background	Priority	Maxwait
OS/2 Mode			
46, 47, 46,...	5:41	Dynamic	0:01
47, 47, 47,...	17:40	Dynamic	0:03
47, 46, 47,...	59:50	Dynamic	0:10
70, 47, 46,...	0:47	Absolute	0:01
70, 47, 46,...	0:45	Absolute	0:03
69, 47, 46,...	0:46	Absolute	0:10
DOS Mode			
46, 47, 47,...	5:37	Dynamic	0:01
46, 47, 47,...	18:30	Dynamic	0:03
46, 47, 46,...	59:42	Dynamic	0:10
70, 46, 47,...	0:49	Absolute	0:01
69, 47, 46,...	0:46	Absolute	0:03
70, 46, 47,...	0:42	Absolute	0:10

Notes:
Time slice = 32:248.
The ellipses mean that the time for the foreground program continued at the last number.
A DOS-mode process is suspended when it is in the background.

Table 3: *Comparing times for applications running under DOS mode and DOS 3.3 shows that you get varied results.*

Application benchmarks	DOS 3.3	OS/2 DOS mode
XyWrite[1]	2:51	2:44
Microsoft Word	0:31	0:33
Lotus 1-2-3	2:48	2:52
dBASE III +	8:35	6:08
AutoCAD	16:02	24:40
STATA	0:52	0:32
MathCAD	0:35	0:36

[1] Times for large program only.

OS/2 and DOS mode in the foreground (see table 2).

When priority was dynamic, the foreground task executed at a fairly constant rate no matter what was going on in the background. When priority was absolute, however, the foreground tasks and the background tasks executed in a round-robin fashion. In these tests, because I started these processes from the command line, they all had the same priority when I configured priority to be absolute. The programmer can set the priority of a thread; in this situation, a lower-priority thread would not get the processor from a higher-priority compute-bound infinite loop.

Table 2 also shows that when DOS mode is in the foreground, it gets scheduled the same way as an OS/2-mode task running in the foreground. A task running in DOS mode is suspended when it is switched to the background.

Table 3 shows the total time for each program's test in the application benchmark suite. (For a description of the application benchmarks, see the article "Introducing the New BYTE Benchmarks" on page 239.) In general, DOS mode was slower on the loads from disk. DOS mode was about 4 minutes slower performing the `Hide` command in AutoCAD than was DOS 3.3. DOS mode had some notable speedups: 5 seconds faster for the XyWrite block move test, and 20 seconds faster for the STATA graphics test. It also showed a lot of improvement in many of the dBASE III Plus tests in the Copy, Index, Append, Pack, Count, and Sort tests. In these tests, it was 29, 21, 24, 55, 41, and 31 percent faster, respectively.

The only problems I came upon when running the application benchmarks in OS/2 mode were memory problems. I had to remove `COMOx.SYS` from memory to run the fast Fourier transform test of MathCAD. The memory limitations prevented me from running the Lotus 1-2-3 Monte Carlo tests at all; the Monte Carlo requires over 512K bytes of memory.

Is It Worth It?

At this time, the average end user can't do a whole lot with IBM OS/2 except run DOS applications in the DOS-mode box. I don't currently have any user applications that take advantage of the advanced capabilities of OS/2, and the thrill of running 12 simultaneous disk directories wears off quickly.

So the question is, is it worth the money and effort to convert to OS/2 Standard Edition now? I think it is. The DOS compatibility box seems to be pretty compatible for most applications unless you have a real memory hog of a program or an incompatible device driver. You can easily boot from a DOS floppy and just run under DOS if you don't want to struggle with these issues.

It takes time to absorb the concepts of a system this complex. Even just the stuff you have to know to be an end user takes some mental adjustment. It took me a few weeks just to get used to the concept of screen groups, the fact that OS/2 has over 50 files in the root directory, and to figure out what the `CONFIG.SYS` commands were good for, just to name a few things.

If you happen to be an applications developer, these are exciting times. Norton Guides has an on-line reference for the OS/2 Application Programmer Interface (API) that makes the approximately 200 OS/2 functions accessible with a keystroke. Laboratory Microsystems has an alternative to the very expensive Microsoft Software Development Kit ($3000) and IBM Toolkit ($795), called UR/FORTH ($350), which is a great system for becoming familiar with the OS/2 API. Unlike C, Forth lets you simply try out an OS/2 function right at the Forth prompt. You don't have the lengthy edit, compile, link, and run cycle of C. I am expecting an avalanche of OS/2 applications any day now. It will be interesting to see how well they all play together. ■

Eva M. White is a technical editor at BYTE.

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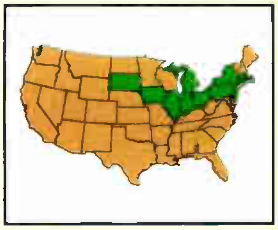
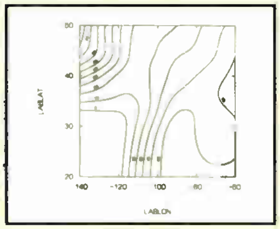
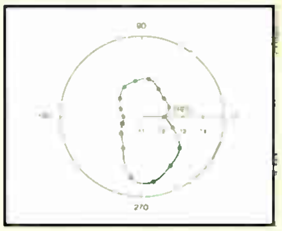



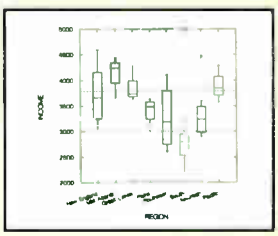
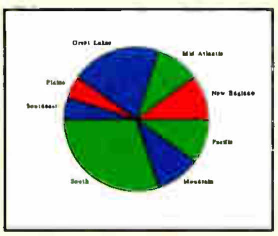
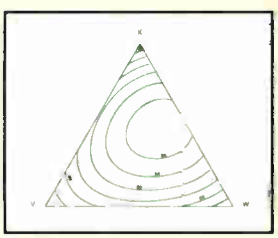
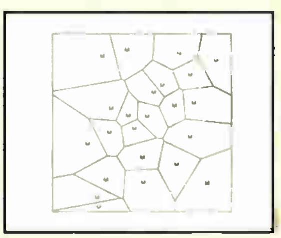
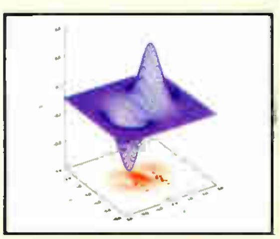
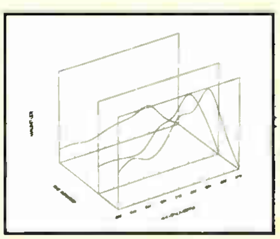

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Two Mac Databases Go Toe-to-Toe

Charles Spezzano

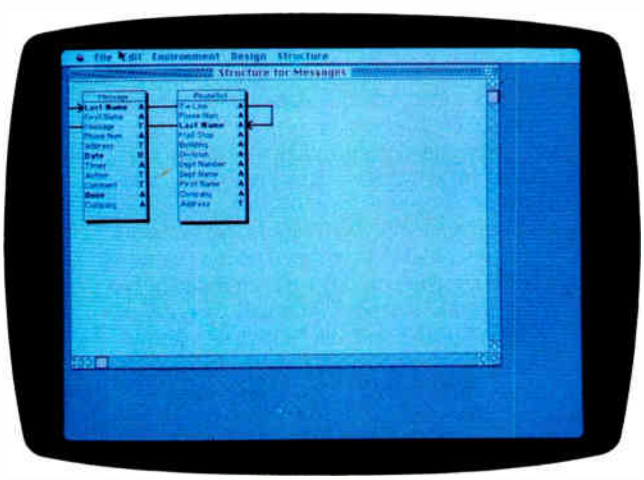
An icon-operated and efficient Double Helix II differs from a powerful and sophisticated 4th Dimension

Double Helix II and 4th Dimension are two of the leading heavyweight contenders in the Macintosh database arena. Both are relational database systems that let you link multiple files of records. With these systems, you can set up customized turnkey database management applications. In fact, you can do almost anything you want in designing customized database applications on the Macintosh.

Despite these similarities, Double Helix II and 4th Dimension have very different personalities. Helix is one of the most visually oriented databases available for the Mac. You don't have to type in instructions for anything; instead, you move icons around. This has been Helix's trademark since its introduction back in the days of the first 128K-byte Macs.

At that time, Helix was a cute but limited program that couldn't even do subtotals. Now it has matured, and it still has an abundance of icons per square inch of computer screen. It also has all the heavyweight features most users need, except for a procedural programming language and a built-in graphics generator.

There is nothing "cute" about 4th Dimension. If you prefer to build your custom applications with a sophisticated Pascal-like programming language, then 4th Dimension is currently the stand-out choice among Macintosh databases. If, however, you don't want to program, then Double Helix II easily and comfortably supplies you with the capability to create your customized relational application.



With Double Helix II (top), you use icons to create a database. With 4th Dimension (bottom), you can link two files.

Double Helix II 40

Odesta Corp. offers Double Helix II version 40 for $595. The program comes on two 3½-inch floppy disks and runs on a Mac Plus with 1 megabyte of memory and a hard disk drive.

Helix has fans like the Mets have fans. Even when Helix had flash and potential, but little power or real business capability, users still loved it. Now, Double Helix II is an easy-to-operate but versatile program for the serious user who prefers to create databases in a graphics development environment by using a palette of icons rather than traditional programming.

What's called a file of records in other programs is called a *relation* in Double Helix II. A collection of relations is a multifile database. When you open a new relation, you are provided with a palette of seven icons. These icons represent the tools that you use to create the relation's structure.

Once you open and name a relation, you can create a field by dragging a Field icon out of its icon "well." Double Helix II handles five different types of data fields: text, number, date, flag (true or false), and picture (screen image of any sort). In addition to setting the type of field that you create, Double Helix II also provides a format button that lets you specify the exact output format of a number, date, or

continued

Double Helix II 40	4th Dimension 1.0
Type Relational database manager and applications developer	**Type** Relational database manager and applications developer
Company Odesta Corp. 4084 Commercial Ave. Northbrook, IL 60062 (312) 498-5615 (800) 323-5423	**Company** Acius Inc. 20300 Stevens Creek Blvd. Suite 495 Cupertino, CA 95014 (408) 252-4444
Format Two 3½-inch floppy disks	**Format** Four 3½-inch floppy disks
Hardware Required Macintosh Plus with 1 megabyte of memory and a hard disk drive	**Hardware Needed** Macintosh Plus with 1 megabyte of memory and a hard disk drive
Language Not available	**Language** Pascal
Documentation 425-page User's Guide 367-page Reference Manual	**Documentation** 204-page Tutorial 367-page User's Guide 172-page Programmer's Reference 268-page Command Reference Utilities and Developer's Notes Changes and Enhancements booklet
Price $595 $395 for the Double Helix II multiuser kit	**Price** $695 $295 for run-time version with four disks
Inquiry 891.	**Inquiry 892.**

flag, and a validate button that lets you set restrictions on the information entered into this field.

You don't have to specify a length for a field (see table 1). Double Helix II allows up to 32,500 characters per field, but it does not allocate a fixed amount of space. Rather, it allocates only the space you actually use when entering data into that field for any record, even if that space differs from record to record.

Once you create fields, you design a form so that you can enter, view, and manipulate the information they will contain. You build applications on forms by manipulating icons that represent each element or data-management activity, such as a value, a calculation, or a selection process.

With Double Helix II, everything you do with your data requires a form. You will need data-entry forms, report forms, mailing-label forms, and so on. Helix doesn't have separate components, such as a report generator that has different procedures that you must learn for each component. You use Template icons exclusively for form design.

You use View icons to enter and view data. For this process, you simply drag and name a View icon, select the Template you wish to use, pull down the view menu, and select Show Form. The form you created in the Template icon is now displayed and ready for data entry. When it's time for your first report, you drag and name a new Template. Then, as with the data-entry form, you can custom design a report form, or you can use a `Quick` command to automatically generate a columnar report.

You can design fields to display and print in a variety of fonts, sizes, and styles. Double Helix II can index the fields to let you view records in a particular order and to help speed up the retrieval of information. To build an index, you use the Index icon. Essentially, you name the index and drag the field to be indexed to the top of a field list. A dialog box shows you that your index is being built, and also how much of the process remains to be completed.

You can join separate fields of information, such as first name and last name, with a calculation. To do this, you use the Abacus icon. In this case, you might name the Abacus icon "Full Name." When you double-click on the Full-Name Abacus icon, a window opens with oblong icons along the left-hand side. These are the famous Helix Calculation Tiles that let you visually program instead of using a programming language with its syntax protocols. You can also use tiles for complex calculations involving number fields; the procedure is similar and just as simple.

The next icon you might use is the User icon, which lets you create personalized custom menus for other people using your application on a single workstation or a multiuser network. Once you name the User icon and double-click on it, a window appears with the necessary elements for creating custom menus either manually or automatically. The automatic procedure assigns all the View icons to the menu.

To further customize your application, you can assign keyboard command equivalents to your menu choices. To do this, you simply click on and drag a number or letter from an on-screen keyboard at the bottom of the custom menu window and place it on top of the appropriate menu choice. Other icons add further power and flexibility to your use of an application.

Key New Features

Posting is the most eagerly awaited new feature of Double Helix II, especially by users of Helix accounting applications. It has been given its own icon on the Helix palette. Basically, *posting* refers to a database's ability to automatically change previously stored data in response to information that is being entered.

More specifically, the posting function automates data management in three ways: It provides an automated method for changing the information in stored records; it lets you change data simultaneously in more than one record and more than one relation; and it provides a method by which you can create more than one new record by simply pressing the Enter key.

In day-to-day business use, here's what this means. With posting, you can automate tasks such as maintaining running totals and global replacing or updating of data either in multiple records in the same file or in multiple files. You can also generate audit trails, enter information that you cannot view or access on the entry form, or tag printed or dumped records.

Double Helix II offers increased protection against data loss and unlimited personalized custom menus and forms for each user. Other features include faster printing; page numbers for reports; "inert" (temporary) fields into which you can enter data for calculations without having to store it; nonselectable rectangles that protect against tampering with the values in specified fields; storing or printing page set-ups; dump and load parameters; shade defaults; shade invalid fields; and data validation. A new Object Manager makes working with large numbers of icons and other objects more efficient.

You can use a `Revert` command to discard changes and reopen the original collection. Helix offers icon well labels, a duplicate suppression/previous tile that eliminates repeating identical entries in a list and blanks out subsequent repeating columns, and over 20 new Abacus tiles, including those for date and time manipulation. A new "Why?" menu, which works with the new data validation features, explains why the data you enter does not meet the criteria previously specified.

For small business owners, managers, and professionals, Double Helix II provides a good combination of power and flexibility, plus ease of use and a short learning curve. Even new database users will be able to build custom applications. By contrast, experienced database programmers will probably be distracted by the new visual development environment in which they will find themselves.

Table 1: *Although 4th Dimension is a robust program, Double Helix II has unlimited capabilities.*

	4th Dimension	Double Helix II
Files per database	99	Unlimited
Fields per file	511	Unlimited
Records per file	16,000,000	Unlimited
Total links	Unlimited	Unlimited

4th Dimension 1.0

This new program from Acius comes on four 3½-inch floppy disks and runs on a Mac Plus with 1 megabyte of memory and a hard disk drive.

Few Macintosh software packages have been as eagerly awaited or given as much fanfare as 4th Dimension. It has been heralded as the greatest French import since the Statue of Liberty. For the most part, this is one time when all the clamor may be justified.

4th Dimension brings to the Macintosh world the first database that maintains a familiar Macintosh graphics-oriented interface while also offering a combination of multiuser Appletalk support, a traditional Pascal-like programming language for applications development, and a host language interface for creating modules externally in Pascal, C, or 68000 assembly language.

For veteran application developers coming to the Macintosh with programming experience on other systems, these features will eliminate the necessity of learning new methods, such as Helix's icon manipulation. For novice users, such a complex system will present some difficulties.

4th Dimension is divided into three environments: design, user, and custom. The design environment contains five editors: structure, layout, procedure, menu, and password. You can use these editors to develop files; fields within each file; relationships between files; input, output, and dialog layouts; procedures (programming); custom menus; and password security. This multiwindow design environment lets you switch quickly between the five available editors.

The user environment comes into play once you've designed a database using the design environment editors—a process in which you can enter data and test the layouts and procedures you have created. You can view and print data through input and output layouts, create standard reports and eight types of graphs, import and export data, set an ASCII map (a character translation table), execute procedures, print mailing labels, and search and sort records.

When I used 4th Dimension's search and sort method, I found that it required fewer steps and was more self-evident than Helix's Query icon method. Helix does offer a simple "quick query," but this method restricts you to three search criteria: "starts with," "contains," and "is found within."

The user environment also contains database functions that let you do the following: enter data without customizing the database; test portions of your application as you develop them; use the generic user-interface for ad hoc queries and database maintenance; and check the design and placement of layouts and dialog boxes.

If you decide to go all the way to a turnkey application, the custom environment lets your application run like a standalone program with its own pull-down menus, password protection, and a run-time version (read-only database) that is available separately for $295 with four disks in the package. The run-time version only implements an application that has been designed with the full version of the program. It does not let you change the structure of the database.

Five Editors

With this overview of the three major environments in mind, you can now take a closer look at the five editors available within the design environment. The *structure* editor lets you create files, assign fields and field types, and create links between files. In the structure window, the entire database is visually represented, with the fields of each file contained in a rectangle.

There are eight types of fields: alphanumeric (2 to 80 characters); text (an editing environment that provides scrolling and word wrap and accepts up to 32,767 characters); real numbers; short (16-bit) integers; long (32-bit) integers; date; pictures; and subfile. A subfile field is actually a file attached to an individual record. Subfiles can have up to 32,767 records, each record having as many as 511 fields. Subfiles nest to five levels.

You may give each field any of six available data- and error-checking attributes: mandatory, display only, can't modify, indexed, unique, and standard choices. The standard choices attribute lets you create a list of prepared entries, from which you can pick when you enter data.

The *layout* editor is the second of the five design environment editors. Layouts are similar to Helix forms, but 4th Dimension provides more drawing tools to create them.

You can select a standard layout from eight choices or custom design an input or report format. You select fields to be included in each layout as well as create Macintosh interface tools such as check boxes, scrollable areas, buttons, graph areas, and any variable you want to include on the layout. You can include displays of layouts from other files or fields from linked files. You can also display formats for dates, numbers, and variables.

The *procedure* editor brings you into contact with 4th Dimension's full-featured, Pascal-like programming language. You can use either the flow chart or the listing method for writing procedures. You use the procedure editor to write and modify global procedures for use as menus, commands, and subrou-

continued

Table 2: *Except for the "load sample file" test, 4th Dimension was significantly faster than Double Helix II. All times are in minutes:seconds.*

	4th Dimension	Double Helix II
Load sample file	39:08	13:20
Search for last record	1:45	4:45
Search for nonexistent record	1:20	4:50
Index a field	2:55	6:07

tines, or to create layout procedures that control processing for a specific layout (e.g., input, output, or dialog). You can also use it to create file procedures for controlling files.

You use the *menu* editor to create custom menu bars and menu command choices. 4th Dimension's menu editor is similar in capability to Helix's custom menu features.

The final editor, *password*, provides the capability of creating a multiple-level password system that can control access to the design and user environments as well as protect menu bars, titles, and items. There is one drawback, however, to 4th Dimension's password scheme: it's an either/or system. Either users can get into a particular layout or they can't. By contrast, Double Helix II lets you further specify exactly what you can do with a particular layout once you've accessed it. On the plus side, though, 4th Dimension's password system keeps track of how many times you use each password, and the date when you used it last.

In my opinion, this is the premiere Macintosh application development tool for experienced programmers. No other program looks and feels like a graphics-oriented Macintosh package, while at the same time giving veteran programmers the procedural language, host language interface, and multiuser AppleTalk support with which they can create a large-scale, completely customized database application. Many users, however, will be in over their heads trying to develop complete turnkey applications with this version of 4th Dimension. The company promises that a future version will provide pop-up menus and similar tools for nonprogrammers.

Linking Files: A Comparison

With both 4th Dimension and Double Helix II, you use the mouse to link files. You link two 4th Dimension files by drawing a line between the linking fields, or from a field in one file to another file of records, which will become a subfile of that field. When you later create the layout for a file, you can include data from any linked file.

4th Dimension automatically writes a layout procedure program that moves the data between the linked files. You can modify these programs with the procedure editor or use that editor to create your own procedures to work with linked data. You might find managing file links with 4th Dimension difficult, depending on your skills in writing these programs.

Double Helix II links are for looking up data in or posting data to another file. You can create these links by dragging objects into the blank spaces on tiles or by specifying in a dialog box what you want placed into the spaces. A subform link, which provides a means to display a list of data from one file within the form of another file, is created in the file containing the data and is then brought into the form where it will be displayed. This procedure is perhaps the most tedious in Helix and involves approximately 20 separate steps, including creating an Index, a Template, and a View icon.

Lines and arrows show the links between files. These links must be set during the design process—a disadvantage compared to Double Helix's Look Up tiles, which let you, while working in one file, retrieve data from another file without the necessity of a predesigned link. With 4th Dimension, if you realize after the fact that cross-file data retrieval requires a link you had not created, you must go back and modify the design of the database.

Making Comparisons

I ran BYTE's benchmark tests on these two programs on a Macintosh 512E that had been upgraded to 1 megabyte of RAM with a Dove 524S MacSnap memory board and SCSI port upgrade. Attached to the SCSI port was a Nova 30 hard disk drive from Micro Tech.

Except on the initial task of importing a 1660-record file, 4th Dimension was significantly faster than Double Helix II (see table 2). It performed searches and built an index three to four times faster than Helix did. These results strongly suggest that, in day-to-day use, 4th Dimension will prove to be a speedier performer than Double Helix II.

The 1660-record ASCII file I imported into both Double Helix II and 4th Dimension consisted of 15 fields per record. Helix took 13 minutes, 20 seconds to complete the importing process while 4th Dimension completed it in 39 minutes, 8 seconds.

I then asked both programs to search an unindexed field for the last record in the file. Helix found and displayed the record in 4 minutes, 45 seconds. 4th Dimension did it in 1 minute, 45 seconds. I conducted a search for a nonexistent record, again on an unindexed field. Helix took 4 minutes, 50 seconds, and 4th Dimension reported back in 1 minute, 20 seconds.

When I indexed the Last Name field in each database, Helix took 6 minutes, 7 seconds, and 4th Dimension took 2 minutes, 55 seconds. Both programs completed searches on the indexed field too fast for me to record on my stopwatch.

And the Winner Is?

These two programs are excellent choices for building custom database applications, because they both make good use of the Mac interface, they have all the features needed to create a turnkey system, and there are so few toe-to-toe competitors currently available for the Mac. Your selection of one or the other may rest largely on whether or not you prefer to build those applications through the visual object-oriented Double Helix II method or with 4th Dimension's traditional programming language.

Other Macintosh database application development programs face stiff competition from these two programs. They both create applications that make good use of the Macintosh interface. They both provide multiuser access. 4th Dimension also steals the high-end programming show from dBASE Mac with smoother search and sort methods, multiuser access, and a host language interface.

In spite of the excitement over the appearance of 4th Dimension in the U.S., I still prefer Double Helix II for my own database needs. That's because I am among the user category of small business owners, managers, and professionals for whom programming is an unwelcome chore. Many full-time programmers, however, will be waiting with open arms for 4th Dimension. ■

Charles Spezzano, of Denver, Colorado, is the author of "Database Managers" in BYTE's Applications Software Today (Summer 1987).

WARNING:

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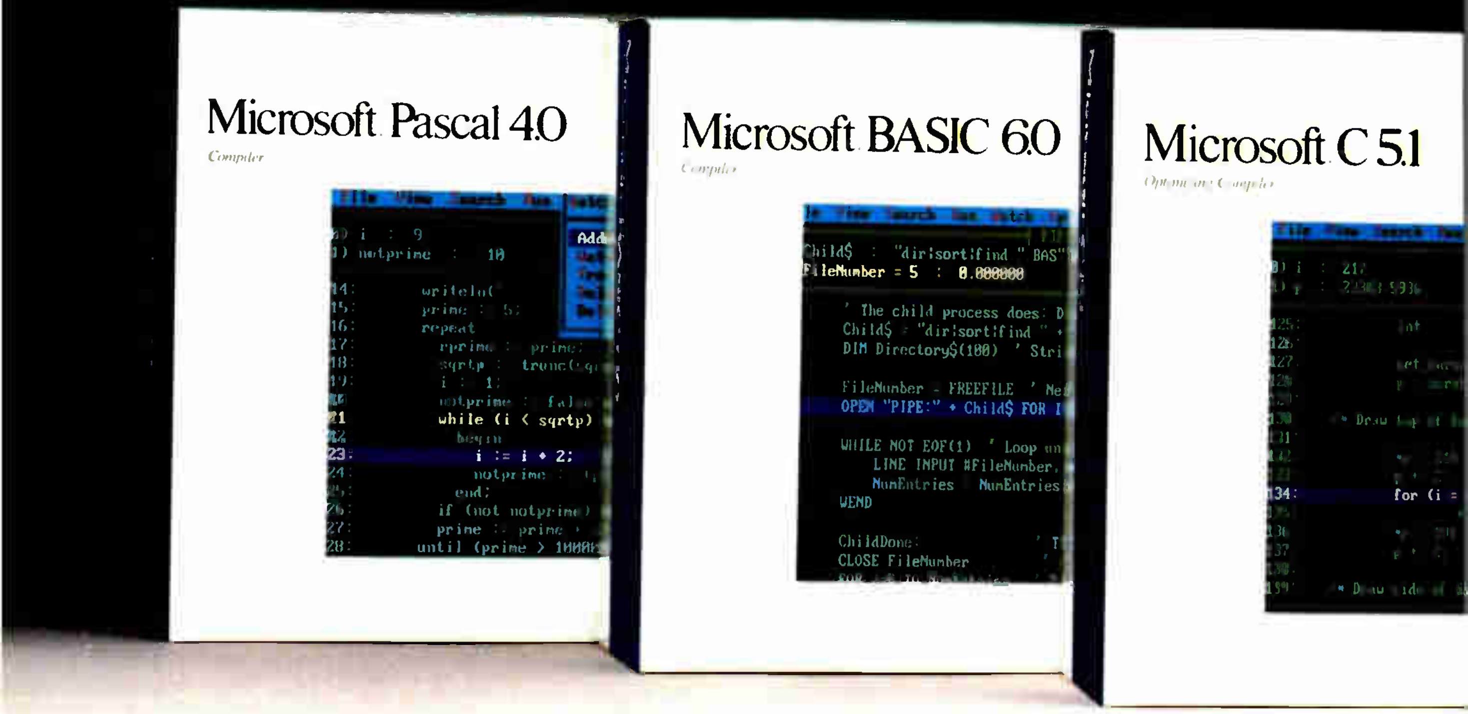

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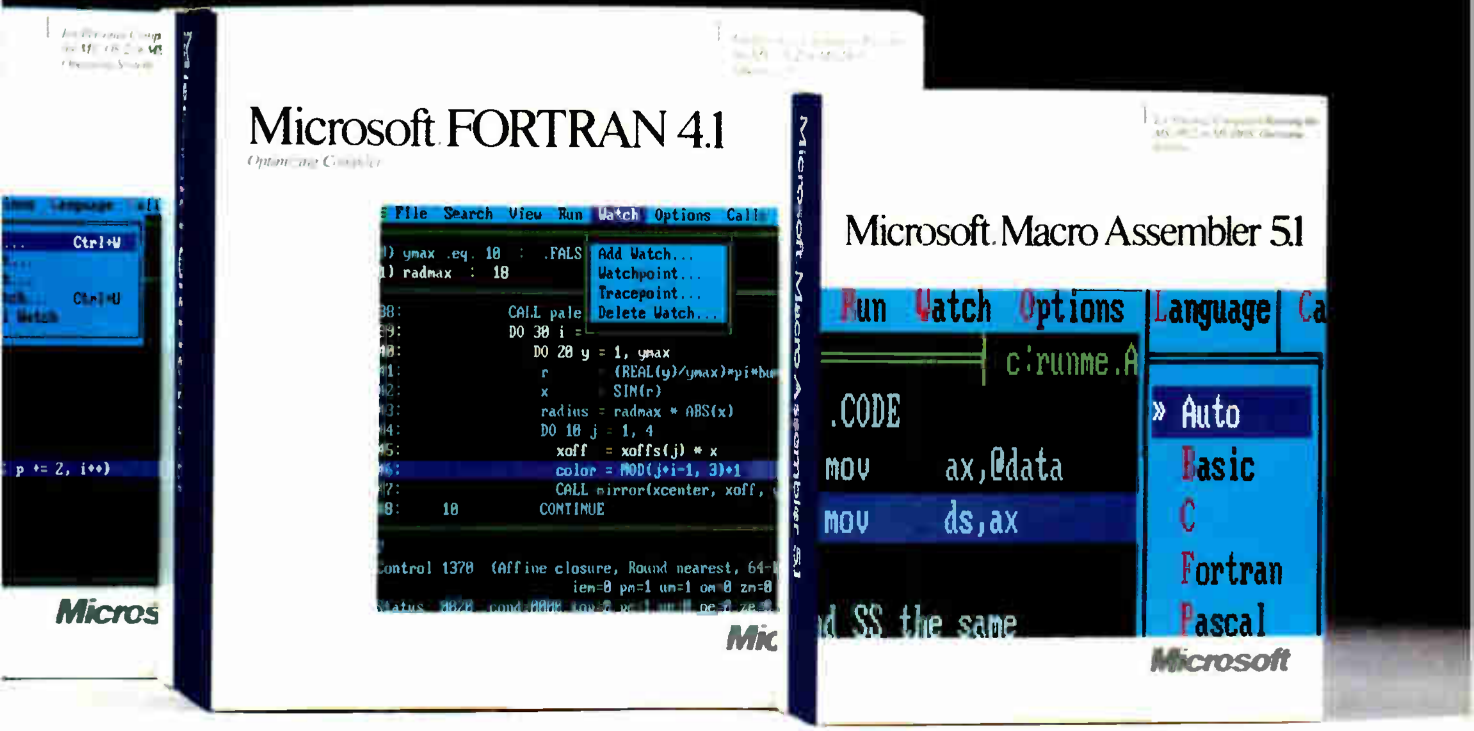

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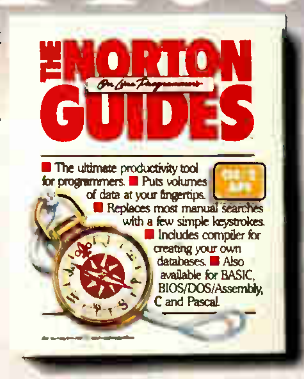

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Double Threats to Lotus 1-2-3

Diana Gabaldon

Quattro and Surpass are souped-up 1-2-3 compatibles that build on the spreadsheet standard

Quattro and Surpass are two spreadsheet programs that, at least in some ways, outshine Lotus 1-2-3. And they do it by being data-compatible with 1-2-3 worksheets. In fact, you could consider Quattro and Surpass functional supersets of 1-2-3.

But there the similarities end. Each program has its own approach to providing a better spreadsheet. Quattro offers an easy-to-use interface and a very attractive price, while Surpass adds features that let you consolidate several different spreadsheets.

Retrieve a Quattro worksheet (top) with four keystrokes. Consolidate several worksheets with Surpass (bottom).

Quattro 1.0

Quattro looks and feels a whole lot like 1-2-3. I was immediately able to do good things with Quattro without so much as looking at the user's manual. If you're a fluent 1-2-3 user, you'll get the hang of this program in about 30 seconds. If you're not, it might take you a couple of hours. Quattro's creators decided not to stray too far from the de facto 1-2-3 standard. It has all the familiar Lotus features, such as block definitions and moves, range naming, built-in functions, file handling, and many of the familiar keystroke rhythms of 1-2-3. But Quattro's creators have gone out of their way to make some of 1-2-3's functions easier to use.

Borland International's $247.50 package runs on the IBM PC, XT, AT, Portable, PS/2s, and compatibles. You need 384K bytes of RAM, but more memory is strongly recommended. Quattro provides both 5¼- and 3½-inch floppy disks and requires DOS 2.0 or higher.

Instead of residing in a two-line area at the top of the screen à la 1-2-3, Quattro's menu choices are displayed in pop-up windows. You press the slash key, and Quattro's first-level function menu appears as a list of command options in a vertical window. As you use your up arrow and down arrow keys to highlight your choice, Quattro displays more details of each function on the first line of your screen.

If you're 1-2-3 adept, you already know many of Quattro's capabilities. Block functions (e.g., copy, move, erase, and name ranges) and column, row, erase, file, and print are essentially the same as 1-2-3's similarly named functions. You can also do a search and replace within a range of cells; this is a very powerful feature that 1-2-3 lacks.

While most popular spreadsheets let you query a database in some fashion, Quattro also lets you assign field names in a query. This means that Quattro names cells in your database, according to labels in the first row of cells. You can then reference these field names instead of cell addresses when specifying the criteria for your query—a more convenient and somewhat faster way of doing things. The program also has useful features such as dependent minimal recalculation, in which only cells affected by spreadsheet changes are refigured.

You can customize Quattro to a very sophisticated level. With this flexibility, you have a range of options: from selecting the most desirable interface to developing your own menu system. You can change either to an interface virtually indistinguishable from Lotus 1-2-3, or to a novice-level menu system.

Quattro's graphics are spectacular. With this program you have the ability to create just about every kind of graph you can think of, with every sort of pattern, legend, marker, grid, and title. About the only thing you can't do is add free-form text to a graph. You can store a graph as an .EPS or .PIC file (the most common graphics file formats) for later desktop publishing purposes, or you can put it in a PostScript file for laser printing.

Quattro's print functions include a Top Heading and Left Heading function; these are the familiar 1-2-3 Border commands. In 1-2-3, I always had trouble remembering whether it was the Column or the Row border that showed up on the left. You will enjoy Quattro's more descriptive command names, which spell

continued

Quattro 1.0

Type
Spreadsheet

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

Format
Four 5¼-inch or two 3½-inch floppy disks

Language
C and assembly

Computer
IBM PC, XT, AT, Portable, PS/2s, and compatibles with 384K bytes of RAM and DOS 2.0 or higher

Documentation
340-page reference guide
440-page user's manual
100-page getting started guide

Price
$247.50

Inquiry 893.

Surpass 1.01

Type
Spreadsheet

Company
Surpass Software Systems Inc.
250 Bel Marin Keys Blvd.
Building F, Upper Floor
Novato, CA 94949
(415) 382-8840

Format
8088 version with three 5¼-inch floppy disks or two 3½-inch floppy disks; 80286/80386 version with one 5¼-inch floppy disk and two 3½-inch floppy disks

Language
Modula-2

Computer
IBM PC, XT, AT, PS/2, or 100 percent compatible with a hard disk drive, 512K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and a monochrome or graphics display adapter

Documentation
650-page document with quick reference and quick access guides and reference manuals

Price
For single-workstation copy: $495
For 10-workstation network version: $1995

Inquiry 894.

easier, faster spreadsheet formatting.

On the down side, Quattro is a memory hog. I had trouble running spreadsheets with 100 columns or more on an IBM XT with 512K bytes. However, the program will use expanded memory, if available. For a first-time spreadsheet user, Quattro is a fine choice. At a much lower price, it offers all of Lotus 1-2-3's main features plus a few extras, such as the ability to use dBASE files. If you're spreadsheet shopping, Quattro is a good pick.

Surpass 1.01

You can run Surpass Software Systems' spreadsheet on an IBM PC, XT, AT, PS/2, or 100 percent compatible with a 5¼- or 3½-inch floppy or hard disk drive, a minimum of 512K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, and a monochrome or graphics display adapter. According to the company, this $495 package works with all RAM-resident accessory programs. When I tried it with SideKick (version 1.56), I had no problems. The package also comes with a special version of Surpass that uses the additional machine instructions of the 80286/80386 chips for better performance and memory utilization.

Surpass does a good job of matching or outdoing 1-2-3. Their user interfaces and general modes of operation are similar. Not provided by Lotus 1-2-3, however, is Surpass's abilities to use both extended and expanded memory and to load an entire spreadsheet into either.

Surpass's screen appearance is slightly different from that of 1-2-3. This is because Surpass uses windows and pop-up menus. You can have several spreadsheets visible in windows simultaneously, and you can concurrently summon and dismiss menu windows at will.

You can open and view multiple directories and disks with this spreadsheet's Visual File Manager, and you can view and graphically traverse the disk's directory tree. You can sort file lists by name, extension, size, DOS order, or time stamp.

Surpass does not have Quattro's ability to search and replace within a range. However, it does let you search a worksheet for a text string, formula, or numeric value, and for a specific condition, such as `+A1<200`. This command causes the program to search for cells containing a value of less than 200. There is a separate `@Replace` function that will let you replace, append to, or delete specified character strings.

There are several nice small features, such as undo, zoom, automatic adjustment of column width to the width of the longest item in the column, macro recording (the program writes a macro by recording your keystrokes), and tracing (single-step execution of a macro so you can see where problems occur). You can keep macros in macro libraries—a feature that lets you use the macros with different spreadsheets rather than only in the spreadsheet where they were created.

You can set recalculation to either manual or automatic. As with Quattro, Surpass also has dependency-based minimal recalculation. This means that only cells dependent on the last data entry are refigured—a process that considerably speeds up the recalculation function in large spreadsheets where changes affect only a few cells. More important, with Surpass, recalculation also runs in background mode so you can continue with data entry or other spreadsheet functions while it takes place. Surpass can use the 8087, 80287, or 80387 math coprocessor (not required), which, if used, increases recalculation speed.

The graphics in this program are certainly adequate for most business uses. There are 21 different types of graphs, among them some interesting three-dimensional bar charts. I particularly liked being able to print a graph without having to exit from Surpass to a separate printing program. Quattro also has this feature, but it does not have Surpass's slide show feature, which lets you set up a programmed sequence of selected graphics screens for later viewing.

Every new software product has one feature that's supposed to really knock your socks off—a feature that everyone mentions when describing the product. Surpass has something it calls a "hot link," a feature that lets you consolidate spreadsheets.

In a way, a hot link is similar to a relation in dBASE III. Just as a `Set Relation` command effectively joins two separate database files, a hot link joins two or more separate spreadsheets. Once two or more Surpass windows (spreadsheets) are hot-linked, they effectively act as one. And with hot links, you can build graphs that use data from several different spreadsheets. This feature is similar to that in the just-out NexView from ADC & Associates, with its distributed spread-

continued

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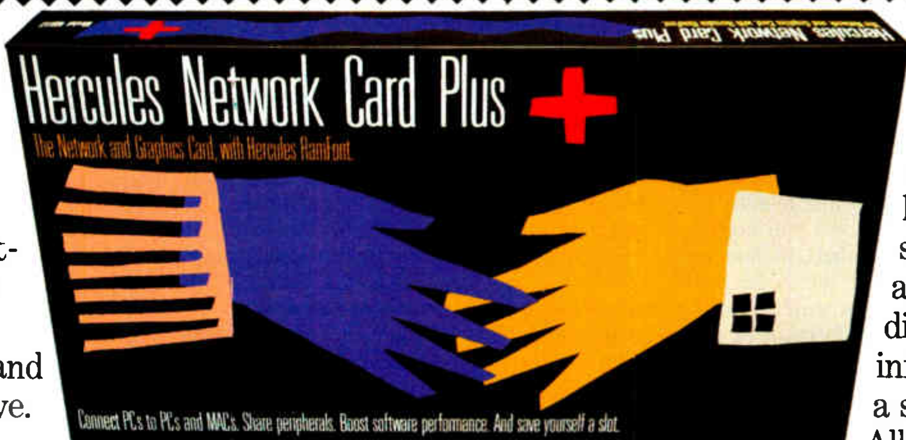

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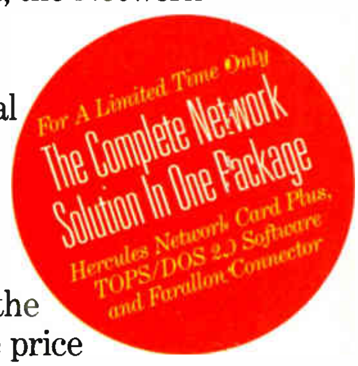

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Table 1: *On the IBM XT, Quattro ran somewhat faster than Surpass in both the Scroll and the Savage tests, while Surpass ran faster in the Recalc test. Quattro, however, did poorly on the Recalc test.*

	Savage	Recalc	Scroll
Quattro	21.37	7.13	37.22
Surpass	28.85	3.08	54.21
1-2-3	28.90	2.44	57.67

sheet database system. According to Lotus, its 1-2-3 version 3 will be available this winter with a similar feature.

The hot-link feature lets you copy a range from one spreadsheet to another with virtually the same keystrokes that you use to copy within a single spreadsheet. You can build a formula in one spreadsheet that "pulls" values from several other spreadsheets. If you copy that formula to other cells in the first spreadsheet, Surpass will copy with relative addressing so that each new formula pulls values from "equivalent" sets of cells.

In effect, hot linking creates a three-dimensional spreadsheet. Not only can you manipulate cells horizontally along rows and vertically in columns, but you can also work front-to-back through "pages" of spreadsheets.

Unfortunately, Surpass's hot-link feature is not implemented in any of the database commands. The most significant limitation of spreadsheets as far as database functions are concerned is that they limit you strictly to "flat"—as opposed to relational—database structures.

I especially like Surpass's hot-link and background recalculation features. While Surpass's price is comparable to Lotus 1-2-3's and considerably higher than Quattro's, the extra features and performance make it a good choice.

How Do They Compare?

The good news is that neither of these spreadsheets is copy-protected. However, the bad news is that neither Surpass nor Quattro works with the multitude of add-in products that lately have bloomed for Lotus 1-2-3. Lotus's add-in manager allows a wide variety of these accessory database handlers, spreadsheet checkers, optimizers, and so forth to work inside the 1-2-3 menu interface. Surpass, though, has several features, among them its hot links, that the add-ins supply for Lotus (see my review "Database Management via 1-2-3," May BYTE).

Quattro does use SQZ!, an accessory data compression program from Turner Hall Publishing. SQZ! was originally developed to work with Lotus 1-2-3 and other spreadsheet files but is now built into Quattro. With this addition to Quattro, merely saving a file using a special three-character extension compresses not only Quattro-generated files but any 1-2-3 `.WKS` and `.WK1` files you may use with Quattro.

I ran the BYTE benchmark tests on an IBM XT with 512K bytes of RAM (see table 1). I ran the Savage test on a worksheet with 1000 rows consisting of a single cell containing a complex formula. Both the Recalc and Scroll tests used a worksheet made up of 100 columns and 25 rows, where each cell is the product of 1.001 times the cell to its left. All measures for Surpass were very close to those for Lotus.

Quattro was about 26 percent faster than 1-2-3 and Surpass in the Savage test—a test that is a check on time and accuracy—and 32 to 35 percent faster in scrolling. However, Quattro did poorly on the Recalc test, taking about 2 to 3 times longer than 1-2-3 and Surpass to complete.

Quattro comes with a perfect-bound reference guide, a user's manual, and a tutorial book called Getting Started with Quattro. Aside from the general inconvenience of perfect binding—the pages never lie flat—the books are attractively laid out and logically organized. In terms of appearance and organization, the Quattro documentation is better than Surpass's.

Surpass comes with a large binder that includes quick reference and quick access guides and reference sections on the spreadsheet and Visual File Manager. This spreadsheet's manual has a good tutorial section, and the index is adequate. Both programs have very good context-sensitive on-line help.

Quattro is subject to at least two constraints on technical-support access. You must have a disk serial number to obtain this perk, and it is not a toll-free call. Technical support for Quattro is also available through Borland's special interest group on CompuServe. The software package includes a copy of *For Quattro*, a monthly newsletter-cum-tip-sheet for users. This publication is also available by subscription for $60 per year ($49 for new users).

Surpass Software Systems provides free unlimited phone support (also not toll-free) from 9 to 5 Pacific time, Monday through Friday. Surpass's phone support is currently available to anyone—a registration number is not required. When I tried calling, I got through at once to a knowledgeable, helpful technician.

For those contemplating a switch from Lotus 1-2-3, the question of compatibility is especially important. Both Quattro and Surpass import and use 1-2-3 files. Surpass also imports and uses 1-2-3 macros. Quattro also has this capability if the 1-2-3 interface is set, and it can read and write dBASE, Paradox, Symphony, and plain old ASCII files.

Surpass is actually keystroke-compatible with 1-2-3, using the same sequence of keys to do similar functions. Quattro is not keystroke-compatible unless you reset its "compatibility defaults" to enable its 1-2-3 user interface.

In the other direction, 1-2-3 cannot read default Surpass files. However, you can save files under different extensions that are readable by 1-2-3. You must save 1-2-3 version 1.0 files under a different file extension than version 2.0 files. Quattro not only reads files from 1-2-3, dBASE, Symphony, and others, but also exports Quattro-made files in any of these formats.

Sum Total

The problem is what to buy. Both Quattro and Surpass offer some distinct advantages over the present version of Lotus 1-2-3. Specifically, Quattro comes in at a much lower price. At $247.50 (compared to $495 for 1-2-3), Quattro, with its customization possibilities, is a good value, though it is no speed demon. Surpass, on the other hand, offers the additional features of background recalculation, spreadsheet consolidation through its hot links, and slightly better graphics—all for the same price as 1-2-3.

Those advantages may disappear, however, when Lotus introduces the enhanced version of 1-2-3. Moreover, neither Surpass nor Quattro works with the large number of add-in products developed for 1-2-3, and if you depend on any of those add-ins, you're also dependent on 1-2-3.

Borland International worked hard to make Quattro "better" than 1-2-3. It may not be better, but it's very good. Surpass Software Systems made its hot-link concept very valuable for users, and it's also very good.

So until the new version of 1-2-3 is ready, I recommend Surpass if you need the ability to consolidate several spreadsheets. If you don't need that feature, you might consider Quattro the better buy. ■

Diana Gabaldon is editor of Science Software, *an international journal for scientists who use computers, and an assistant research professor for Arizona State University's Center for Environmental Studies.*

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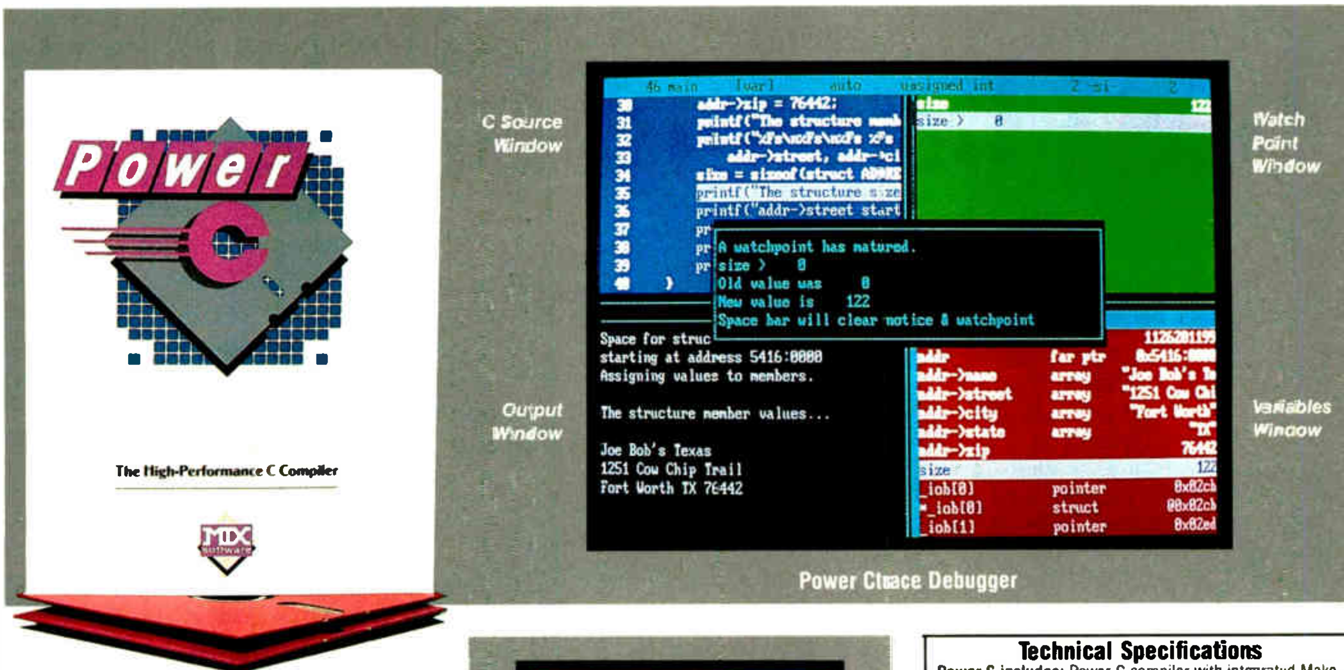

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4) diskio	13.5	14.4	14.3
5) report	11.0	71.7	60.7
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Compile/Link	73.9	113.5	81.4
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Paul Schauble

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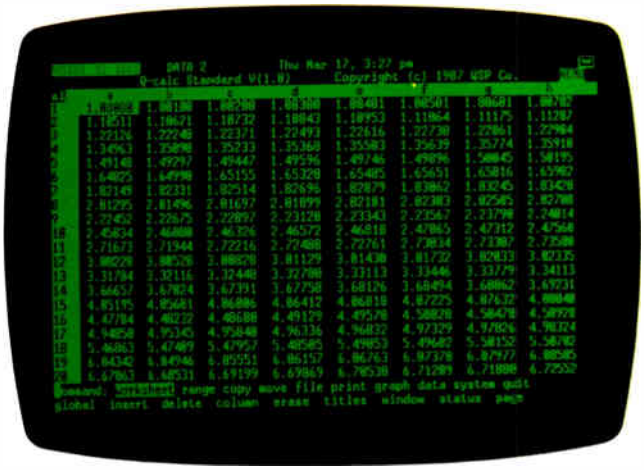

Although Lotus 1-2-3 has spawned a host of imitators, Q-Calc Standard is different: it runs under Unix. Q-Calc Standard is compatible with Lotus 1-2-3 version 2.01, can use .WKS and .WK1 spreadsheets, and has multiuser capabilities inherent in Unix-based systems.

Q-Calc operates under various versions of Unix System V; BSD 4.1, 4.2, and 4.3; Xenix V; and HP-UX. It runs on a wide variety of hardware, including the IBM PC AT and compatibles, many 80386 machines such as the Compaq Deskpro 386, and many 680x0-based systems such as the Macintosh II, Sun workstations, Convergent Technologies workstations, and the NCR Tower. Other Unix systems include the IBM RT PC, Honeywell Level/6, DEC VAX, and IBM 30xx mainframes, to name a few.

For graphics output, Q-Calc supports Tektronix 4014, HDS 220, and Visual 550 terminals. It also supports some bit-mapped workstations, such as those from Sun. Q-Calc produces hard-copy graphics on PostScript-based printers, the HP LaserJet, IMAGEN Impress printers, the IBM Proprinter, and an assortment of pen plotters.

My review package came with a single 1.2-megabyte 5¼-inch floppy disk and a manual in an 8½- by 11-inch three-ring binder. The clearly written and well-organized manual includes installation instructions, a tutorial, and a reference section. The tutorial is a good introduction to Q-Calc, but it does not have enough examples on how to use Q-Calc commands to introduce a novice to spreadsheets. The reference section has a fairly complete index. The features and command set are close enough to 1-2-3 that an experienced user might not need the manual.

The version of Q-Calc I used was optimized for Xenix running on an IBM PC AT-compatible 80386-based system and required 250K bytes of RAM and 500K bytes of hard disk space. This package costs $450; versions for other systems sell for up to $4000. For this review, Q-Calc was run under SCO Xenix 2.2.1 on an Everex 3000, a 16-MHz 80386 system with 4 megabytes of RAM, and a CGA card.

Installation Problems

Unix software is more difficult to install than MS-DOS software. The IBM PC AT and MS-DOS standard covers not only the software but also most of the details of the hardware. An MS-DOS program running on the IBM PC AT knows exactly what type of hardware it's using. In contrast, because Unix runs on a very large variety of hardware, a Unix program must be explicitly configured for the type of hardware it will run on.

The installation proved to be the most difficult part of this review. The installation section of the Q-Calc manual gives specific instructions for installing the program on a Xenix V system. When I followed these instructions, the system displayed an error message, `tar: 0 files extracted`, from one of the Unix utilities. There were no other installation instructions packaged with the disk, nor any manual update. I probed the distribution disk for a half hour, with the Xenix utilities `dd`, `tar`, and `ls` showing me how the disk is organized, and I was then able to complete the installation. The instructions in the manual were apparently for another version of Xenix.

Q-Calc was designed and written by Quality Software Products and is published, distributed, and supported by UniPress Software. The software had been repackaged by UniPress for various operating systems, and the manual had not been updated.

After installation, you must configure Q-Calc for the specific terminal hardware that each user runs. This process identifies the functions available on the screen and keyboard. Each user has his or her own profile, which describes the keyboard and screen in use and sets Q-Calc options. For example, the profile may specify that a Control-Z is equivalent to the slash (/) graph view command. The profile also determines printer setup, query before delete, and many other Q-Calc options.

The defaults provided work well with many common terminals. The ANSI terminal model, used by Xenix for the CGA, and the VT-100 terminal model were usable without specific customization. Other terminals may require building a user profile. This task is comparable in difficulty to making a Unix `terminfo` entry. It is a job for an experienced Unix user or system administrator.

Spreadsheet in Action

The organization of Q-Calc and its commands and functions are almost identical to those of Lotus 1-2-3 version 2.01. Macros work in the same way, although you must invoke them by a different key sequence than Alt-keystroke. Several of my macros did not work correctly because a Q-Calc feature interrupted the macro and asked for confirmation when I attempted to delete rows or columns, or when I erased region commands. However, I could disable the confirmation feature through the user profile.

Also, Q-Calc provides a feature that is unique to Unix systems. The Lotus file import and export features have been extended to work with Unix pipes. This lets you process part of a worksheet through

continued

Q-Calc Standard

Type
Lotus 1-2-3-compatible spreadsheet program for Unix systems

Company
UniPress Software Inc.
2025 Lincoln Highway, Suite 209
Edison, NJ 08817
(201) 985-8000
(800) 222-0550

Format
One 1.2-megabyte 5¼-inch floppy disk for the IBM PC AT version; four 360K-byte 5¼-inch floppy disks for the AT&T Unix PC 7300

Language
C

Hardware Needed
IBM PC AT or compatible running a version of Unix with 640K bytes of RAM, a CGA, and a hard disk drive; AT&T Unix PC 7300 with 1 megabyte of RAM and a hard disk drive. Packaged for most versions of Unix or Xenix systems.

Documentation
428-page installation, tutorial, and reference manual

Price
For an IBM PC AT-class machine: $450 (additional $150 for graphics)
For an AT&T Unix PC 7300: $750 (additional $245 for graphics)
Contact vendor for larger machine pricing.

Inquiry 895.

any filter program, or read from any file or database through a filter. A filter can read a database file and convert it into a worksheet format. Most filters are written in C. Writing a filter is not difficult for a programmer, although the average spreadsheet user will probably not want to tackle it.

Q-Calc uses the same file format as 1-2-3 version 2.01 to store its own worksheets. If you move a 1-2-3 file to Unix, Q-Calc can use it directly and then transfer it back to DOS and 1-2-3.

I used the standard set of BYTE spreadsheets for the timing tests. The Savage spreadsheet consists of 100 rows by 10 columns filled with the formula:

```
@tan(@atan(@exp(@ln(@sqrt
  (x^2)))))+1
```

where *x* is the previous cell in the sequence. The final value in the sequence should be 1000. The Columns spreadsheet is 25 rows by 100 columns filled with the formula $x \times .1001$, where *x* is the previous cell in the sequence. The Scroll Right test used the Columns worksheet and measured the time needed to scroll right from column 1 to column 100 by repeated use of the right arrow key. In addition, I used spreadsheets from my previous projects to test compatibility: Cook's and Cook's Consolidation are ordering worksheets that test macros and the ability to consolidate individual worksheets onto a master; Reanal does a rate of return analysis for a real estate property. I transferred the spreadsheet files from DOS to Xenix via the doscp Xenix utility.

The BYTE spreadsheet files executed successfully, but my other spreadsheets did not. I could load them correctly, but they would fail to execute on the first recalculation. I tracked down the cause to a problem with the SCO Xenix floating-point arithmetic routines. When I installed an 80287 math coprocessor chip into my computer, the spreadsheet files recalculated correctly.

In working with all the spreadsheets, Q-Calc had a different feel than 1-2-3. Running under DOS, 1-2-3 provides nearly instantaneous response. Q-Calc was much slower, even with the 80287 (see table 1). Compared to 1-2-3 running under MS-DOS on the same machine, Q-Calc took from 1 to 7 times longer to perform most operations. If the Unix system serves more than a single user, Q-Calc's performance will be reduced even further.

Screen control was more limited than with 1-2-3. Although my computer had a color monitor, the worksheet appeared in white on a black background, with only inverse video to show highlighted areas. Q-Calc does not support color choice or use of other colors to specify highlighted or protected areas. Highlighting was inconsistent. At times, I would have highlighted areas when I used the down arrow key but not when I used PageDown, or vice versa. The current cell cursor is also shown in inverse video. I found that operations with cell protection enabled were confusing; it was difficult to quickly locate the inverse video cursor among the inverse video unprotected areas.

The standard Q-Calc keyboard assignments follow the 1-2-3 keyboard as closely as possible. The cursor keys, PageUp, PageDown, and most of the function keys have the same use in Q-Calc and 1-2-3. Some of the 1-2-3 keys, such as Escape and Control-right, cannot

continued

Table 1: *Benchmark results clearly show that Q-Calc runs slower than Lotus 1-2-3 even with an 80287 math coprocessor chip. (All times are in seconds.)*

	Environment		
Worksheet	**Xenix Q-Calc with 80287**	**Xenix Q-Calc without 80287**	**DOS 1-2-3 without 80287**
Savage	33	150	14
Columns	7	16	1
Scroll Right	66	239	16

be duplicated on the Xenix keyboard. All the commands are also available by entering a Control-X followed by a letter for the specific command. Some users prefer this form for commands because it is the same on all terminals, while the function keys may be in different locations or missing completely. An apparent bug prevented me from marking a region by starting at the lower left corner and moving up. Another bug resulted in several aborts with core dumps when I pressed PageUp. I saw this both with worksheets imported from 1-2-3 and with worksheets constructed with Q-Calc. This problem occurred only when operating on a color video card and appears to be a bug in SCO Xenix. Q-Calc operated correctly with a monochrome video card.

[Editor's note: *To verify that Q-Calc does operate correctly in a Unix environment, BYTE obtained another copy of Q-Calc and installed it on an AT&T Unix PC Model 7300 running Unix System V. The Unix version of Q-Calc had the correct installation instructions. On the AT&T 7300 system, Q-Calc ran all the test spreadsheets with no problems.*]

Graphics

The Q-Calc Standard/Graphics package is priced separately from Q-Calc. Its operation is very similar to PrintGraph. You use Q-Calc to prepare and preview the graph and to make a graph file. This file is then made into hard copy using one of the supplied graphics drivers. All the 1-2-3 graphics types (e.g., line, bar, and pie charts) are supported. In addition, Q-Calc adds a commodity chart that plots high, low, and closing price information from a stock market chart.

The supported set of graphics display devices in Q-Calc is very limited. In particular, the IBM CGA and EGA video cards are not supported in graphics mode. Q-Calc can draw crude graphs using ASCII or the IBM line-drawing character set. This is barely adequate for debugging and proofing graphs and is essentially worthless for presentations.

UniPress is aware of this limitation but has no specific plans to remove it. Instead, the company invites you to write your own device driver—not something the average spreadsheet user wants to undertake—and provides interface specifications.

Growing Pains

This product shows a lot of potential, but the current version is lacking in polish. In comparison with the best PC-DOS spreadsheets, Q-Calc is slow, limited in display versatility, and awkward to use. This package isn't going to make anyone rush out and buy a Unix system just to do spreadsheets.

Almost all these limitations are the result of Unix software standing at arms' length from the hardware. Where MS-DOS applications have been optimized for performance on PCs, Unix applications are optimized for portability. If you must use Unix, it is difficult to conceive of a spreadsheet program that works in this environment that would remove all these limitations.

Still, Q-Calc has some problems. The lack of automatic installation procedures is usual for Unix software, but having to inspect a hex dump of the distribution disk is not. UniPress needs to improve its documentation in this area.

The utility of Q-Calc depends on the environment it will be operating in. It is best used where other considerations dictate using both DOS and Unix and require spreadsheet use on both systems. In this case, Q-Calc's similarity to 1-2-3 and its ability to use `.WKS` and `.WK1` files are major advantages that might outweigh its other problems. Q-Calc could be an excellent product for this niche. If this interchangeability is not a requirement, then you should examine other alternatives. ■

Paul Schauble is an independent program developer in Glendale, Arizona, who has been working with Unix-based systems for over 10 years.

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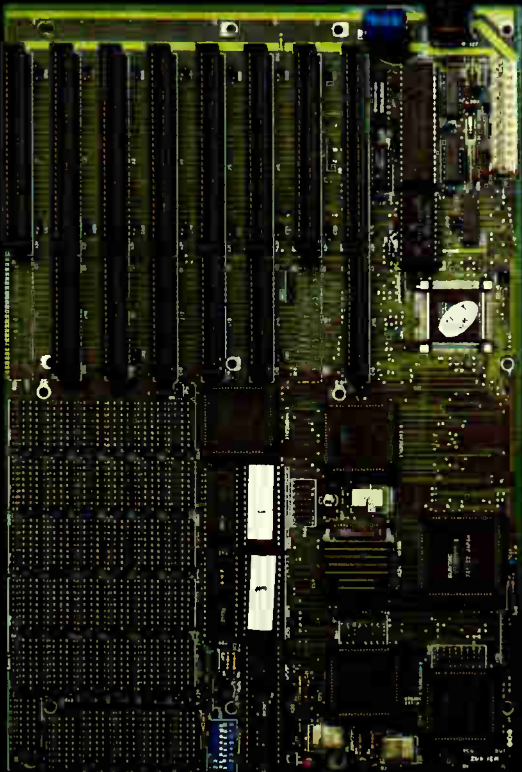

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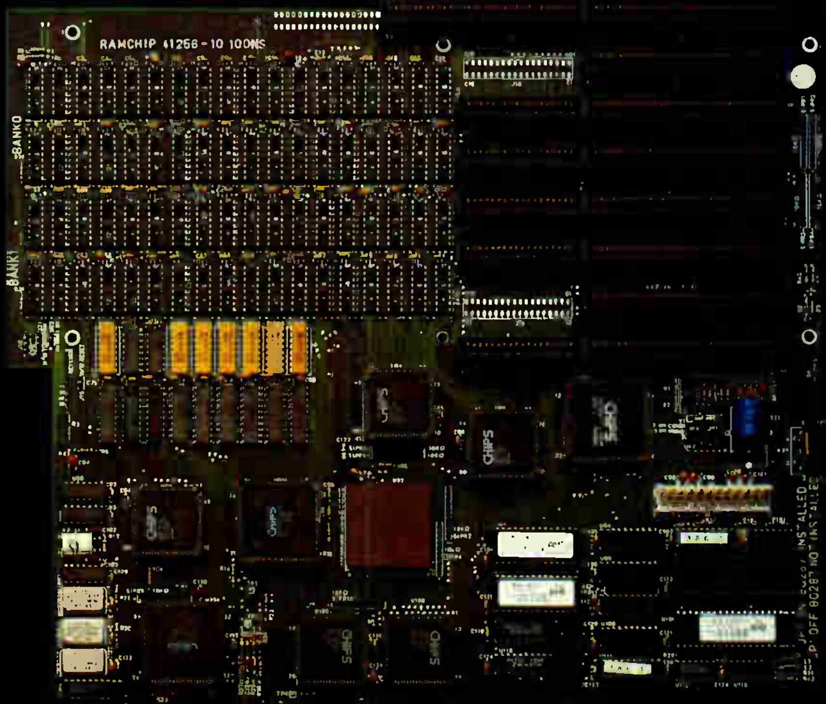

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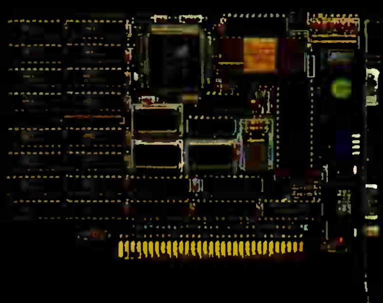

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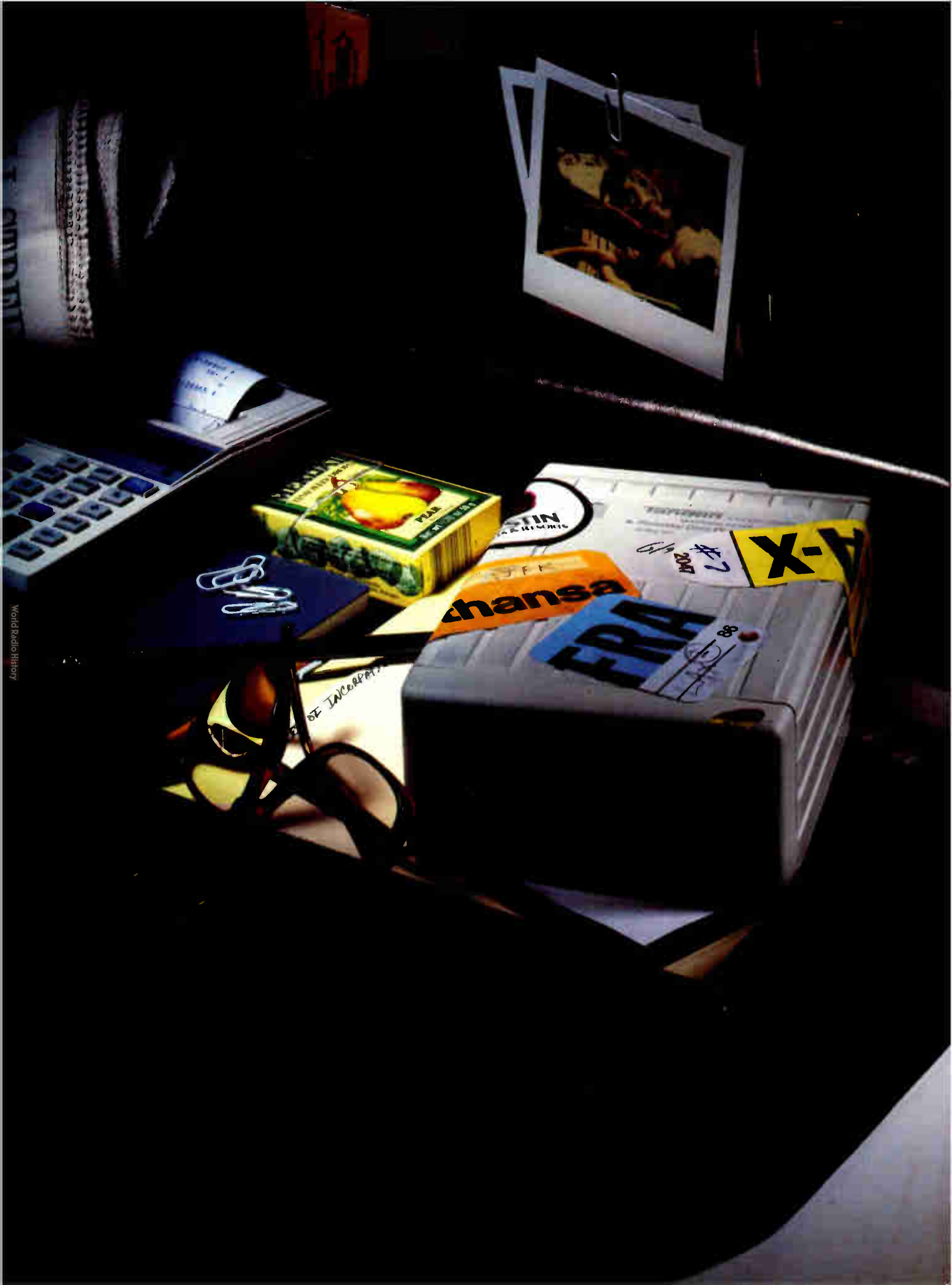
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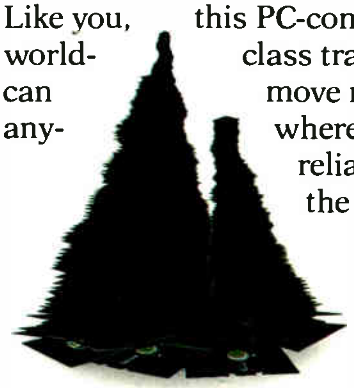

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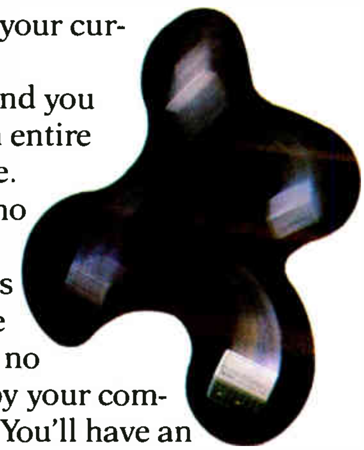

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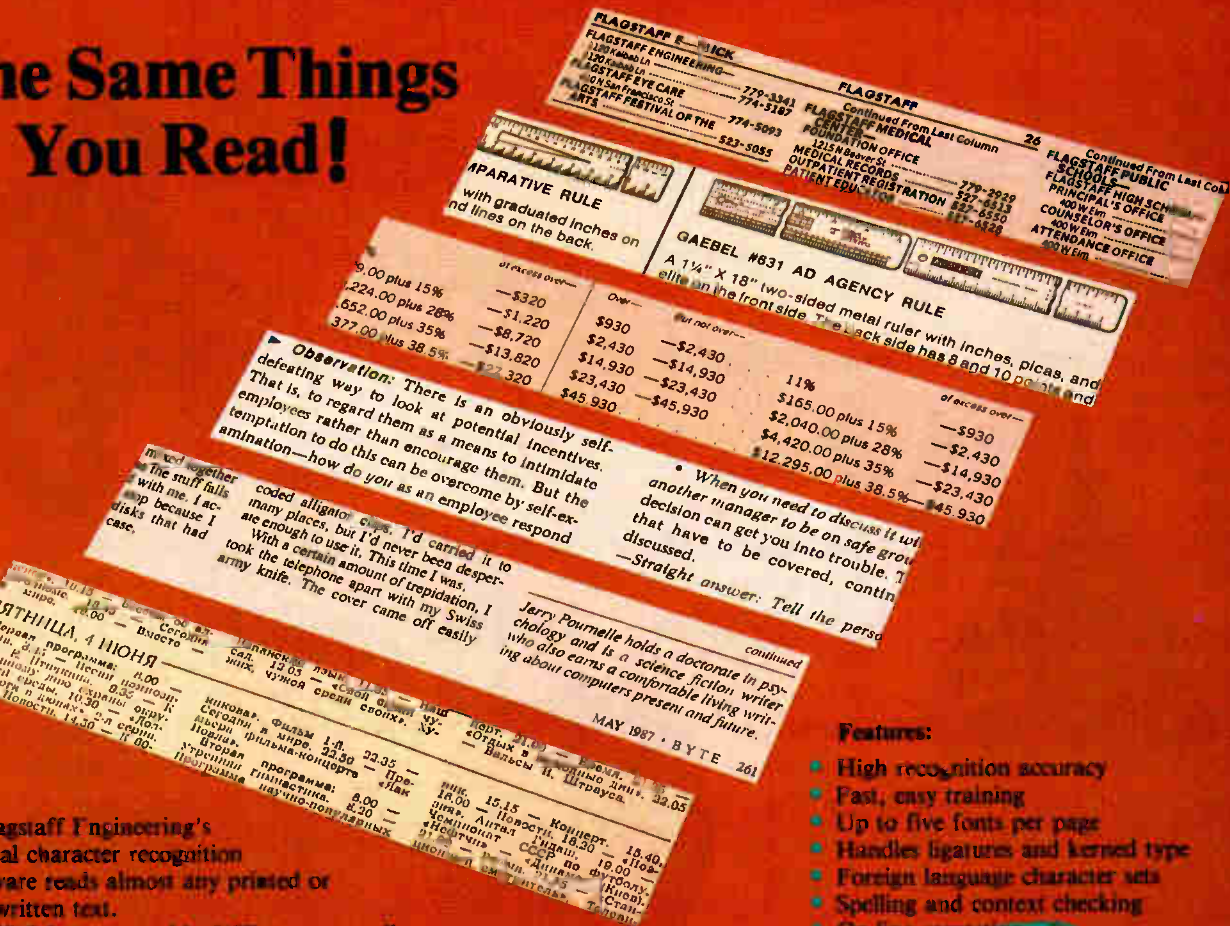

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A New Member of the Family

Jerry Pournelle

Someday this place is going to vanish under a vast sea of paper, software, and cables. Looking at the view from my chair, you'd probably say it could happen in the next few hours: there is literally no flat surface, including the couch and the top of the fish tank, that isn't covered with something. It's just like the day after Christmas—and I certainly enjoy having all this to play with—but I'm afraid it's getting out of hand.

Still, my desk was actually down to bare wood last night, and there's nothing on it now that isn't relevant to this column; I've got some new volunteers to help sort through the software; and my motto—"Every day throw something away"—has cleared out enough of the storeroom that much of this clutter can be put away when I get a free moment.

On the other hand, my column is due tomorrow, *Prince of Mercenaries* is almost completed but long overdue, *Wrath of God* is due all too quickly, and I'm going to Memphis in 3 days, then to a meeting of the advisory board of the Lowell Observatory, during which time more will come in. Sigh.

Zanna Lee is her name, and she just happens to be a Zenith Z-386

Zanna Lee

One reason for the clutter crisis is that I've spent the last 2 days setting up Zanna Lee, the Zenith Z-386. It took longer than I thought it would, but then everything does, and I suppose it's not surprising that changing to a new main machine would be complex.

One reason for the change is disk capacity. Zanna Lee has an 80-megabyte hard disk drive made by the Magnetic Peripherals Division of Control Data. I've heard good things about them, but I confess some partiality to Priam hard disk drives. I've had one of those in the Golem, my CompuPro Z80/286 Dual Processor, since about 1983, and there's been no hint of a problem; ditto for the 40-megabyte hard disk drive in Fast Kat the Kaypro 386.

I first saw Priam hard disk drives at the first Atlanta COMDEX; they were showing the then-new system of mechanical head lifters that click in on power loss. Now just about everyone uses that concept, and a good thing, too.

Anyway, I invited my son Alex over to help set up the Z-386. Our first job was to configure Zanna Lee's hard disk drive. Actually, the machine did come preconfigured, but in my rush to transfer data from Fast Kat to Zanna Lee, I copied a whole bunch of files off Fast Kat's root directory. Some were system utilities, and one was, I think, `COMMAND.COM`; anyway, shortly after that we got version conflicts with `CHKDSK` and other utilities, sometimes even on start-up depending on the `CONFIG.SYS` file, and then Zanna Lee stopped talking to most of the partitions on the hard disk drive.

This was annoying enough that I decided it was time to see that the exact same version of DOS was running on every machine in the house. I suppose strictly speaking that's not legal; but in my defense I have an original DOS for every machine, so all I'm actually doing is updating.

Updating DOS is easy but tedious, and you do have to pay attention. First, you copy all the DOS system utilities from your floppy disk copy (surely you aren't working with the original disk!) to the appropriate hard disk drive subdirectories. That turned out to be a problem, since many of my machines came preconfigured. Those system utilities reside in the `\UTIL` subdirectory on one system, `\BIN` on two others, `\2861` on a third, and so forth. I still haven't decided what to standardize on.

Anyway, eventually I got it done, after which I went around using the `SYS` command on everything in sight. The whole DOS update procedure is described in great detail in Chris DeVoney's *Using PC DOS* (Que, 2d edition)—a book I can't get along without.

Once we had DOS updated, we still had to configure the hard disk drive. The Z-386 came with Zenith software to accomplish that, but after about 4 hours of working with it (and discovering that it likes a version of DOS different from the one we had just installed everywhere, sigh), we gave up and got out SpeedStor.

I don't seem to have the latest version of SpeedStor, but the one I do have worked fine. SpeedStor is menu-driven and quite well documented: the manual actually explains what's going on. Most of its text about hardware applies to IBM PC XTs, PC ATs, and very close clones, and there's little about backplane systems like the Z-386, but there's enough to get the job done. Recommended.

SpeedStor offers the alternative of formatting Zanna Lee's hard disk drive as one great big drive, but there are drawbacks to doing that. After thinking about the situation, we partitioned the drive into three more or less equal chunks, meaning that Zanna Lee now has drives C, D, and E. Once that was done, I made a floppy disk copy of the new C:\ partition to save the system and setup files, then used Fastback Plus to bring over everything from the Kaypro onto the Z-386's C and D drives, and finally copied over the Kaypro stuff with the systems and setups I'd just saved.

After that, it was time to purge the Kaypro of files I don't have permission to keep on more than one machine; the tool of choice there is PC Sweep, a shareware program that is invaluable for chores like this.

Zenith sent a Z-515 memory board for the Z-386. That's 4 megabytes of 32-bit memory, which is a lot. The Z-515 can be set up to dedicate part of that memory

continued

to the Expanded Memory Specification (EMS), as well as automatically filling out the main system memory to 640K bytes. The EMS option looked like a good idea at first, and in my first installation I reserved some memory for EMS; but on reflection this seemed pointless.

The real advantage of having a 386 is the ability to use DESQview or VM/386 so you can keep lots of different programs and utilities in memory; and if you have those, you don't really *need* expanded memory. If you do reserve memory for EMS, you'll find that as far as the computer is concerned, that memory has just plain vanished: it's not shown as either system or extended memory on boot-up. It's also simple to disable EMS.

Mice and Memory

The next step was to install a mouse. The Kaypro has been using the Logitech Bus Mouse, which is a good one, but that takes up a slot. On the other hand, I sure didn't want to use Zanna Lee's only serial port for the mouse. I was going to have to put some kind of board in there. Why not make it do double duty?

The easiest solution would have been Logitech's EGA&Mouse board. That works fine, especially with Logitech's excellent Autosync monitor; I used both in Zanna Lee's setup exercises. If you want a good EGA system, I think there's no better value for the money than the EGA&Mouse board.

Autosync is a fine monitor, but I'm in love with the 14-inch Zenith ZCM-1490 Flat Technology Monitor; you can't believe how nice that is, even in a sunny room with windows behind you. It's good enough, in fact, that I'm going to try it as the main screen in place of the Electrohome 19-inch monitor.

I'm a bit concerned about the screen size, but after all, I used a 14-inch Hitachi monochrome monitor for years; and perhaps because the ZCM-1490 is truly flat, text displayed on it seems easier to read than on traditional monitors. One fair warning: the ZCM-1490 has an internal fan. It's not loud enough to bother me, but you can hear it.

The ZCM-1490 is driven by the Zenith 31-kHz video card. Video cards used to come with serial ports, but Zenith's doesn't. I wish it did; I could simply address that to COM2 and plug the mouse in. For that matter, I wish computer designers would recognize that mice are essential and slots are in short supply: a single serial port isn't enough. Machines should come with at least two serial ports.

Since I'd have to use a slot anyway, the simplest solution was to install a Cheetah Combo card. This takes an AT slot and comes with a megabyte of 16-bit memory, a serial port, and a parallel port. I can't use a second parallel port—who can?—but the serial port can be addressed as either COM1 or COM2. Cheetah cards come with an installation program that's absurdly simple to use: you just tell the program what you need, and it shows you a pictorial diagram of how to set the DIP switches on the Cheetah card.

I addressed the Combo card to just above the address of the Z-515, giving Zanna Lee 640K bytes of system memory and 4608K bytes of expanded memory. The top megabyte of that is 16-bit memory, and thus considerably slower than the rest, but it's not likely I'll use it much either; I'll probably turn it into a RAM disk when I get time to figure out how to do that.

CD-ROMs

The next step was to install the Amdek Laserdek. This comes with a controller card. By now, the Z-386 was getting a bit full. Only three slots were left: one short

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Like most clones, the Zenith's PC and AT slots and bus are fully IBM compatible. Again like all 386s, the 32-bit slot and bus are not standard; each manufacturer has a particular bus design, which is why if you want 32-bit memory, you have to buy it from the manufacturer of your 386 machine. Someday, I hope, that will change.

The controller requires only a short (PC) slot, so that's where I put it. It took about 5 minutes to install the Amdek CD-ROM hardware. There are two cable connectors on the back of the reader. Neither one is labeled, which bothered me until I read the instructions: they're interchangeable. Either can connect to either the computer or another drive.

The Laserdek is external, and fairly awkward in size, being 14 inches wide, 13 inches deep, and 3 inches high. There are ventilating holes on top. I got to wondering why the thing is so large, so I opened it; there's no real reason for it to be so large. The Laserdek mechanism is about the size of a disk drive, and the rest of the box contains very loosely arrayed electronics.

On the other hand, I learned that it's very sturdily made, and so long as the monitor is not so heavy that it actually distorts the case shape, and you don't completely block off the holes on the side behind the Laserdek, there's no reason you can't put it on top of your computer and the monitor on top of it.

Software installation comes in two parts: installing the DOS extensions so your computer can find the Laserdek, and installing software so you can read the actual contents of the laser disk.

The first part is pretty simple. The instructions and software come with the Laserdek, and a Setup program does most of the work. The instructions are not too informative, but if you follow them, you'll soon have the computer listening to the Laserdek. The important thing is to put the proper statements into `CONFIG.SYS` and `AUTOEXEC.BAT` and copy a program called `MSCDEX.EXE` into a place where the system can find it.

One option is to put a good part of the access software into expanded memory. The command processor extensions take about 40K bytes of system memory, and some of that—I confess I haven't tried the experiment—apparently can go into EMS if you like.

Another option is the letter designation of your CD-ROM. By default, it's the "next" device; in my case, since Zanna Lee has logical hard disk drives C, D, and E, the CD-ROM becomes F. You can, however, explicitly name the letter if you like.

Once installed, the CD-ROM drive acts like a write-protected hard disk drive. You can read its directory, change directories within it, copy files from it, and do anything you could do with a truly enormous disk that you can't write to.

One caution. If you have a CD-ROM disk in the drive, it spins continually. I don't know if this does any harm or not; after all, 8-inch floppy disk drives spin constantly, as do hard disk drives. On the other hand, it's one more thing to worry about. I noticed when I opened the Laserdek that if there is no disk the motor shuts down, so I left the drive empty during my overnight heat test.

It's my practice when I fill a system with boards to let it run all night and test it the next afternoon, when it's as hot as it's likely to be. I did that with the Z-386, and, sure enough, the machine hung during the boot-up process.

This was annoying. "Heat problems," I muttered. "Too much memory, plus the

continued

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ECOSOFT

CD-ROM controller, plus the WORM (write once, read many) drive controller, plus all the other stuff. Overloading the bus, maybe. Too much heat."

I took the cover off the machine to cool things off. It didn't seem particularly warm in there. Could I be doing something wrong?

As a matter of fact, yes. It wasn't Zanna Lee's fault at all. If you have the CD-ROM drive turned on, but there's no disk in there, when `MSCDEX.EXE` runs, there is a 30-second interval during which it tries to access the Laserdek but can't do it. Eventually it times out and continues with the start-up process.

If, on the other hand, you have the Laserdek turned off (whether there's a disk in the drive or not), the delay is about 1 second. In neither case is there an error message. The solution to this might be to switch the Laserdek off when it isn't in use, but, alas, the on/off switch is on the back where it's not easy to get at.

Other than that, the installation of the Laserdek went smoothly and simply. I tested it against about a dozen CD-ROM disks, and it was able to read files from all of them. So far, so good.

Bookshelf

Once you get the Microsoft DOS extensions installed so that DOS can find the CD-ROM drive, you'll still need software to make use of the information in the CD-ROM. There are exceptions to this—for example, the public domain software CD-ROMs distributed by user's groups. I have one published by Alde Publishing. This thing contains about a million programs, including utilities, games, languages, source code, and a partridge in a pear tree, all accessible as soon as you've run `MSCDEX.EXE`.

However, while you can cram hundreds of megabytes of ordinary files onto a CD-ROM—and get at them without anything special—most of the other neat things you can do with CD-ROMs are more complicated.

Case in point: Microsoft Bookshelf. Bookshelf combines *The Chicago Manual of Style*, *Roget's Thesaurus*, *The American Heritage Dictionary*, *Bartlett's Familiar Quotations*, the *National Five Digit ZIP Code & Post Office Directory*, *The World Almanac and Book of Facts*, and probably something I've forgotten, along with elaborate indexes and software for looking through all those books. As I've said before, every professional writer *has* those books, but not many of us actually *use* them because it's too much trouble to go get the book and look things up.

Microsoft Bookshelf makes that a lot easier. It's not perfect. The worst glitch is the "coarseness" of the scroll bars. If you're browsing through, say, *The World Almanac*, you can use the on-screen scroll bars (maybe Apple will sue Microsoft for "look and feel"?) to jump through the text, but the smallest possible movement of the scroll-bar bullet corresponds to over 50 screens of text, which you have to page through one at a time if what you want is right in the middle of that 50-page clump. This defect is pretty serious, since the whole point of having Bookshelf is quick access to the included documents.

Bookshelf doesn't support all word processors. In particular, it won't quite work with Symantec's Q&A Write. I can access and use Bookshelf from within Q&A Write; Bookshelf can even look up misspelled words and find synonyms. What I can't do is paste the results into the text. When I try, the program tells me that the write function has been disabled. I presume that Bookshelf does this when it doesn't quite understand the word processor that you're using, but so far I've been unable to get anyone at either Microsoft or Symantec to admit knowing anything about it.

Bookshelf is a valuable addition to any writer's tool kit; as I've said before, I'm willing to bet that within a couple of years Bookshelf or something like it will be as ubiquitous among writers as word processors are now. It's valuable enough, in fact, that I'm seriously thinking of switching over to a word processor that can make good use of Bookshelf.

If I do switch, it will probably be to XyWrite III Plus. The Bookshelf manual says that it works fine with XyWrite III Plus, while every week I find that more of my colleagues have fallen in love with XyWrite. This word processor is rapidly becoming the default text editor on New York's Publishers Row, partly because it integrates with Atex so well, and partly because it's almost infinitely customizable.

Installing Bookshelf is theoretically simple: you log onto the CD-ROM drive and run Setup; everything you need is right there on the CD-ROM itself. In practice, it wasn't quite that easy. Setup ran all right, and it went in to modify my `CONFIG.SYS` and `AUTOEXEC.BAT` files; but when I then rebooted the system to invoke Bookshelf itself, I got the disturbing error message `Out Of Environment Space`. Looking up "environment" in Chris DeVoney's *Using PC DOS* produced words but not much enlightenment.

Environment, as it happens, is memory that DOS reserves to store things it needs to know; in particular, the path, the

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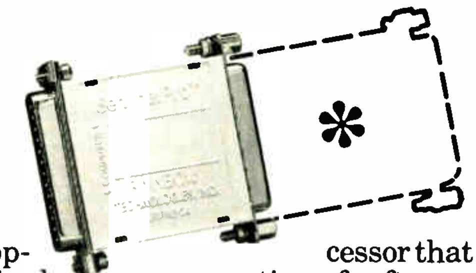

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names of various devices, and other strings it needs to look at fairly often. The default environment is 160 bytes; you can increase it (in 16-byte increments) by using the SHELL command. However, *Using PC DOS* also warns you that careless or improper use of SHELL can lock up your computer something awful, to the point where you may have to boot with the original system floppy disk.

Since I didn't really understand environment to begin with, and I sure didn't have time to recover from a locked-up system, I called Microsoft technical support. It took a few minutes to get the right people, but after that there was no problem. Microsoft really does understand DOS.

The line

```
SHELL = \COMMAND.COM/E:512/P
```

inserted into your CONFIG.SYS will increase environment space to 512 bytes. If you do invoke SHELL, *do not omit* the /P; if you do leave it out, have an unmodified floppy boot disk handy, because your machine is going to be dead in the water, and resetting won't do you a bit of good. Believe me.

Lost in Space

Once I got the CD-ROM drive properly installed and Microsoft Bookshelf running, it was time to look at other CD-ROM disks. In particular, I wanted a good look at the two disks of space data I got from the Jet Propulsion Laboratory. One of these disks features a number of images from the *Voyager* Uranus encounter; the other is a sampler of data and images from all over the solar system.

The software needed to display these disks is called IMDISP, and it's more ambitious than good. The documentation that comes with it is simultaneously tedious and dense. It took me an hour to figure out what was going on, and I still don't understand all the commands. Some of them seem to hang the machine.

Attempting to access many images gives the comment `Attempt to read past end of file`. Others tell me `Input file does not have a proper label` and ask me to specify the number of lines; in the example they give 370, but nowhere does it explain where that number came from or how you might figure out how many lines there are on each of the many images on the disk.

Even so, there's a lot to see on these disks. The images of the Jupiter Galilean moon Io are easily accessed and startlingly good. I make no doubt that careful reading of IMDISP's operations manual will eventually let me access nearly all the images on both disks. It will take work, but it should be worth the effort.

It's probably not worth buying a Laserdek just for the JPL disks; on the other hand, it's one more reason to have a Laserdek. Besides, it's pretty certain that there will be many other disks of scientific data.

One oddity: since EGA video doesn't have square pixels, the images are somewhat egg-shaped.

Pournelle's Insight

Last month, as I was listening to Dr. Joseph Dionne, chairman of McGraw-Hill, speak at the CD-ROM conference in Seattle, I was suddenly hit with some inspiration.

Dionne was speaking about CD-ROMs from a publisher's view. In the course of his speech, it became obvious that there's a far larger CD-ROM market than I ever thought of. McGraw-Hill makes and sells a lot of them and is about to market more. All are hideously expensive and generally sell to a rather narrow vertical business market; most contain topical information that's updated fairly often. The

continued

nearest thing to a horizontal market is the *McGraw-Hill Encyclopedia of Science & Technology*, which includes some 7300 articles plus the dictionaries of physical and life sciences.

Dionne wasn't the only speaker to make the point that, yes, there's a CD-ROM market out there, but at the moment it's vertical. Of course I knew that; I was reminded of the MicroMedix CD-ROM medical encyclopedia running on Mrs. Pournelle's system. (It came with its own CD-ROM reader, but it also runs fine on the Laserdek.)

What's happening with CD-ROMs is almost the reverse of what happened with microcomputers. In the early days of microcomputers, the market was dominated by hobbyists and small businesspeople; big business wanted nothing to do with little computers. Most of the early development was done by small start-up companies. The big boys didn't jump in until later.

The CD-ROM field is just the opposite. Big outfits like Phillips, Microsoft, and Amdek are developing the interface, while the CD-ROM disks tend to be published by giants like McGraw-Hill; and while most early microcomputer software was developed by BYTE readers who tried to appeal to a broad spectrum of users, most CD-ROM systems are being custom-designed for specialized users and priced accordingly.

After Dr. Dionne's speech I got to wondering why this should be, and I offer the following: microcomputers were and are a threat to centralized control of computing. MIS managers and directors of central computing are scared to death of them. CD-ROM technology, on the other hand, lends itself nicely to centralized control.

If I'm right, this time big business will pay to develop our toys. It will probably take a bit longer for that technology to spread widely, especially since the MIS types don't want it spread around, but the CD-ROM is just too useful to stay bottled up in central computing. The Library of the Month Club isn't here yet, but it's coming.

WORMs

The last thing I added to Zanna Lee was Information Storage's WORM drive with WORM-TOS. WORM disk cartridges are somewhat larger than CD-ROM disks and hold 200+ megabytes; each one costs about $60 just now, but I expect that price to fall dramatically.

The drive comes with its own controller. As an experiment I tried it in the short PC, the medium AT, and the long 32-bit slots; it worked in all of them. What I wanted, of course, was to be able to use the SCSI interface so that I could daisy chain the WORM drive to the Laserdek—I'm running out of slots in there!—but that won't work. Oh, well.

Hooking up the WORM drive is simple enough: drop the controller board into the machine; run a cable to the WORM drive, which is a heavy box about the size of a shoe box; and plug the drive in. Then you add stuff to your `CONFIG.SYS` file and reboot. It's all explained pretty well in the manuals.

If you're trying to run both the WORM drive and the Laserdek at the same time, you may have a problem. When I first booted up the whole system I kept getting errors, probably caused by conflicts in the port addresses. You can change the ports—the WORM controller needs eight in sequence—with DIP switches on the controller board. What I did was fool around with the switches until everything worked; I think I set the system so that the first port address is 200 hexadecimal, but I'm not sure. Whatever it is, it works fine now.

After you get the computer to acknowledge the WORM drive, you need to decide whether to partition your WORM disk cartridge into large sections—up to 128 megabytes—or to stay within the DOS 32-megabyte limits. It's simplest to use short segments, and being lazy, that's what I did. The decision isn't irrevocable; that is, it is not possible to change the 32-megabyte segment I already formatted, but according to the documents I can, if I like, install the proper software and set the next partition to be 100 megabytes. I suppose I'll have to try that sometime.

So far, all I've done with the WORM is test it. It certainly works. You use it just like any other drive, except that you want to be careful since you can't erase anything written. If you write two different files with the same name to the disk area, WORM-TOS keeps track of that, and there's software that lets you step back through the various versions of files with that name until you find the exact one you like; then you can read it or copy it. The default, of course, is the latest one.

I intend to get a lot of good out of my WORM: I have a lot of work on old CP/M 8-inch disks. The Golem can read those disks, and I can use CompuPro's ARC-NET PC system to transfer them over. I haven't yet tested the WORM drive's ability to work with the network, but I'm prepared for it not to; all I really need is to get those files onto Zanna Lee's hard disk drive. Then I'll move them to a WORM cartridge.

WORMs are great for archiving. I don't know how long WORM cartridges last, but they could be nearly eternal. To the best of my knowledge, none of them have gone bad from age alone. Of course, they haven't been around all that long, but they're certainly more durable than any floppies I've ever seen.

They're also great for backups. I'd rather have a WORM than a tape drive.

Now What Do I Do?

The major point of setting up Zanna Lee was to compare new 386 control software, particularly IGC's VM/386, with DESQview.

DESQview, as most of you probably know, is a control program that lets you keep a whole bunch of programs in memory and jump around among them. There are ways to let programs run simultaneously, although, except for communications programs, I don't find that nearly so useful as being able to go quickly from one program to another. I've used DESQview for about a year now, and I'd really hate to try getting along without it—unless, of course, I can find something better.

VM/386, on the other hand, is a program that lets you set up several *virtual machines* and jump back and forth among them. Each virtual machine thinks it is a single 640K-byte computer. Each can have a different `CONFIG.SYS`, and each can run a different `AUTOEXEC.BAT` on start-up. Each can be reset (with Ctrl-Alt-Del) independently of the others.

Each of these programs has strengths and weaknesses. VM/386, for instance, really creates independent virtual machines—and since your computer has only a limited number of peripheral devices, you'll have to assign and reassign them as you change from one virtual machine to the next. There's no housekeeping program to track that for you.

DESQview, on the other hand, lets you load certain things into memory prior to invoking DESQview, then use them in any window you have open. The system mouse, for instance, is recognized at all levels; in VM/386, the mouse is another device that has to be switched among

continued

Items Discussed

DESQview 2.0 ....$129.95
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica, CA 90405
(213) 392-9851
Inquiry 934.

EGA&Mouse $399
Logitech Inc.
6505 Kaiser Dr.
Fremont, CA 94555
(415) 795-8500
Inquiry 935.

Expert 87 ....$495
Magic7 Software
101 First St.
Suite 237
Los Altos, CA 94022
(415) 941-2616
Inquiry 936.

Lane Mastodon vs. the Blubber Men of Jupiter $12
Infocom
90 Sherman St.
Cambridge, MA 02140
(617) 876-4433
(800) 342-0236
Inquiry 937.

Laserdek $995
Amdek
1901 Zanker Rd.
San Jose, CA 95112
(408) 436-8570
Inquiry 938.

Math Aquarium $89.95
Seven Seas Software
P.O. Box 411
Port Townsend, WA 98368
(206) 385-1956
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.

Planetary Data System Space Science Sampler
NASA JPL
4800 Oak Grove Dr.
Pasadena, CA 91109
(818) 354-6347
Inquiry 941.

Public Domain Software CD-ROM $99
Alde Publishing
P.O. Box 35326
Minneapolis, MN 55435
(612) 835-5240
Inquiry 942.

Snoop II .... Price not available
TriDOS Software Publishers
4004 Barbur Blvd.
Portland, OR 97201
Inquiry 943.

SpeedStor $99
Storage Dimensions
981 University Ave.
Los Gatos, CA 95030
(408) 395-2688
Inquiry 944.

The Documentor $295
WallSoft Systems Inc.
233 Broadway
Suite 869
New York, NY 10279
(212) 406-7026
Inquiry 945.

VM/386 ....$245
IGC
4800 Great America Pkwy.
Suite 200
Santa Clara, CA 95054
(408) 986-8373
Inquiry 946.

WORM drive
internal mount $1888
external mount $2088
Information Storage Inc.
2768 Janitell Rd.
Colorado Springs, CO 80906
(303) 579-0460
Inquiry 947.

XyWrite III Plus $445
XyQuest Inc.
44 Manning Rd.
Billerica, MA 01821
(617) 671-0888
Inquiry 948.

Z-386
Model 40 .... $6499
Model 80 .... $7499
ZCM-1490 ....$999
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(800) 842-9000, extension 1
Inquiry 949.

windows, as well as set up in each.

VM/386 won't let you set up the WORM drive to be available to every window; if you want the WORM, it has to be installed in each virtual machine. This is also true for the CD-ROM device drivers. My preliminary experiments show that this works; that is, I can have Microsoft Bookshelf available in several virtual machines, but only if it's loaded into each on start-up.

VM/386 uses less system memory than DESQview; each virtual machine can be a true 640K-byte system. DESQview has enough system overhead that it's between hard and impossible to make a window leave more than 512K bytes available.

DESQview, on the other hand, has system utilities like MARK and TRANSFER (cut and paste; it doesn't always work, though). VM/386—at least the current version—has no such thing. If you want to transfer something from one place to another, you first have to grab it with a memory-resident program like SideKick, store it on disk, then change virtual machines and retrieve it. This is awkward.

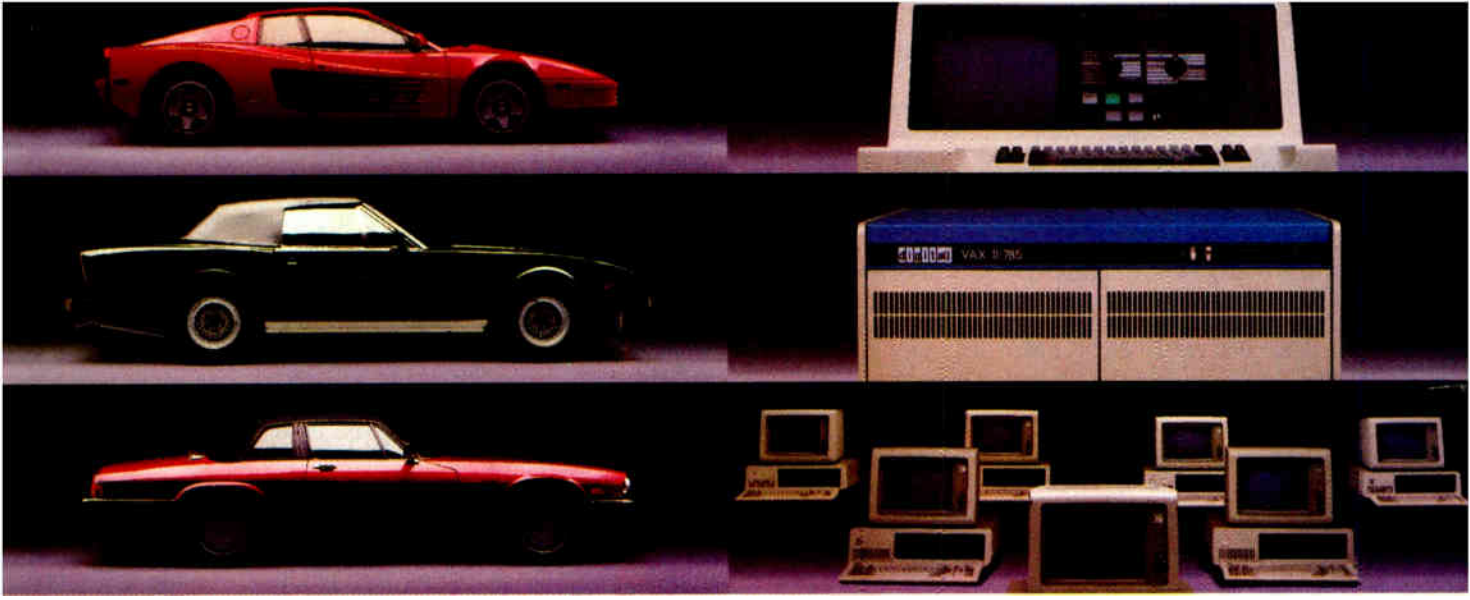
DESQview has some odd glitches. For example, sometimes I'll hit the Alt key to bring up the DESQview command window, tell it to open a file, select Crosstalk, and tell it to open Crosstalk. The machine trundles for a second, the Crosstalk logo appears on the screen—and then everything closes down so that I'm at the point where I was before I opened the DESQview command window in the first place!

The first few times this happened I was so upset that I quit DESQview and reset the computer, but it happened often enough that eventually I just did everything again exactly as before: invoke DESQview, tell it to open a file, select Crosstalk, open that. This time it worked fine, and examining the other windows showed that apparently none of them were harmed. This may be a harmless bug, but it's annoying. Maybe VM/386 won't do things like that, although it probably will.

I'd hoped to know a lot more about VM/386 by now, but it took longer to set up Zanna Lee than I'd thought; and once I was caught by deadlines, I had no choice but to go back to DESQview to get this written. With any luck, by next month I'll know more not only about VM/386, but also about Microsoft Windows/386.

I also have OS/2, but I don't think I want to do anything with it. OS/2 1.1 with Presentation Manager (i.e., OS/2 plus a bug-free Windows) may be interesting, but I think I can safely ignore the current version, at least until there's a lot

continued



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more software out there that can take advantage of it.

Comic Books?

I like Infocom games—I really do—so when I got the latest release from Infocom I was ready to try it despite the title: "Lane Mastodon vs. the Blubber Men of Jupiter."

What I had, I soon discovered, isn't a game at all. It's a kind of comic book with primitive animation. It is *not* an interactive story; there's only one action line, one ending, and nothing you can do will change the story at all. The gimmick is that you can read the comic book from the viewpoint of the hero, the villain, and subsidiary characters. The idea is to read along until you come to one of the (obvious) choice points, where you can jump off the track and follow some other character. You can also run the "projector" backward to a choice point and shift again.

From time to time, the action is interrupted to let you witness a comic book dialogue between two critics who have supposedly been watching this mess on a movie screen. For reasons best known to the designers, these rather unattractive male cartoon figures aren't wearing any clothes. They say a few meaningless things about the action so far, and the story continues. The breaks are clearly intended to make you go to the main character's story line from time to time, and they're needed, since hero Lane Mastodon is so dumb that only a twit would want to watch things from his point of view.

The artwork is pretty grim; it's certainly so compared to what real comic artists are doing now in Marvel Comics and the Watchman series. The story line might amuse cretin dwarves, though I doubt it; not only is the story implausible, but it knows that you know that. The notion is to invite you to share the joke. If you can do that, feel free; you might even enjoy this mess.

I watched this thing through to the end because I was interested in the technique, but you'd have to pay me money to get me to do it again. In my judgment, Infocom has come up with the answer to software piracy: a story so dumb that no one in their right mind would want to steal it.

Take It Apart

Disassembly of a program is the art of taking a finished program and turning it into source code that can be reassembled into the original. It's a black art even with good disassembler programs.

When I first got started with microcomputers, my mad friend Dan MacLean introduced me to a computer maniac we called "The Mad Disassembler." This chap worried excessively that somewhere out there was a program to which he didn't have source code. He worked in the computer department of a large aerospace company, and thus had some pretty powerful machinery at his disposal; and whenever he saw a new program, he'd take it apart with the company's mainframe. So far as I know, he never *did* anything with the source codes he generated. He just liked to have them.

If the original programmer had taken steps to make disassembly difficult, that merely added spice. One example is Michael Shrayer's Electric Pencil, which was a disassembler's nightmare. Shrayer had encrypted all the ASCII messages. He wrote meaningless code sequences and jumped around them. In places where a careful programmer had error traps, Shrayer had time bombs. And so forth. None of that mattered: within a week, "The Mad Disassembler" had a complete source code to Electric Pencil.

Back in those days, a lot of disassembler programs were distributed on bulletin boards.

I haven't noticed many disassemblers lately, so when I received Snoop II from TriDOS, it was like a voice from the past. Just for amusement I aimed Snoop II at a popular word-processing program. I was amazed at the results. Disassembly is still as much art as science, but Snoop II takes a lot of the sting out of it. Recommended for the insatiably curious.

Documentor

There are probably more people programming in dBASE II than in any other language. Every one of them needs The Documentor.

This program takes dBASE code and creates documentation for it. It generates a concordance and a cross-reference list. It comments code. It sets it up for pretty printing. The result is impressive. If you do any dBASE programming, you need this program. Highly recommended.

Winding Down

Once again I'm out of space, and I haven't got started good. One thing I simply *have* to talk about next time is the Amiga 2000, which can be a highly frustrating machine. The disk access is slow. It bombs far more often than it ought to. The PC part of it is plain vanilla, and because of the way Commodore chose to let the Amiga half-communicate with the PC, very few add-on PC boards will work. For all that, the Amiga 2000 has a prominent place here, because it's just plain *fun* (if frustrating).

If you do have an Amiga, be sure to get Math Aquarium, one of the most unusual programs I've ever seen: it turns equations into visual treats, providing both colorful and informal results. It isn't quite worth buying an Amiga just for this.

I also want to talk about Expert 87, which, despite its name, isn't an expert-system program at all, but rather a program to help make your preferences explicit and identify conflicts. It can also be used to generate consensus opinions from a group of experts. Used properly, this could be an extremely valuable program in both home and business.

The book of the month is by Archer Jones, *The Art of War in the Western World* (University of Illinois Press). This is a comprehensive military history with strong theoretical analyses, and quite the best work of its kind since Lynn Montross's *War Through the Ages*.

The computer book of the month is *Peter Norton's DOS Guide* (Brady). Norton's book isn't as encyclopedic as DeVoney's *Using PC DOS*, but for that very reason it's easier to read. Norton is very good at highlighting obscure but useful DOS features. Get DeVoney's book for reference, but read Norton's book to understand what's going on.

The game of the month remains Empire (from Interstel) for the Atari ST. I can't believe how much time I've spent on that game.

I'm writing this at tax time. I was going to use TurboTax on the IBM PC, but the new MacInTax package came yesterday, and I may as well get some use out of the Mac Plus, assuming that there is life after tax reform. Wish me luck. ■

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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Planning and Publishing

Ezra Shapiro

InstaPlan lowers the cost of project management; RagTime 2 falls short of greatness

There seems to be a lot of virus programs kicking around these days, nasty little scraps of code that know how to attach themselves to other programs and then reproduce like crazy. Last week, my Macintosh became infected with one of them. I still haven't figured out how it happened, but at this point it's immaterial. The little fellow seemed relatively benign; all it did was copy itself into my system file—and every application I used thereafter.

Fortunately, someone on BIX quickly posted a description of the virus and a cogent treatise on removing it. I followed the instructions to the letter and had a clean system within several hours, but the narrowness of my escape left me shaken.

A couple of years ago, I inadvertently launched a program that left a time bomb implanted in my MS-DOS computer. It slowly and imperceptibly chewed away at my file allocation table, eventually trashing the directory for 30 megabytes' worth of hard disk. In contrast, this Mac virus was sweetness and light; at least it didn't do anything destructive. It had a silly "look what I can do" bravado about it, rather than the sheer hostility of the earlier IBM PC program.

My first reaction was a deep sense of relief at getting away from the virus unscathed. After a few minutes, though, the relief gave way to anger and outrage. My hard disk is a very personal place; my privacy had been violated.

Sad to say, I believe there's going to be a lot more of this kind of thing. As computer ownership spreads in our society, the population of computer users is going to become more and more like the general population of which it's a subset. What this means, unhappily, is that we can expect to see all the ills of our civilization reflected in events in the microcomputer world.

Our one faint hope in this dark time is that the act of launching a destructive virus program will turn out to be a rare event rather than a commonplace one. If it goes the other way—and launching a virus becomes the equivalent of scrawling graffiti on a wall —it's going to be tough out there.

I'm already being very careful about which electronic bulletin boards and online services I use as a source of software downloads; I won't touch a program that hasn't been thoroughly checked by a competent sysop. I've "inoculated" both my Tandon IBM PC AT clone and Mac SE with antiviral software, though experience suggests that these viruses will quickly mutate to overcome these feeble countermeasures. Right now, I'm hoping that widespread paranoia about viruses won't kill off alternate distribution schemes, or we'll witness the death of shareware.

What can be done about this plague? Not a whole lot, at least not directly. We can try to broadcast the notion that writing and distributing infectious or destructive programs is simply not cool and thereby discourage the casual prankster. But we won't be able to control vandalism in software until we can control it on the streets.

Prodigious Planner

It's time to haul out the superlatives for InstaPlan (InstaPlan, $99), the first MS-DOS project management package I've seen that I might actually consider using. It's well designed, complete, fast, powerful, and inexpensive. What more could you want?

I ought to interrupt this flow of praise to point out that I usually find project management software to be the most irritating stuff that crosses my desk. I've got a number of reasons. First, the discipline of project management itself is grounded in obscure jargon; most of the software follows that lead and is incomprehensible to anyone without an advanced degree in obfuscation. Second, the accompanying manuals (like most computer documentation) provide good information on *how* to use the software but little advice on *why* or *when*; unless you know what to do beforehand, you're lost.

Third, I can't shake the suspicion that most managers have little use for Gantt charts, PERT, and critical path analysis; scribbled notes and flowcharts seem adequate for all but the most enormous projects. It's one of those cases where computerizing the task often takes more time than simply doing it. And finally, this is an expensive category; project management packages start at $300 or so and continue up the scale to between $1000 and $2000. That's quite a bit higher than most other software aimed at the average businessperson.

For me, the most important point in InstaPlan's favor is its price. At $99, it's the lowest-priced full-featured product in its category. The price is reasonable enough to let you buy it on a whim, to see if you like or need project tracking software in your daily routines. Since project management is an arcane art, nearly impossible to learn quickly without a good software package, it makes a lot more sense to start out with InstaPlan than with one of its competitors at quintuple the price.

If you discover that project management is over your head and something you'll never need, you can throw InstaPlan out the window without feeling too much guilt. On the other hand, InstaPlan has so much going for it that it might inspire you to adopt its approach to planning and implementing all sorts of projects, from medium-size to gigantic.

But price isn't the only consideration. InstaPlan offers great flexibility and an initial planning approach that beats anything else I've seen. Like all project man-

continued

Items Discussed

InstaPlan $99
InstaPlan Corp.
655 Redwood Hwy.
Suite 311R
Mill Valley, CA 94941
(415) 389-1414
(800) 852-7526 for orders
Inquiry 950.

RagTime 2 .... $295
Orange Micro Inc.
1400 North Lakeview Ave.
Anaheim, CA 92807
(714) 779-2772
Inquiry 951.

agement packages, InstaPlan lets you track tasks over the course of time, allocate both human and material resources, keep a running total of costs, and prepare elaborate breakdowns and reports.

To get you started, though, InstaPlan lets you type in your notes as if you were using an outline processor. In operation, it's similar to jotting down a quick list with Ready! or ThinkTank. You enter tasks and subtasks in an indented outline, and you can reorganize them by selecting and moving them around with the cursor keys. The program also lets you enter time estimates at this point.

Once you're done, you can hit a keystroke or two and open up an expanded view of your project—a Gantt chart (bar graphs over time), a PERT view (linked boxes that help you visualize interdependencies), a spreadsheet view (for determining resource costs and manipulating data), and so on. You can jump between views to do your patching, pruning, and refining where it makes the most sense.

You can use InstaPlan to track up to 600 activities, and you can revise your plan during the course of your project if factors change. Data can be exported and imported in both Lotus 1-2-3 and dBASE formats, so you can perform industrial-strength analyses of cost data.

The developers of InstaPlan point out that the program is particularly effective for the early stages of project planning, when you're meeting with others and playing what-if with the variables. However, from what I've seen of competing software, InstaPlan's tracking ability and report generation rank right up there with the best, from the beginning all the way through to the successful conclusion of any project.

Documentation is thorough and clearly written, which I demand for any subject as convoluted as project management. Within a few minutes, I'd mastered the difference between Gantt and PERT and was arriving at an understanding of InstaPlan's Gantt Variance View. It was all falling into place rapidly. Hats off to the author.

InstaPlan is an excellent piece of software, quite capable of holding its own against all but the most expensive project management products. I'm hesitant to compare it directly to the over-$1000 members of this fraternity, which are aimed at *serious* managers with *big* problems, but I'd bet that it could be used in many situations as a low-price substitute without any loss of functionality.

InstaPlan is a good deal for anyone who merely wants to experiment, but it also has the strengths to satisfy those with professional requirements.

Highly recommended.

RagTime Repeat

About a year and a half ago, I wrote about a Macintosh desktop publishing package called RagTime. It was an odd blend of layout program, word processor, and spreadsheet. Though I found it easy to use, I was annoyed at the lack of business graphics, which struck me as essential in a product aimed at this market niche. I also found both the word-processing and layout elements of the program to be inferior to stand-alone products.

But there was still something charming about RagTime; it was appealing, though I wasn't quite sure why. So I railed about its shortcomings, hoping my diatribes would reach the ears of RagTime's manufacturers.

Time has passed, and I'm now poking at RagTime 2 (Orange Micro, $295), the latest version of the package. Unfortunately, it still falls just short of greatness; it's an attractive product that doesn't quite have the horsepower to take it to the top of the heap. I find this even more frustrating than a program that's simply rotten; I want to grab the programmers and shake them until they make this program live up to its potential.

Since that isn't going to happen, I suspect RagTime will quietly vanish sometime down the road when the inevitable desktop publishing shakeout occurs. In the meantime, though, if the product's unique collection of features speaks to you, I recommend it. RagTime is an acceptable desktop publishing tool for anyone who needs to manipulate both text and small spreadsheet grids.

The basic look of the program is somewhat reminiscent of Ready-Set-Go. You

continued

you see here.

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- A wide range of expansion options
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Now here's what you *don't* get: a spelling checker, dictionary-based hyphenation, business graphics based on the spreadsheets you've built in RagTime, adjustable guidelines, and style sheets.

RagTime has a pretty solid list of features, even allowing for the few omissions, and the program works well. If you're interested in self-calculating forms, RagTime is not as spectacular as Trapeze, the forthcoming Wingz, or the upcoming revision of Excel, but it gets simple jobs done with less hassle than any of the flashier products.

However, desktop publishing software from other manufacturers is not standing still; it's getting better faster than RagTime is. This year will see new versions of PageMaker, Ready-Set-Go, and Quark XPress, all of which will probably outfeature RagTime. They won't have the built-in spreadsheet, of course, and they'll be more expensive, but RagTime will not look great in comparison.

But I have to say that I do like the product. I just don't want you to go out and buy it, then accuse me of glossing over its deficiencies. Take that as a midlevel recommendation with a grain of salt. ■

Ezra Shapiro is a consulting editor for BYTE. You can 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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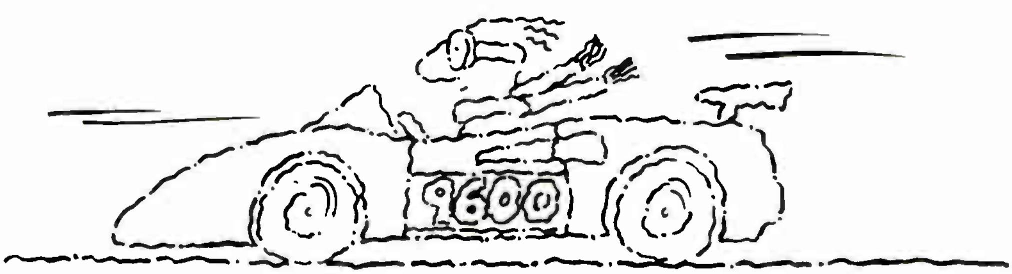

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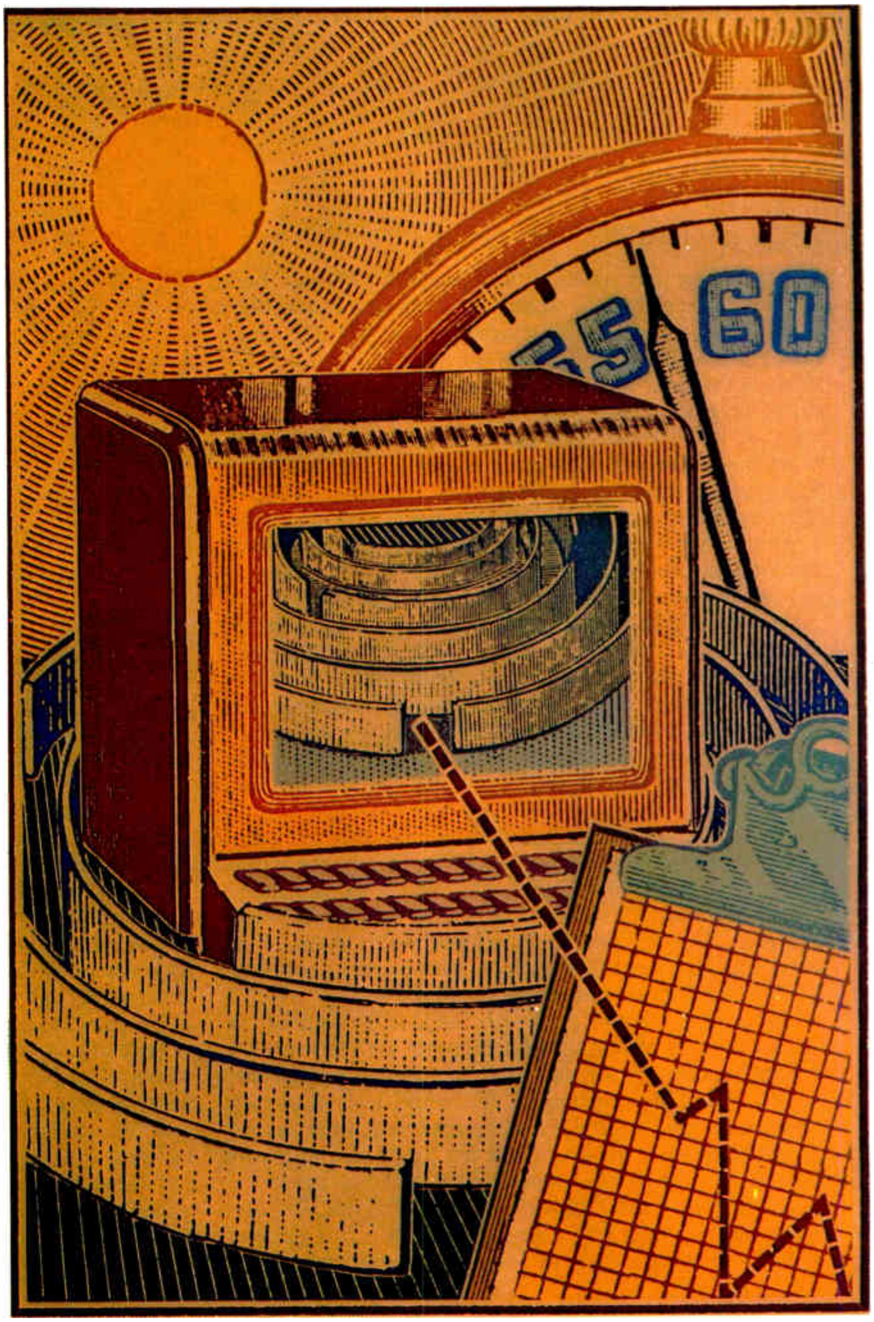
Benchmarks



Introduction

Benchmarks

For the past six months, the lights at BYTE have been blazing at all hours—weekdays, weekends, and holidays alike. What generated this flurry of activity? The short answer is "benchmarks."

No, not running them. We've been designing, coding, and testing an entirely new suite of BYTE benchmarks. Along the way, we've overhauled the Small-C language to work with today's state-of-the-art microprocessors. We're making both our benchmark code and the new versions of Small-C freely available on disk, via BYTEnet and BIX, and in print.

Why did we do all this? Because we'd realized for some time that our old benchmarks—like most benchmarks currently in use—were tired, worn, and in need of replacement. Some were originally developed for old-style, narrow-bandwidth machines. Others, including some established standards, really didn't do a very good job of testing what they purported to test. In one way or another, almost all had aspects we believed we could improve—that we *had* to improve—if we were to continue our tradition of providing the kind of reliable, meaningful results that you demand and deserve.

In this issue, we present the first of our new tests in "Introducing the New BYTE Benchmarks," written by the BYTE editors who have come to know the subject so intimately: Richard Grehan, Tom Thompson, Curtis Franklin Jr., and George A. Stewart. In coming months, we'll be expanding on the foundation established here. We welcome your comments, compliments, and constructive criticism.

Also in this month's In Depth section, we look at the whole subject of benchmarking. We begin with an overview of what benchmarks are and what they should be in "That 'B' Word!" by Bill Nicholls. This article deals with such questions as why we write benchmarks, what they're for, and what they tell us—and don't tell us. It also discusses some of the more familiar benchmarks in our industry.

In "Problems and Pitfalls," Alfred A. Aburto Jr. discusses what's wrong with many benchmarks, what kinds of mistakes we're apt to make in writing them, and how we tend to misinterpret—or overinterpret—benchmark results. His article also details some of the problems found in many of today's popular benchmarks.

Finally, Ron Fox presents "Why MIPS Are Meaningless," an article that discusses micro benchmarks—those that test the various parts of a system rather than the system as a whole. Ron also presents a series of his own micro benchmarks that you can use to test some of the components in your own system.

Benchmarks—you can't live with them, and you can't live without them. They are infinitely tedious to design and code, because there seems to be an infinite number of variables within them. But they are also the best method we have so far for comparing one system—or component or software package—to another. Well-designed benchmarks provide an objective evaluation of competitive products and thus give us the information with which to make informed choices.

—*Jane Morrill Tazelaar*

Illustration by Robert Tinney © 1988

That "B" Word!

What it is, where it's going, and why we subject ourselves to it

Bill Nicholls

BENCHMARKS. SAY THAT word in some circles and you might be swearing. It drags up memories of nights spent writing benchmark programs, modifying them, testing them, and testing them some more, only to find that you're not testing what you thought you were, the compiler has optimized your code out of existence, or you're comparing the proverbial apples and oranges.

A benchmark is simply a standard for judging the performance of various computers. But what gives the "B" word emphasis is that there's no official standard for benchmarks, and, to make matters worse, computer technology isn't exactly holding still.

Given that the task is difficult and ever-changing, why do we try to do it? First, without benchmarks, we have no basis for preferring one computer over another except price. And second, given any architecture, benchmarks provide feedback on how well it performs, thus providing information for those designing new architectures.

Benchmarks measure performance, a complex issue, and yet they supply only a simple number as a result. Unless a benchmark clearly identifies what it's testing (i.e., a single component or the whole system), these simple numbers can be the seeds of misinformation.

One such seed is MIPS, or millions of instructions per second. With no standard set of instructions and no standard MIPS benchmark, you can't compare MIPS *across* different CPU architectures with any hope of accuracy; sometimes, you can't even compare them accurately *within* a single line of machines. MIPS has become "meaningless information on performance for salesmen."

Regardless of the difficulties, however, we need benchmarks—both general-purpose and specific—that don't become worthless as technology changes.

What Makes a Good Benchmark?

A good benchmark has four general requirements. First, it must be meaningful. The benchmark must test a factor that is relevant to the user. Second, the benchmark must be accurate. Results should contain a measure of the accuracy achieved, and that measure should be reported as part of the results. Third, the test should be repeatable. The variance in results (called *noise*) should also be reported. Fourth, the benchmark should be able to discriminate between systems that are really different and report similar results for similar systems.

A meaningful benchmark is a test that measures something relevant to our purposes. The trick, of course, is to ask the right questions. Given the output from a good benchmark (e.g., a table of benchmark data based on running the same program with the same level of compiler optimization), you can do a valid comparison of the results between systems.

You can divide benchmarks into two categories: microscopic, looking at the components of a system in detail, and macroscopic, looking at the system as a whole. You must be careful, however, not to interpret the results of microscopic tests as having meaning at the macroscopic level.

Micro benchmarks are useful for finding the maximum capability of a component within a system. They are helpful in system design and in estimating maximum performance possible for an application under development. Hardware comparisons made with the same executable code can be quite valid for the test performed. And since different compilers for the same language, or even different languages, can compile the same test for a given machine, we can develop tables of software comparisons as well. For a further discussion of micro benchmarks, see "Why MIPS Are Meaningless" by Ron Fox on page 225.

Real applications are valuable as system benchmarks, as long as the work you choose is representative of what you're trying to test. Recently, it has become possible to find applications that are supported across a wide range of configurations and, in a few cases, across systems; these benchmarks are becoming more and more meaningful as the end user performs more complex work.

Designing a benchmark test is a lot more difficult than it appears. Most people start by running benchmarks, then decide what they want to accomplish. The correct approach is to decide what you need to establish, choose appropriate benchmarks, run them, look at the significance of the results, and, finally, decide whether the differences are significant.

Choosing the appropriate benchmark requires some understanding of each benchmark process and its relative accuracy. You need to separate those bench-

continued

marks that test components from those that test systems, and try not to compare the results of those two different categories of tests. And you need run only those tests that reflect the environment and work you intend to perform. If you add benchmarks beyond this, you increase work and confuse the issue by adding results not relevant to your objective.

Having run a suite of benchmarks, how do you determine what they mean? There is no simple answer to this because it depends on your objectives. If you are evaluating processors for pure performance and use an appropriate benchmark, a significant difference between results makes a decision fairly easy.

What makes a difference significant is the issue of repeatability. If you run the same test 10 times, are all the answers within 1 percent of each other? Within 10 percent? If you know that noise number, you can conclude that differences between systems less than the noise amount are insignificant; a benchmark that shows differences between systems less than the noise amount can't be used to differentiate between them.

Studying the Classics

Several benchmarks have been around long enough to be considered classics. Whetstone, one of the oldest, was designed to be representative of typical scientific programs. It was based on the analysis of 949 ALGOL 60 programs. Whetstone was originally considered quite good, but recent analysis has shown that it's vulnerable to modern optimizing compilers.

The best general-purpose test developed thus far is Dhrystone (named as a pun on Whetstone). Despite sensitivity to some kinds of optimization, it's a good effort and a useful performance test. Revisions are under development to address known weaknesses; the current version (1.1) has some flaws that are being addressed in version 2.0.

The Sieve, another classic, generates a small set of primes using an algorithm that does a minimal amount of calculation. In addition, the run is quite small, and some modern compilers recognize the algorithm and perform special optimizations on it. While it purports to test computational performance, it primarily tests integer operation and indexing. This and other familiar benchmark tests are discussed in "Problems and Pitfalls" by Alfred A. Aburto Jr. on page 217.

The SI (Norton's System Indicator) is an example of a benchmark built without remaining independent of architectural differences within a single family of chips. Originally intended to point out the differences between various 8088 speeds, the SI gives misleading results when used to compare different generations, such as 8088 versus 80286.

Why We Need New Ones

In the past, BYTE's benchmarks have been flawed, as in their continued use of unrealistic I/O tests like Format and Copy. The standard tests didn't cover a wide enough range, and some of the tests had very little discriminatory power. A second problem was the limited set of comparisons in any one article. A full set of comparisons over a range of benchmarks would have been helpful. The new set of benchmarks described in "Introducing the New BYTE Benchmarks" on page 239 resolves many previous problems and shortcomings.

PC Labs' benchmarks also contain basic weaknesses. Some of the tests lack discrimination. The test results for different products are so close that any significant differences are lost in the noise. Another problem is the use of subjective quality judgments without providing a scale for the basis of judging. Printer-quality output is a prime example of this problem. A third problem is the use of multiple testing personnel, adding another subjective element to the results.

PC Tech Journal has compiled detailed component benchmarks and pseudo-real-world tests. While accuracy in the component tests has been a prime concern, some of the tests have minimal discriminatory power, and the results are often difficult to read. However, the basic data is good. The real-world tests typically are limited in value because of the small size of the environments tested, making extrapolation to larger environments with different structures risky. One example of this is the database benchmark series.

The *Software Digest* benchmarks are a different class of tests than most of the others. Most of them are subjective, but a major effort has been made to limit this subjectivity by averaging test results over a number of cases to smooth any single observation. The overall score generally reflects the product's measurement. However, the basic tests are judgmental in nature, and the standards used may not reflect what you consider important. This remains a problem despite the detailed reporting of the component results.

The Art of Benchmarking

Benchmarking is not just science or engineering; it is an art. While parts of the process have been reduced to engineering techniques, the task as a whole remains very much an application of the human art of judgment. "Good judgment comes from experience. Experience comes from bad judgment." This homily is the key to progress in benchmarking. Until you've had hands-on experience benchmarking a number of systems, the results of your effort are liable to be unpredictable.

The earliest benchmarks, such as the Sieve, tested the CPU and memory. It appeared to be easy to test the CPU, and that was central to an understanding of performance. But both the Sieve and our understanding of performance have undergone substantial evolution since then. Further problems have arisen as tests for one generation of equipment were rerun on a later generation; for example, some tests designed for the IBM PC were later used for an 80386 system.

To date, benchmark testing of I/O has been limited, and much of what we've done is too simple. The typical I/O benchmark failed to test random access and such items as repeated access to directories and file access tables. One exception to this is the Coretest hard disk benchmark for the IBM PC AT and compatibles, which tests both random access and transfer rates.

Graphics is another area of limited testing. With the exception of component tests of the EGA by *PC Tech Journal* and some performance tests by BYTE, little has been done. The main problem in benchmarking graphics and video is the extreme sensitivity of the results to hardware configuration and the quality of the code. Another whole class of problems arises when you try to figure out *what* to test (see references 1 and 2).

Although benchmarking components (i.e., micro benchmarks) may be the most popular test, how the *system* runs when you use it for practical work is the most important. Except for the Whetstone, this important fact did not get much attention until recently. Using popular applications as benchmarks is bringing some interesting facts to light, such as the sensitivity of an AT or 80386 system, especially a multiuser system, to the performance of the disk subsystem. In many cases, this performance is more important than CPU performance and has led to a demand for faster disk subsystems.

An effort is under way at the IEEE to develop benchmarking standards. It has been delayed by the lack of anyone to head the volunteer effort. When a set of IEEE standards can be developed, they will be of great value in reducing the current chaos in the area of benchmarking.

On the Hard Side

Identifying the problems involved in benchmarking is an ongoing process. The more we learn, the more problems we find. The basic dilemma is the number of variables. Even in simple cases,

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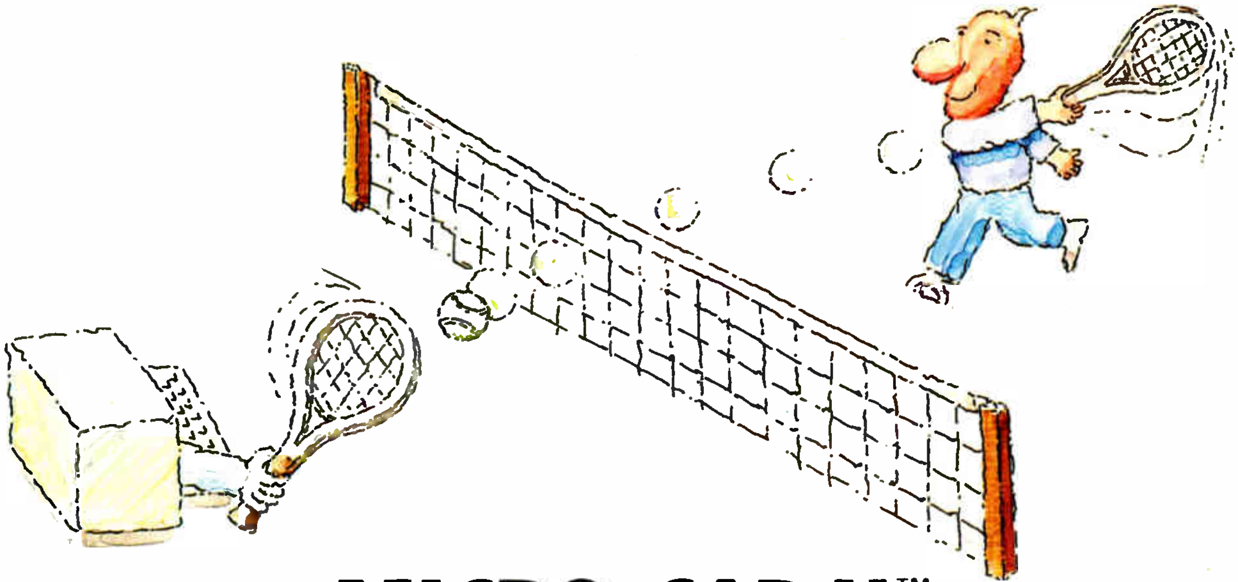

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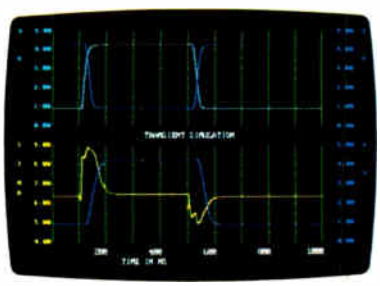

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you have the processor, the auxiliary processors, the memory speed and interface, the I/O bus, and all the I/O devices and their interactions. Worse, it's not at all clear which variables are important or how they interact. In addition, many are not under your control, or not easily changed if they are.

Small hardware differences often cause problems. For example, the IBM PC AT has a slow interface to the 80287 chip. Note that the 80287 runs at a slower clock speed, but its interface to the 80286 was chosen for simplicity, which also limits its performance (see reference 3). In this case, many of the clone makers have built a faster interface without losing compatibility.

Cache is another variable that affects the benchmarking task. Currently, there are software caches to improve the effective speed of the hard disks and hardware caches to speed up or eliminate memory access for instructions and data. Adding cache to the benchmarking environment complicates the testing because of various cache algorithms, different cache sizes, and nonlinear cache effects. Thus, a cache adds two or more dimensions to an already complex benchmarking process. Current benchmarks simply avoid cache testing where possible.

Hardware cache comes in two main varieties: external and on-chip. External cache sits between the main memory and the CPU and comes in a variety of sizes and implementations. Its purpose is to reduce the delay between the memory request and the time data available at the processor. Its performance depends on the programs running, the operating system, the workload, and the specific size and implementation of the cache itself.

On-chip cache, as in the Motorola 68020, is a newer element. It is for instructions only and is very small, but it totally eliminates memory-access delays for small loops and can generate large performance differences.

On the Soft Side

Along with the hardware complications are a few from the software side as well. One is compiler optimization. In the early days, compilers simply generated object code for a given source, and you were happy if it worked. Compilers are now "smarter," so the code will run faster. This has been a real disaster for the early benchmarks, as many of them were trivial tests done numerous times. The smart compilers simply eliminate meaningless operations, reducing some benchmarks to almost no operations and rendering the results meaningless.

Another problem arises when benchmarks use different compilers without reporting that fact and thus introduce varying amounts of error into the results. When this occurs, the results cannot be validly compared with other systems.

The software disk cache is another problem area. It can be disabled in most operating systems except Unix. Since the cache is not usually built in, eliminating it at start-up is easy for the purpose of benchmarking. However, Unix (and probably future systems) will have built-in cache, and since systems typically run faster with it than without it, they'll have to be tested with software disk cache.

Multitasking software adds another level of complexity that minicomputers and mainframes have faced for years. Measuring the performance of one task while others are running becomes a statistical exercise at best, a waste of time at worst. This area will get more attention as microcomputer multitasking becomes more common. New benchmarks in this area will need a wider set of environmental settings for comparison purposes.

continued

Even without multitasking, changing operating systems can change your results. The differences can be caused by overhead variations between the operating systems or by different facilities and compilers. Typically, changing the operating system per se doesn't produce a major effect, but the variation in facilities, compilers, and concurrent tasks complicates the measurements.

Tomorrow and Tomorrow

We can now see the directions of tomorrow's benchmarks: improving the current ones and using both synthetic and real applications. Third-generation development has begun already with Dhrystone 2.0, Calcpi, search, and memory-access routines.

At this time, there still are fixed system benchmarks. That is, the benchmark designer fixes the steps and operations involved, and the user isn't allowed to change them. In the future, we'll see synthetic benchmarks, or benchmark shells, that contain a large number of basic operations typical of applications code. Users can then develop scripts that reflect their current or future applications and run those scripts on several machines.

The future will also bring more real applications used as benchmark tests. This is perfect if you are using that specific application, and also useful if you are using that category of application. The reason for this change is simple. As systems become more complex, the work involved in generating and validating a new system benchmark increases. At some point, the work involved in creating the new benchmark exceeds the value that you can get out of it, and real applications test the system sufficiently.

The years ahead will see significant improvement in benchmarking capability as these trends bear fruit. The limiting factor, as it has always been, is the understanding and care of the person using the benchmarking process. ■

Editor's note: *For BIX references and selected readings, see graphic.disp/bibliography on BIX.*

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Bill Nicholls is an author and a computer consultant with BGW Systems Inc. in Puyallup, Washington.

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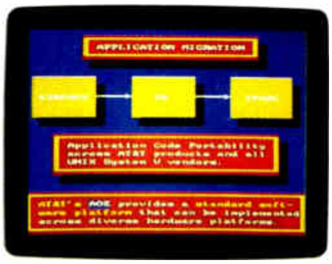

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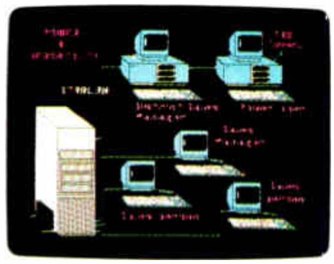

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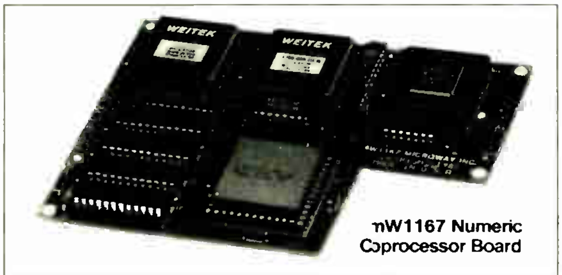

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Problems and Pitfalls

What's wrong with the old benchmark programs?

Alfred A. Aburto Jr.

FROM TIME TO TIME, even benchmarks need a checkup. It's time to review the state of their health when the mere mention of benchmarks sparks debate and controversy. And it's time for treatment when we find anomalies in the data or contradictory results between one independent series of tests and another.

The trouble with benchmark results doesn't always lie in the programs; it often lies in the test methods and procedures used or with how the results are reported. And often it appears that the tests haven't taken into account all the variables that can significantly affect performance.

It's easy to make errors in conducting benchmark tests and unknowingly report erroneous, misleading, or contradictory results. Despite the problems and the controversy, however, developers and evaluators of computer hardware, software, and systems continue to use benchmark programs to demonstrate product improvements. And the rest of us run them, or read them, to help us decide which products to buy.

Getting All Your Ducks in a Row

The lack of controlled and appropriate test methods and procedures causes many of the problems with benchmarks. For example, if we wish to compare the performances of processor A and processor B using C language compilers, then we must ensure that the C compilers used generate the best code for each CPU. If we fail to account for all the differences in code-generating efficiency between C compilers, our results may be controversial and unreliable, relative to our original objective. Poor-quality software can easily mask the native processing power of an otherwise capable CPU.

Another example: We know that disk-buffer size can greatly affect the performance of disk I/O, but we rarely see the buffer size taken into account, analyzed, or even mentioned in many of the typical disk I/O or spreadsheet tests. We simply can't leave unknown or hidden variables floating around in our tests.

Rick Richardson's excellent summaries of Dhrystone 1.1 results (Usenet, comp.arch, September 20, 1987) contain many examples that illustrate the variations in benchmark performance on the same CPU at similar clock speeds. For example, the 80386 results at 16 MHz and 20 MHz showed performance results ranging from 1724 to 9436 Dhrystones per second. Certainly, this variation of 5.5 in performance isn't due to the CPU type, which was an 80386 in each case, or to the clock speed, which changed by only a factor of 1.25. Therefore, it must be due to other factors, such as the type of C compiler, compiler and linker options, global code optimizer, cache memory, number of memory wait states, and so on.

These results illustrate how important it is to keep track of *all* the variables that might significantly affect the outcome of a benchmark test. If you don't, then you can't expect to make "apples-to-apples" comparisons of system performance.

Optimized or Obliterated?

Optimizing compilers can significantly affect a poorly designed benchmark program. They can eliminate subroutine-call overhead delays by in-line-coding the subroutines, remove loop-invariant code, automatically assign register variables, eliminate common subexpressions, and perform other operations that destroy the intent and usefulness of the benchmark. The trouble isn't that compilers optimize code; it's that many benchmarks are highly susceptible to optimization.

Dhrystone 1.1, Whetstone, Float, Loops, QuickSort, and Savage can all be optimized to varying degrees. For example, a compiler can significantly improve the Whetstone's performance by in-line-coding its three tiny subroutines, but that ruins one of the Whetstone's primary features: measuring procedure-call efficiency. Also, if the subroutines are in-line-coded, the Whetstones-per-second performance output becomes misleading and invalid. The performance isn't improved because the system executed floating-point operations any faster, but because the optimizing compiler removed hundreds, or even thousands, of processor instructions from the code.

In addition, some versions of the FORTRAN and C Whetstone programs contain loop-invariant code, which an optimizing compiler may completely remove. It may also delete floating-point instructions—perhaps millions of them, depending on the loop count—resulting in an invalid and misleading Whetstone-per-second output. Other benchmarks suffer a similar fate.

In Dhrystone 1.1 in C, optimizing compilers can remove useless code and

continued

in-line-code and optimize the string-copy and compare routines, improving performance by as much as factor of 2. It's wonderful that optimizing compilers can improve performance in these ways; however, the results of the Dhrystone are no longer valid.

In the Float program, an optimizing compiler can remove all floating-point instructions, resulting in an empty shell. It can also obliterate the Loops program, resulting in a meaningless benchmark that takes no time at all to run. The compiler can in-line-code the QuickSort subroutine and automatically place its variables in registers, resulting in ambiguous performance comparisons. It can reduce Savage to a simple loop, a = a + 1.0, producing a trivial program that no longer computes the transcendental and trigonometric functions originally intended.

The benchmarks that are susceptible to these compiler problems need to be redesigned to prevent optimizers from invalidating their measures of performance or distorting and confusing performance comparisons. Dhrystone 2.0 is intended to achieve this goal. However, there doesn't seem to be much hope for the Whetstone, Float, or Loops programs. Such benchmarks as the Sieve, Fibonacci, and Fbench seem to be mostly—but not totally—immune from high degrees of optimization.

Sifting through the Sieve

Jim Gilbreath originally proposed the Sieve of Eratosthenes as a benchmark for computer systems in 1981 (see reference 1). It has since become a classic, frequently quoted in the literature and used by developers to demonstrate compiler and system improvements. Results exist for hundreds of different computers and numerous flavors and versions of compilers. It is unfortunate, however, that no single database of results has been maintained to provide a historical perspective on Sieve performance, although Gilbreath's early work (see references 1 and 2) did contain hundreds of results.

The Sieve won wide acceptance primarily because it was simple; it was easily coded in many different computer languages, and it computed something useful that was recognizable and verifiable: prime numbers. These are strong points in favor of the Sieve, because, in general, those benchmark programs that do nothing useful or verifiable are the ones most susceptible to compiler optimization (e.g., Loops, Float, and Dhrystone 1.1). The Sieve speed at generating prime numbers tells us something about the efficiency of the total system—compiler plus hardware. Performance improvements reflected in the Sieve will also be reflected in other applications that do similar types of operations.

The Sieve was intended to measure system efficiency, or capability, with respect to memory references, simple structured control statements, and integer operations. Gilbreath stated that the Sieve was not the only criterion by which to judge a language or a compiler. Other tests or considerations are necessary for a more complete picture of system performance. Exactly *what* additional tests you should conduct is an open question. Exactly how you combine and "weight" the different test results is also open to discussion.

Problems and anomalies can arise in comparing the Sieve performances of different systems. One problem with the C version of the Sieve program (see reference 3) is that an optimizing compiler could eliminate the outer `iter` loop because it performs no useful computational task. You can remove it without altering any computations or outputs except the run time. The intent of the outer loop is to increase the run time to make the time measurement easier and more accurate, but optimizing compilers work to make programs more efficient, or faster, by removing such unnecessary or wasted code.

Another problem with the C Sieve is the `int` definition of the variables. Some compilers define `int` variables as 16-bit signed numbers, while others set them up as 32-bit signed numbers. Because of this ambiguity, it would have been more appropriate to specifically define these variables as `short`, `unsigned short`, `long`, or `ulong`, as the type of variable used can make a difference in the Sieve results.

Table 1 contains some examples of this confusion. The Manx Aztec C compiler defines `int` variables as 16-bit (`short`), whereas the Lattice C compiler defines `int` variables as 32-bit (`long`). Using the `int` definition, Aztec C runs the Sieve faster than Lattice C. However, if you change Sieve's `int` definition to `short` so that they both use the same size numbers, then Lattice C runs the Sieve slightly faster.

In other words, if you compare the two compilers on an equal footing with respect to 16-bit variables, then there's only a slight difference in performance. However, if you change the `int` definition to `long`, then Aztec C may or may not run the Sieve faster, depending on whether it is linked with 16-bit or 32-bit standard C libraries.

To make a fair and equal comparison, you should run the Sieve with either the `short` (16-bit) or the `long` (32-bit) and avoid the more ambiguous `int` type. Usually `short` will be 16 bits and `long` 32 bits, but even these definitions are machine-specific.

More Chaff for the Sieve

Another problem came to light with the Sieve benchmark results published in the September 1987 BYTE (see reference 4). Table 2 contains those Sieve results and some others. All the systems ran the same Sieve source code, all used C compilers, and all contained 68020 CPUs with 32-bit memory at very similar clock speeds, yet there was a factor of 3.4 maximum variation in performance. The outstanding performer was Definicon Systems' DSI-780 with the Silicon Valley Software (SVS) C 2.0 compiler.

Trevor Marshall, then of Definicon, explained that these results were due to SVS C's automatic use of register variables (variables whose "home" is a designated CPU or FPU register instead of RAM). That is, while the source code says `int`, the SVS C compiler actually generates `register int` variables. This is a form of code optimization. The Sun Microsystems C compiler also generates `register int` variables, but only when you set the -O optimize flag during compilation. Other compilers, such as Amiga Lattice C and Aztec C, can also work with `register int`, but the variables

continued

Table 1: *Sieve performance variations for an Amiga with a 14.32-MHz 68020 and 32-bit memory (100 iterations). Note the difference the variable type makes on the run time.*

C compiler	Variable type	Run time (seconds)	C library
Aztec C 3.4B	`int` (16-bit)	12.3	16-bit
Aztec C 3.4B	`short` (16-bit)	12.3	16-bit
Aztec C 3.4B	`long` (32-bit)	17.0	16-bit
Aztec C 3.4B	`long` (32-bit)	12.6	32-bit
Lattice C 4.0	`int` (32-bit)	14.7	32-bit
Lattice C 4.0	`short` (16-bit)	12.0	32-bit
Lattice C 4.0	`long` (32-bit)	14.7	32-bit

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In contrast, some compilers, such as those available with some Unix systems, ignore a request for `register int` variables; since register variables have no specific memory address, they can cause problems with subroutine calls and pointers. Other compilers generate extremely poor code with register variables; for example, some force a register variable to have an address for a subroutine call by unnecessarily pushing it onto the stack and then pulling it from the stack back into its home register. All these features of register variables can greatly affect the Sieve performance and confound the performance comparison of system A with system B if we aren't careful to understand both the system's and the compiler's operation.

We can avoid these problems by deliberately coding the Sieve to run efficiently with and without register variables defined. When the Turbo-Amiga Aztec C compiler was run with register variables defined, the run time decreased to 6.3 seconds. We could make further improvements if we redefined the Sieve's global variable, `size`, as a register variable, too. In this case, the Sieve run time decreased to 5.8 seconds, much more in line, in view of the clock-speed differences, with the DSI-780's SVS C result of 4.9 seconds.

As stated by Gilbreath, the Sieve was designed partly to examine memory efficiency, but it fails to do this because the array size is fixed and relatively small. Actually, it's *very* small, since modern CPUs can address vast memory spaces, and typical microcomputer systems might have 1 or more megabytes of RAM.

Table 3 shows the memory-efficiency problems that can occur with some systems as you increase the Sieve's array size. Notice the great penalty paid in performance by the IBM PC XT and the IBM PC AT as the array size passes the 32K-byte boundary. The efficiency loss appears to be related to inefficiencies in the address calculations with signed `long` instead of signed `short` integers.

The problem might have been avoided, at least temporarily, if the array-index variables had been defined as `unsigned short` instead of `int`. However, for arrays larger than 64K bytes, the variable type, in this case, must be `long` or `ulong`.

In any case, varying the array size has taught us something about the relation between Sieve performance and memory efficiency; that is, the relative ranking of Sieve performance depends on the array size (see table 3). Thus, it's not always correct to deduce a relative ranking of Sieve performance based on a fixed array size; you can obtain a more accurate picture of performance by varying the array size.

A revised Sieve program, designed to handle these problems and ambiguities, is available in the BIX supermicros conference.

Table 2: *Sieve benchmark results on a variety of 68020 machines (100 iterations). Again, notice that the main ingredient of the speed differences seems to be the variable type.*

System	C compiler	Time (seconds)	Variable type
Definicon DSI-780 (16 MHz)	SVS C 2.0	4.9	`int (=register int)`
Turbo-Amiga (14.32 MHz)	Lattice C 4.0	12.0	`short`
Turbo-Amiga (14.32 MHz)	Aztec C 3.4B	12.3	`int (=short)`
Turbo-Amiga (14.32 MHz)	Aztec C 3.4B	12.6	`long`
Turbo-Amiga (14.32 MHz)	Lattice C 4.0	14.7	`int (=long)`
Mac SE/Prodigy (16 MHz)	Consulair C 5.04	14.8	`int (=long)`
Mac SE/HyperCharger (16 MHz)	Consulair C 5.04	14.9	`int (=long)`
Mac II (15.67 MHz)	Consulair C 5.04	16.7	`int (=long)`

Table 3: *Sieve performance as the array size increases (10 iterations). Notice the severe degradation as the AT and XT pass the 32K-byte boundary, while the execution time for the other machines grows at a predictable rate.*

Array size (bytes)	8191	10,000	20,000	40,000	80,000	160,000
System			**Time (seconds)**			
VAX 8600	0.38	0.53	1.19	2.64	5.57	11.88
Turbo-Amiga	0.44	0.56	1.14	2.32	4.68	9.46
VAX-11/780	1.09	-----	3.04	6.38	13.34	-----
Amiga	2.26	2.82	5.68	11.50	23.30	47.06
VAX-11/750	2.41	-----	6.11	13.13	29.65	-----
IBM PC AT	3.71	-----	8.13	99.71	-----	-----
IBM PC XT	11.60	-----	35.30	351.50	-----	-----

Floating Away

The original Float program in C (see reference 3) is perhaps one of the worst examples of a benchmark program. (Reference 4 corrects the worst of the errors.) A number of optimizing compilers, such as those available for the Sun and VAX systems, can logically reduce the code to a simple `c=a`. The result is an invalid Float program that does no floating-point operations and runs in almost no time at all.

A compiler can optimize the Float to such a great extent because it's a contrived program that performs no useful task and provides no outputs. Compilers such as Microsoft C 5.0 can optimize the Float so that the resulting code bears little resemblance to the original source code.

The Float is intended to perform double-precision floating-point multiplication and division, but it provides no useful output and doesn't check floating-point accuracy. Some sort of computational accuracy check and output would be desirable, since accuracy is important in floating-point processing. Also, a definite relationship exists between speed and accuracy in floating-point processing. A floating-point benchmark program should provide estimates of both.

Another failing of the Float is that the program provides no `register double` option. Without this option, the program can report misleading comparison results, since some types of compilers automatically generate `register double` variables (even if the source code says `double` only). Other compilers do so only when the `register double` option is put in the source code or when the `-O` optimize flag is set during compilation.

Running the Float with `register double` variables instead of `double` variables can, in some cases, result in a change in performance of a factor of 3. For example, an Amiga with a 68020 at 14.32 MHz and Manx Aztec C 3.4B (a nonoptimizing compiler) takes 2.98 seconds to run the Float with `double` variables, but it takes only 1.04 seconds with `register double` variables.

If the `-O` flag is set, the results become confused, with timings of a fraction of a second or 0. If these various factors

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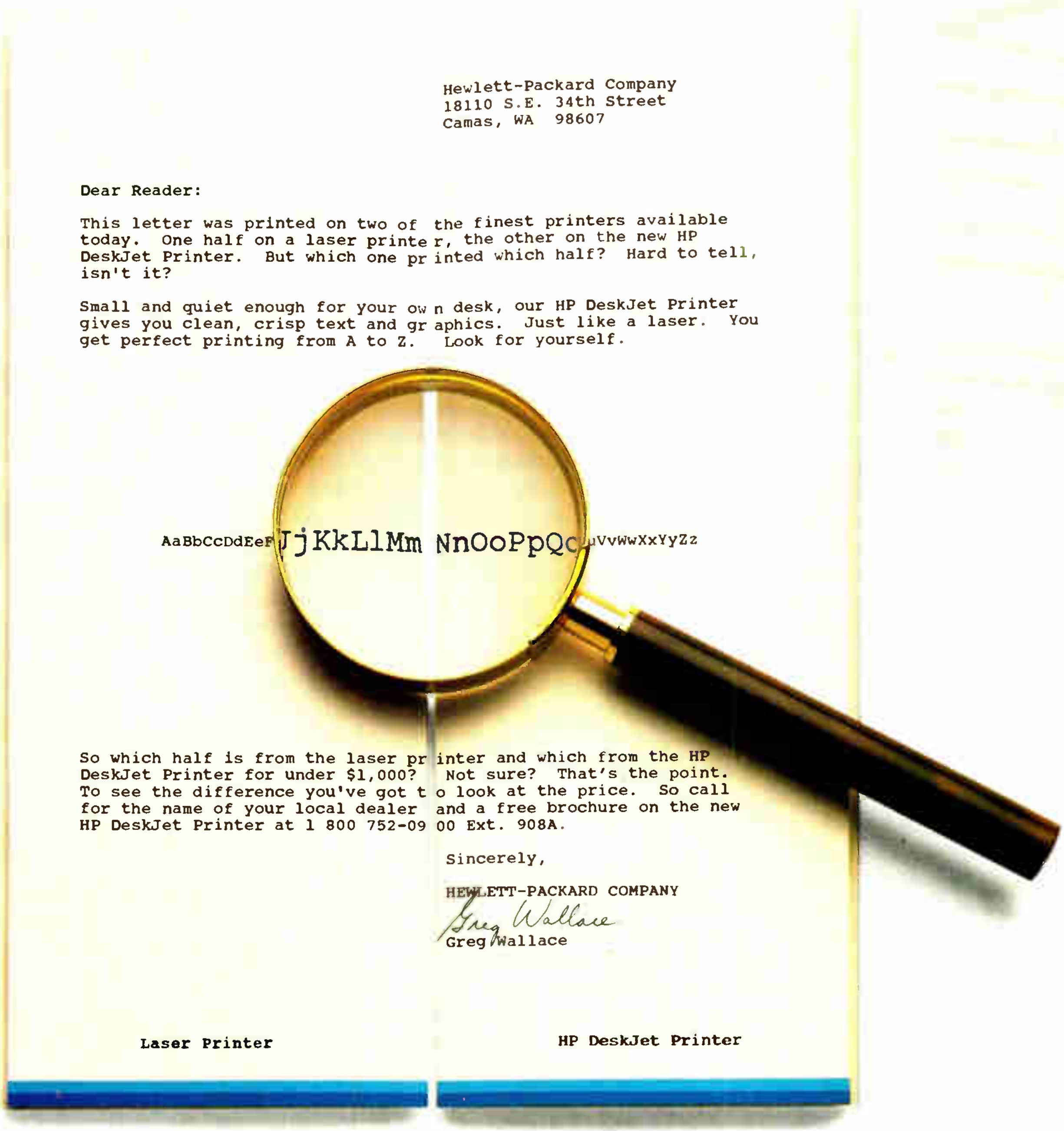

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aren't accounted for in the benchmark testing, the comparison results will be confused and not very meaningful.

The Float program is a good example of how to optimize do-nothing code to nothing. It should be laid to rest and a new floating-point scalar-arithmetic benchmark constructed. My suggestions for its specifications, based on my experience with the Float, are as follows:

- The program should do something useful, recognizable, and verifiable.
- It should exercise single- and double-precision floating-point operations.
- It should provide accuracy-check output.
- It should provide `register double` and `register float` options.
- It should exercise scalar-arithmetic addition, subtraction, multiplication, and division (+, −, *, and /) operations.
- It should apply weighting factors so that the outputs reflect typical usage of the floating-point addition, subtraction, multiplication, and division operations. This is important because otherwise the divide operation, which takes the most time to execute, may unfairly bias the results. Also, it's just not used as frequently as the others. For example, the Weitek 1167 FPUs take about 0.6 microseconds for a double-precision add, but about 3.8 μs for the divide.
- While the standard output based on typical instruction usage is provided in thousands, or even millions, of floating-point operations per second, I would prefer KFLOPS.
- The program should provide a peak KFLOPS estimate based on the addition operation. This would shed some light on the range of performance you can expect.
- The code must be optimized from the beginning as much as possible to prevent optimizing compilers from doing dastardly things to the performance results.

Some progress has been made toward achieving these requirements in the `FLOPS.C` program, which is available in the BIX supermicros conference under the long.msg topic.

To Soothe a Savage Beast

The Savage benchmark is named for Bill Savage, who published the original BASIC version (see reference 5). A listing of the C version of the program is available in reference 3. Savage exercises some of the standard math functions (`tan`, `atan`, `exp`, `log`, and `sqrt`). It is one of the few old BYTE or C benchmarks that provide an error check; it has some problems, however.

The Savage error result is dominated by the `atan(x)` function, so the accuracy obtained does not reflect the much greater accuracy available from the other functions. The error in `atan(x)`, when x is greater than 500 or so, is generally so large that you can't run Savage reasonably in single-precision. In general, the only way to keep the error under control is to run with double-precision only. The function `atan(x)` requires many digits of precision to maintain reasonable accuracy when the argument x is large.

Savage in C also doesn't account for `register double` variables. This isn't a significant problem; only about a 10 percent variation in performance has been observed when running Savage with and without `register double` variables.

Although it hasn't happened to my knowledge, Savage could be optimized to a trivial loop of `a=a+1.0`, resulting in a Savage test where no math functions are tested at all.

Finally, Savage doesn't account for the typical usage frequency of the standard math functions. The `sin()`, `cos()`, and `sincos()` type of functions are frequently used in graphics and many other applications, yet Savage doesn't test them.

We need a new benchmark program for the standard math functions. It should test all the functions, provide accuracy checks, and weight the performance outputs in accordance with typical usage.

Fib Is a Little White Lie

The Fibonacci program in C (see reference 3) has problems similar to those found with the other benchmarks. The question of whether `int` equals 16 bits or 32 bits is not addressed in this program. The outer loop contains one loop-invariant call to the `fib()` function. You can completely separate the loop and the function call without affecting any calculations except the timing. Due to this loop-invariant code, the outer loop is subject to deletion by a smart compiler.

The program doesn't provide a `register int` option. When I assigned some of the variables to registers, the performance didn't improve; it degraded by approximately 30 percent. This illustrates how under certain conditions compilers have troubles handling `register` variables efficiently.

Fib uses a recursive function call to calculate the twenty-fourth Fibonacci number starting from a value of 1 for the first and second numbers. You could simplify the logic in the function call somewhat, because the function's input parameter x is always greater than 2 (it is fixed at 24). Fibonacci seems to be an attempt to test recursive function-call efficiency, but the trouble is that no compari-

continued

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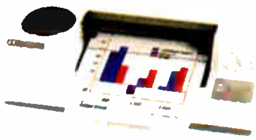

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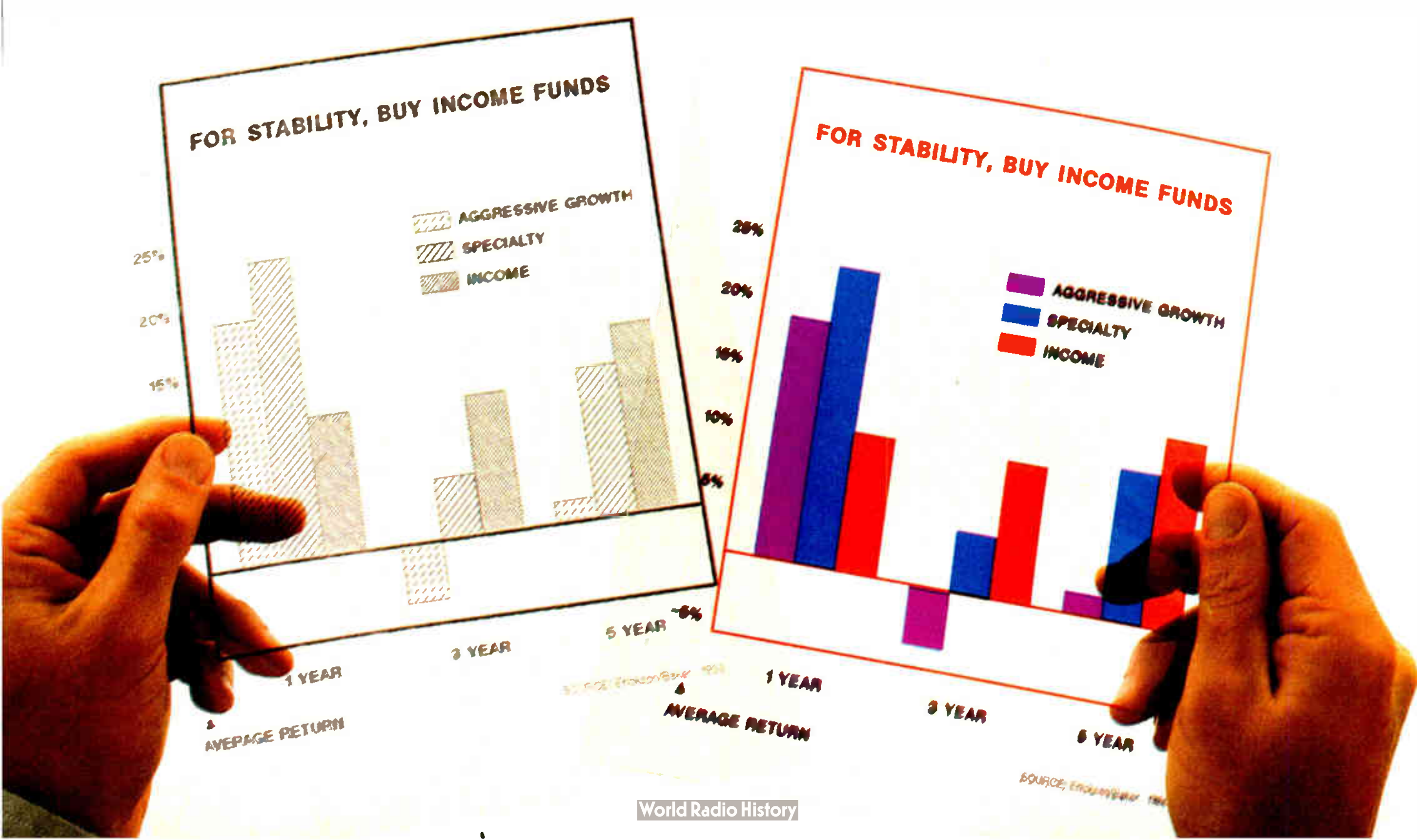

son reference point is provided.

I wonder how useful Fibonacci is as a benchmark. A test of recursive function-call efficiency is an interesting point, and Fibonacci is an extremely simple benchmark, but it seems to take forever to run on most systems. For a performance comparison, I coded a nonrecursive form of Fibonacci into the original benchmark and made a timing comparison. The results were unbelievable at first, but each program was calculating exactly the same sequence of Fibonacci numbers. These were the results, in seconds, for an Amiga with a 68020 and 32-bit memory at 14.32 MHz (for 100 iterations):

recursive run time = 55.10
nonrecursive run time = 0.0118

The Fibonacci appears to be a good test of procedure-call, or function-call, efficiency. The performance differs by a factor of over 4500. Apparently, recursive function calls are highly inefficient. This leads me to believe that Fibonacci could be turned into a useful benchmark test providing insight into the comparative efficiency of recursive function calls.

Sorting Things Out

QuickSort in C (see reference 3) has problems similar to those encountered in the other benchmarks. It doesn't define `int` variables as 16-bit or 32-bit. It should use variable types, `long` and `short`, so that the results are uniformly comparable in most cases.

The program doesn't account for significant variations in performance that can occur when some compilers automatically generate `register int` or `register long` variables. Options for `register int` and `register long` should be part of the program. The function `random()` is simple and could be in-line-coded to eliminate the function-call overhead delay. Some compilers can optimize this program considerably.

To qualify as a meaningful benchmark, QuickSort needs a specific purpose. It's not clear exactly what the program is supposed to be testing.

Dry Stones?

The Ada Dhrystone benchmark was created by Rheinhold P. Weicker. Reference 6 contains documentation and a listing of it. The C version of the Dhrystone is by Rick Richardson, who maintains a database of results.

The Dhrystone is a good benchmark that attempts to measure system performance based on an analysis of real program usage. It measures CPU performance plus compiler efficiency based on a statistical analysis of typical programs. It does no floating-point operations whatsoever, because they weren't found to be typical overall. Dhrystone is a general program not intended to describe system-performance expectations for numerous specific applications.

Dhrystone 1.1 has problems similar to those found in the other benchmarks. It provides no useful output that you can use to verify correct operation. It appears to be dominated by string-handling procedures, which some compilers can optimize to various degrees. The new Dhrystone program, version 2.0, is designed to prevent optimizing compilers from distorting its measure of performance, Dhrystones per second.

The Dhrystone doesn't address the `int` ambiguity (16 or 32 bits, `short` or `long`). You can improve the performance of those compilers where `int` is 32 bits by changing `int` to `short`. The benchmark has an option to handle register variables.

Overall, the Dhrystone is one of the more outstanding benchmark programs currently available, but it can't be used in isolation to describe specific system performance on different applications.

Out with the Old

What's wrong with the old benchmarks? Just about everything. But benchmarks can be improved. We need to provide more uniform and unambiguous measures of performance. We need to be sure that our benchmarks have specific purposes and that they perform those purposes under carefully controlled conditions. Some tests can be modified, and others must be rethought, redesigned, and rewritten. This process has been started; the new BYTE benchmarks are introduced on page 239. ■

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Why MIPS Are Meaningless

Component benchmarks tell you about subsystems, not about the system as a whole

Ron Fox

SCIENTIFIC COMPUTING tends to weight floating-point and memory performances highly, while word processing tends to weight integer computations more heavily. In theory, if you know the application mix, and you measure the performance of each subsystem in isolation, you should be able to calculate the system's performance as a whole—when it's running those applications.

A typical computer system consists of several subsystems. A typical set of subsystems might be an integer and logical ALU, the processor, memory, I/O interface, and a floating-point unit (FPU). The overall performance of a computer system is some weighted sum of the performances of these subsystems. The weights vary, depending on the application mix.

One way to determine the performance of each subsystem is to time the execution of programs that isolate the subsystem. These programs are called *micro* benchmarks, because they look at performance in microscopic detail, whereas application-level benchmarks look at performance from a macroscopic view, as a whole.

Some problems crop up in each of the subsystems when you try to produce micro benchmarks for them; problems also crop up when you try to compare the performance of two systems at the microscopic level.

Under the Microscope

The first step in building an accurate micro benchmark is to isolate the particular computer subsystem you want to test. Practically speaking, this is an almost impossible task.

Consider the Savage benchmark, which is primarily intended to test the accuracy and speed of transcendental functions. Careful analysis shows that the program uses the ALU to control the loop, and that it accesses memory for program fetches and data. The effect of these contributions is small for CPUs without an FPU capable of performing transcendentals; however, as FPUs with direct transcendental support (via rough lookup tables and series corrections) become common, you can no longer ignore the contributions of the rest of the program to execution time.

Thus, we have the basic principle of micro benchmarking: It is not possible to build a program that totally isolates the performance of a single subsystem. The best we can hope to do is to correct for the contributions of the subsystems we aren't benchmarking.

To make these corrections, we rely on incremental timing. This involves taking time estimates on two different sections of Savage. [Editor's note: *The author has created a series of benchmark programs that are discussed in this article. They are available on BIX and in other formats. See page 3 for details.*]

The first section of SAVAGERF.C estimates the time required for the overhead calculations; the second section times the complete benchmark. (See the text box "Time on the Bench" on page 230.) The difference between these two is the incremental time required to perform the transcendental calculations; that's the part we really wanted to time in the first place.

Isolating the ALU

A commonly used measure of performance for the ALU subsystem of instructions is MIPS, or millions of instructions per second. It would be more descriptive to call them meaningless instructions per second. As you can see from the two 8088 assembly language code fragments in figure 1, depending on your choice of instructions, MIPS can vary by an enormous amount. We need a more stable set of measurements than that.

You can usually divide the instruction set of an ALU into several instruction groups: data movement, simple arithmetic, multiplication and division, bit operations, and flow control. Typically, the instructions within each group have similar timings.

In addition, if you expand the number of instructions used into reasonably sized classes, you can create benchmarks that make the processor do some semblance of real work. Throughout the process, however, you must remember that you want to write benchmarks that isolate the time contributions of the class of instructions you're interested in from the time used by other, overhead instructions and from the effects of finite memory speed.

The data-movement class of instructions is responsible for moving data from memory to processor, processor to memory, and memory to memory on processors capable of memory-to-memory op-

continued

The first step in building an accurate micro benchmark is to isolate the subsystem you want to test. Practically speaking, this is an almost impossible task.

erations. The program MOVESRF.C is a benchmark that times register-to-memory moves, constant-to-memory moves, and memory-to-memory moves. It also times its overhead incrementally, timing the differences between loops with one or two randomizer calls—included to prevent optimization—and looking at the differences to produce a time for the execution of the loop construct alone.

Even in this case, however, the timing is not necessarily for the moves alone. Some CPUs might need additional instructions to compute the effective address of the source or destination operands before they can actually do the moves. On the MC6800 8-bit micro, for example, the single indirection-and-index register would require quite a bit of register shuffling to do the memory-to-memory move.

In addition, CPUs without autoincrementing address modes must do some additions between loop passes. Since these computations are necessary for typical data-movement operations, whatever the context, it is fair to include them in the timing for the data-movement group. This overhead is functional, unlike that associated with the benchmark itself. Note that I haven't eliminated additions to the timing due to memory speed from this benchmark.

We can create benchmarks for simple arithmetic, multiplication, division, and bit-manipulation operations by modifying MOVESRF.C. If we use the data-movement timings as a base for the incremental timings, we can get purer timing numbers for these operations. The benchmark OPSRF.C estimates times for these instructions.

The flow-control instruction group includes all instructions that break up the linear flow of control from one instruction to the next. These include conditional branches, procedure calls, and unconditional branches. Since a conditional branch without a prior condition test is useless, this class of instructions often includes condition-code-setting instructions, such as tests and compares, despite the fact that such operations usually fall more in the range of simple arithmetic.

The benchmark program FLOWRF.C estimates the time for subroutine calls and conditional branches. The overhead-timing routine for the conditional branch tries to separate the condition test from the actual branch. How successful this attempt is depends on the CPU. Incremental timing between the conditional branch and the procedure call lets us pinpoint the amount of time used by the call/return pair quite accurately. In high-level languages, you can't separate the call and return, as they are naturally paired in the language constructs.

If you wanted to, you could refine the FLOWRF.C benchmark further. As it stands, the call/return pairs are not pure; that is, returning a result takes some time. In addition, since most computers don't care if the conditional branch is part of an IF...THEN...ELSE, WHILE, or FOR construct in a high-level language,

continued

The NOP program loop

```
LOOP: NOP                ; 3 clocks
      JMP  LOOP          ;15 clocks
;--------------------------------------------------------------------------
;                 Total  :18 clocks = about 0.5 MIPS (at 4.77 MHz)
```

The IDIV program loop

```
LOOP: IDIV  BX           ; 165 to 184 clocks
      JMP   LOOP         ; 15 clocks
;--------------------------------------------------------------------------
;                 Total  : 180 to 199 clocks = about 0.05 MIPS (at 4.77 MHz)
```

Figure 1: *Why MIPS are meaningless. You could use either of these two code fragments to estimate MIPS on a machine, but their execution times differ significantly.*

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Asynchronous FPUs provide higher throughput on programs with a mix of floating-point and integer computations.

it is sufficient to time a single conditional-branch construct. The `IF` is convenient, since it is easy to create an incremental-timing benchmark.

Examining the FPU

It is of secondary importance whether an FPU is intrinsic to the processor (as it is on the MicroVAX and the IBM 3090), a tightly bound coprocessor (such as the 80387 and the 68882), or a loosely bound peripheral (such as the various Weitek floating-point chip sets). What is most important is the degree of *asynchronism* with which the FPU can operate relative to both the ALU and earlier floating-point operations.

The simplest FPUs are synchronous; the ALU can't continue fetching and executing instructions until the FPU becomes idle. Asynchronous units, on the other hand, can run independently of the ALU. A program can start a floating-point operation, go away and do some integer operations, and then at some later time synchronize with the FPU, either transparently in hardware (as on the FPU option boards in the DEC PDP-11/45) or programmatically (as in the 8087 family of coprocessors).

Asynchronous units can provide higher throughput on programs with a good mix of floating-point and integer computations. If the program can schedule code well between the ALU and the FPU, it can keep both units active and reduce the total time required for execution.

Some asynchronous units provide internal asynchronism for independent floating-point operations. The simplest way of doing this is with multiple functional units. For example, the FPS-164 attached minisupercomputer contains independent floating-point adders and floating-point multiplication and division units. They let the FPU add and multiply completely independently.

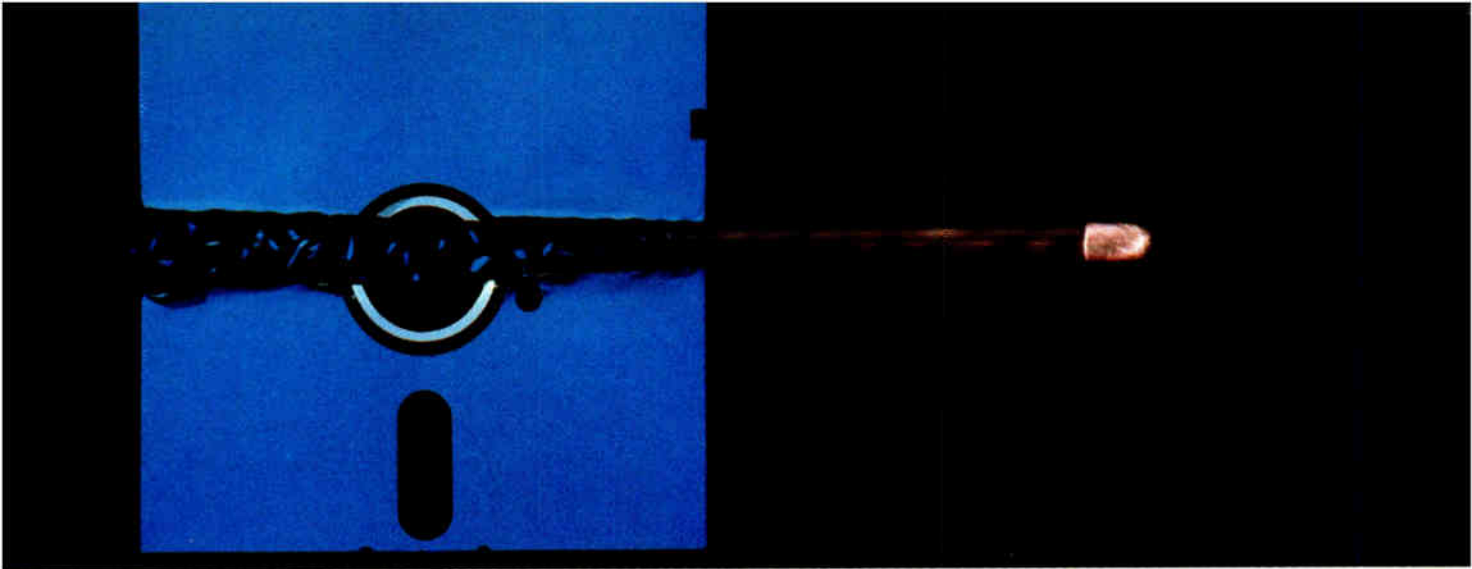
A slightly more complex form of asynchronism is pipelining, in which you break a time-consuming operation into several substages. The computation moves from stage to stage, and the FPU can accept a new computation each time the entry stage becomes idle.

While the first computation on an n-stage pipeline requires n units of time to complete, the second will complete one unit of time later. Thus, if a program can keep the pipeline full, the FPU can crank out computations with a throughput of one per unit of time; if the pipeline empties out, the FPU requires n time units for one computation or for the first of a series all over again, and the throughput time increases significantly. The FPS-164 pipelines the multiplication and division units to further improve potential throughput.

Parallels and Pipelines

Microscopic benchmarks for FPUs should explore the various possible opportunities for parallelism. They should try to determine how well you can schedule code to take advantage of any potential for parallelism, as well as test for its presence. The program `FOPSRF.C` tests for parallelism and measures the speed at

continued



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Time on the Bench

When doing the precise timings required of micro benchmarks, using a stopwatch is not good enough. The errors in start and stop times with a stopwatch are on the order of milliseconds, while you want benchmark timings for micro benchmarks to be accurate to microseconds if possible.

The best way to time a micro benchmark is to have the program use the system-timing functions to start and stop its own "stopwatch." When you need *very* precise timing, you must also estimate the time required to call the stopwatch functions. The incremental timing approach takes this time into account.

With the exception of the memory-thrash benchmark, all the programs discussed in this article used a set of timer routines that should be relatively easy to port to any machine with timing functions: The routine `initimer()` initializes the timing system and determines the time required to actually get the time, and `gettimer()` returns the time as a double-precision floating-point number representing the time used since the call to `initimer()` in seconds.

Listing A is a Microsoft C-compatible module containing these functions. If you wish to port these routines to other systems, the `clock()` function returns the time used by the process. The time given is a `clock_t` type, which is really an integer with `CLK_TCK` ticks per second.

Listing A: *The timer routines used in the benchmarks in this article.*

```
#include <stdlib.h>
#include <time.h>
#include <stdio.h>
static clock_t calltime, cumcal;

double gettimer()

{
   clock_t time;
   long clock();

   time = clock();
   time = time-cumcal;
   cumcal += calltime;
   return (double)time/(double)CLK_TCK;
}
void initimer()
{
  double time1, time2;

/*    Calibrate the clock     */

  calltime = 0;
  cumcal   = 0;
  time1 = gettimer();
  time2 = gettimer();
  calltime = (clock_t)((time2-time1)*CLK_TCK);
  cumcal = time2;

}
```

which basic floating-point operations can be performed. It's basically a modification of OPSRF.C.

To explore possible parallelism between the FPU and the ALU, we would need to introduce integer computations between the floating-point computations. If the total benchmark timings remain relatively constant or don't increase by the previously measured time required to perform the inserted integer operations, then parallelism exists. We can explore it by successively increasing the number of integer operations added between the floating-point operations until the benchmark time begins to increase significantly.

If we want to explore pipelined parallelism, we must string several floating-point operations together within a single loop. *Without* pipelining, the time should go up linearly with the number of operations in the loop. *With* pipelining, the incremental time required for each additional operation should be quite small relative to that required for a single operation.

An additional micro benchmark would be to estimate the time required to perform transcendental functions and to test the accuracy with which they are performed. Many older FPUs can't directly compute transcendental functions, such as logarithms and tangents, while newer ones, such as the MC68881/2 and the Intel 80x87, can.

When you test the transcendental functions, it is important to both time them and test their accuracy. SAVAGERF.C does this and is also a relatively simple program. It uses functional inverses to perform the accuracy tests. TRANSRF.C is a more systematic test that times the basic transcendental functions and tests for their accuracy.

Between Memory and CPU

None of the subsystems discussed so far are as tightly bound as the CPU and its memory. The CPU fetches instructions from the memory subsystem, the instructions get their operands from the memory, and the CPU deposits the results of an instruction in the memory after the instruction is completed. As CPUs become faster, eventually it will cease to be cost-effective to build an entire memory system fast enough to keep up with the processor. There are two possible ways to deal with this: Allow the memory to bottleneck performance, or incorporate a hierarchical-memory system.

Hierarchical-memory systems contain small amounts of high-speed memory capable of running at processor speed, larger amounts of memory that are somewhat slower, and so on, in an increasingly slower hierarchy of memory subsystems. The most common multilevel memory hierarchies are three-level virtual memory systems. Typically, the fastest level is an associative cache from which the CPU references instructions and perhaps some data as well. The second level is the main memory; in most systems, this level is simply dynamic RAMs. If you use a cache for your instructions, you can use relatively inexpensive, slower RAMs for the main memory.

In a virtual memory system, main memory is segmented, typically into fixed-size units known as *pages*. A memory map makes a correspondence between the virtual addresses that a program sees and the physical addresses that main memory sees. Some virtual pages may not have corresponding physical pages; the nonresident pages are kept on a "backing store," which is often a disk drive.

Hierarchical-memory systems work well because typical programs obey the principle of "referential locality"; that is, memory references tend to be clustered about a relatively small set of addresses for a relatively long period of time. We can explore the effectiveness of this organization by running nontypical programs. For example, THRASH.C, a benchmark written by Hank Vaccaro, randomly references elements of a large array. It is interesting to plot the speed per reference against the array size. A modified Thrash program, THRASHRF.C, gathers the data for just such a plot.

The graph in figure 2 shows the timings for THRASHRF.C when run on a MicroVAX II under VMS (virtual memory operating system). Although this machine doesn't have a cache to speak of—it does have an instruction-prefetch queue, but the timing of the benchmark should be dominated by data references—the program address space is nevertheless accessible in a distinct three-level hierarchy.

Under VMS, each program has a "working set" of directly addressable pages. For the run shown in figure 2, this working set was 3000 512-byte pages, or 1.5 megabytes. As long as you confine your references to this working set, the program should execute quite rapidly. Once the program gets outside the 1.5-megabyte range, however, it begins *page faulting*; that is, it references memory locations that the program can't directly address. When THRASHRF.C needs a new page of memory, VMS places a page from the working set on a list—this will be the free list if the page hasn't been modified, or the modified list if it has. The needed page then becomes part of the working set.

Memory references tend to cluster around a small set of addresses for a long period of time.

When VMS puts a page on the free or modified list, it doesn't immediately break the actual binding between page and process virtual address. Eventually, VMS writes modified list pages to disk and then puts them on the free list, still bound to the processes from which they came. Only when VMS needs the page for another process or for another virtual address within the original process is this binding broken.

continued

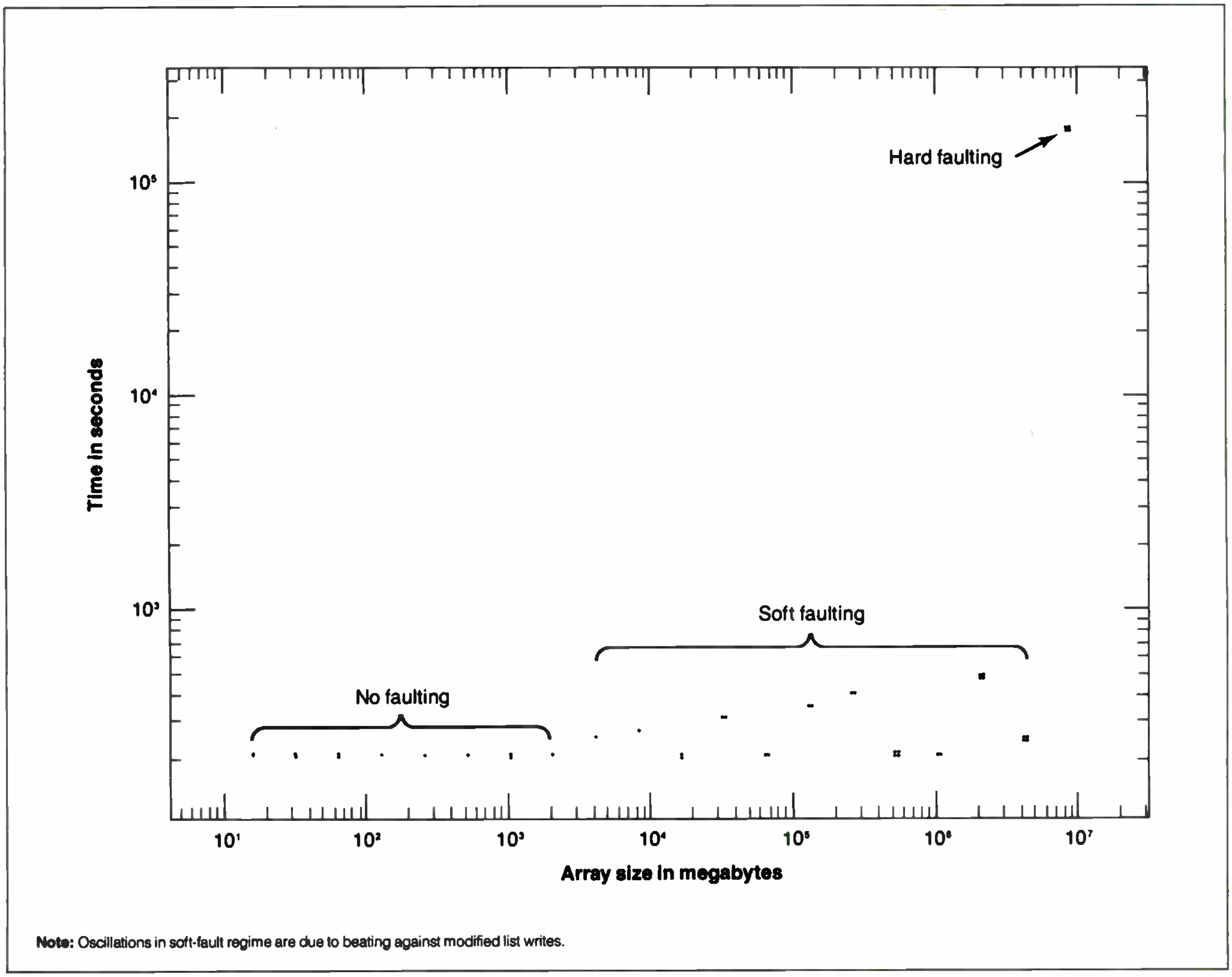

Figure 2: *When a program tries to address memory outside the working set of directly addressable pages, execution time increases: slightly on a soft fault (memory found on the free list), and significantly on a hard fault (disk I/O required).*

Listing 1: **(a)** *shows the code generated by the Ecosoft-C88 C compiler for the* FOR *loop shown, while* **(b)** *shows the code I was trying to benchmark.*

```
; for( i= 0; i < ASIZE; i++)
; dest[i] = 0;
;
; Code generated by ECO-C88
```

(a)

```
 mov word ptr [bp][-20002],0
L?9f label near
 cmp word ptr [bp][-20002],5000
 jge L?9e
 mov ax,word ptr [bp][-20002]
 shl ax,1
 lea bx,word ptr [bp][-10000]
 add bx,ax
 mov word ptr [bx],0
L?a0 label near
 inc word ptr [bp][-20002]
 jmp short L?9f
L?9e label near
```

(b)

```
 MOV CX,ASIZE
 MOV BX,[BP][dest]
L?9F LABEL NEAR
 MOV WORD PTR [BX], 0
 ADD BX,2
 LOOP L?9F
```

Thus, if a page is removed from the working set and is then requested before it is bound to another process, the free- and modified-page lists act as a cache, preventing the costly disk I/O that you would otherwise need to obtain the page. A page fault satisfied from either the free or the modified list is called a soft fault. A page fault that can be satisfied only by a disk I/O is called a hard fault. These provide the two additional levels of the memory hierarchy.

Figure 2, therefore, shows three distinct speeds. The fastest timings occur when the memory references all lie within the 1.5-megabyte working set of pages. Next is a plateau that involves a large number of soft faults, but few or no hard faults; that is, the memory references fit within the free physical memory of the MicroVAX II but are too big to fit in the process's working set. The MicroVAX II has "only" 9 megabytes of physical memory; once the referenced program address space no longer lies within the free physical memory, a significant number of hard faults begins to occur. This accounts for the third timing plateau, where hard faults begin to dominate program execution time.

Stumbling Blocks

In trying to produce a set of reasonably portable high-level-language benchmark programs, I have ignored the actual generated code. My approach results in two problems. First, using high-level languages makes the exact sequence of the instructions being timed imprecise; and second, optimizing compilers can reduce the program until some timing loops are doing nothing.

The first point is fairly easy to see. Let's look at the generated code from one instruction in the MOVESRF.C benchmark. The compiler is Ecosoft's C88, which is deliberately not a highly optimizing compiler. Listing 1a is the generated machine code for the clear-memory loop of the memory-access timings, but listing 1b shows what we had really wanted to benchmark.

This kind of code expansion makes it difficult to claim that a C benchmark actually tests memory-movement timing. The most we can say is that it tests the timing of typical memory references within high-level-language programs.

In writing micro benchmarks, you effectively have two choices: You can build portable benchmarks and put up with the associated imprecision, but be able to compare performances *between* different architectures (e.g., Intel 80x86 vs. MC680x0 vs. AT&T32000); or you can build benchmarks in assembly language, allowing complete control over the instruction sequences you are timing, but requiring extensive rewrites to compare different architectures. This allows comprehensive comparisons *within* an architecture (e.g., Intel 80386 vs. 80286 vs. 80186 vs. 8086 vs. 8088, or MC68008 vs. 68000 vs. 68010 vs. 68020 vs. 68030).

On the other hand, with a highly optimizing compiler, you must deal with code deletion. The optimizer can decide to remove large pieces of the code that you wanted to time. One example of this is the original FLOAT.C benchmark, which, for nonoptimizing compilers, measures the speed of the multiplication and division family of floating-point instructions. For an optimizing compiler, however, the benchmark effectively disappears.

Reasonably good optimizing compilers can determine that the computations are loop-invariant and that they are all done with constants and thus can be computed at compile time. Once this is done, the compiler deletes all but one of the pairs of multiplications and divisions in the loop, pulls the computations outside the loop, evaluates them at compile time, notices that the loop is null, and deletes the loop, leaving a program that executes instantaneously.

One technique you can use to prevent your benchmarks from being annihilated is to write all computational results based on a certain condition. This condition could be determined by user input or hardwired into a separately compiled function, thus hiding from the compiler's optimizer. If you avoid loop-invariant computations and compile-time constants, you can prevent most loop and expression optimizations.

No Substitute for Understanding

There is really no substitute for understanding the architecture you are studying. If you don't understand how the subsystems interact to form a system, even the results of a good micro benchmark are useless. For example, a micro benchmark might demonstrate that an ALU can give 5 million additions per second. If, however, the system is I/O-bound, these results are misleading.

No micro benchmark is completely portable, due to the wide variations in the ways computer systems are designed. For example, a memory-reference benchmark does not have much meaning on a vector processor. High-level-language micro benchmarks have their own set of problems: for example, the trade-off between portability and instruction-stream precision, and the battle against ever-improving compiler optimizers.

Micro benchmarks measure in detail the performance of selected subsystems of a computer system. If your system will be used in a well-defined set of applications, micro benchmarks can give you an idea of its performance. ■

ACKNOWLEDGMENTS

I would like to thank Trevor Marshall, Al Aburto, and Hank Vaccaro. Their active participation in the supermicros/benchmark topic on BIX sparked my interest in performance measurements.

Ron Fox develops data acquisition programs for the National Superconducting Cyclotron Lab at Michigan State University in East Lansing, Michigan.

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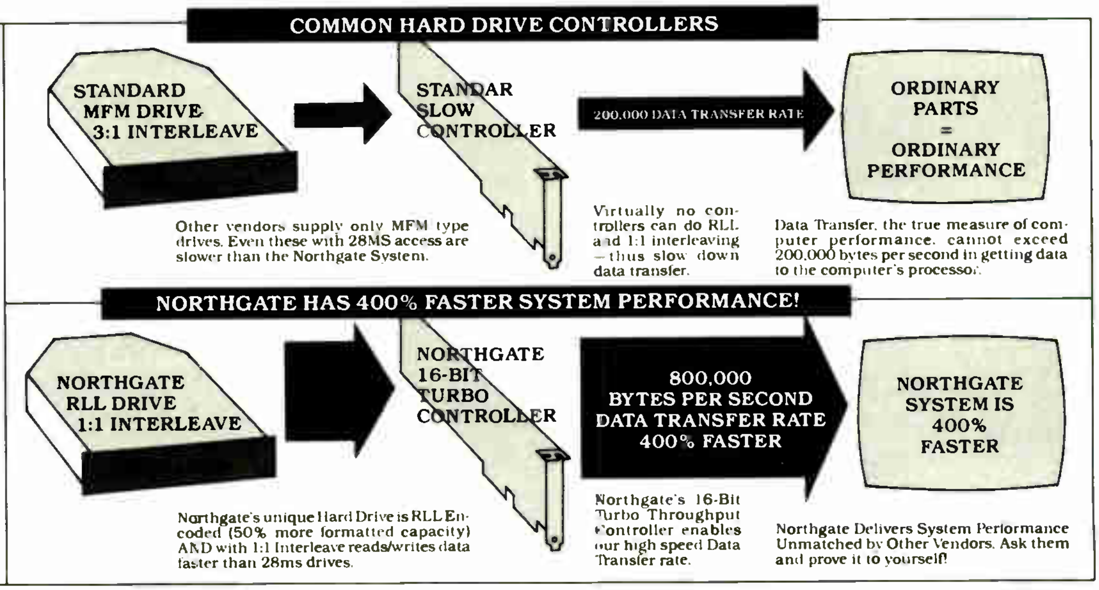

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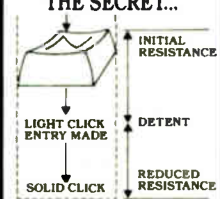

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A set of staff-written programs that gauges total system performance

Richard Grehan, Tom Thompson, Curtis Franklin Jr., and George A. Stewart

THE GOAL OF benchmarking is a noble one. You run a program on a computer, and a number pops out to tell you whether or not the computer is worth its salt.

But benchmarking is like playing the Oriental game of GO. Rules that at first appear simple blossom into complexity as you begin applying them. So, what starts out sounding like the simple job of devising programs to test the relative performance of microcomputer systems runs you headlong into the problems of different CPUs, different FPUs, different operating systems, and before you know it you're just a pair of eyes peering through the turns of a Gordian knot. The trick is to design some sort of common ground, a model that acts as a guiding force to keep things real and reasonable.

To date, no benchmarks have openly, clearly, and reliably tested both within and across brands and architectures. Oh, there are plenty of "black box" benchmarks: Plug in a disk, spin it up, and get a number. But what does the number mean? How does it relate to the real world? What actually was tested? And how? You might as well read tea leaves.

There are also all kinds of machine-specific benchmarks. For example, you can grind away at any one of the many PC benchmarks until your system smokes, and you still won't have any idea how your machine stacks up against, say, a Mac II or SE.

Our new benchmarks are a major first step toward remedying these and other flaws. The benchmarks include a set of low-level tests and a set of application-level tests. (Tables 1 and 2 show test results for PC-DOS/MS-DOS machines and Macintosh machines, respectively.) For the low-level tests, we started by going back to the Small-C compiler, first devised for the CP/M world, and building from there (see the text box "BYTE Small-C" on page 256). We devised tests, chose algorithms, coded, debugged, and debugged again.

No black box, these: BYTE's benchmarks have always been open, and our newest ones follow in that tradition. We will freely distribute the source code of both the benchmarks themselves and the custom versions of Small-C. You can read the source code; you can see exactly what our benchmarks test, and how.

Why Small-C?

Low-level benchmarking presented us with a number of dilemmas. If we wanted laser-beam accuracy, we'd have to hand-code in assembly language whatever algorithms we picked for every processor out there, and someone would always be popping up with a coding trick that would shave 2 bytes and 20 clock cycles off the code. (Notice we said "algorithms"; we wanted benchmarks that at once were low-level and had some connection to the real world. We didn't want to just code up a big pile of `NOP` or `MOVE.L D1,D1` instructions and time them.) And assuming we did take that tack, we'd end up arguing over what the "best" implementation of a given algorithm would be for a given processor. Would it be the smallest version? The fastest? Not necessarily the same thing.

We chose to modify the Small-C compiler for the 80xx8 and 68xxx machines so that it would give us the spyglass into assembly language that we wanted and, at the same time, provide us with a vehicle that was as close as possible to being common across different processors. To put it another way, Small-C defined a model, and we would ask each processor to take its best shot at executing that model. Naturally, where one processor would have an instruction that might give it an advantage in one area of the model, another processor would have an advantage in a different area.

Small-C lets us create benchmarks based on algorithms that bear a resemblance to real-world applications. We can then port those benchmarks more easily from machine to machine than if we had hand-coded them, and—thanks to the fact that Small-C emits assembly language source code—we can understand why one processor performs better than another for a given algorithm. Additionally, Small-C's `#asm` directive lets us dip into pure assembly code. This is especially handy in those cases where we "step outside" the bounds of Small-C to test some system feature it doesn't support.

And last but not least, Small-C is in the public domain, so we can freely share our source code with you. It opens the doors for discussions on optimization techniques, improvements to the run-time library, language design, and more.

CPU Benchmarks

• *Sieve*. You may think that we're just keeping the Sieve of Eratosthenes around

continued

because we've become so attached to it. There's some truth in that, but within that truth lie other, more compelling facts that we can't ignore: Language and system designers the world over have used the Sieve as a basic performance test. The Sieve makes use of arrays (indirect addressing), comparison operations, and simple math. We thought it worthwhile to keep the old firehorse around.

For comparison, listing 1 contains the complete source code file for the new BYTE Sieve of Eratosthenes.

• *Sort*. The new Sort benchmark now uses three sorting algorithms: a Quicksort, a Shell sort, and a heapsort. All three sorting techniques make heavy use of indirect addressing, comparison operations, and basic integer math operations. But there are differences that allow the new benchmark to exercise more aspects of the machine than the old Sort did. Specifically, Quicksort is a recursive sorting procedure, while Shell sort uses a repeating-loop algorithm, and the heap sort uses a repetitive call to a subroutine. (Currently, the time reported for the Sort benchmark is the aggregate for all three algorithms. However, if you're interested in determining which algorithm works fastest, you can modify the source code to report on the individual times.)

Listing 2 contains the source code for the Sort algorithms' major subroutines.

• *Matrix*. The job of the Matrix benchmark is to exercise the kind of operations that must take place to manipulate matrices—in this case, two-dimensional arrays. Primarily, this involves indirect addressing, but the Matrix benchmark also tests integer math operations. Note that some integer math must occur as a program calculates the offset of an array element. Most high-level compilers that support multidimensional arrays handle this math for you automatically, but since BYTE Small-C allows only one-dimensional arrays, such math is necessarily explicit.

The Matrix benchmark times three common matrix operations: Add two square matrices, multiply two square matrices, and perform a transposition on a square matrix. The benchmark calculates the total time for all these operations and prints the results. You'll find the source code for the major routines of the Matrix benchmark in listing 3.

• *String Move*. The String Move benchmark's operation is easy to state: It moves lots of bytes from one place to another. Here, however, is a program whose portability becomes tricky. Consequently, the String Move benchmark makes heavy use of assembly language routines, and these routines are coded differently for each processor. There is another detail

Table 1: *BYTE benchmarks for PC-DOS/MS-DOS machines.*

Low-level Test	IBM PC	IBM PC AT	IBM PS/2[1] Model 80	Compaq[1] 386/20
CPU				
Matrix	66.51	11.69	4.75	3.06
String Move				
Byte-wide	378.18	80.41	39.31	26.11
Word-wide:				
Odd-bnd	275.1	80.41	39.09	31.01
Even-bnd	275.1	40.26	19.66	13.07
Sieve	298.46	73.65	29.11	23.18
Sort	330.30	84.39	33.11	26.89
FLOATING POINT[2]				
Math	70.80	46.46	10.77	7.01
Error[3]	0.0	0.0	0.0	0.0
Sine(x)	26.92	20.05	4.61	3.30
Error	2.0E−9	2.0E−9	2.0E−9	2.0E−9
e^x	23.39	17.20	4.50	3.06
Error	1.0E−9	1.0E−9	1.77E−2	1.77E−2
DISK I/O				
Hard Seek[4]				
Outer track	6.47	3.28	3.34	3.34
Inner track	6.54	3.30	3.35	3.31
Half platter	23.34	11.30	10.00	6.66
Full platter	39.89	16.59	14.17	9.98
Average	19.06	8.62	7.71	5.82
DOS Seek				
1-sector read	16.26	11.66	9.98	2.07
8-sector read	59.34	24.33	20.54	10.89
File I/O[5]				
Seek	.92	.22	.12	.13
Read	.06	.021	.017	.007
Write	.069	.022	.016	.012
1-megabyte				
Write	1:06.70	8.92	5.14	3.48
Read	16.91	8.16	5.67	2.88
VIDEO				
Text				
Mode 0	50.47	11.55	4.73	3.76
Mode 1	50.64	11.53	4.73	3.77
Mode 2	50.97	13.15	5.00	3.88
Mode 3	51.30	13.13	4.96	3.85
Mode 7		11.73*	4.98	3.51*
*No display, but timed				
Graphics				
Mode 4	18.62	4.69	1.98	1.33
Mode 5	18.62	4.69	1.96	1.38
Mode 6	19.99	5.11	2.27	1.49
Mode 13			3.68	3.35
Mode 14			4.41	3.57
Mode 16			3.85	3.48
LINPACK				
(single precision)	1646.72	1010.22	246.40	171.15
Livermore Loops				
(MFLOPS)	.0169	.0237	.1150	.1735
Dhrystone (Microsoft C 5.0)[6]				
(Dhrystones/sec)	391	1721	3977	6321

[1] All figures were generated using the 8088/8086 version of Small-C (16-bit integers). Figures for the 80386 machines shown here do not use 80386-specific instructions.
[2] The floating-point benchmarks used 8087-compatible coprocessor instructions only.
[3] The errors reported for the floating-point benchmarks indicate the difference between expected and actual values, correct to 10 digits or rounded to two decimal places.
[4] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).
[5] Read and write times for the File I/O benchmarks are in seconds per Kbyte. All others are in minutes:seconds.fractions.
[6] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

Application Test	IBM PC	IBM PC AT	IBM PS/2 Model 80	Compaq 386/20
WORD PROCESSING				
XyWrite III Plus 3.52				
Load (large only)	:57	:22	:17	:14
Word count (med./large)	:23/3:03	:07/:55	:03/:25	:02/:16
Search/replace	:43/2:44	:12/:56	:06/:27	:05/:19
End of document	:11/1:48	:04/:37	:02/:16	:02/:11
Block move	:50/:49	:23/:23	:10/:10	:10/:10
Spelling check	1:18/10:06	:22/2:52	:10/1:16	:06/:47
Microsoft Word 4.0				
Cursor move	4:22	3:34	:15	:11
Forward delete	2:54	:59	:16	:11
Aldus PageMaker 1.0a				
Load document	1:12	:27	:13	:06
Change/bold	4:00	1:02	:31	:19
Align right	3:33	:56	:25	:14
Cut 10 pages	2:40	:43	:22	:12
Place graphic	:38	:12	:05	:03
Print to file	22:29	7:15	3:12	1:41
SPREADSHEET				
Lotus 1-2-3 2.01				
Block copy	:34	:08	:04	:03
Recalc	:12	:04	:02	:01
Load Monte Carlo	Insufficient	Insufficient	:18	:09
Recalc Monte Carlo	Memory	Memory	:06	:04
Load rlarge3	:28	:10	:05	:03
Recalc rlarge3	:07	:02	:01	:01
Recalc Goal-seek	:32	:12	:04	:02
Microsoft Excel 2.0				
Fill right	:48	:12	:05	:04
Undo fill	16:45	5:11	1:52	1:28
Recalc	:17	:03	:02	:01
Load rlarge3	4:18	1:12	:28	:17
Recalc rlarge3	:20	:05	:01	:01
DATABASE				
dBASE III Plus 1.1				
Copy	3:33	2:30	1:12	:39
Index	:51	:23	:19	:05
List	5:29	2:23	1:34	:54
Append	6:59	3:17	2:01	1:22
Delete	:08	:03	:02	:01
Pack	5:16	2:05	1:42	1:04
Count	:38	:19	:17	:03
Sort	3:22	1:44	1:28	:52
ENGINEERING/SCIENTIFIC				
AutoCAD 2.52				
Load SoftWest	10:30	2:45	:54	:35
Regen SoftWest	6:15	2:21	:41	:28
Load St. Pauls	2:15	:35	:13	:08
Regen St. Pauls	:59	:21	:07	:05
Hide/redraw	2:18:30	1:44:45	14:07	9:01
STATA 1.5				
Graphics	2:39	:49	:36	:19
ANOVA	1:48	:37	:16	:11
MathCAD 2.0				
IFS 800 pts.	2:32	1:00	:17	:12
FFT/IFFT 1024 pts.	2:57	:52	:18	:12
COMPILERS				
Microsoft C 5.0				
XLisp compile	31:49	9:45	4:48	3:00
Turbo Pascal 4.0				
Pascal S compile	:41	:11	:06	:03

GENERAL SYSTEM SPECIFICATIONS

1. The PC system includes a 4.77-MHz 8087, 512K-byte system memory, a CGA card, and a 20-megabyte external hard drive.
2. The PC AT includes an 8-MHz 80287, 512K-byte system memory, a CGA card, and a 30-megabyte hard drive.
3. The IBM PS/2 Model 80 includes a 16-MHz 80387, 6-megabyte system memory, a VGA graphics adapter, and a 40-megabyte hard drive.
4. The Compaq Deskpro 386/20 system includes a 20-MHz 80387, 6-megabyte system memory, an EGA graphics adapter, a 300-megabyte hard drive, and a 20-MHz 82385 cache controller.

All disk tests refer to a single DOS partition on the hard drive except for Hard Seek, which refers to the entire disk.

with the String Move benchmark that makes its port across processors, shall we say, "uneven." We can best illustrate this by describing how the benchmark runs for the different processors.

8088/8086/80286—The benchmark moves bytes a byte at a time and a word at a time. For the word-at-a-time moves, the benchmark actually runs its test twice, first for odd-byte alignment and then for even-byte alignment.

68000/68020—The benchmark moves bytes a byte at a time, a word at a time, and a doubleword at a time. Since the 68000 *must* access words and doublewords on even-byte boundaries, there is no odd-byte-boundary test.

80386—This version of the benchmark will be a kind of hybrid of the first two. Bytes will be moved a byte at a time, a word at a time, and a doubleword at a time. For the word- and doubleword-width moves, the benchmark will test even- and odd-byte alignments.

The following is pseudocode for the new BYTE String Move benchmark:

```
begin main
    count = 10000
allocate_memory(source_buffer)
    allocate_memory(dest_buffer)
    begin timer
transfer_bytes(source_buffer,
        dest_buffer, count)
    end timer
    report(elapsed_time)
    begin timer
    source_buff_pointer = odd
    dest_buff_pointer = odd
    transfer_word(source_buffer,
         dest_buffer, count)
    end timer
    report(elapsed_time)
    source_buff_pointer = even
    dest_buff_pointer = even
    transfer_word(source_buffer,
         dest_buffer, count)
    end timer
    report(elapsed_time)
 release_memory(source_buffer)
     release_memory(dest_buffer)
end main
```

One further note: For the 80xx8 ver-

continued

sions, the String Move benchmark uses the `REP MOVSx` instructions. Since these instructions use `DS` as the source segment and `ES` as the destination segment, this has the effect of testing moves from one segment to another.

FPU Benchmarks

Most of the work for the floating-point coprocessor benchmarks went into crafting a floating-point coprocessor library that we could attach to BYTE Small-C (see the text box "Small-C Support Functions" on page 261). Small-C does *not* support a floating-point data type. This means that BYTE Small-C has to manipulate floating-point numbers as arrays of bytes, and perform floating-point operations by making calls into the floating-point library. For example, to add two floating-point numbers in BYTE Small-C, the instruction would look like this:

```
f2add(ptr1,ptr2,ptr3);
```

where `ptr1` and `ptr2` are pointers to the arrays holding the floating-point numbers, and `ptr3` points to the array holding the destination. Consequently, the code to implement a floating-point algorithm looks like a series of function calls rather than a traditional assignment statement.

This also means that BYTE Small-C will not have a floating-point emulator library. We decided that such a library would involve too much work for too little return; emulating floating-point operations involves integer math and logical operations, and our other benchmarks already give an indication of the processor's performance in such areas.

We did, however, code the coprocessor library so that calls into it are similar across processors, and the source for the floating-point benchmark program is almost identical for the 80xx8 and 68xxx processors. The library also includes functions for converting from integer to floating-point and back, as well as an output routine that can print floating-point numbers in scientific notation.

BYTE's new floating-point coprocessor benchmark is in two parts, packaged in a single program. The first part is a large loop that simply tests the four basic math operations: add, subtract, multiply, and divide. The second half gives the transcendental functions a workout; it executes a numerical integration algorithm known as the *trapezoidal rule* for two functions—sine(x) and e^x—over a fixed interval. Both the basic math and transcendental tests return results as well as execution times, so we'll be able to test accuracy as well as speed.

Listing 4 contains the source code for the floating-point benchmark.

Table 2: *BYTE Macintosh benchmarks.*

Low-level Test	Mac Plus	Mac SE	Mac II[1]
CPU			
Matrix	79.3	67.1	21.2
68020 version	N/A	N/A	10.2
String Move			
Byte-wide	431.6	374.5	93.9
Word-wide	215.9	186.7	45.6
Long word-wide	147.0	92.4	22.9
Sieve	200.1	170.2	40.2
Sort	179.7	154.2	44.2
FLOATING POINT[2]			
Math	N/A	N/A	175.3
Error			0.0
Sine(x)	N/A	N/A	84.8
Error			1.05E−9
e^x	N/A	N/A	112.5
Error			1.05E−9
DISK I/O			
Sub-Finder Seek			
Sony:			
Sector read[3]	66.6	61.9	62.7
40K-byte read[3]	137.0	137.1	136.1
Sector read[4]	63.0*		
40K-byte read	136.8*		
SCSI:			
Sector read:	46.7*	41.1	14.6
40K-byte read	65.5*	52.8	19.4
File I/O[5]			
Seek	.7	.5	.2
Read	.116	.052	.023
Write	.092	.039	.014
1-megabyte			
Write	13.9	14.8	5.2
Read	7.5	8.1	1.8
VIDEO			
Text			
Textedit	17.3	15.1	5.6
Drawstring	4.3	3.8	1.8
Graphics[6]			
Slow test	96.6	84.4	46.2
QuickDraw	1.1	1.1	0.3
LINPACK			
Single precision	2685	2319	364**
Double precision	4894	4229	348**
Dhrystone (MPW C version 2.0)[7] (Dhrystones/sec)	675	805	2861

[1] All figures were generated using the 68000 version of Small-C. Figures reported for the Mac II do not use 68020-specific instructions, except where noted.
[2] The floating-point benchmarks used the SANE library.
[3] These times are for the floppy disk drives.
[4] These times are for the Mac20 hard disk drive.
[5] Read and write times for the File I/O benchmark are in seconds per Kbyte. All others are in minutes:seconds.fractions.
[6] The Slow test uses codes written in Small-C to perform the circle draw and fill. The QuickDraw version uses QuickDraw commands to draw and fill the circle.
[7] For the Dhrystone test only, higher numbers mean faster performance.

* External drives
** 68020 version

Application Test	Mac Plus	Mac SE	Mac II
WORD PROCESSING			
MacWrite 5.0 (small/large)			
Load	:08/:16	:06/:14	:04/:05
Search/replace	1:32/10:39	1:20/9:40	:78/3:09
Find last page	:03/1:07	:03/:06	:02/:03
Merge small.txt	:13/:16	:12/:17	:06/:07
Spelling check	3:22/***	2:47/21:43	1:08/7:40
Store document	:15/1:13	:14/1:07	:12/:27
MultiWord (small/large)			
Word count	:11/1:13	:10/1:07	:06/:35
Microsoft Word 3.01			
Cursor down 640 lines	2:27	2:2	1:21
Search/replace	1:15	1:07	:22
Store document	:48	:46	:16
Aldus PageMaker 2.0a			
Load document (20,586 words)	:17	:17	:11
Change/bold	1:32	1:31	:29
Align right	1:25	1:10	:29
Cut and refill first 10 pages	:50	:44	:19
Place 80K-byte graphics file	:26	:21	:10
Print document to PostScript file	2:59	2:26	:52
SPREADSHEET			
Microsoft Excel 1.0			
Full right B1...AY50	:32	:25	:10
Undo fill	21:13	17:20	5:22
Recalc	:01	:01	:01
Load rlarg3.x12	:50	:41	:15
Recalc rlarg3.x12	:06	:06	:02
DATABASE (1200 RECORDS)			
McMax 87.2			
Copy	:31	:28	:10
Index	:20	:19	:07
List	2:14	2:11	2:04
Append 832 records	:34	:32	:11
Delete	:02	:02	:01
Pack	:12	:11	:04
Count	:07	:07	:03
Sort	1:08	:54	:19
ENGINEERING/SCIENTIFIC			
Minicad 3.15			
Load	:25	:23	:06
Redraw	13:40	11:37	2:54
Hide and shade	16:19	14:55	3:59
Data Desk 1.12			
Regression analysis	5:13	5:13	1:01
Correlation analysis	5:59	5:59	1:17
COMPILERS			
Lightspeed C 2.11			
XLISP compile	2:51	2:25	1:02
Turbo Pascal 1.0			
Pascal S compile	:17	:14	:07

*** Insufficient memory to spell-check BYTE benchmark large document

Disk I/O Benchmarks

As storage subsystems become responsible for more and more of the time you spend at the computer, it becomes more important to get an accurate picture of how a particular disk will affect total system performance. If hardware and software vendors could agree on a single way to access disks, the job of benchmarking would be easy. Unfortunately for those of us who have to write and run the benchmarks, there are almost as many schemes for getting at storage as there are storage devices.

In addition to the number of access methods and interfaces available, the number of components involved with any storage access makes accurate performance testing of any one component very difficult. In general, the storage device itself, the device controller, and the computer's operating system are involved with any transaction. In some interface systems, such as small-computer-system-interface (SCSI) systems, a device driver is involved as well.

In most situations, it's impossible and nonsensical to divorce the performance of the disk from the performance of its controller or driver. Our benchmarks don't attempt to force this separation, concentrating instead on factoring various degrees of operating-system overhead out of the performance equation. Since different programmers and hardware designers view the facilities of operating systems with varying degrees of contempt, we varied the tests based on how heavily they rely on each operating system's file system.

The first test in the suite is the BIOS-level benchmark. On an IBM PC or compatible running MS-DOS, this benchmark "goes around" the operating system, manipulating the disk with direct calls to the machine BIOS. This test is designed to gauge the speed of the disk/controller combination, with as much of the operating system overhead as possible factored out of the results.

The program begins by getting information from the disk and then proceeds to test the disk in four stages, with each stage repeated 100 times. The program first seeks between the two outermost tracks, reading one sector on each. It then seeks between the two innermost tracks, the outermost and middle tracks, and the outermost and innermost tracks, reading a sector on each track. The times from all these seeks are collected, and an "average seek time" is calculated.

The following is pseudocode for the BIOS-level benchmark:

```
begin main
 get_disk_info
```

continued

We gave this card a built-in IC memory.

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512K bits
*(1M bits)
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64K bits 128K bits 256K bits
512K bits 1M bits

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Circle 190 on Reader Service Card

```
      disk_identifier
      number_of_heads
      number_of_cylinders
      sectors_per_track
  outer_track_seek
     first = outermost_track
     second =
  next_to_outermost_track
     doseek (first, second)
     display (accumulated_time)
  inner_track_seek
     first =
  next_to_innermost_track
      second = innermost_track
      doseek (first, second)
      display (accumulated_time)
  half_platter_seek
     first = outermost_track
     second = (total_tracks)/2
     doseek (first, second)
     display (accumulated_time)
  full_platter_seek
      first = outermost_track
      second = innermost_track
      doseek (first, second)
      display (accumulated_time)
  end main

  begin doseek (first, second)
    accumulated_time = 0
    begin repeat (100 times)
       begin_timing
       seek to (first), sector 1
       read 1 sector
       seek to (second), sector 1
       read 1 sector
       stop timing (calculate
           elapsed_time)
       accumulated_time =
           accumulated_time +
       elapsed_time
   end repeat
  end doseek
```

We have confidence in the results we get from this test, but it does have a couple of shortcomings. First, since it deals with the hardware in a most intimate fashion, the program is quite hardware-dependent. It will have to be significantly rewritten for new systems that might come out. The second will become more apparent as more of the world moves to the SCSI interface for hard disks. SCSI is a black-box design that effectively hides the geometry of the device from programmers. It is so effective at this hiding that our BIOS-level test will simply not translate to the SCSI environment.

The next benchmark is not nearly so subversive as the BIOS-level test. In the second BYTE disk-subsystem benchmark, the operating system is used, but at a level of explicit device calls instead of relying on its file system. The testing methodology is relatively straightforward in an MS-DOS system. The main portion of the program is run twice. In the first iteration, the device is told to step through its sectors in 10 even steps, reading one sector at each step. In the second iteration, the same 10 steps are used, but eight sectors are read at each stop. The time for each of these iterations is reported. This test is designed to be portable across a variety of system types, though we realize that some degree of reprogramming will be required for each new system.

Pseudocode for OS Level—Explicit:

```
begin main
  test_device = drive to be
      tested
get_disk_info (test_device)
   disk_identifier
   number_of_heads
   number_of_cylinders
   sectors_per_track
   total_sectors
accumulated_time = 0
sector = 0
  begin repeat (50 times)
  track_seek (0,1)
  begin repeat (10 times)
    sector = sector +
       (total_sectors/10)
    begin_timing
    track_seek (sector,1)
     end_timing; calculate
       elapsed time
   accumulated_time =
      accumulated time+elapsed
      time
   end repeat
   report (accumulated_time)
end repeat

begin repeat (50 times)
   accumulated_time = 0
   sector = 0
   track_seek (0,1)
   begin repeat (10 times)
   sector = sector +
     (total_sectors/10)
   begin_timing
   track_seek (sector,8)
   end_timing; calculate
       elapsed time
   accumulated_time =
      accumulated
      time+elapsed time
  end repeat
  report (accumulated_time)
 end repeat
end main

begin track_seek
      (sector_position,
        #_sectors_to_read)
 move to sector at
      (sector_position)
 read (#_sectors_to_read)
end track_seek
```

A case in point is the way this benchmark was ported to SCSI drives under the Macintosh operating system. After several conversations with the folks at Jasmine Technologies, who produce SCSI drives, we decided that going beneath the Finder to make calls directly to the device driver provided by the disk drive manufacturer results in the functional equivalent of the MS-DOS version. This is probably the test that will require the most effort to port to new interfaces and operating systems.

The third test owes a great debt to our old file I/O C-language benchmark. The program is designed to measure the interaction of the disk/controller and the operating system's file system. In the normal course of working with a storage device, three basic operations exist: creating files, appending files, and reading files. The benchmark creates 10 files of varying sizes. Each is then appended by a chosen amount. The test then uses an arbitrarily chosen number (actually a constant pseudorandom number) to determine the location and size of the reads and writes that follow. Reading and writing in the last portion are performed at a ratio of three reads for every write, since this approximates the usage pattern of disk users we observed. The accumulated times for reading, writing, and seeking are returned, along with the total number of bytes written and read.

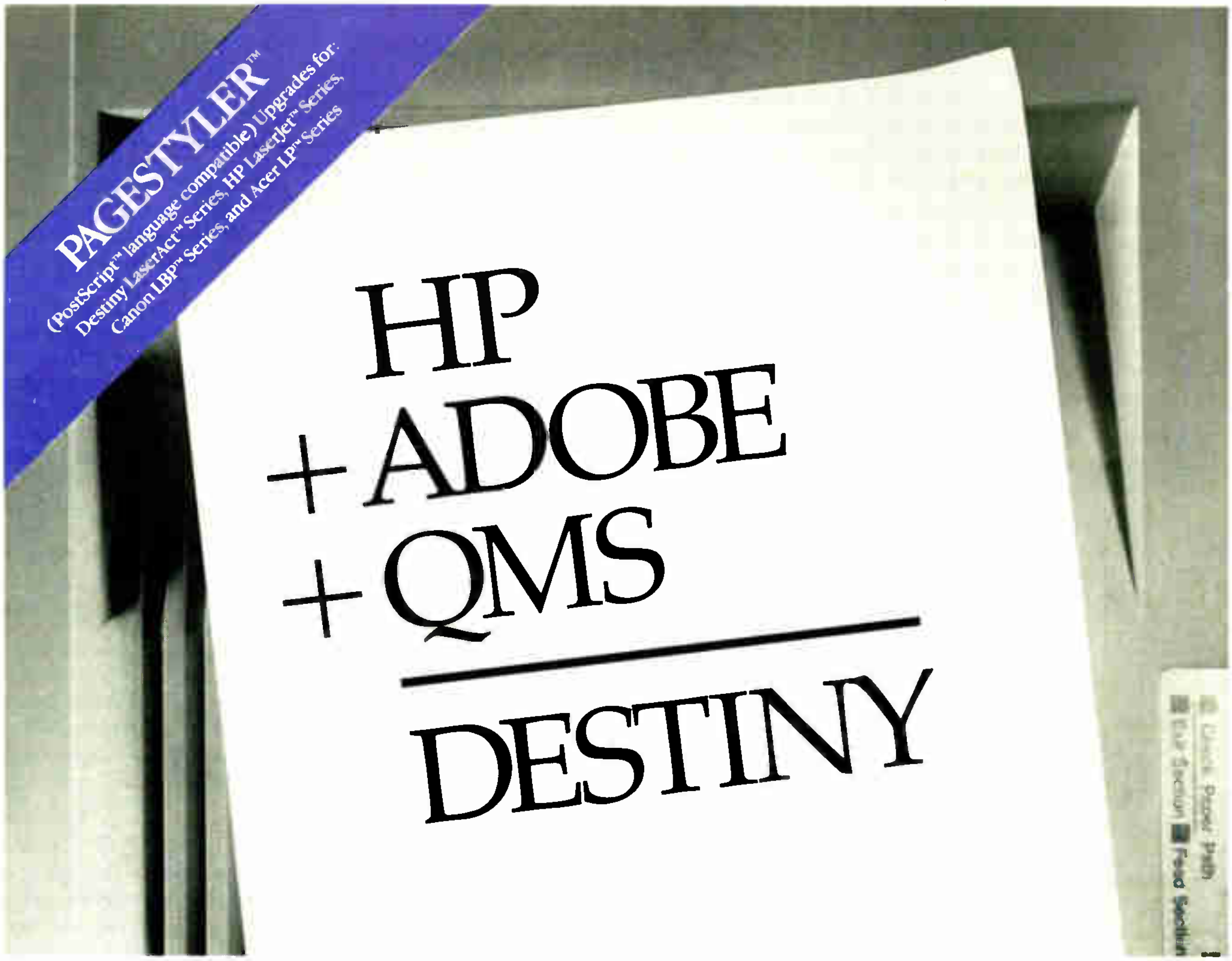
This program translated readily to the Macintosh. The only significant change was to allow for the difference in the way the 80x86 and 680x0 processors deal with pointers to disk addresses. The 80x86 processor requires two integers for the pointer, and so two "random" numbers must be generated for the read and write addresses. The 680x0 uses a single 32-bit integer and requires only one "random" number.

Pseudocode for OS-Level File:

```
begin main
 count = 120
 write_time = 0
 write_bytes = 0
 read_time = 0
 read_bytes = 0
 seek_time = 0
 total_seeks = 0
 begin repeat (10 times)
    create_file
 end repeat
 begin repeat (10 times)
   extend_file
 end repeat
 random_read_and_write
 report
end main

begin create_file
 file0_size = 4000
 file1_size = 10000
 file2_size = 500
 file3_size = 2800
 file4_size = 25000
 file5_size = 14000
 file6_size = 8000
 file7_size = 8800
 file8_size = 300
 file9_size = 21111
 for each file begin
    open filex
```

continued



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```
    write_bytes = write_bytes +
        filex_size
    begin timer
    write to file
    end timer; calculate
      elapsed_time
    write_time = write_time +
      elapsed_time
    close filex
  end
end create_file

begin extend_file
 file0_append = 12000
 file1_append = 20300
 file2_append = 31111
 file3_append = 3400
 file4_append = 9099
 file5_append = 20755
 file6_append = 7000
 file7_append = 400
 file8_append = 22000
 file9_append = 27000
 for each file begin
    open filex for appending
    write_bytes = write_bytes +
       filex_append
    begin timer
    append file
    end timer; calculate
        elapsed_time
    write_time = write_time +
        elapsed_time
    close filex
 end
end extend_file

begin random_read_and_write
 begin repeat (COUNT times)/*see
       main for value of
    COUNT*/
   begin repeat (3 times)
      select random file
      select i random sectors
        into file
       open file
       begin timer
       seek i sectors into file
       end timer; calculate
         elapsed_time
       seek_time = seek_time +
         elapsed_time
       total_seeks = total_seeks
              + 1
       select n random bytes to
         read
       begin timer
       read n bytes
       end timer; calculate
           elapsed_time_read
       read_time = read_time +
           elapsed_time_read
       read_bytes = read_bytes +
              n
       close file
   end repeat
   select random file
   select i random sectors into
           file
   open file
   begin timer
   seek i sectors into file
   end timer; calculate
          elapsed_time
   seek_time = seek_time +
          elapsed_time
   total_seeks = total_seeks +
          1
   select n random bytes to write
   begin timer
   write n bytes
   end timer; calculate
          elapsed_time_write
   write_time = read_time +
          elapsed_time_write
   write_bytes = write_bytes +
          n
   close file
 end repeat
end random_read_and_write
```

The final test in our suite is simplicity itself. It uses all the help the operating system can offer to first write and then read a 1-megabyte file. Here is pseudocode for Large File Read and Write:

```
begin write
 allocate 10000 byte buffer
 fill buffer with character 'A'
 open file 'bigfile.dat'
 begin timer
 begin repeat (100 times)
   write buffer to file
 end repeat
 end timer
 close file
 report
end write

begin read
 allocate 10000 byte buffer
 open file 'bigfile.dat'
 begin timer
 begin repeat (100 times)
    read file to buffer
 end repeat
 end timer
 close file
 report
end read
```

In all, we've tried to create a suite of tests that will give all users an idea of how a disk subsystem will perform in a variety of circumstances, and will also give users with special requirements an indication of how the device will perform with the level of control they require.

BYTE Video Benchmarks

One of the most fundamental operations a microcomputer performs frequently is writing to its display. Like the process of printing a document, this type of task can become "bound" by the rate at which the display hardware can update the screen. Naturally, faster display hardware permits these video operations to finish sooner, freeing the processor to handle other tasks. Our tests measure this aspect of a microcomputer's performance.

Deciding how best to measure this particular microcomputer subsystem posed a bit of a problem. A test of any sophistication became dependent on the algorithms used to implement the test program. This is clearly undesirable: The first requirement for the tests is that the effect of the software should be minimized. This means that the benchmarks should be coded in assembly language to minimize this effect and to execute as fast as possible.

However, another requirement of the benchmarks, at odds with the first, is that the benchmark programs have to run on a wide variety of machines, meaning that the test programs have to be portable as well. Fine-tuned assembly language procedures garner the best possible speeds for a given microcomputer but would be useless on another machine, and might not even work on the same machine with a new operating system or a new version of the old operating system.

The problem was resolved by devising a set of simple low-level video benchmark tests that would test certain basic graphics operations. The bulk of the benchmark programs would be written in Small-C, and, where it became necessary, assembly language would be used to operate the display hardware.

An important point must be made here. These programs were primarily designed to be portable. The best possible implementation for a given test was not used, nor were the tests designed to provide the fastest possible speed. The benchmarks provide a nominal measurement of basic graphics operations that could be compared across machines.

Having said that, what did we decide to measure? For IBM PCs, PC compatibles, and PS/2 systems, there are several basic video operations: writing characters (text), positioning the cursor, and manipulating pixels. For the Macintosh, everything drawn on the screen is a collection of pixels: Theoretically, there is no distinction between text and graphics. Nevertheless, the Macintosh is used often as a word processor where text is manipulated on the screen, so we believe that, in reality, the distinction between text and graphics still applies.

Video Specifics

Measuring text throughput is simply a matter of writing a certain number of characters on the screen and measuring the time it takes to do this. Since cursor positioning is often used in word-processing applications, we decided that its effects would also be measured as a part of text operations. First, 80,000 characters of text are written to the display. Then the cursor is repositioned, and 80,000 characters are written again.

Pseudocode for the new BYTE Text Throughput benchmark:

continued

Listing 1: *Source for BYTE's new Sieve benchmark. If you're a regular reader, you'll find it's practically identical to the source we've used before. The only additions are the timing functions* `gtime()` *and* `calctim()`.

```
/*
** BYTE Sieve Benchmark  Version 1 for 8088/8086/80286/80386
** Feb. 17, 1988  Written in BYTE Small-C
** Based on Small-C by J.E. Hendrix
** This program executes the infamous Eratosthenes Sieve Prime
** Number Program from BYTE, Jan. 1983.
**
** Operation:
** 1. Turn on stopwatch
** 2. Execute SIEVE for LOOP iterations
** 3. Turn off stopwatch
** 4. Report time and number of primes found
** 5. Exit
*/
#include stdio.h
#define size  8190
#define LOOP  100
#define TRUE  YES
#define FALSE NO

    int tblock[4];      /* Timer holding array */
    char flags [size + 1];

main()

{
    int i, prime, k, count, iter;

/* Announce yourself */
    printf("BYTE Sieve Benchmark\n");

    printf("%d iterations\n",LOOP);

/* Start timer and execute loop */
    gtime(tblock);
    for (iter = 1; iter <= LOOP; iter++)
          {
          count = 0;                 /* prime counter */
          for (i = 0; i <= size; i++) /* set all flags true */
                flags [i] = TRUE;
          for (i = 0; i <= size; i++)
               {
                    if (flags [i])    /* found a prime */
                    {
                    prime = i + i + 3; /* twice index + 3 */
/*                  printf ("\n%d", prime);  */
                    for (k = i + prime; k <= size; k+= prime)
                                flags [k] = FALSE;
                                    /* kill all multiple */
                    count++; /* primes found */
                    }
                }
      }
      calctim(tblock);

/* Report results */
     printf("Results:  (HH:MM:SS:1/100ths)\n");
     printf("Elapsed time: %d:%d:%d:%d\n\n",tblock[0],
             tblock[1],tblock[2],tblock[3]);

     printf ("%d primes.\n\n", count);
                    /* primes found on 100th pass */

/* Exit */
     printf("Press RETURN to exit:");
     fgetc(stdin);
     exit(0);
 }
```

Listing 2: *Source for the major routines of the Sort benchmark.*

(a) *The Quicksort algorithm.*

```
qsort(aray,bot,top)
int aray[],bot,top;
{
 int i,j,temp;
  while(bot<top) {
/* Set ranges and choose
partitioning element */
  i=bot;
  j=top;
  temp=aray[bot];
/* Partition array */
  while(i<j) {
   while(aray[j]>temp) j-=1;
   aray[i]=aray[j];
   while((i<j)&&(aray[i]<=temp))
     i+=1;
   aray[j]=aray[i];
  }
  aray[i]=temp;
/* Call qsort recursively */
  qsort(aray,bot,i-1);
  bot=i+1;
  }
}
```

(b) *The Shell sort routine.*

```
shsort(aray,bot,top)
int aray[],bot,top;
{
 int i,gap,nex,temp;
/* Set gap width */
  gap=(top-bot)/2;
  do {
   do {
    nex=1;  /* No exchanges yet */
    for(i=0;i<=top-gap;++i )
    { if(aray[i]>aray[i+gap])
      {  temp=aray[i];
         aray[i]=aray[i+gap];
         aray[i+gap]=temp;
         nex=0; /* Exchange happened */
      }
    }
    } while(nex==0);
   gap=gap/2;
  } while(gap!=0);
}
```

(c) *The heapsort routine.*

```
hsort(aray,bot,top)
int aray[],bot,top;
{
 int i,temp;
/* First...make a heap */
  for(i=(top/2);i>1;--i)
   sift(aray,i,top);
/* Extract maximum */
  for(i=top;i>1;--i) {
   sift(aray,0,i);
   temp=aray[0];
   aray[0]=aray[i];
   aray[i]=temp;
  }
}

sift(aray,i,j)
int aray[],i,j;
{
 int k,temp;
 while((2*i)<=j) {
  k=2*i;
  if(k<j)
  if(aray[k]<aray[k+1]) ++k;
  if(aray[i]<aray[k]) {
   temp=aray[k];
   aray[k]=aray[i];
   aray[i]=temp;
   i=k;
  }
  else i=j+1;
 }
 return;
}
```

```
begin main
    count = 80000
    get_current_mode(old_mode)
     ;get current
     ; video mode
    prompt_user_for_mode(video_mode)
     ;see what user
     ; wants
    length =
    determine_length(video_mode)
     ;type of
     ; mode determines
     ; number of chars per
     ; line
    string =
     build_string(length)
    lines = count / length
    row = column = 1
    row_counter =
     column_counter = 1
    begin timer
    switch_video_mode(video_mode)
    begin repeat (lines)
     ;write string
     ; to display
    display_string(string,
     length)
    end repeat
    begin repeat (count)
     move_cursor(row, column)
      ;position
      ; cursor...
     display_char(char, 1)
      ; ...and write
      ; character
     if (row = 25) row_counter =
       -1
     if (row = 0) row_counter
       = 1
     if (column = length)
      column_counter = -1
     if (column = 0)
      column_counter = 1
     row = row + 1
     column = column + 1
     if ((char + 1) > 'Z')
      char = 'A'
    end repeat
    end timer
    compute time
    switch_video_mode(old_mode)
    ;restore original
    ; mode
    report(accumulated_time)
    begin timer
     ;time loop overhead
    begin repeat (lines)
    end repeat
    begin repeat (count)
    end repeat
    end timer
    compute time
    report(accumulated_time)
end main
```

Although graphics operations are simply a matter of manipulating pixels, pixel throughput requires more than simply blasting pixels to the display. Pixels are used to represent objects. As these objects are drawn, the state of certain pixels must be read to permit certain graphics operations, such as clipping, to be performed on the object. Finally, drawing these objects can require that certain areas of the screen be flooded or filled with colors. Since the color must fill only the object, this again requires that the state of pixels be read. Since objects on the screen are typically drawn and then filled, the object drawn for the Pixel Throughput test is flooded with color using a seed fill.

For the Pixel Throughput test, the object drawn is a circle. We chose a circle for the target object because, interestingly enough, the algorithm for drawing a circle was much simpler than algorithms to draw lines; thus, it minimized the code overhead for the test. The circle is drawn eight times around a common origin, with the radius of each successive circle increasing by a fixed amount. Once each circle is drawn, it is filled with a color using a seed-fill algorithm, and then the next circle is drawn. The seed-fill algorithm may not be the fastest possible for this test, but the seed fill demands that the state of many pixels be read and written, which is the point of the measurement.

Pseudocode for the new BYTE Pixel Throughput benchmark:

continued

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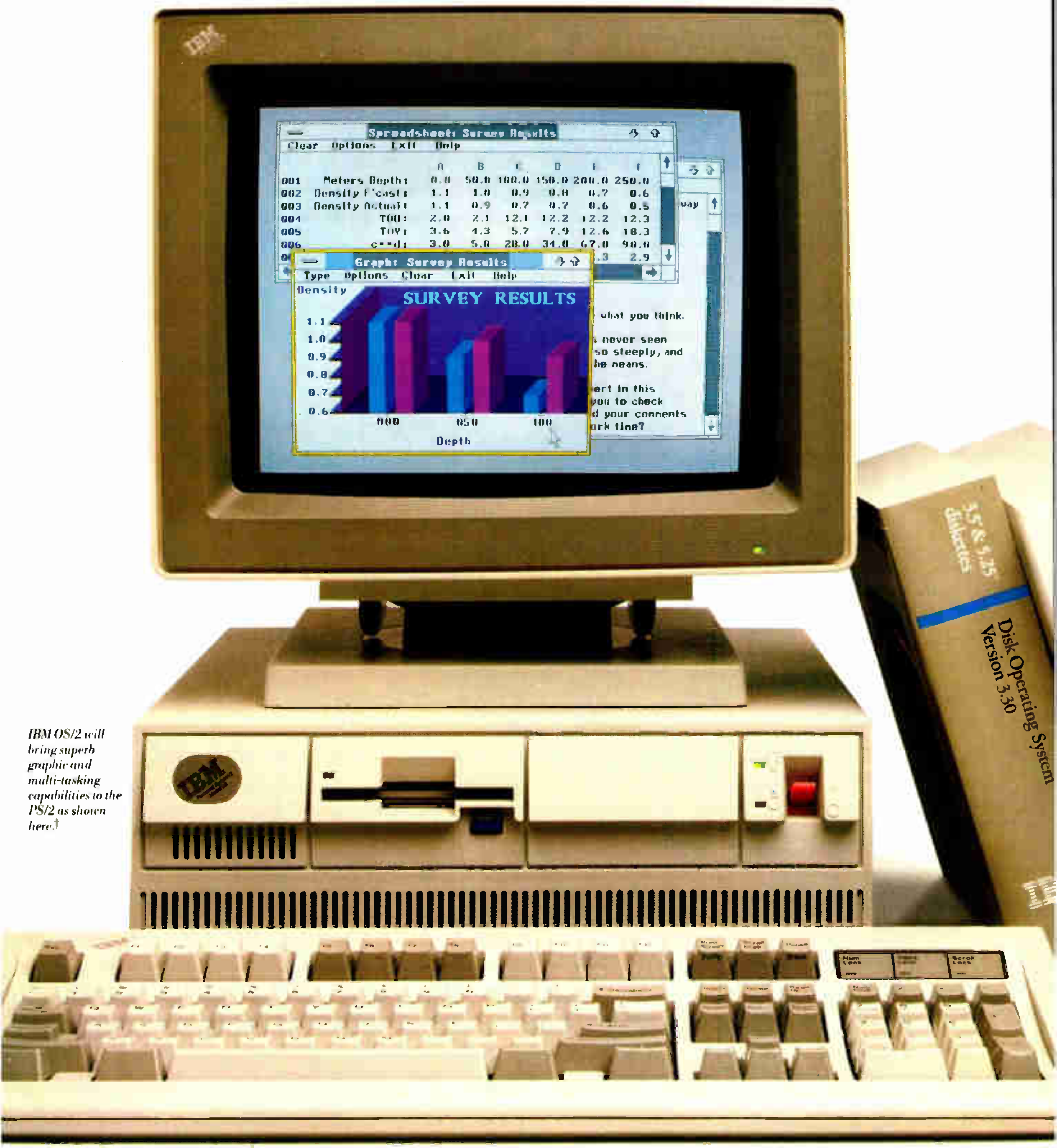

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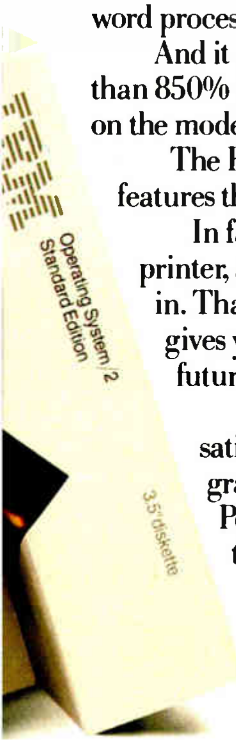

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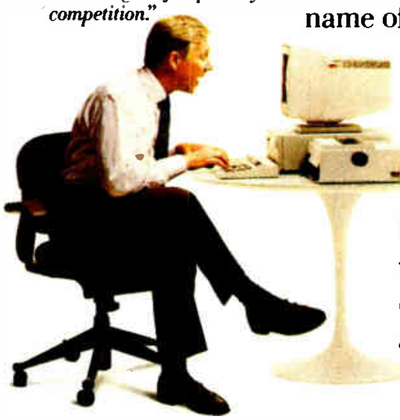

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IBM. The Bigger Picture

*Based on performance test results published in the April, 1987 and January, 1988 issues of *PC Digest*, comparing the PS/2 Models 30, 50, 60 and 80 to the IBM PC XT, running Lotus 1-2-3 and DisplayWrite 4.
†This simulated screen shown was developed using the IBM Storyboard Plus program. IBM, Personal System/2 and PS/2 are registered trademarks; PC XT, Operating System/2, OS/2, Micro Channel and DisplayWrite are trademarks of IBM Corporation. Lotus and 1-2-3 are registered trademarks of Lotus Development Corporation. © IBM 1988.

Listing 3: *The major components of the Matrix benchmark:* **(a)** *adds two square matrices,* **(b)** *multiplies two square matrices, and* **(c)** *performs the transposition of a matrix. Note that Small-C supports only one-dimensional arrays, so we have to simulate square matrices.*

(a)
```
madd(aray1,aray2,aray3,trows,tcols)
int aray1[],aray2[],aray3[];
int trows,tcols;
{
 int i,j;
 for (i=0;i<trows;++i)
  for(j=0;j<tcols;++j)
   aray3[i*tcols+j]=aray1[i*tcols+j]+
   aray2[i*tcols+j];
   return;
}
```

(b)
```
mmult(aray1,aray2,aray3,row1,col1,row2,col2)
int aray1[],aray2[],aray3[];
int row1,col1,row2,col2;
{
int i,j,k;
for(i=0;i<row1;++i)
 for(j=0;j<col2;++j)
 {  aray3[i*col1+j]=0;
    for(k=0;k<col1;++k)
    aray3[i*col1+j]+=aray1[i*col1+k]*
                     aray2[k*col2+j];
  }
  return;
}
```

(c)
```
mtrans(aray1,aray2,row,col)
int aray1[],aray2[];
int row,col;
{
 int i,j;
  for(i=0;i<col;++i)
   for(j=0;j<row;++j)
    aray2[i*col+j]=aray1[j*row+i];
  return;
}
```

```
begin main
    number_of_circles = 7
    get_current_mode(old_mode)
        ;get current video
        ; mode
prompt_user_for_mode(video_mode)
        ;see what user
        ;wants
    switch_video_mode(video_mode)
        ;change mode
    set_size(video_mode, cx, cy)
        ;get x-y limits for
        ;this mode
    begin timer
    radius = 20
        ;starting size
    draw_circle(cx, cy, radius,
        color)
    begin repeat
        (number_of_circles)
      radius = radius + 10
      draw_circle(cx, cy,
     radius, color)
          ;draw new
          ; circle
      flood_circle(cx+radius-5,
         cy, color) ;flood the
                          ; circle
    end repeat
    end timer
    compute time
    switch_video_mode(old_mode)
         ;restore original
         ; mode
    report(accumulated_time)
end main
```

The benchmark programs work reliably across the IBM PC family, from the first PC to the PS/2 Model 80. This is because the video buffer's address has remained stable over time, although the size of the video buffer has grown. A menagerie of video modes has been introduced since then, each with its own idiosyncrasies.

Nevertheless, the PC video benchmark programs support MDA, CGA, EGA, MCGA, VGA, and Hercules graphics modes. The test prompts the user for the desired video mode, and the output is modified as necessary to support the mode requested. The timings for the tests are measured by the computer under test.

For the Macintosh, a window of fixed size is opened. This window fits within the smallest Mac display: the 9-inch diagonal built-in monitor on the Mac Plus and Mac SE. The active port is set to this window, and the graphics operations are run. QuickDraw is used to draw text or pixels in the window. Again, the computer itself times the operations to minimize error.

Down the Pike

As graphics boards with coprocessors become available, the benchmarks will be modified to work with them. If necessary, more sophisticated tests will be devised to thoroughly test the new capabilities provided by these coprocessors.

Applications-Level Benchmarks

BYTE's new applications-level benchmarks are designed to measure system performance in five areas of interest: science/engineering, database management, word processing, software development using compilers, and spreadsheet calculation. Each application area places a different balance of demands on a system's resources, and, as a result, a group of systems may achieve different rankings in the various tests.

The key variables that determine performance in these tests are CPU, effective presence of an FPU, effective presence of a GPU, operating system, speed of memory, and disk. (We say "effective" because not all applications are written in such a way as to take advantage of numeric and graphics coprocessors, relying instead on the CPU.) The terms FPU and GPU refer not necessarily to chips but also, in some cases, to floating-point or graphics processor boards.

Why test applications, given the abundance of numbers emanating from our low-level and mid-level tests? Primarily as a reality check. Most users will not have firsthand experience with our lower-level benchmarks, but they will almost certainly have some experience with one or more of the application areas we're testing. Perform a global replace on 1000 occurrences of the word *first*—anyone can relate to that. Our applications benchmarks will give you an easy-to-grasp handle on system performance.

Applications benchmarks also offer some corroboration of the results from lower-level tests. A system that does extremely well on the FPU benchmarks should excel in certain areas of our engineering/scientific benchmarks as well. In cases where our applications results are at odds with our lower-level measurements, deeper probing is called for. This brings up a third use for applications

continued

BYTE Small-C

Richard Grehan

Small-C has a history that stretches back to 1980 when Ron Cain first presented it in the May *Dr. Dobb's Journal of Computer Calesthenics and Orthodontia*. Originally written for 8080-based CP/M machines (there were lots around back then), Small-C's attraction was its ability to compile itself. Compiling a program with Small-C yielded assembly language source that you fed to M80 and L80 (Microsoft's CP/M assembler and linker) to create an executable file. Though Small-C handled only a subset of the features of a full-blown C compiler (e.g., it supported only `char` and `int` data types), it was powerful enough to handle applications that were quite robust. For proof, check the references at the end of this text box. L. E. Payne and J. E. Hendrix took this version of Small-C, added substantially to its syntax, and presented a hefty system library for the language. Again, this version of Small-C ran on 8080-based CP/M machines.

BYTE Small-C is a modified version of Hendrix and Payne's Small-C with all the necessary enhancements added to bring it to processors and operating systems in widest use today. As of this writing, BYTE Small-C is running on the 8088/8086 (and 80286) under PC-DOS, on the 68000 and 68020 of the Macintosh family, and on the 80386 using Phar Lap's RUN386 environment. As with the original Small-C, BYTE's version emits source code that you hand to the appropriate assembler and linker. I've tried to keep the language as consistent across ports as possible; I've also tried to keep the library routines as similar to Payne and Hendrix's in operation and call structure as I could. There are some differences—some good, some bad.

Here's a potpourri of major features BYTE Small-C enjoys (or doesn't enjoy) over its predecessors:

- The original Small-C handled many of its logical, math, and comparison operations by calling a math/logic library. When you consider that Small-C was running on an 8080 processor, the reasons for this are obvious—a 16-bit subtraction operation could consume many bytes of code. BYTE Small-C encodes such operations "in-line," and it can do this thanks to the improved instruction sets of today's processors. The result is faster code, since the program doesn't have to do a `CALL` instruction just to perform an add or subtract. For some operations, this also generates more code (since some comparison operations require several instructions), but given the amount of memory most machines have today, I decided that the speed-to-size trade-off was worth it.
- The 8088/8086/80286 version of BYTE Small-C defines integers as being 16 bits big. The 80386, 68000, and 68020 versions, however, use 32-bit integers. Pointer variables follow the same pattern (which means, of course, that the data area for an 8088/8086/80286 program is restricted to 64K bytes).
- The 8088/8086/80286 version generates code that is MASM-compatible. The 68000 and 68020 version emits MDS assembler/linker-compatible code. Finally, the 80386 version produces code for Phar Lap's 386|ASM/LINK package. I've recoded the library for the PC-DOS machines to make use of the DOS functions added with DOS 2.0 and higher (i.e., the Unix-style file I/O calls). The Macintosh version uses a run-time library adapted from code first presented by Steve Williams (see references).

Finally, I would like to personally thank the people who have gone before me, and whose work made all this possible—namely, Ron Cain, J. E. Hendrix, L. E. Payne, and Steve Williams. They have all put staggering amounts of time into work that they have graciously shared with us, and they have permitted us to share it with you. BYTE Small-C will be released into the public domain in source-code form (see page 3 for details). Use it, modify it, learn from it, and all we ask is that if you create something with it, give conspicuous credit to those whose efforts brought it to you.

REFERENCES
1. Hendrix, J. E. *The Small-C Handbook*. Reston, VA: Reston Publishing Company, 1984.
2. *Dr. Dobb's Toolbook of C*. New York, NY: Prentice-Hall, 1986.
3. Williams, Steve. *Programming the Macintosh in Assembly Language*. Berkeley, CA: Sybex, 1986.

Richard Grehan is a BYTE senior technical editor at large.

benchmarks—as a way of measuring total system performance.

In most applications, we have selected more than one program to use. We picked programs that have a significant user base and fit nicely with our testing needs (e.g., having macro languages and the ability to execute batch files). Where possible, we picked programs that are available on both the Macintosh and the PC.

Avoid the natural temptation to see these tests as software benchmarks. For instance, in the word-processing area, we are not testing the performance of Word versus XyWrite on MS-DOS computers; the tests weren't set up to make that kind of comparison at all. We use more than one program in each category as a way of better covering the application, and to gain extra assurance that our overall rankings are independent of the particular program we used to test the application performance. For instance, it might be that XyWrite and Word would produce a different ranking on a given set of computer systems. That's important, because it tells you that there may be no clear winner in that application area.

Science/Engineering

Scientific and engineering applications place heaviest emphasis on graphics and numeric processing. We divide this area into CAD, statistics, and numeric analysis/plotting of functions. All our applications programs will use the 80x87 (68881 for the Mac) FPU if one is installed.

For the CAD test, we use a 208,172-byte `.DWG` file called `SOFTWEST.DWG` that produces a multilayer printed circuit board layout. The file is from The Great Softwestern Company and was specifically designed to exercise CAD functions. We also use AutoCAD's St. Paul's Cathedral file, `STPAULS.DWG`; the drawing includes thousands of vectors and is a good test of raw graphics speed. Timed tests are:

SE1. Load and display `SOFTWEST.DWG`. Disk and computation time dominate.
SE2. Regenerate the screen image. For such a large file, disk and computation

continued

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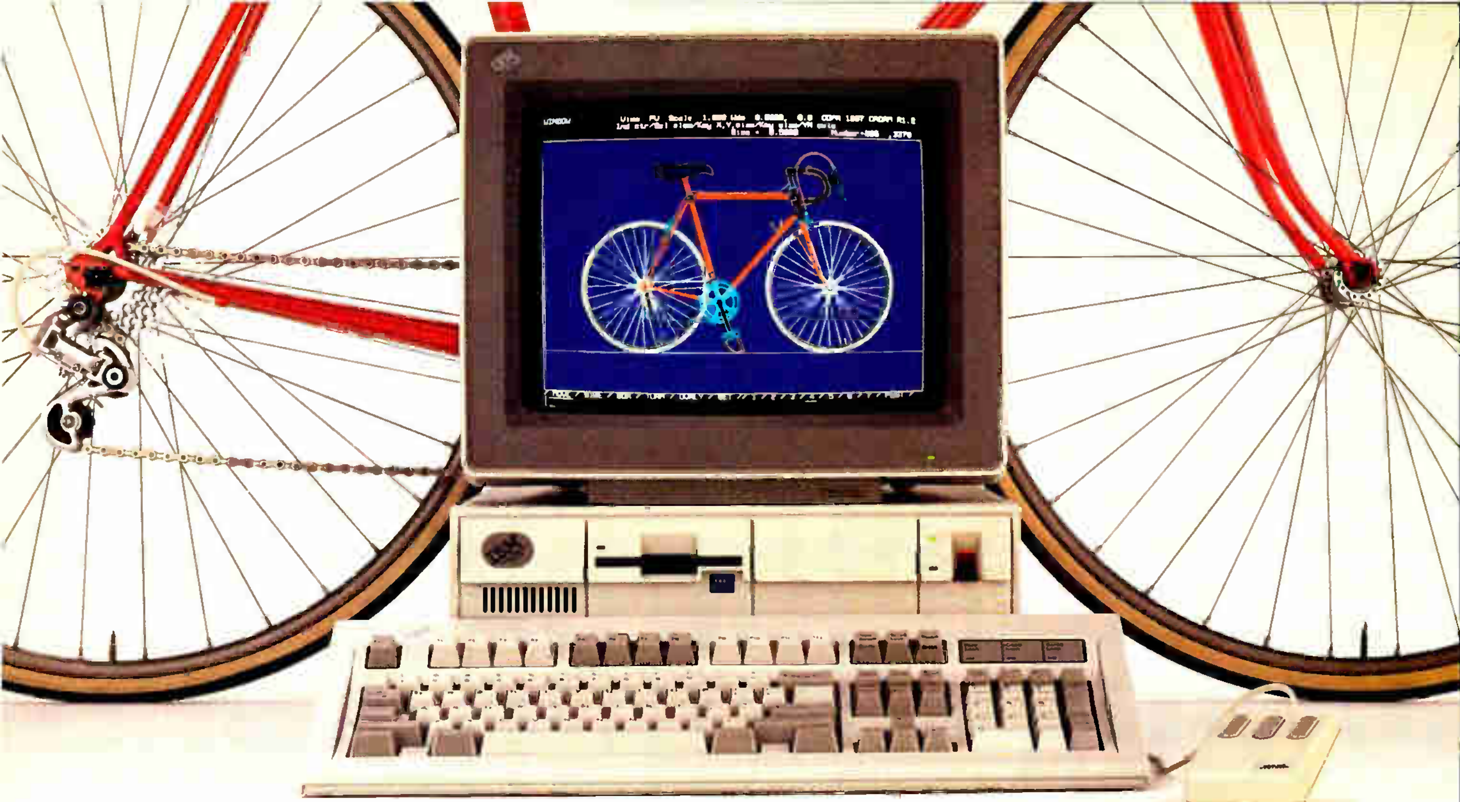

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Small-C Support Functions

To aid in the crafting of the low-level benchmarks, we created quite a number of support functions to interface with our Small-C programs. This is particularly true of the floating-point coprocessor benchmark. So that you'll find the source and pseudocode in this article more readable, here is a brief catalog of the more important functions and what they do.

Floating-Point Functions

Small-C has no floating-point type, so the library functions operate on blocks of 8 bytes (you can use a four-element integer array). This means that numbers are manipulated in the IEEE long-real-number format (i.e., 1 bit for the sign, 11 bits for the exponent, and 52 bits for the mantissa). Nearly all these floating-point functions operate on their arguments via pointers.

•`finit()`—Initialize the floating-point coprocessor.
•`fint2float(ptr)`—Converts the 2's complement integer (stored as a quadword) pointed to by `ptr` into floating-point format.
•`ffloat2int(ptr)`—Converts the floating-point number at `ptr` to a 2's complement integer (quadword).
•`f2add(fac1,fac2,dest)` — Adds the floating-point number at `fac1` to the floating-point number at `fac2` and places the result at `dest`.
•`f2sub(fac1,fac2,dest)` — Subtracts the floating-point number at `fac2` from the floating-point number at `fac1`, placing the result at `dest`.
•`f2mult(fac1,fac2,dest)` — Multiplies the floating-point number at `fac1` by the floating-point number at `fac2`, placing the result at `dest`.
•`f2mult(fac1,fac2,dest)` — Divides the floating-point number at `fac1` by the floating-point number at `fac2`, placing the result at `dest`.
•`fload(ptr)`—Loads the floating-point number onto the top of the coprocessor's internal stack.
•`fstore(ptr)`—Stores the top number on the coprocessor's internal stack at `ptr`.
•`fadd(ptr)`, `fsub(ptr)`, `fmult(ptr)`, `fdiv(ptr)`—These functions operate like their `f2xx` counterparts mentioned above, except that `fac1` is the top number on the coprocessor's stack, `fac2` is given by `ptr`, and the result is left on the coprocessor's stack.
•`fabs()`—The top number on the coprocessor's stack is set to its absolute value.
•`fconst(n)`—Loads the top of coprocessor stack with the constant given by `n`. For `n=0,1,2`, the constants loaded are 0, 1, and π, respectively.
•`fcompz(ptr)`—The floating-point number at `ptr` is compared with 0. This function returns a −1 if less, 0 if equal, and +1 if greater.
•`fcomp(ptr1,ptr2)`—This function returns −1 if `ptr1<ptr2`, 0 if `ptr1=ptr2`, and +1 if `ptr1>ptr2`.
•`fsin(ptr,dest)`—Calculates the sine of the floating-point number at `ptr` and returns the result in `dest`.
•`fex(ptr,dest)`—Calculates e^x, where x is given by the number at `ptr`. Stores the result at `dest`.
•`fltprint(n,ptr)`—Prints the floating-point number at `ptr` in scientific notation (i.e., `+/-x.xxxxxE+/-yyy`). The integer `n` selects the number of digits (up to 19) to print.

Timing Functions

•`gtime(tblock)`—This function returns the current system time in the four-element integer array `tblock[]`, so that `tblock[0]` holds hours, `tblock[1]` holds minutes, `tblock[2]` holds seconds, and `tblock[3]` holds hundredths of a second for MS-DOS machines, or sixtieths of a second for Macs.
•`calctime(tblock)`—This function calculates the difference between the current time and the time held in the `tblock[]`. The resulting elapsed time is returned in the `tblock[]` array and has the same format as described in the `gtime()` function.

time still dominate.
SE3. Load and display `STPAULS.DWG`.
SE4. Calculate the hidden lines and display. Computation time and memory handling dominate this item.
SE5. Regenerate the `STPAULS.DWG`. Graphics speed dominates this number.

We use AutoCAD for MS-DOS computers and Minicad for the Macintosh. Tests SE1, SE2, and SE3 are primarily dependent on disk access and computational speed; SE5 is the most direct indicator of graphics throughput, since the calculations have been completed already and display lists generated. Test SE4 is again computation- and memory-han-

continued

dling-dependent, since it requires generation of a 10,000-plus list of hidden lines.

For statistical work, we use STATA 1.5 (MS-DOS) and Data Desk Professional (Macintosh). In the MS-DOS case, we execute two do-files; one (SE6) performs a series of ANOVA operations, and the other constructs and displays 27 data graphics. In the Macintosh case, we do a regression analysis and a correlation analysis on a set of 10 1000-observation variables.

As an additional check on computation speed, we ran a couple of models written for the MS-DOS-based MathCAD program. One model (reported as SE7) performs an iterative floating-point operation to generate 800 x,y points in a list, and then plots the points; another computes the fast Fourier transform (FFT) and inverse FFT on a 1024-point data set. The time to execute the entire FFT is reported as SE8.

Database Management

We use dBASE III Plus (MS-DOS) and dBASE McMax (Macintosh) as typical DBMS tools. Both packages run a do-file that performs eight timed tests using a 1200-record, 490K-byte mailing list.

DB1. Copy 1200 records to another file.
DB2. Create an index file on a randomly sorted field.
DB3. Using the indexed file, list last name, first name, country to the screen.
DB4. Using the indexed file, append 832 records to the database.
DB5. Using the indexed file, seek and delete the appended records.
DB6. Pack the (unindexed) database.
DB7. Count records with a specified country field.
DB8. Sort the database to another file, two sort keys.

Word Processing

The word-processing tests use XyQuest's XyWrite III Plus, Microsoft Word 4.0, and Aldus PageMaker 1.0a for MS-DOS computers; and MacWrite 5.0, Microsoft Word 3.01, and Aldus PageMaker 2.0a for Macintosh computers. Two ASCII documents are used: `small.txt` (6072 words) and `large.txt` (24,108 words). For the PageMaker test, we fill in Aldus's blank Business Templates with our own text and graphics files to create a 35-page handbook document.

Using a XyWrite macro program, we time each of the following operations for `small.txt` and `large.txt`:

WP1. Load document (`large.txt` only).
WP2. Count words.
WP3. Global search and replace, then

continued

Listing 4: *BYTE's new floating-point benchmark.*

```
/*
** BYTE Small-C Floating-Point Benchmark
** Version 1 for 8088/8086/80286
** March, 1988
** Written in BYTE Small-C
** Based on Small-C by J.E. Hendrix
**
** Operation:
** 1. Initialize the coprocessor.
** 2. Execute fourbang(), which:
**     a. Generates space for temporaries and constants.
**     b. Turns on stopwatch.
**     c. Executes loop FCOUNT times.  Loop consists of:
**        8 each of floating add, subtract, multiply, divide.
**     d. Turns off stopwatch.
**     e. Calculates time for an empty loop.
**     f. Reports time and result of operations.
** 3. Executes finteg(), which:
**     a. Generates space for temporaries and constants.
**     b. Turns on stopwatch.
**     c. Executes a trapezoidal integration method for sin(x)
**        from 0 to pi/2.
**     d. Turns off stopwatch.
**     e. Calculates time for an empty loop.
**     f. Reports time and result of operation.
**     g. Turns on stopwatch.
**     h. Executes a trapezoidal integration method for e^(x)
**        from 0 to 1.
**     i. Turns off stopwatch.
**     j. Calculates time for an empty loop.
**     k. Reports time and result of operation.
** 4. Exits.
**
** NOTE:
** Since Small-C does not support floating-point, we simply
** manipulate floating-point numbers as 4-element integer
** arrays.  The floating-point library functions handle the
** actual calls to the coprocessor, including the routine
** to print out a floating-point number.
**
** Expected results:
** For first test: 1.000000000E1  (10.0)
** For trapezoidal of sine(x): 1.000000000E0  (1.0)
** For trapezoidal of e^x: 1.718281828E0 (e-1)
*/

#include stdio.h

#define FCOUNT 20000   /* Number of times the four-banger test */
            /* is repeated.            */
#define ICOUNT 32000   /* Stepsize for the integration test    */

/* Timer holding variables */
int tblock[4];
int mtblock[4];        /* For empty loop timing */

main()
{
     /* Announce yourself */
     printf("BYTE Small-C Floating-Point Coprocessor Benchmark\n\n");

     /* Initialize the math coprocessor */
     finit();

     /* Do four-banger test */
     fourbang();

     /* Do integration */
     finteg();
```

```
     /* Go home */
     finit();

     printf("Press RETURN to exit:");
     fgetc(stdin);

     exit(0);
}

/*
** fourbang()
** Executes a loop of floating-point additions, subtractions,
** multiplications, and divisions.
*/
fourbang()
{
     int ten[4];    /* Holder for 10 */
     int one[4];    /* Holder for one */
     int temp[4];   /* Temporary storage */
     int i;

     /* Announce yourself */
     printf("Basic Math Test (+,-,*,/)\n");

     /* First set up constants */
     ten[0]=10;
     ten[1]=ten[2]=ten[3]=0;
     fint2float(ten);
     fconst(1);
     fstore(one);

     /* Initialize temp location */
     fload(ten);
     fstore(temp);

     gtime(tblock);
     /* Do the operation */
     for(i=0;i<FCOUNT;++i)
     {
          f2add(temp,one,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2div(temp,ten,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2add(temp,ten,temp);
          f2div(temp,ten,temp);
          f2add(temp,one,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2div(temp,ten,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2add(temp,ten,temp);
          f2div(temp,ten,temp);
          f2add(temp,one,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2div(temp,ten,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2add(temp,ten,temp);
          f2div(temp,ten,temp);
          f2add(temp,one,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2div(temp,ten,temp);
          f2sub(temp,one,temp);
          f2mult(temp,ten,temp);
          f2add(temp,ten,temp);
          f2div(temp,ten,temp);
     }
     calctim(tblock);
```

continued

```
/* Now calculate an empty loop */
gtime(mtblock);
for(i=0;i<FCOUNT;++i) ;
calctim(mtblock);

/* Report results */
printf("***Results: (All times are HH:MM:SS:1/100ths\n");

printf("Total time: %d:%d:%d:%d\n",tblock[0],tblock[1],
    tblock[2],tblock[3]);

printf("Empty loop time: %d:%d:%d:%d\n",mtblock[0],mtblock[1],
    mtblock[2],mtblock[3]);
printf("Value:");
fltprint(10,temp);
printf("\n\n");

return;

)

/*
** finteg()
** Do integration.
**
*/

finteg()
{

    int two[4];       /* Holder for two */
    int pitwo[4];     /* Holder for pi/2 */
    int temp[4];      /* Temp location */
    int sinex[4];     /* Sine value */
    int ex[4];        /* e^x value */
    int accum[4];     /* Accumulator */
    int x[4];      /* Holder for x */
    int i;

    /* Announce yourself */
    printf("Trapezoidal rule for sin(x) 0->x->pi/2 \n");

    /* Generate 2 */
    two[0]=2;
    two[1]=two[2]=two[3]=0;
    fint2float(two);

    /* Generate pi/2 */
    fgetpi2();         /* Get pi over two */
    fstore(pitwo);        /* Store pi over two */

    /* Generate stepsize */
    temp[0]=ICOUNT;
    temp[1]=temp[2]=temp[3]=0;
    fint2float(temp);
    f2div(pitwo,temp,temp);   /* Stepsize in temp */

    /* Clear accumulator */
    fconst(0);
    fstore(accum);

    /* Store x(0) */
    fconst(0);
    fstore(x);

/* Do trapezoidal rule for sine(x) */
    gtime(tblock);
    for(i=0;i<ICOUNT+1;++i)
    {
```

continued

```
        fsin(x,sinex);          /* Get sinex */
        f2add(accum,sinex,accum);
        if((i!=0)&&(i!=ICOUNT))
          f2add(accum,sinex,accum);
        f2add(x,temp,x);   /* Increment by step */
    }
    f2mult(accum,temp,accum);     /* Times stepsize */
    f2div(accum,two,accum);       /* Divided by 2 */

    /* Calculate time */
    calctim(tblock);

    /* Get time for an empty loop */
    gtime(mtblock);
    for(i=0;i<ICOUNT+1;++i) ;
    calctim(mtblock);

    /* Report results */
    printf("**** Results: (All times are HH:MM:SS:1/100ths)\n");

    printf("Total time:  %d:%d:%d:%d\n",tblock[0],tblock[1],
        tblock[2],tblock[3]);
    printf("Empty loop time: %d:%d:%d:%d\n",mtblock[0],mtblock[1],
        mtblock[2],mtblock[3]);

    printf("Value:");
    fltprint(10,accum);
    printf("\n\n");

/* Now do trapezoidal rule for e^x */

    printf("Trapezoidal rule for e^x  0->x->1\n");

    /* Generate stepsize */
    temp[0]=ICOUNT;
    temp[1]=temp[2]=temp[3]=0;
    fint2float(temp);
    fconst(1);

    fdiv(temp);
    fstore(temp);      /* Stepsize in temp */

    /* Clear accumulator */
    fconst(0);
    fstore(accum);

    /* Store x(0)  */
    fconst(0);
    fstore(x);

    /* Do trapezoidal rule */
    gtime(tblock);
    for(i=0;i<ICOUNT+1;++i)
    {
        fex(x,ex);          /* Get sinex */
        f2add(accum,ex,accum);
        if((i!=0)&&(i!=ICOUNT))
          f2add(accum,ex,accum);
        f2add(x,temp,x);   /* Increment by step */
    }
    f2mult(accum,temp,accum);    /* Times stepsize */
    f2div(accum,two,accum);      /* Divided by 2 */

    /* Calculate time */
    calctim(tblock);

    /* Get time for an empty loop */
    gtime(mtblock);
    for(i=0;i<ICOUNT+1;++i) ;
    calctim(mtblock);
```

continued

```
    /* Report results */
    printf("***** Results: (All times are HH:MM:SS:1/100ths)\n");

    printf("Total time:  %d:%d:%d:%d\n",tblock[0],tblock[1],
        tblock[2],tblock[3]);
    printf("Empty loop time: %d:%d:%d:%d\n",mtblock[0],mtblock[1],
        mtblock[2],mtblock[3]);

    printf("Value:");
    fltprint(10,accum);
    printf("\n\n");

    /* Go home */
    return;
}

/*
** fgetpi2()
** Puts the value pi/2 on top of the floating-point stack.
*/
fgetpi2()
{
    int two[4];     /* Holder for 2 */

    two[0]=2;
    two[1]=two[2]=two[3]=0;
    fint2float(two);

    fconst(2);      /* Get pi on top of stack */
    fdiv(two);      /* pi/2 now on floating point stack top */
    return;
}
```

search and replace the original text (small.txt = (6072 − 4898) × 2 = 2348 instances, large.txt = (24,108 − 20,477) × 2 = 7262 instances).
WP4. Find the last page of the paginated document.
WP5. Perform 12 block moves.
WP6. Spell-check.

With Word, we time the following:

WP7. Move cursor down 640 lines.
WP8. Delete forward, 1552 characters.

MacWrite doesn't do word counts (WP2), so we use a desk accessory, MultiWord Counter. Microsoft Word does tests WP3, WP7, and the store.

PageMaker provides us with an opportunity to manipulate both text and graphics in a desktop publishing test. We take a large document and then time these operations:

WP9. Load text document (20,586 words of text).
WP10. Convert all text from normal to bold.
WP11. Realign all text from the left to right column guide.
WP12. Cut the first 10 text pages and refill the document.
WP13. Place a large graphic.
WP14. Output the document to a PostScript printer file.

The tests are the same for MS-DOS and Mac machines, except for the graphic placed in WP12. For MS-DOS we use a 70K-byte AutoCAD PLT file, and for the Mac we use an 80K-byte scanned encapsulated PostScript format image.

Spreadsheet

Our spreadsheet tests use Lotus 1-2-3 on MS-DOS computers and Microsoft Excel on both MS-DOS and the Macintosh; these are leading packages for the respective machines. We time the following tests for Lotus 1-2-3:

SP1. Given a 75 by 2 spreadsheet (t1) of the form:

```
1           (a75*1.001)
(a1*1.001)  (b1*1.001)
(a2*1.001)  (b2*1.001)
...   ...
(a75*1.001) (b75*1.001)
```

perform an overlapping block copy as follows: from (b1..bw75) to (c1..bx75), resulting in an extension of the above matrix to 75 by 75.
SP2. Recalculate.
SP3. Load a sparse-matrix spreadsheet RLARGE300.WKS (81,440 bytes).
SP4. Recalculate.
SP5. Load a 330K-byte Monte Carlo simulation spreadsheet.
SP6. Recalculate.
SP7. Run a 1-2-3 binary search macro program to seek a result to a tolerance of 10^{-10}.

For Excel, we use a 45 by 45 matrix and do a block fill, the equivalent to an overlapping block copy. We also add an undo fill command to further test the machine's number-crunching capability:

SP8. Fill right.
SP9. Undo fill right.
SP10. Recalculate 45 by 45 matrix.
SP11. Load RLARGE300.WKS.
SP12. Recalculate.

SP1 is a good test of the basic spreadsheet function for relative addressing and block copies with relative addressing, indicating CPU speed and memory-access time. The presence of an FPU would be a major factor in SP2.

SP3 is a test of disk-access time and general computation time. The sparse matrix (i.e., a large, widely distributed percentage of cells are empty) places demands on a spreadsheet's memory-handling functions.

Compilers

Two compiler tests round out our applications benchmarks. For MS-DOS systems, we chose two widely used compilers, Microsoft C 5.0 and Turbo Pascal 4.0. For Macintosh systems, we selected Lightspeed C 2.11 and Turbo Pascal 1.0.

The C test is a compilation of XLisp source files. The source consists of 25 files containing 225K bytes of code. For Pascal, we compile the Pascal S source code, which consists of three files containing 44K bytes of code.

The Fundamental Things Apply

There you have them—the new BYTE microcomputer benchmarks. As you've seen, each is the result of a good deal of consultation, introspection, and analysis. The process is open-ended, too. Some of these benchmarks are going to be modified as new equipment appears—but then again, that's the beauty of what we've done. We've now got benchmarks that can remain consistent and valid in spite of updates. It's probably not entirely appropriate to tell people to enjoy themselves by exploring the intricacies of something as picayune as benchmarks, but at least we're confident that you can run these tests with the assurance of accuracy and the understanding that you'll be gaining important, objective information. ■

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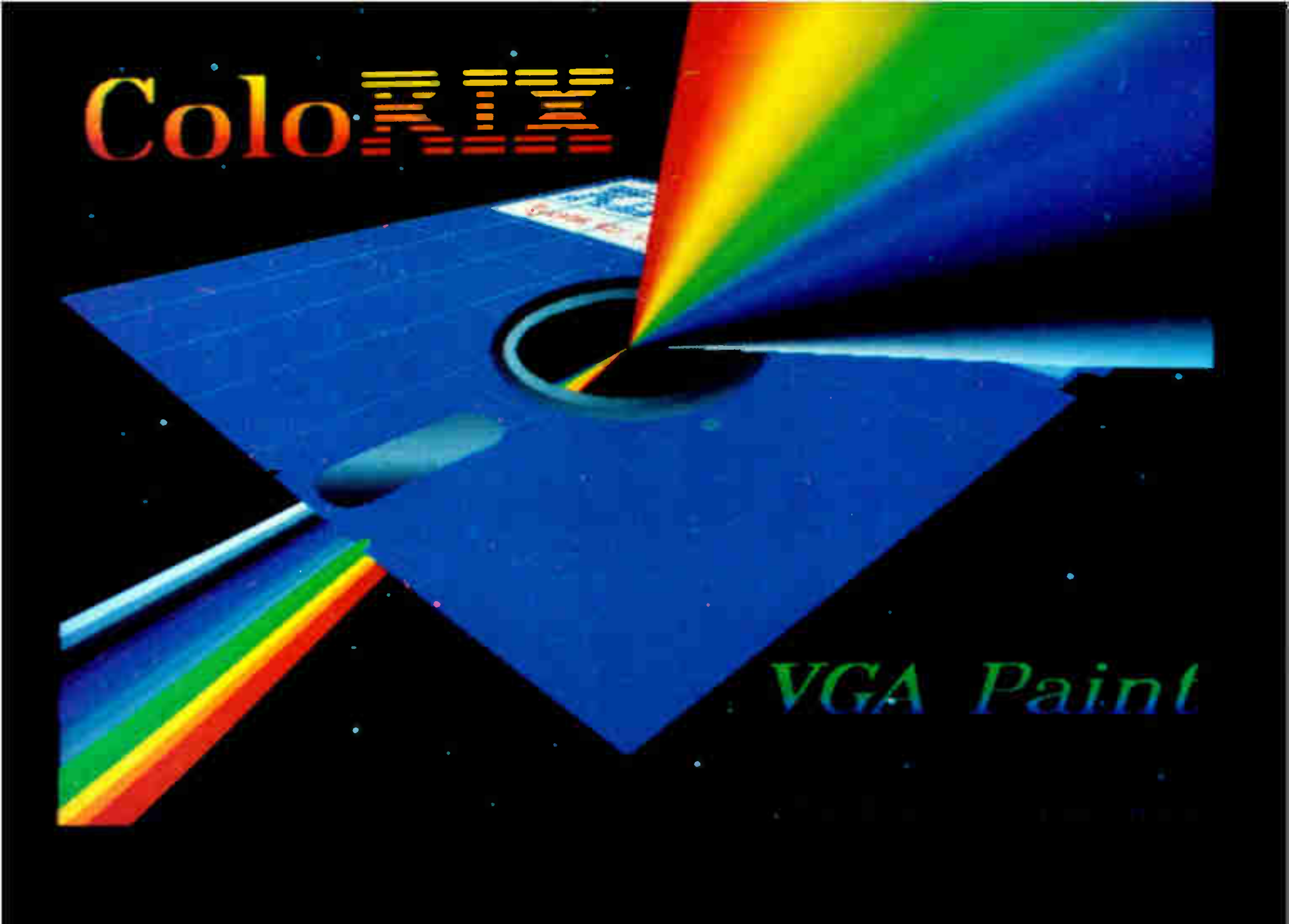

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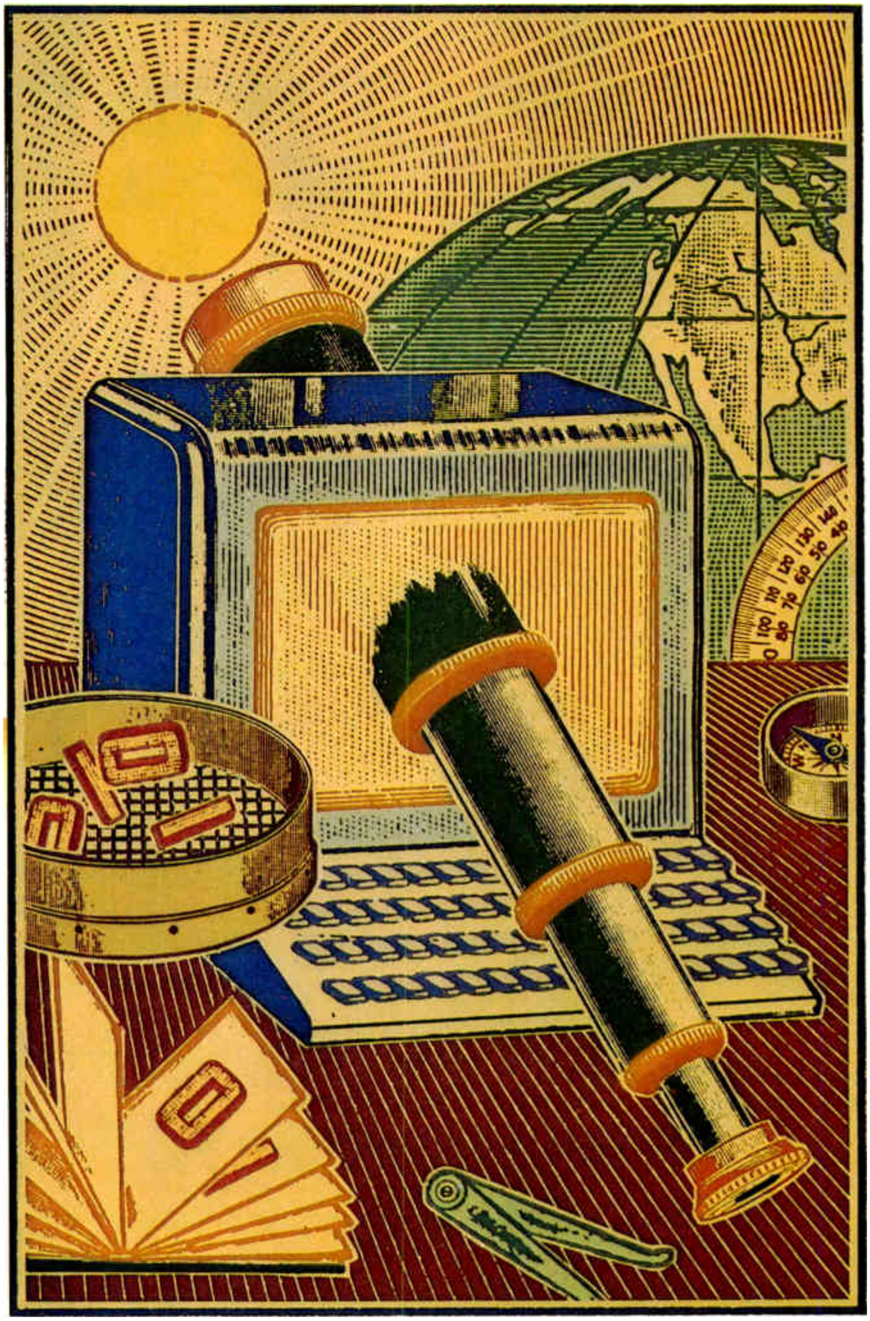
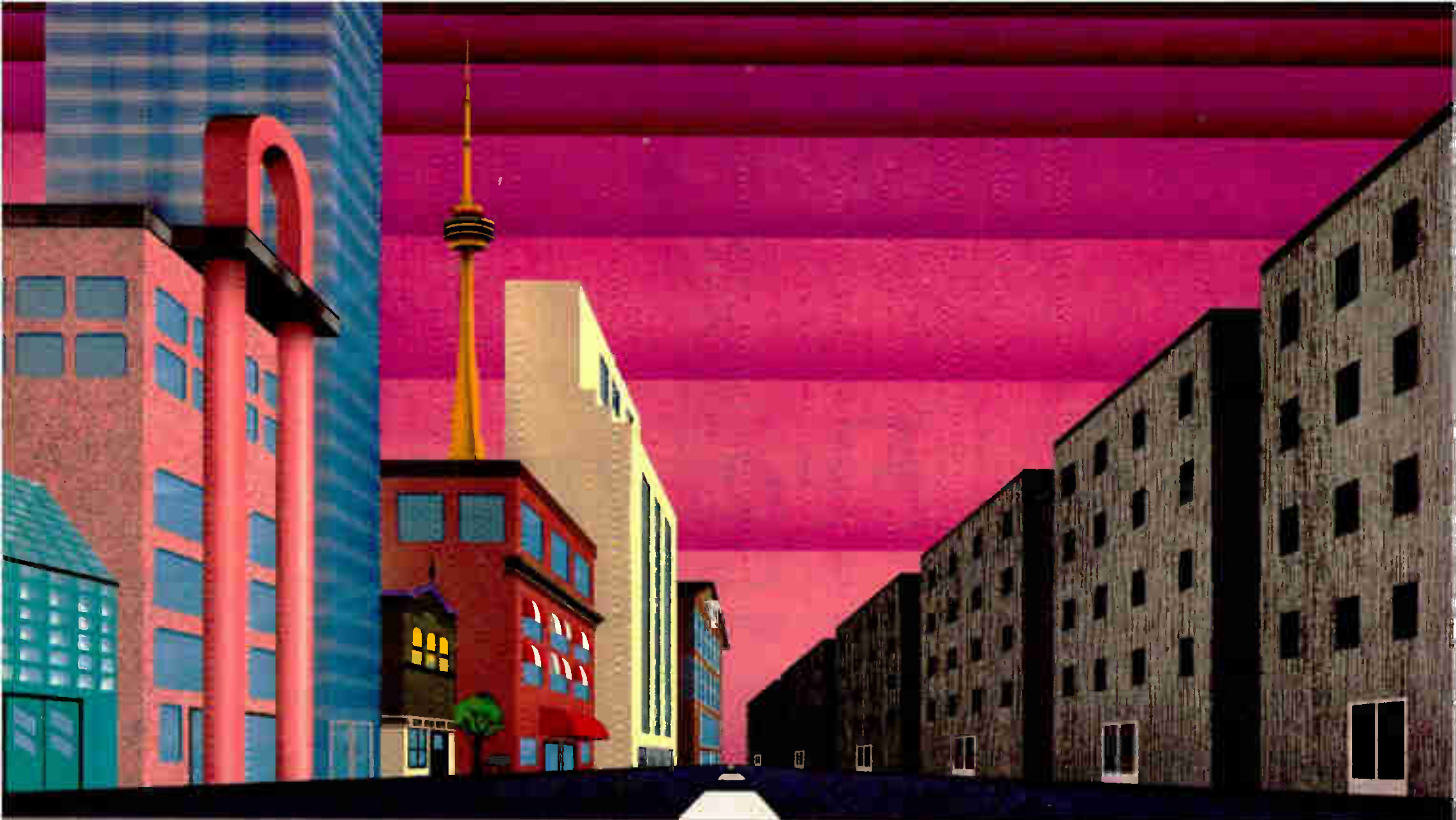
Features





QNX vs. OS/2 UNIX

QNX: Bend it, shape it, any way you want it.

ARCHITECTURE If the micro world were not so varied, QNX would not be so successful. After all, it is the operating system which enhances or limits the potential capabilities of applications. QNX owes its success (over 55,000 systems sold since 1982) to the tremendous power and flexibility provided by its modular architecture.

Based on message-passing, QNX is radically more innovative than UNIX or OS/2. Written by a small team of dedicated designers, it provides a fully integrated multi-user, multi-tasking, networked operating system in a lean 148K. By comparison, both OS/2 and UNIX, written by many hands, are huge and cumbersome. Both are examples of a monolithic operating system design fashionable over 20 years ago.

MULTI-USER OS/2 is multi-tasking but NOT multi-user. For OS/2, this inherent deficiency is a serious handicap for terminal and remote access. QNX is both multi-tasking AND multi-user, allowing up to 32 terminals and modems to connect to any computer.

INTEGRATED NETWORKING Neither UNIX nor OS/2 can provide integrated networking. With truly distributed processing and resource sharing, QNX makes all resources (processors, disks, printers and modems anywhere on the network) available to any user. Systems may be single computers, or, by simply adding micros without changes to user software, they can grow to large transparent multiprocessor environments. QNX is the mainframe you build micro by micro.

PC's, AT's and PS/2's OS/2 and UNIX severely restrict hardware that can be used: you must replace all your PC's with AT's. In contrast, QNX runs superbly on PC's and literally soars on AT's and PS/2's. You can run your unmodified QNX applications on any mix of machines, either standalone or in a QNX local area network, in real mode on PC's or in protected mode on AT's. Only QNX lets you run multi-user/multi-tasking with networking on all classes of machines.

REAL TIME QNX real-time performance leaves both OS/2 and UNIX wallowing at the gate. In fact, QNX is in use at thousands of real-time sites, right now.

DOS SUPPORT QNX allows you to run PC-DOS applications as single-user tasks, for both PC's and AT's in real or protected mode. With OS/2, 128K of the DOS memory is consumed to enable this facility. Within QNX protected mode, a full 640K can be used for PC-DOS.

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QNX

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Circle 237 on Reader Service Card

Part 1

Steve Ciarcia

Computers on the Brain

Clever signal amplifiers, noise rejection, and A/D conversion are all part of the HAL EEG

A lot has been written recently about artificial intelligence (AI). Some writers declare that we are on the threshold of the most important advances in computing since Boole and Babbage began fooling around with two-valued logic and the difference engine. Others decry the hype and note that the majority of recent software releases are now touting some form of AI influence in their design or execution, weakening the meaning of the term in order to sell products.

Even after 100 years of study, not all psychologists are in complete agreement as to what constitutes intelligent behavior (look around you—how much have you seen lately?). Intelligence has generally been defined as the global ability to solve problems, to adapt to new situations, to form concepts, and to profit from experience.

However, it is obvious that there are many different types of behavior—many different ways of responding to the same problem—that can be called intelligent. Within the last 20 years, experts have paid much attention to the basic types of intelligence and how they are mediated by the biological substrate of the human brain.

Experts have long supposed that human beings use two major modes of thought: the way of reason and the way of emotion. A commonsense view is that these two ways of thought occasionally conflict. Some writers conceptualize the differences as analytic versus synthetic, successive versus simultaneous, or even digital versus analogical.

Paralleling the conceptualization of two modes of thought have been the results of research on the two hemispheres of the brain. Psychobiologist Roger Sperry of the California Institute of Technology won the 1981 Nobel Prize for Physiology and Medicine for his studies on the functions of the two hemispheres of the brain.

Essentially, Sperry and his colleagues studied individuals who had undergone a commissurotomy, an operation that severs the main bundle of nerve fibers that support the bulk of neural communication between the left and right hemispheres. They found that each hemisphere seems somewhat specialized for different tasks. For approximately 95 percent of the population (right-handed individuals and two-thirds of left-handed individuals), it appears that the left hemisphere of the brain is better organized for executing tasks characterized as:

- Verbal: language skills, speech, reading and writing, recalling names and dates, and spelling.
- Analytical: logical and rational evaluation of factual material.
- Literal: literal interpretation of words.
- Linear: sequential information processing.
- Mathematical: numeric and symbolic processing.
- Contralateral movement: controlling movement on the right side of the body.

The right hemisphere is better organized for tasks characterized as:

- Nonverbal: using imagery rather than words.
- Holistic: processing information simultaneously, in parallel.
- Visuospatial: functions involving perceptions of location and spatial relationships.
- Emotional: experiencing feelings.
- Dreaming: imaginative and metaphoric visual image-making.
- Contralateral movement: controlling movement on the left side of the body.

Hemispheric Activation Level Detector

This month's Circuit Cellar project is a brain-wave-monitoring biofeedback device that provides real-time information about predominant hemisphere activation. That is, this Hemispheric Activation Level Detector (HAL, for short) graphically displays the relative amounts of brain-wave activity in each brain hemisphere (see photo 1).

HAL can distinguish among grossly different conscious states, such as between concentrated mental activity and pleasant daydreaming. For example, if you are debugging a program, HAL should show a predominance of left-hemispheric activity. If you are listening to some light music and daydreaming, it should show a predominance of right-hemispheric activity.

HAL is a relatively sophisticated, low-cost, stand-alone, fully isolated four-channel electroencephalogram (EEG) brain-wave monitor. It gathers analog brain-wave voltages from four sets of scalp contacts, filters them, converts them to digital values, and transmits them via an RS-232C port (making HAL compatible with any computer) for recording or analysis.

HAL includes a two-channel fast Fourier transform (FFT) analysis-and-display routine for an IBM PC. (HAL's PC software is intended only as a graphics display demonstration—and there are limitations in processing power when using a straight 4.77-MHz PC—so it displays only two channels, even though HAL sends data on four channels.) If you have a more powerful machine, you should be able to expand the software to display more channels.

When running this special analysis-and-display package, the PC separates out various amplitudes and frequencies of alpha, beta, and theta waves, as well as phase differences between the hemispheres. The result is a graphical representation of what is going on in your brain in real time.

continued

Warning

HAL is presented as an engineering example of the design techniques used in acquiring brain-wave signals. It is not a medically approved device, no medical claims are made for it, and it should not be used for any medical diagnostic purposes. Furthermore, the safe use of HAL requires that the electrical power and communications isolation described in its design not be circumvented. HAL is designed to be battery-operated only. Do *not* substitute plug-in power supplies.

Analyzing HAL's circuitry illustrates practical design techniques, including differential amplifiers for low-level signal detection in a high-background-noise-level environment, a low-frequency band-pass filtering-rectifying-integrating detector, optoisolation for safety, and A/D conversion.

I'm presenting HAL as a two-part project. This month, I'll look at the problems involved in picking up microvolt-level signals, amplifying and digitizing them, and sending them to your computer.

Science and the Brain

As I investigated this area, I found that a great deal of serious research has been going on regarding what we know about how our brain works. Much of this thinking is finding its way into computer science; even the Macintosh and the IBM PC now have neural-network hardware and software available for the experimenter.

In his book *Megabrain*, Michael Hutchison quotes National Institute of Mental Health neurochemist Candace Pert (discoverer of the opiate receptor in the brain and researcher on endorphins—the brain's own painkillers):

> There's a revolution going on. There used to be two systems of knowledge: hard science—chemistry, physics, biophysics—on one hand, and on the other, a system of knowledge that included ethology, psychology, and psychiatry. And now it's as if a lightning bolt had connected the two. It's all one system—neuroscience. . . . The present era in neuroscience is comparable to the time when Louis Pasteur first found out that germs cause disease.

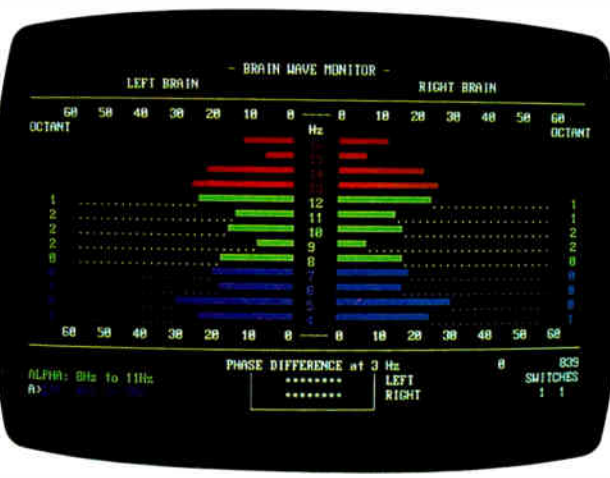


Photo 1: *HAL's output shows energy level by frequency of brain-wave signals for both sides of the brain.*

Hutchison further quotes neuroanatomist Floyd Bloom of the Scripps Clinic in La Jolla, California:

> A neuroscientist used to be like a man in a Goodyear blimp floating over a bowl game: He could hear the crowd roar, and that was about it. But now we are down in the stands. It's not too long before we'll be able to tell why one man gets a hot dog and one man gets a beer.

Much of the activity in this area has centered around the electrical characteristics of the brain. Advances in semiconductor technology have made available inexpensive ICs that let you design physiological monitoring equipment with laboratory quality at experimenter prices. When interest in alpha-wave biofeedback peaked about 15 years ago, a good-quality EEG feedback unit (which provided less information than HAL) cost $1000 for just one channel. Now, you can build four channels for under $200.

Digging into the Waves

The brain is a source of many electrical signals. An EEG is a recording (usually a strip chart) of the electrical potential differences between pairs of electrodes fastened to the scalp.

Silver-silver chloride electrodes pick up the signals. You must take some care to clean the area of the scalp with alcohol and perhaps use a mildly abrasive conducting cream to ensure good electrical contact. Ideally, there will be less than 10 kilohms impedance between any two electrodes, but anything under 25 kohms works (I'll describe placement of the electrodes next month).

It takes a trained eye to determine specific information about a person from an EEG. At present, we can only generalize as to what these recordings mean, and we are unable to correlate specific waveforms with intelligence. The observable electrical activity, however, does offer some clues.

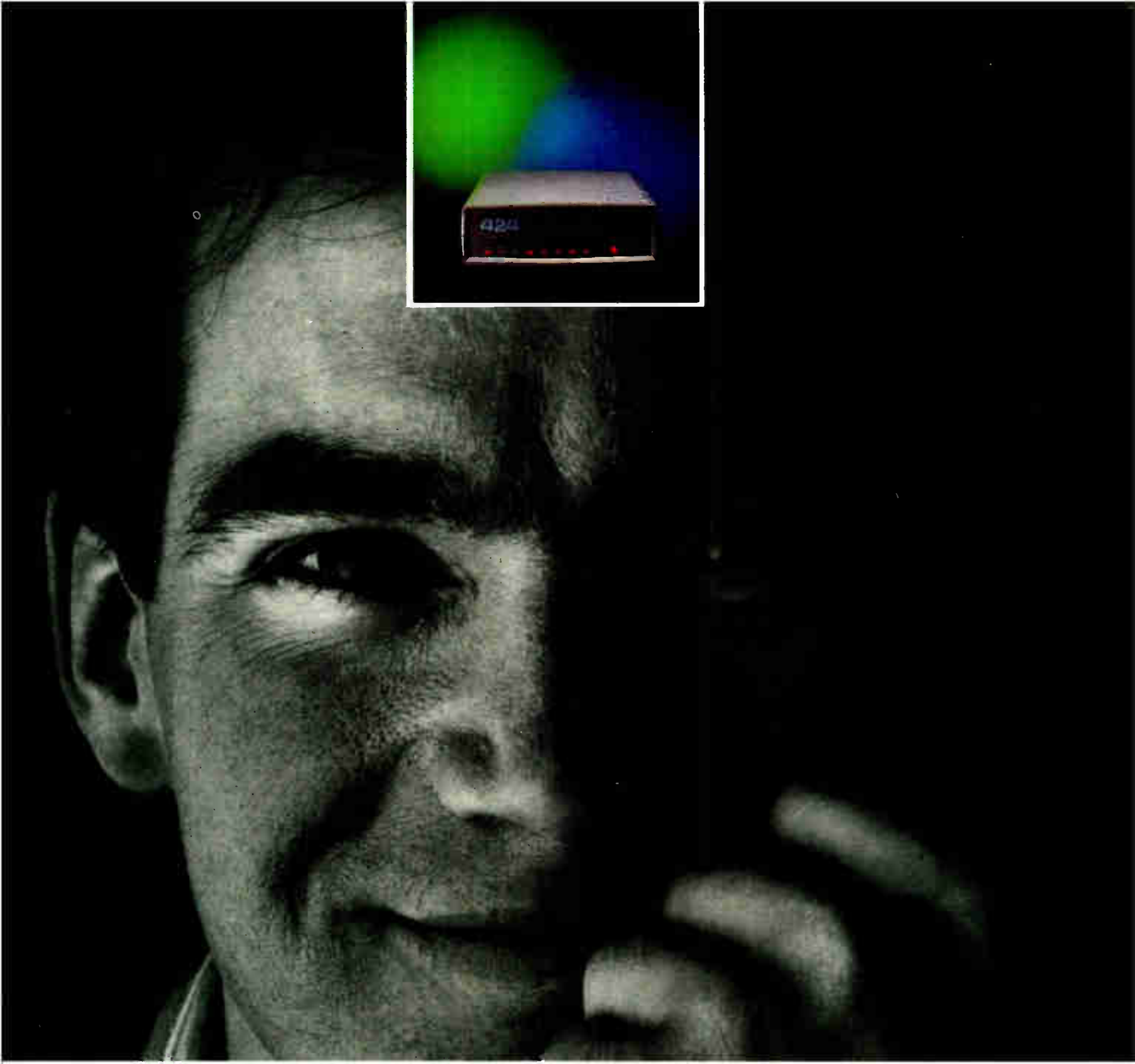
According to medical and psychological research, by monitoring this activity, you could, in a gross way, investigate how the brain functions in a variety of circumstances. For example, if you monitor the two hemispheres while a person is solving problems, the type of problem could be indicated by the relative preponderance of one hemisphere's activity as compared to the other's. Sometimes you can even determine the activity (sleep versus reading; relaxed versus agitated).

The electrical signals we are currently able to monitor and identify from the brain are categorized as follows:

Alpha: Research has already indicated that in an awake person, the presence of alpha waves indicates a relaxed person with an absence of problem-oriented brain activity. (Alpha-wave activity describes electrical activity in the range of 8 to 12 Hz, a nearly sinusoidal signal at a voltage level of between 5 and 150 microvolts [μV]—typically 20 to 50 μV.)
Beta: When a person is thinking or attending to some stimulus, alpha-wave activity is replaced by beta-wave activity (14 to 25 Hz, activity of a lower amplitude).
Theta: Theta-wave activity (4 to 8 Hz, 20 μV and higher) usually appears during sleep, but it has been associated with deep reverie, mental imagery, creativity, dreaming, and enhanced learning ability.
Delta: Delta-wave activity (from 0.5 to 4 Hz) is seen in the deepest stages of sleep.

In addition, you must remember that I am describing an attempt to correlate cerebral electrical activity with subjectively observed events (types of cognitive tasks). While brain waves may be varying tens of times per second, our subjective experi-

continued



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To eliminate unwanted noise, HAL incorporates a band-pass filter that rejects frequencies under 4 Hz and over 20 Hz. While this compromises delta-wave acquisition, it does filter out most of the undesired signals.

ence varies more slowly. It may take a second or two to change concentration and to focus on a new task. Hence, you need to integrate the readings over a short period of time. Previous research in this area suggests that ¼ second to ½ second is reasonable.

A Noisy Environment

It's possible for HAL to "hear" more than we want. HAL is sensitive enough to detect artifactual signals: muscle activity from the forehead, eye and head movements, heart-rate activity, brain-wave "spikes" or irregular slow-wave activity, and—if you're not careful—60-cycle power-line hum. To eliminate this noise, HAL incorporates a band-pass filter that rejects frequencies under 4 Hz and over 20 Hz. While this compromises delta-wave acquisition, the benefit is that it filters out most of the undesired signals.

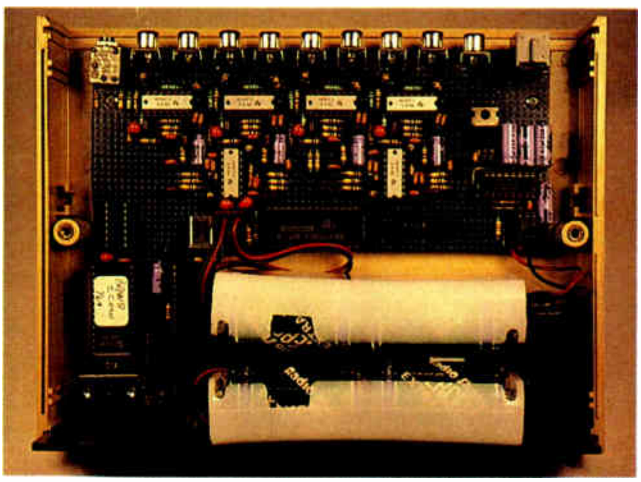

Photo 2: *HAL in the prototype stage. The input jacks are arranged along the top; HAL's battery is near the bottom.*

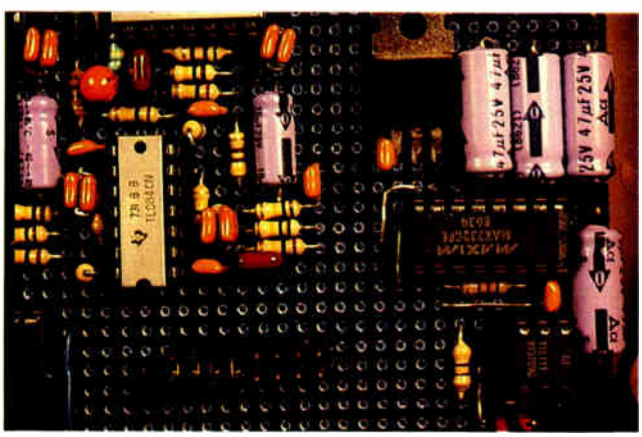

Photo 3: *HAL's optoisolated RS-232C circuitry.*

Detecting 4- to 20-Hz signals with a minimum amplitude of 5 μV from a source with approximately 10- to 20-kohm impedance is not an insignificant task. Ideally, the band-pass filter section should have a flat (±1-decibel [dB]) response across the passband; it should provide at least −18 dB per octave attenuation of signals outside the passband. The frequency response of the amplifier should be at least 50 to 60 dB down at 60 Hz. An equivalent input noise level of 0.5 μV or less would be good. Finally, input DC current should be less than 50 nanoamperes.

HAL's Circuitry

HAL's hardware circuitry is divided into two sections: preamplifier/filter and digitizer/control (see photo 2). The preamplifiers and filters acquire and boost the microvolt-level analog signals to useful levels. The digitizer section does the signal conditioning and A/D conversion and sends the data through an optocoupler to the host computer for analysis (see photo 3).

Several factors contributed to the evolution of the analog section of the circuitry. Initially, I planned to use narrow passband hardware filters to detect and measure only the alpha waves for each channel. Such an approach would discard a significant amount of information coming from the brain, essentially making the monitor capable of only simple "digital" discrimination—the presence or absence of alpha waves. This hardly seemed an achievement, since it merely duplicated the simple alpha biofeedback units available for the last 15 years.

Discussions with hardware and software experts eventually led to the conception of a more sophisticated system, one in which I considered the slowness of the EEG waveforms, the speed of the A/D conversion, and the analyzing power of an IBM PC. Ultimately, I decided that the HAL EEG monitor would function as a raw data accumulator and transmitter. The host computer would perform all signal analysis and display the results. (HAL's data output is RS-232C serial and can be analyzed and displayed on any computer. I chose to use an IBM PC here only for convenience.)

I expanded the bandwidth to allow the possibility of analyzing beta and theta waves. Even though these amplitudes are much lower than alpha waves, they are associated with some interesting phenomena.

To accomplish this task, I had to develop a special preamplifier/filter that would amplify only the specific EEG signals picked up from the scalp of the subject and amplify them to a level that is high enough for A/D conversion. Each HAL preamplifier/filter channel takes six operational amplifiers (op amps). Four of them provide amplification and impedance matching, and two others provide 60-Hz rejection filtering.

I designed the amplifiers and active filters in figure 1a around the TL-084 quad op amp and used as many common values as possible. The TL-084 provides junction-field-effect-transistor inputs with picoampere bias currents, low power consumption, and adequate input noise level. (If you are building this project, you should not substitute another type of op amp.) The bandwidth of the analog section is about 16 Hz (−3 dB at 20 Hz).

You can calculate the equivalent input noise by integrating the noise voltage as a function of frequency over the bandwidth. This 180-nanovolt equivalent noise, combined with the noise from the differential input stage multiplied by the system gain, yields a calculated output noise level of approximately 2.5 millivolts (mV).

Actual measurements of the noise output of the four-channel prototype were 3.5 mV root mean square, with a source imped-

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ance of 13-kohm impedance per input. I decided this was acceptable for the system with a 10-mV per bit A/D sensitivity.

I used three sections of IC1A to make a differential input instrumentation preamplifier. (Note that all six op amps associated with channel A are labeled IC1A and IC2A. Channel B's op amps are labeled IC1B and IC2B, respectively, and so forth.) An ideal difference amplifier will amplify only the voltage difference between the two inputs. Voltages that appear on both inputs when referenced to the ground lead are called common mode voltages.

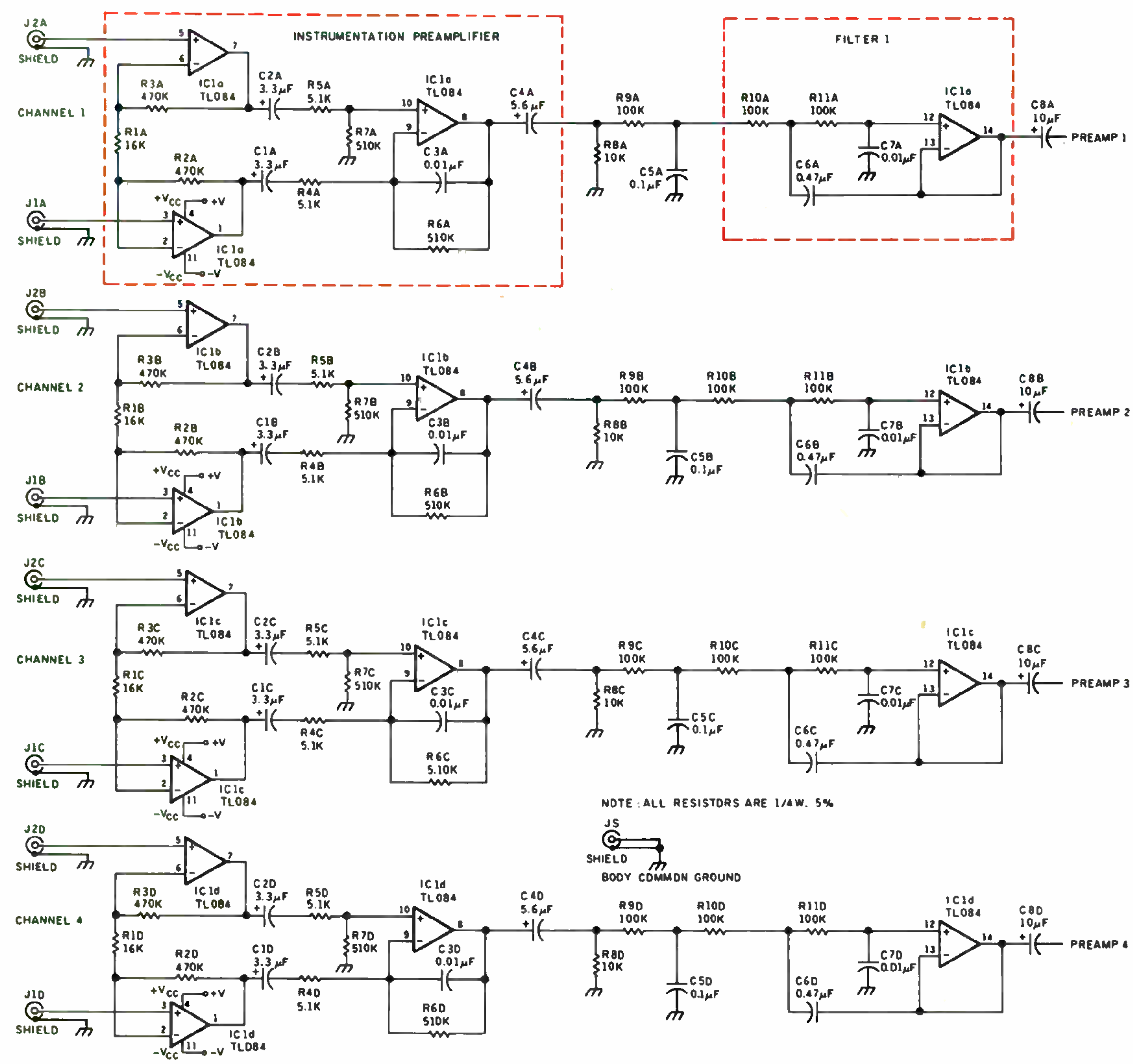
For example, if the voltage on one input is +50 μV and the other input is +15 μV, the difference signal would be 35 μV and the common mode signal would be 15 μV. HAL measures the difference signal between the two electrode positions. The difference amplifier measures this difference by applying one signal to the inverting input of the op amp and the other signal to the noninverting input.

The ability of the op amp to amplify only the difference is specified as the common mode rejection ratio. In HAL, I measured this experimentally by shorting the inputs, applying an input signal between the shorted inputs and ground, and comparing the output with that obtained by applying the same signal across the two inputs. The common mode output was 43 dB down below the differential output. (You would correctly suspect that the major component of common mode voltages in HAL will be induced by the 60-Hz power line. I'll discuss how HAL rejects the 60-Hz signals later.)

I set the voltage gain of the preamplifier to 5800 and incorporated AC coupling between the stages to eliminate DC offset voltages and provide some low-frequency roll-off. Feedback capacitor C3 provides high-frequency roll-off, with the gain down 9 dB at 60 Hz. The third-order active filter stage has a −3-dB frequency of 22 Hz and is 30 dB down at 60 Hz. You'll find the same third-order filter at the input of each final amplifier to the A/D converter (ADC), thus providing another 30 dB, for a total of 69 dB attenuation at 60 Hz.

The interstage coupling capacitors set the low-frequency passband of the amplifiers. The low-frequency roll-off is 24 dB

(a)



per octave, with the −3-dB point at 6 Hz. This is well above muscle activity and other noise.

A 2.5-volt reference diode sets the analog references to the ADC at 1.75 V and 3.25 V, or ±1.25 V of half the power supply. The last amplifier stage is DC offset to one half the power supply voltage, with the AC signals having a permissible peak value of 1.25 V. I set the overall gain of the amplifier stage to 12,500 so that a 100-μV signal would be the maximum input. This amounts to about 0.8 μV per bit sensitivity.

Since the ADC0808 is generally thought of as a DC converter and HAL measures AC signals, offsetting the reference to the ADC lets it measure signals that swing above and below some point designated as "zero" (offset binary converter). When you apply 0 V to the ADC, its output will be 80 hexadecimal.

A voltage gain of 12,500 corresponds to 82 dB (20×log Av). The 60-Hz rejection of 69 dB results in a 60-Hz gain of 13 dB (82 dB − 69 dB). The common mode rejection of 43 dB reduces the 60-Hz gain to a loss of −30 dB (13 dB − 43 dB). This all means that a 60-Hz common mode signal at the inputs is reduced by a factor of 0.03 in getting to the ADC.

To show up as a ±1-bit ripple on the data, the common mode input signal would have to have an amplitude of 300 mV peak to peak. This 300 mV would be reduced by a factor of 0.03 to become 10 mV at the ADC. When I connected a 1-inch unshielded lead to HAL's input, it picked up about 100 mV peak to peak of noise. This seems adequate, but all the same, don't use HAL while standing directly beneath a neon sign transformer!

The Digitizer and Control Section

The signals from the four preamplifier/filter channels go to four of the eight analog inputs of the ADC0808. An 80C31 CPU performs channel selection and transmission to the host CPU. (While it is possible to duplicate the preamplifier/filter section to ultimately produce an eight-channel version of HAL, the current level of software for the 80C31 is designed for only four channels.)

Figure 1c shows the microcontroller part of the headset cir-

continued

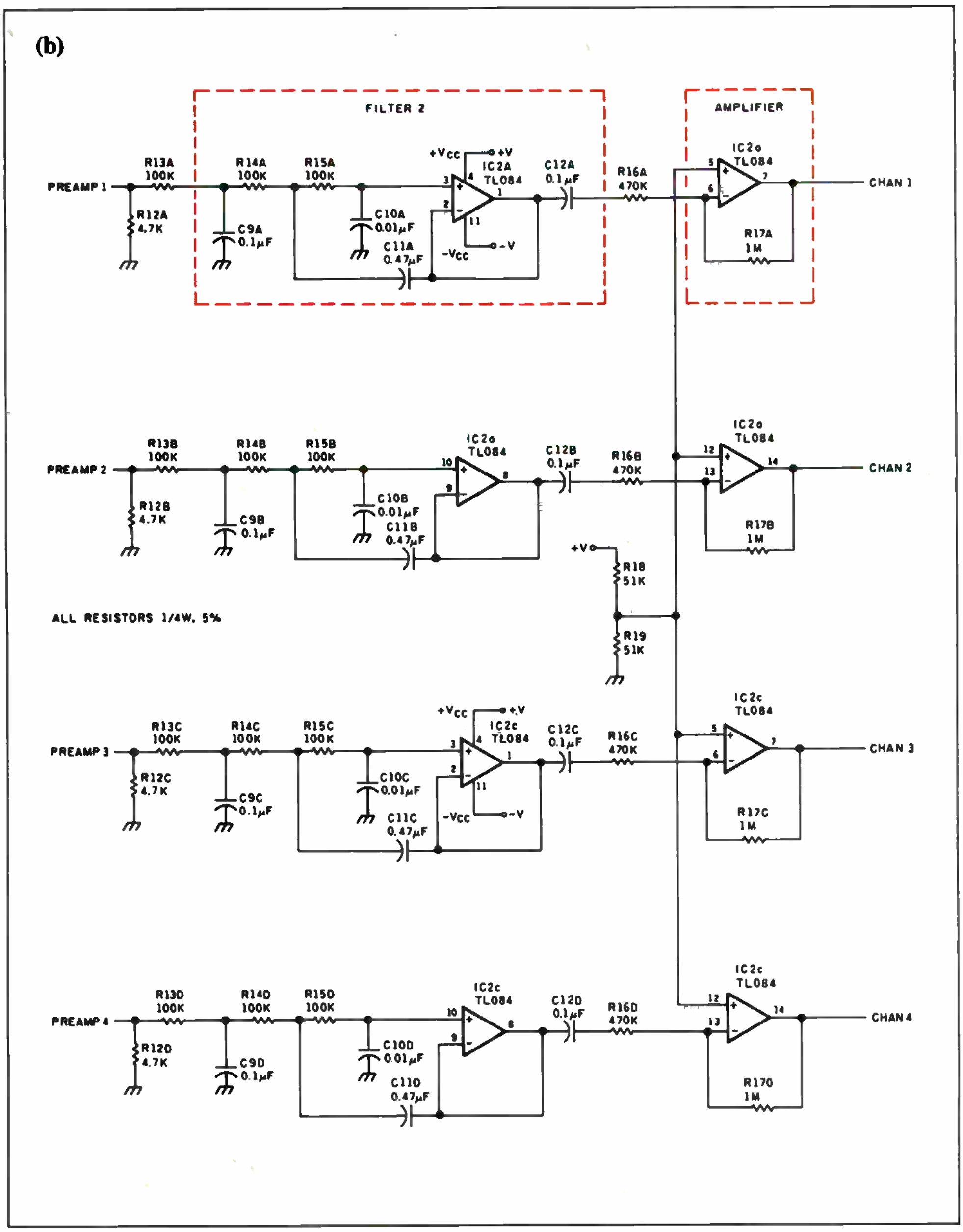


Figure 1: *The schematic for HAL.* **(a)** *Electrode pickup, preamplifier, and part of the filter stage.* **(b)** *More filtering and the final amplifier.*

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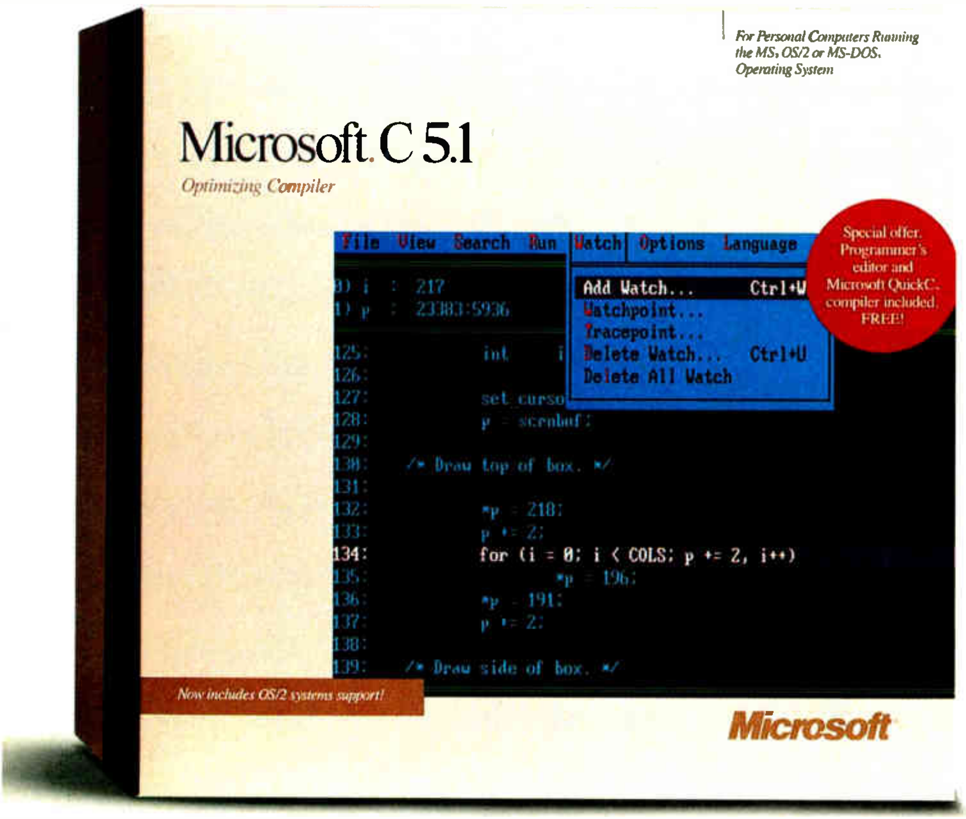

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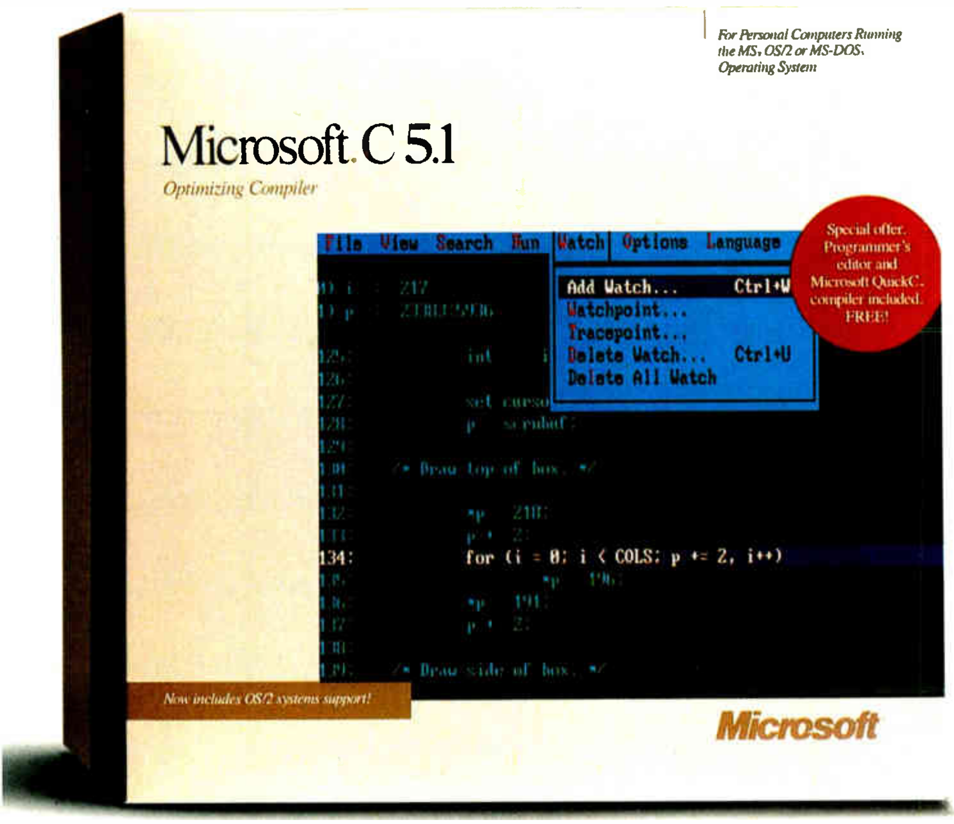

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cuitry. The 80C31's port 1 connects to the ADC0808's data outputs, with all the control and status bits handled by port 3. Bits from port 1 also drive the serial output line and the two event marker switch inputs. Because port 2 is dedicated to the upper half of the program address and port 0 is the EPROM data bus, no port bits are left for anything else.

The timing requirements are so simple that the code doesn't even need interrupts. It samples the two switches, reads the left and right hemisphere voltages from the ADC0808, and sends the results out serially. Each data sample consists of a 5-byte

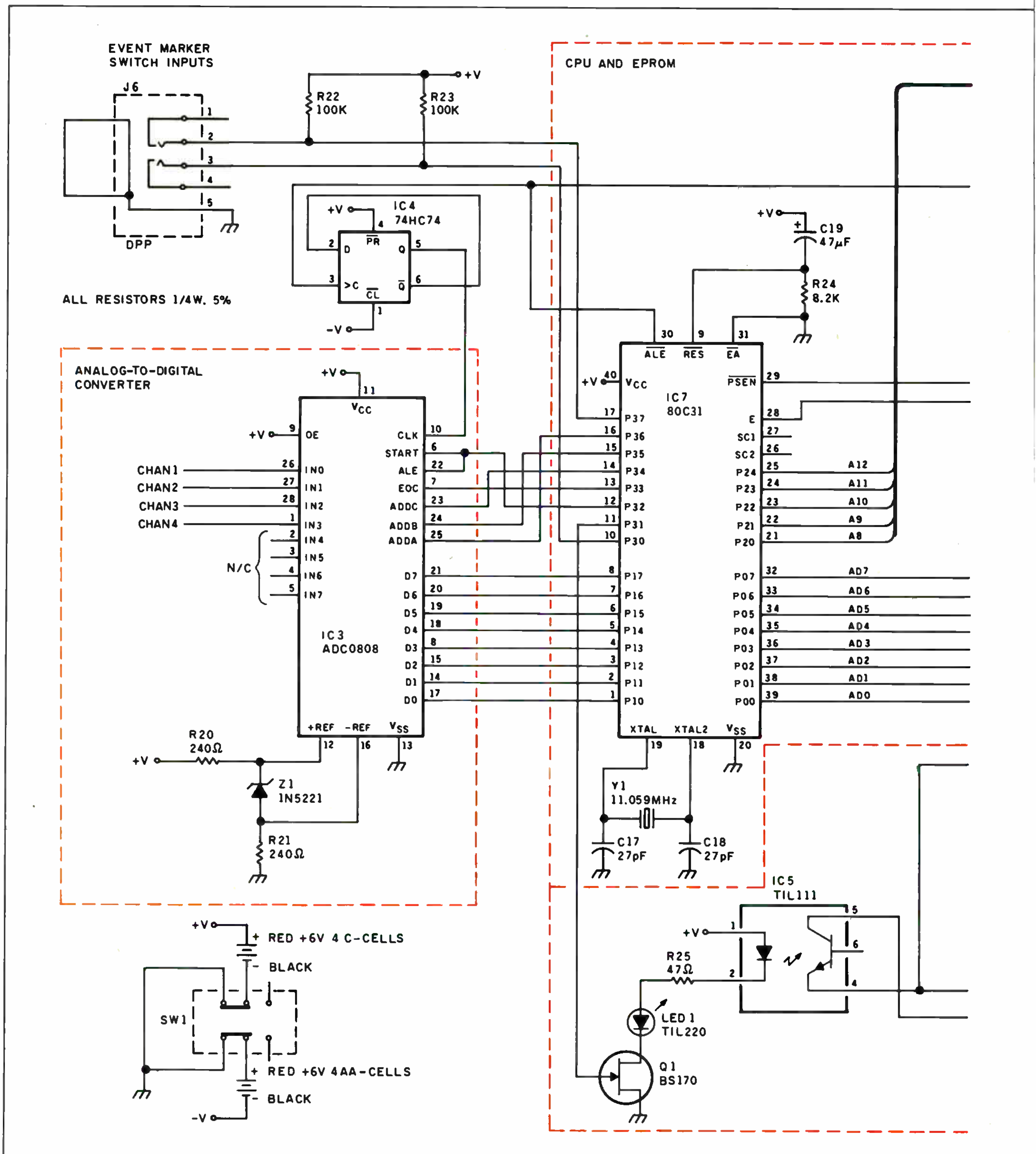
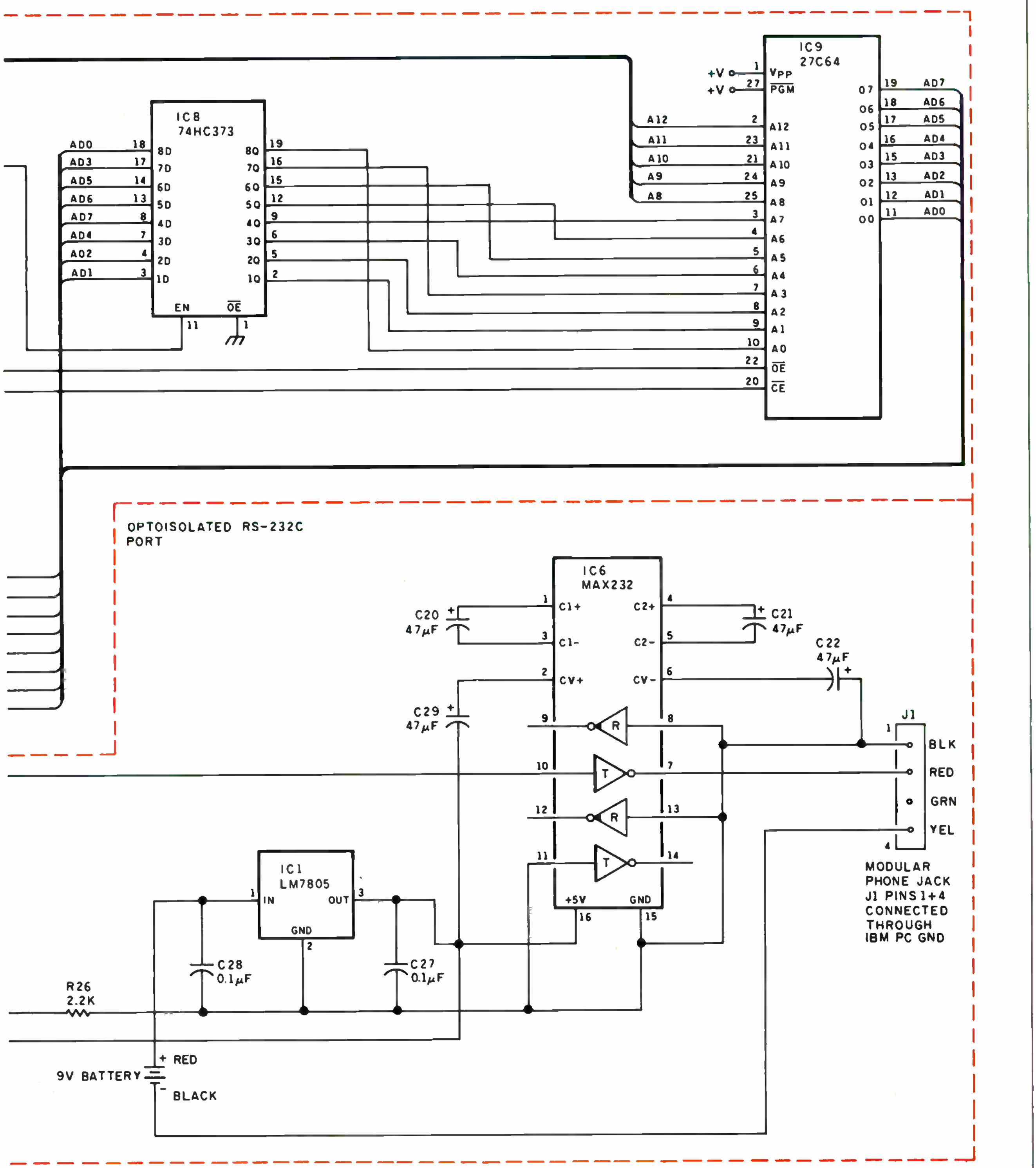


Figure 1c: *HAL's A/D converter, on-board CPU, and RS-232C port.*

transmission. The data sequence is first byte, two switch position codes with 6 bits of leading zeros, followed by 4 bytes of sequentially sampled A/D channels.

HAL is battery-powered. Four alkaline C cells provide +6 V, and 4 AA cells provide −6 V for the op amps. The CMOS digital circuitry runs from the 6-V supply. Current drain with all CMOS components is 225 milliamperes (mA) at 6 V and 50 mA at −6 V. (OK, I know that most chips like 5 V, but CMOS digital chips will work fine in this application at 6 V.) An addi-

continued



Listing 1: *Source code for HAL's main loop.*

```
; -- 80C31 main loop

ADCdata  EQU   P1    ; data inputs
ADCctls  EQU   P3    ; control I/O
start    EQU   2     ; + to start conversion
ready    EQU   3     ; + on end of conversion
switches EQU   81H   ; switch bit locations
ADC0     EQU   10H   ; low order address bit
ADCaddr  EQU   70H   ; address bit location
sync     EQU   P3.0  ; sync out of switch input!

;>> setup code omitted

;wait for Timer 0 to run out, then reload it
again EQU   $
      JNB   TF0,again    ; loop until timer tick
      CLR   sync         ; blip scope sync down
      NOP
      SETB  sync         ; ... and back up again
      CLR   TR0
      MOV   TH0,#HIGH -T0period ; reload
      MOV   TL0,#LOW  -T0period
      CLR   TF0          ; clear end flag
      SETB  TR0          ; restart counter
;--- read the channels in a great rush
      CALL  getADC
;--- read the switches and send them out
      MOV   A,ADCctls    ; grab input bits
      ANL   A,#switches  ; strip switches
      RL    A            ; move to bits 1-0
Lsw   JNB   TI,Lsw       ; will set every time!
      MOV   SBUF,A       ; send byte
      CLR   TI           ; reset ready flag
;--- send analog data
L0    JNB   TI,L0        ; wait for trans ready
      MOV   SBUF,R0      ; drop in the value
      CLR   TI           ; reset trans ready
L1    JNB   TI,L1        ; repeat for channel 1
      MOV   SBUF,R0
      CLR   TI
      JMP   again
```

Listing 2: *The code HAL uses to read its A/D converter.*

```
;--------------------------------
; Get channels from the ADC input
; Values are stashed in registers
getADC PROC
       MOV  A,ADCctls  ; reset address
       ANL  A,#NOT ADCaddr
       SETB ACC.ready  ; ensure this bit is a 1
       MOV  ADCctls,A
;--- grab channels
       SETB ADCctls.start ; blip start line
       CLR  ADCctls.start ;  with 1 us pulse
; Wait for EOC to go away
Lw0r   JB   ADCctls.ready,Lw0r
; Now wait for EOC active
Lw0e   JNB  ADCctls.ready,Lw0e
       MOV  R0,ADCdata ; save data in reg
       ADD  A,#ADC0    ; tick channel number
       MOV  ADCctls,A
       SETB ADCctls.start ; repeat for chan. 1
       CLR  ADCctls.start
Lw1r   JB   ADCctls.ready,Lw1r
Lw1e   JNB  ADCctls.ready,Lw1e
       MOV  R1,ADCdata
       RET
getADC ENDPROC
       END
```

tional 9-V battery (10 mA) provides power for the serial communication.

The two-push-button switch inputs (J6) allow operator signaling to the host computer. Serial data output drives the TIL111 optocoupler by means of a BS-170 field effect transistor. A MAX232 (IC6) converts the optocoupler's output to RS-232C levels compatible with the serial input of the IBM PC host computer. The MAX232 is powered by the separate 9-V battery to maintain isolation between HAL and the PC when the serial port is connected. (Do not try to use the 6-V C cells that power the main HAL circuit to power IC6.)

The Control Program

HAL's firmware control program (the main loop is shown in listing 1), contained in a 2764 EPROM (IC9), is called BIO31. Nearly all BIO31's time is spent in line waiting for timer flag 0 (TF0) to become a logic 1. Whenever that happens, the code reloads timer 0 to produce the next 1/64-second delay and clears the flag again.

While the 5 bytes in each sample take only 6.25 milliseconds to transmit at 4800 bits per second and there's lots of idle time on the link (the PC code needs 64 samples per second; we don't send it faster because the PC analysis program would choke), the FFT software in the PC presumes that all the data points are sampled at the same instant in time. As a requirement, then, BIO31 runs the ADC as fast as possible between samples. I used in-line code to eliminate the overhead of subroutine calls and returns, although I'll be the first to admit that the few microseconds probably don't make any difference at all. Listing 2 shows what's needed to grab channels 0 and 1 from the ADC0808.

Throughout the conversions, the accumulator holds a copy of port 3, so changing the ADC channel address is simply a matter of adding 1 to the proper accumulator bit and reloading port 3. The code sets the ADC ready bit to a 1 to make sure that the bit is always an input; writing a zero to that bit would turn it into an output.

Toggling the ADC's start bit using a pair of CLR/SETB instructions provides a 1-microsecond pulse on that output. One of the nice things about the 8031 is that you can tell exactly how long each instruction will take, so generating precise time intervals is quite simple.

The ADC0808 takes a few microseconds to drop the line that signals the end of conversion before starting the next one, so the code includes a loop to wait for that bit to go away before continuing. This is one of those cases where the computer can outrun the peripheral!

Next Month

I'll examine the software components of HAL, including an 8088 machine language discrete FFT callable from BASIC. I'll provide BASIC source code so you can design your own software and reconfigure HAL into a sophisticated brain-wave biofeedback monitor or a continuously recording EEG, or so you can add additional channels. ■

Special thanks for help provided on this article to Dr. Robert Stek, David Schulze, Rob Schenck, Jeff Bachiochi, and Ed Nisley.

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

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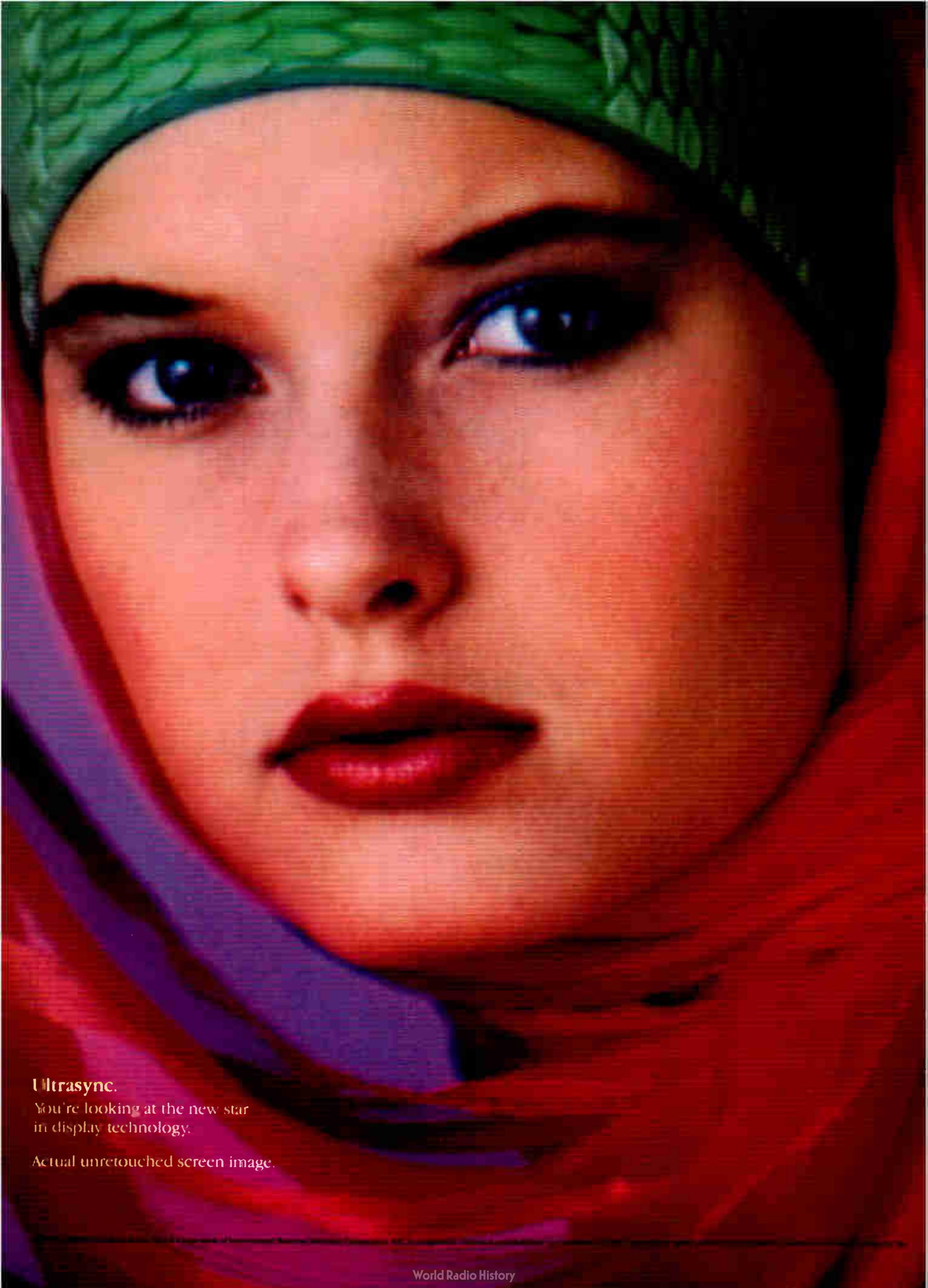
Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, he can be reached at P. O. Box 582, Glastonbury, CT 06033.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Peter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

Error-Free Fractions

Computers can store rational numbers exactly with the use of factorial-base format

Most computer users know their machines can't represent all fractions exactly. Many programmers even know *why*. Something about finite memory and infinitely repeating decimals....

However, if you're willing to depart from conventional (exponential-base) representation formats, you *can* store fractions exactly. You can even do exact calculations without fear of dreaded roundoff errors. A Pascal listing presented in this article demonstrates the technique (see listing 1). Unfortunately, rational-number math written in Pascal cannot keep up with highly optimized floating-point code: The computations done in the demonstration program aren't so fast as those done in floating point. But they *are* exact.

The mathematics involved aren't really new; nineteenth-century German mathematician Georg Cantor (see reference 1) presented the scheme and proved that it allows any rational number to be represented exactly in a finite series—no repeating decimals (see the text box "A Mathematical Proof" on page 290). Before explaining why factorial base gives exact fractions and conventional exponential base does not, I'll show how similar they are.

A Question of Place Values

Both systems use place values to represent infinitely many different numbers with a finite set of digits. For instance, in base 10, the sequence of digits 104.32 corresponds to the series

$$1 \times 10^2 + 0 \times 10^1 + 4 \times 10^0 + 3/10^1 + 2/10^2.$$

The place values are 10^2, 10^1, 10^0, $1/10^1$, and $1/10^2$.

Before proceeding, a word about notation. Every base-2 number in this article is identified by a subscripted 2, as in 10.1_2; every factorial-base number is identified by a subscripted F, as in 12.1_F. I'll often spell it out as well.

The base-2 systems indigenous to silicon worlds are the same as base 10, except that they use 2 as the radix instead of 10 and have only two distinct symbols or digits, as in 10.011_2, which really means:

$$1 \times 2^1 + 0 \times 2^0 + 0/2^1 + 1/2^2 + 1/2^3,$$

with place values 2^1, 2^0, $1/2^1$, $1/2^2$, and $1/2^3$.

Factorial bases are almost the same, except that the place values are factorials rather than exponential values: 301.102_F corresponds to the series

$$3 \times 3! + 0 \times 2! + 1 \times 1! + 1/2! + 0/3! + 2/4! = 19\,7/12.$$

Recall that the notation 3! (3 factorial) means $3 \times 2 \times 1$, and in general, $n!$ means $n \times (n-1) \times (n-2) \times \cdots \times 1$. So the place values are 3!, 2!, 1!, 1/2!, 1/3!, and 1/4!. As a convenience, figure 1 gives the ten factorial place values around the decimal point.

One major difference between exponential base and factorial base concerns the use of digits: In factorial-base notation, the largest allowable digit depends on which place you're looking at: in $a_n a_{n-1} \cdots a_1 . a_{-1} a_{-2} \cdots a_{-n}$, you must have $0 \leq a_i \leq |i|$. For instance, in 321.123_F, each digit is at its maximum value for the position it's in.

Computing with Factorial-Base Numbers

Analogies between the factorial-base and base-10 computation make the new system especially attractive. Numbers that contain the maximum value in each digit, like 321_F (which is equal to 23 base 10) are 1 less than the value of a 1 in the next significant position ($1000_F = 24$), just as $9999 = 10{,}000 - 1$. Fractions that contain the maximum value in each position are close to 1 in both cases ($.123456_F$ and .999999).

The whole process of adding two factorial-base numbers is exactly the same as adding two base-10 numbers if you remember that the maximum value allowed in each position changes from one place to another, so that you know when to carry.

For instance, adding 1/24 ($.001_F$ in factorial base) to 11/24 ($.023_F$) looks like this:

1	1		carry
.0	0	1_F	addend
.0	2	3_F	addend
.1	0	0_F	sum

Note that two carries are needed because the maximum value is 3 in the right column and 2 in the center column. The process of carrying digits extends similarly to the integer portion.

The algorithms for the other functions are also analogous to ordinary arithmetic. Division is the most difficult operation, just as it is in regular arithmetic, requiring an estimation process to calculate the digits.

The Root of the Problem

The best introduction to factorial-base arithmetic comes from learning exactly where the base-10 and base-2 representations fail. Both handle all integers exactly, but only some rational fractions exactly. For instance, ½ is exactly .5 in base 10 and exactly $.1_2$ in base 2. But ⅓ is nonterminating and hence inexact

continued

A Mathematical Proof

The proof that any rational number has an exact factorial-base representation has two parts. First, that any integer p can be expressed as a sum of n products involving factorials:

$$p = \sum_{i=1}^{n} a_i i!$$

with $a_i \leq i$. The exact, finite factorial representation is just the sequence of coefficients $a_n a_{n-1} a_{n-2} \cdots a_1$.

Choose n such that $n! < p < (n+1)!$ and set a_n to the integer part of p divided by $n!$. Notice that this a_n cannot exceed the maximum value for this position, n, because p is less than $(n + 1) \times n! = (n + 1)!$.

Repeat this process with p set equal to the remainder of the previous division, and it will return the value for a_{n-1}. This continues until all the digits are computed. The process must terminate exactly (i.e., give a 0 remainder) at a_1 because the remainder stays less than $i + 1$ at each step, and, at a_1, the only nonnegative integers less than $i + 1 = 2$ are 0 and 1. Both of these leave no remainder after division by 1.

Furthermore, the representation $a_n \cdots a_1$ is unique because the largest value that can be represented with $n-1$ digits is strictly less than the multiplier of the nth digit ($n!$), so the $i!$ terms are linearly independent with respect to multipliers that lie between 0 and i.

The second part of the proof establishes that every p/q, $p<q$, can be represented as a sum of n quotients involving factorials:

$$\frac{p}{q} = \sum_{i=1}^{n} \frac{a_{-i}}{(i+1)!}$$

with $a_{-i} \leq i$. The exact, finite factorial representation is just the sequence of coefficients $a_{-1}a_{-2}a_{-3} \cdots a_{-n}$.

The proof begins by pointing out that if $(i + 1)\,p > q$ then $p/q > 1 / (i + 1)$. Compute a_{-1} as the result of integer division of $(1 + 1)\,p$ by q, which in this case is 1 if p/q is greater than ½ and 0 if it isn't.

Set p equal to the remainder of this division and repeat this step to calculate a_{-2} as the result of integer division $(2 + 1)\,p/q$. The value a_{-2} is between 0 and 2.

Take the remainder as p and repeat for a_{-3}, a_{-4}, and so forth. You will find a 0 remainder at the smallest i such that q divides $i!$, because the remainder after each step is $p \times i! \bmod q$. Eventually, i will be large enough so q will evenly divide $i!$.

Once you have the 0 remainder, you have an exact representation of p/q. The program in listing 1 uses this algorithm to convert the quotient into a factorial-base representation.

Beyond Rational Numbers

The preceding proof does not show exactly what happens with irrational numbers, but it does intimate that they would appear as infinite strings just as they do in a fixed exponential-base representation. Any irrational number x can be bounded by two rational numbers $p_1/q_1 < x < p_2/q_2$; these two rationals can be converted into factorial base. As the two rational numbers get closer and closer together, the terms of the factorial-base representation also come closer together. In this fashion, you arrive at a factorial-base approximation of the irrational number. This ability to easily approximate irrational numbers is one of the advantages of the system.

One particularly interesting instance of this capability is the value of e that you can calculate from the familiar series:

$$e = \sum_{i=0}^{\infty} \frac{1}{i!}\,.$$

Converting this to the factorial-base system yields a very simple-to-remember constant, $10.111111_F \cdots$.

By a similar reference to series expansions for sine and cosine, you find some surprising patterns:

$$\sin(1) = .1\ 2\ 0\ 0\ 5\ 6\ 0\ 0\ 9\ 10\ 0\ 0 \cdots,$$

and

$$\cos(1) = .1\ 0\ 0\ 4\ 5\ 0\ 0\ 8\ 9\ 0 \cdots.$$

Clearly, factorial-base numbers present some unique opportunities in any computer-mathematical application involving factorial terms.

---

in finite space ($.333333\cdots$ in base 10 and $.01010101_2 \cdots$ in base 2).

The difference between exact and inexact fractions lies in the denominator's relation to the base number. For instance, 2 divides both 10 and 2; hence, ½ is exact in bases 10 and 2. The number 3 divides neither 2 nor 10 and thus ⅓ has no exact representation in either base.

In general, the base-n representation of a fraction p/q terminates only when there exists an integer m such that $p/q = m/n^i$ for some integer i. For example, in base 10, the number $3/20$ has an exact decimal representation because $3/20 = 15/10^2 = .15$.

In this respect, base 10 has a slight advantage over base 2: It can represent all fractions of the form $p/2^i5^j$, while base 2 can handle only those in the form $p/2^i$. Base 30 would be better still because $30 = 2 \times 3 \times 5$, and it's not difficult to realize that base 210 $(2 \times 3 \times 5 \times 7)$ could handle an even larger part of the rational numbers.

Continuing along these lines, the base would eventually grow so big that it would be difficult to use, and it would still leave out a portion of the rational numbers—the ones with factors that are relatively prime to every prime factor in the base.

Factorial-base numbers are an elegant alternative. They provide a base system that can handle any p/q without much extra effort. For example, ⅓ in factorial base is $.02_F$ because $1/3 = 0/2 + 2/6$. The fraction $5/8$ is $.103_F$, and 23 becomes 321_F. The text box above gives some of the math theory.

Putting Theory into Practice

The Pascal program in listing 1 provides a routine that converts a rational number in the form p/q to factorial base, as well as other routines that do addition, subtraction, multiplication, division, absolute value, and negation. The routines are based on the work of Patrick Staley at Southwestern University (see reference 2).

The numbers themselves are stored in an array. The integer

continued

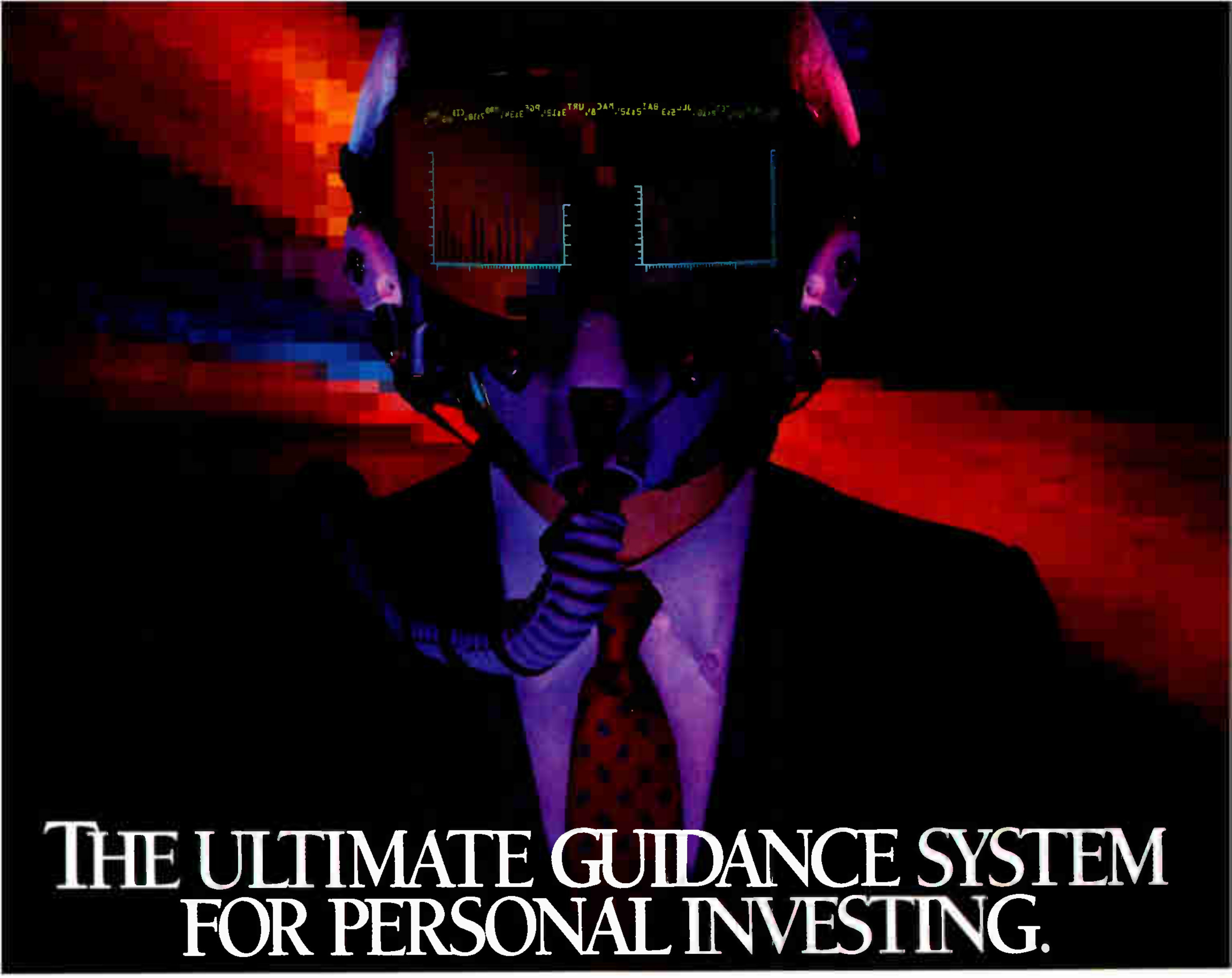

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Figure 1: *The ten factorial place values around the decimal point.*

Listing 1: *A Pascal program demonstrating the use of factorial-based numbers for exact fractions.*

```
PROGRAM fact;
 CONST
  maxarraysize = 12;
 TYPE
  number=ARRAY[1..maxarraysize] OF longint;
  {The coefficients of a factorial-base}
  {number. Slot i contains a(2-i).}
  {Slot 1 is used to carry the integer}
  {part of the number.}
 VAR
  i, j, m: integer;{Counters}
  a, b, c: number;{Factorial-Base}
   {numbers for calculations.}
  k: longint;{A temporary register.}
  zero, one: number;{Two global variables}
  {containing zero and one.}
  float: real;{A floating-point variable}
   {with regular arithmetic.}
 PROCEDURE convert (VAR result: number;
               p, q: longint);
 {A routine that takes a p and q and}
 {converts into a factorial-base number.}
  VAR
   i: integer;
 BEGIN
  result[1] := p DIV q;
  IF (p<0) AND (p MOD q <> 0) THEN
   result[1] := result[1] - 1;
  p := p MOD q;
  FOR i := 2 TO maxarraysize DO
   BEGIN
    p := p * i;
    result[i] := p DIV q;
    p := p MOD q;
   END;
 END;{Convert}

 FUNCTION lessequal (x, y: number): boolean;
 {Tests 2 numbers and returns true if x<=y}
  VAR
   i: integer;{A counter}
 BEGIN
  i := 1;
  WHILE (x[i]=y[i]) AND (i<maxarraysize) DO
   i := i + 1;
  lessequal := (x[i]<=y[i]);
 END;{lessequal}
 FUNCTION notequal (x, y: number): boolean;
 {Tests two numbers and returns}
 {true if x<>y}
  VAR
   i: integer;{A counter}
 BEGIN
  i := 1;
  WHILE (x[i]=y[i]) AND (i<maxarraysize) DO
   i := i + 1;
  notequal := (x[i] <> y[i]);
 END;{notequal}
```

continued

part of the number is kept as an integer in the first array element because the arithmetic for integers is already exact. The a_i digits to the right of the decimal, beginning with a_{-1}, are stored together in the $(1-i)$th component.

Only the integer part can hold negative values, so the fractional part of a negative number is handled in much the same way as such values are stored in two's complement arithmetic. In this method, $-1/3$ is represented as $-1 + 2/3$. This method of storage lets you take advantage of the speed of regular integer arithmetic.

The algorithms themselves are not much different from the steps that everyone learns by rote in grade school. Addition and subtraction are carried out term by term, and a third routine called `smooth` handles carrying the overflow and borrowing from the previous term. Two short routines handle multiplication and division term by term, calling `smooth` to handle borrows and carries. Higher-level functions use these routines to perform multiplication and division of complete factorial-base numbers.

The procedures for addition and subtraction are very stable and will overflow only if the results grow larger than the size of the largest integer the machine can represent. The multiplication routine can overflow sooner; for instance, when a number is multiplied by a large integer, it is possible to overflow the individual term's array component. If the division routine is operating upon two numbers of similar size, the results will not overflow the machine, but if a larger number is divided by a number close to 0, an overflow error can occur. (The estimation algorithm could be improved to help avoid this problem.)

Some Experimental Results

I've used mathematical reasoning to show the benefits of factorial-base numbers, but how do these numbers work in practice in a computer? To find out, I executed the following code using factorial-base and standard floating-point (an extension of the exponential-base) number formats:

```
x:=1/n;
for i:=1 to 30 do
  x:=(n+1)*x-1;
```

Mathematically, the function $f(x) = (n + 1)x - 1$ is invariant at the point $x = 1/n$; that is, $f(x) = x$ for $x = 1/n$. On paper, then, you would expect the Pascal variable x to remain unchanged after 30 iterations of the loop. This was the case when I used factorial-base numbers. But the standard floating-point system failed badly and returned 286,331,161.6 instead of .33333 when n was set to 3.

From previous discussions, you might expect the floating-point software to find the correct answer at least for n = 10 because $1/10 = .1$ exactly in base 10. This was quite far from the truth: x should have equaled .1 but turned into 2.36378547759 e21 after 30 loops. All the calculations are, of course, done in binary. The floating-point software finds the correct answer only when n is 2.

The only negative aspect of the factorial-base system is the slowness of the calculations. My Pascal program could not compete with the optimized floating-point code. The algorithms aren't that different from the regular arithmetic, but they must deal with the shifting base, which adds a lot of overhead. The factorial-base arithmetic could be recoded into assembly code for better speed. Even better, it could be converted into silicon by designing a special chip.

Until such a time, the code should be saved for problems where speed can be sacrificed for accuracy. These problems may range from mathematical analysis (as in the last example) to

continued

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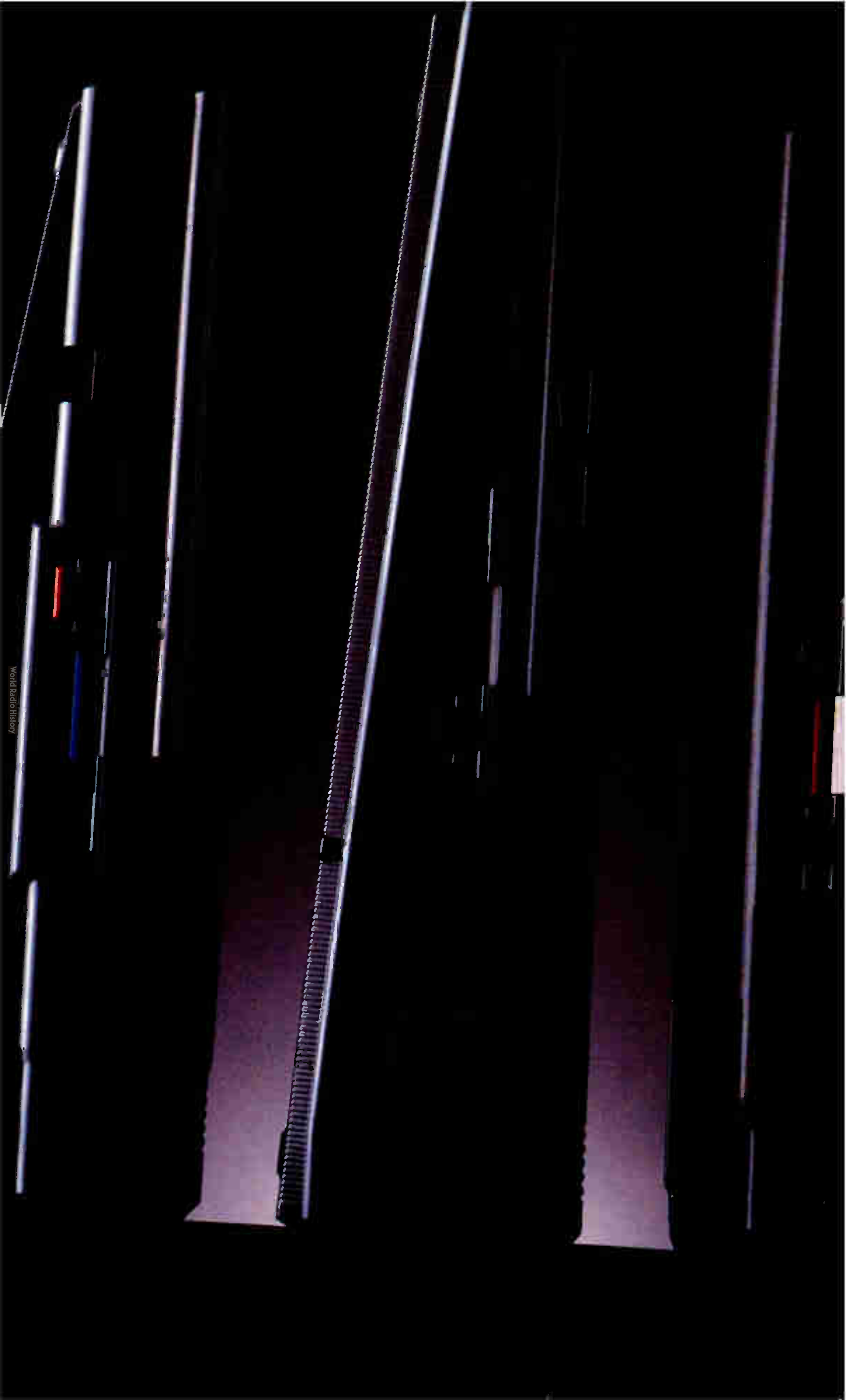

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```
FUNCTION smooth (VAR x: number): number;
{Takes a number and does all the carrying}
{and the borrowing.}
  VAR
    i: integer;{A counter}
BEGIN
  FOR i := maxarraysize DOWNTO 2 DO
    BEGIN
      x[i - 1] := x[i - 1] + x[i] DIV i;
      IF (x[i]<0) AND (x[i] MOD i <> 0) THEN
        x[i - 1] := x[i - 1] - 1;
      x[i] := x[i] MOD i
    END;
  smooth := x;
END;
FUNCTION add (x, y: number): number;
{Adds two factorial numbers}
  VAR
    i: integer;
    temp: number;
BEGIN
  FOR i := 1 TO maxarraysize DO
    temp[i] := x[i] + y[i];
  add := smooth(temp);
END;{add}
FUNCTION subtract (x, y: number): number;
{Subtracts two factorial numbers}
  VAR
    i: integer;
    temp: number;
BEGIN
  FOR i := 1 TO maxarraysize DO
    temp[i] := x[i] - y[i];
  subtract := smooth(temp);
END;{subtract}
FUNCTION absolute (x: number): number;
{Returns the absolute value of x.}
{This is trickier than flipping a bit}
{because the sign bit is attached to x[1].}
{So if x[1]<0 then compute -x[1] subtract}
{the rest of the terms x[2..n]}
  VAR
    i: integer;{a counter}
    y: number;{A temporary register if x<0}
BEGIN
  IF x[1]<0 THEN
    BEGIN
      y[1] := -x[1];
      FOR i := 2 TO maxarraysize DO
        y[i] := 0;{Zero rest of the array.}
      x[1] := 0;
      x := subtract(y, x);
    END;
  absolute := x;
END;
FUNCTION negative (x: number): number;
{Converts a positive x to negative form.}
  VAR
    i: integer;{counter}
    temp: integer;{A temporary register.}
    y: number;{Temporary, for subtraction.}
BEGIN
  temp := -1 - x[1];
  x[1] := 0;{Save the first value and}
    {let x=fraction(x).}
  FOR i := 2 TO maxarraysize DO
    y[i] := 0;{Zero the array.}
  y[1] := 1;{But let it equal one.}
  x := subtract(y, x);
  x[1] := temp;
  negative := x;
END;
```

```
FUNCTION multbyint (x: number;
                int: longint): number;
{Multiplies x by an integer int.}
  VAR
    i: integer;
    temp: number;
BEGIN
  FOR i := 1 TO maxarraysize DO
    temp[i] := x[i] * int;
  multbyint := smooth(temp);
END;{multbyint}
FUNCTION divbyint (x: number;
                int: longint): number;
{Divides x by the integer int.}
  VAR
    i: integer;{A counter}
    carry, part: longint;
      {Two registers to carry on digits.}
    temp: number;{Temporary result}
    negativeflag: boolean;
      {Set to true if a negative number.}
BEGIN
  negativeflag := (x[1]<0);
  IF negativeflag THEN
    x := absolute(x);
  carry := 0;
  FOR i := 1 TO maxarraysize DO
    BEGIN
      part := x[i] + carry * i;
      carry := part MOD int;
      temp[i] := part DIV int;
    END;
  temp := smooth(temp);
  IF negativeflag THEN
    temp := negative(temp);
  divbyint := temp;
END;
FUNCTION multiply (x, y: number): number;
{Multiplies x and y in factorial base.}
  VAR
    i: integer;{A counter.}
    partial, temp: number;
  {The partial sum of the multiplication}
  {and a register}
BEGIN
  partial := zero;{Zero the array.}
  FOR i := 1 TO maxarraysize DO
    BEGIN
      y := divbyint(y, i);
        {Shift y over one decimal place.}
      temp := multbyint(y, x[i]);
        {Now temp contains y* (x[i]/i!).}
      partial := add(partial, temp);
        {Add it in and continue.}
    END;
  multiply := partial;
END;{Multiply}
FUNCTION divide (x, y: number): number;
{Divides x by y in factorial-number}
{representation. Begins by scaling the}
{numbers to find an easy, accurate way of}
{computing the first value. After that it}
{proceeds to use long division.}
  VAR
    i, j: integer;
    negativeflag: boolean;
      {A marker to preserve sign.}
    temp, partial: number;
      {A temporary number: partial result.}
    denom: integer;
```

continued

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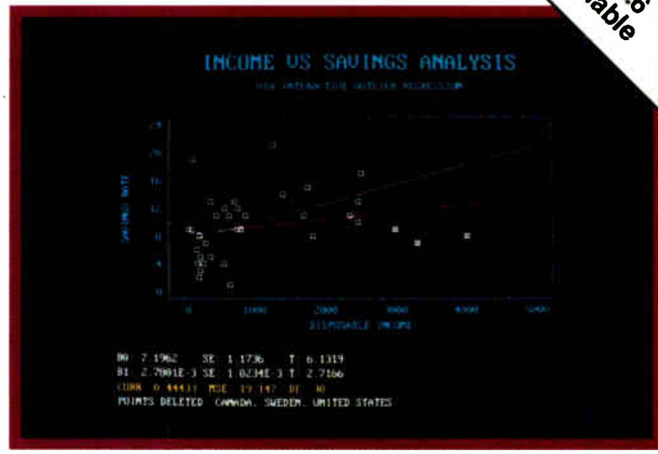

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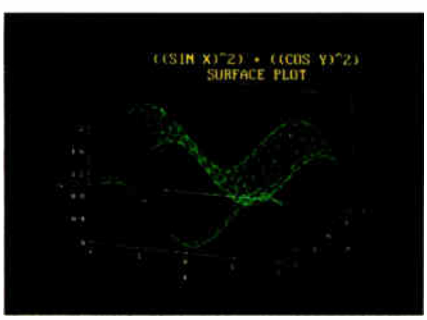

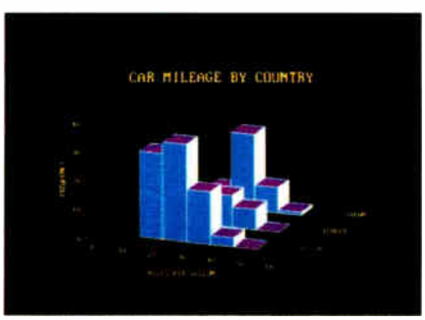

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```
      {The p part of an approximation of}
      {the denominator.}
    denomfact: longint;
      {A factorial counter,}
      {q part of the denominator,}
      {approx: p/q.}
    posit: integer;
      {Marks the position being calculated.}
    estimate: longint;
      {An estimate of this value.}
BEGIN
  negativeflag := ((x[1]<0) AND (y[1]>0)) OR
                              ((x[1]>0) AND
                              (y[1]<0));
{Take care of negative & positive numbers.}
  x := absolute(x);
  y := absolute(y);
  i := 1;
  denomfact := 1;
  denom := y[1];
  WHILE (denom<100) AND (i<7) DO
  {Get approximately 3 significant figures}
    BEGIN
      i := i + 1;
      denom := denom * i + y[i];
      denomfact := denomfact * i;
    END;
posit := 1;
partial := zero;{Zero the answer}
WHILE (notequal(x, zero)) AND
          (posit<=maxarraysize) DO
  BEGIN
    estimate := (x[1] * denomfact) DIV
                              denom;
    REPEAT
      temp := multbyint(y, estimate);
      estimate := estimate - 1;
    UNTIL lessequal(temp, x);
    x := subtract(x, temp);
      {Calculate the remainder}
    partial[posit] := estimate + 1;
      {Record the result.}
    posit := posit + 1;
      {Move over one notch.}
    x := multbyint(x, posit);
      {Shift the numerator over one notch.}
  END;
  { Do loop until x=0 for best accuracy.}
partial := smooth(partial);
IF negativeflag THEN
```

```
    partial := negative(partial);
  divide := partial;
END;
PROCEDURE print (x: number);
{Prints out a number.}
  VAR
    i: integer;{a counter}
    y: number;
      {A temporary register if x<0.}
BEGIN
  IF x[1]<0 THEN
{The numbers are stored in the form}
{sum x[i]/i!  so convert to an}
{equivalent positive number by}
{subtracting the x[2..max] terms}
{from -x[1], the integer part of}
{the number.}
    BEGIN
      y[1] := -x[1];
      FOR i := 2 TO maxarraysize DO
        y[i] := 0;
          {Zero the rest of the array.}
      x[1] := 0;
      x := subtract(y, x);
      write('-');
    END;
  write(x[1]: 3, '.');
  FOR i := 2 TO maxarraysize DO
    write(x[i]: 3);
  writeln('  ');
END;{Print.}
BEGIN    {Main Program}
  FOR i := 1 TO maxarraysize DO
    zero[i] := 0;{Zero the array.}
  one := zero;
  one[1] := 1;
  {Set 1 equal to zero plus one.}
  float := 1 / 3;
  a := one;
  a := divbyint(one, 3);{Set a equal to 1/3}
  FOR i := 1 TO 30 DO
    BEGIN
      float := 4 * float - 1;
      a := multbyint(a, 4);
      a := subtract(a, one);
    END;
  print(a);
  writeln('Using floating point:', float:
                                   20);
END.    {Program FACT}
```

any real-world calculations requiring exact representation of rational numbers.

Other Exact Formats

There are several other ways to represent rational numbers exactly, but all have major disadvantages. The simplest approach is to store the numbers *p* and *q* in two registers. This is quite easy to handle mathematically, but it introduces some new problems. For instance, it's hard to tell if $^{501}/_{1024}$ is greater or less than $^{5203}/_{10456}$ without calculating the quotient, whereas 1.023_F is obviously greater than 1.022_F.

The limits of the computer's integer representation also hobble the two-register system faster than they do with factorial-base numbers. For any *n*, the fraction $1/n!$ requires just $n - 1$ 0s and a 1 in factorial base; that same value will overflow 32-bit integers for *n* as low as 14. Other systems involving residue arithmetic and p-adic numbers (see references 3 and 4) are beyond the scope of this article; while they can be more efficient, they are quite unintuitive—the numbers must be reconverted into fixed base before they can be recognized and compared, for instance. ■

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Peter Wayner studies computer science at Cornell University.

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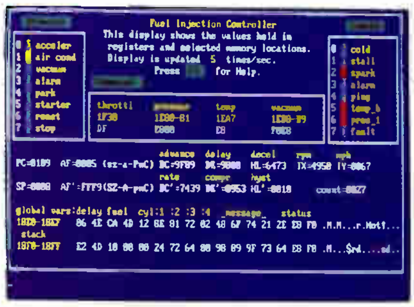

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Dick Pountain

A Personal Transputer

The prototype Atari Abaq, with the Helios operating system, could put a Transputer on your desk

The Atari Abaq is the first of a new breed of computers built around the INMOS Transputer chip, a high-performance 32-bit processor with a unique communications-based architecture designed for parallel processing systems.

Since its launch in 1984, the most common application for the Transputer has been in the "personal supercomputer," an array of Transputers acting as a powerful calculating engine, with a conventional computer acting as a frontend and supplying disk and display services through a conventional operating system such as Unix or PC-DOS. For this type of work, and in embedded control applications, Transputer programs (usually written in the Occam language) run on the bare hardware, with no intervening operating system to provide standardized services.

Beyond the personal supercomputer arena, the lack of a standard operating system that runs on the Transputer itself has become an obstacle to its wider adoption. The Transputer has a totally new architecture and instruction set: on-chip static RAM in place of registers, a hardware stack for expression evaluation and a 4-gigabyte linear address space with no memory management. (See "The DSI Transputer Development System" by John Poplett and Rob Kurver in the February BYTE.) Because of these new features, industry-standard operating systems would need to be completely rewritten for the Transputer. More importantly though, no existing operating systems have the characteristics to make full use of the Transputer's power.

Existing multitasking/multiuser operating systems (e.g., Unix and its relatives) were originally developed on minicomputers and expect to see a single CPU that runs multiple tasks by time-slicing in a shared memory space. The Transputer was designed with an altogether different model of computing—one in which different processes run on different processors with separate memory spaces.

This model is more like a local-area network of machines, in which different tasks can be distributed to different workstations. Extensive efforts are being made to produce versions of Unix in which the kernel can be distributed over many processors, but no such version is in widespread use yet.

The job of providing a new sort of operating system for the Transputer is now approaching completion, spurred on by Atari's announcement of the Abaq at the Fall 1987 COMDEX. The new operating system is called Helios and is being written by Perihelion Software Ltd. of Cambridge, England. Perihelion Software is run by Tim King, late of Metacomco, developer of AmigaDOS for the Commodore Amiga. Helios is a general-purpose operating system for Transputer systems, and although Atari is an important customer for Helios, there are several others, including the graphics supercomputer firm, Meiko.

Transputer-Powered Graphics Workstation

"Abaq" is a Hebrew word meaning "from the sands" (suggesting silicon), and the root from which "abacus" is derived. The Atari Abaq was developed by Perihelion Ltd. (sister to Perihelion Software) and is due to be launched in September. [Editor's note: *Because a Belgian firm has prior rights to the name Abaq, it is likely that Atari will have to find a new name before the September release.*] It is a Transputer-powered graphics workstation that, at least in its first iteration, uses an Atari Mega ST as an I/O processor. At the time of this writing, it exists only as a board-level prototype. The basic machine will be powered by a single T800-20 floating-point Transputer, but more Transputers can be added in groups of four by inserting cards into expansion slots (three on the prototypes, but probably four in the final design).

At present, two versions of the Abaq are being planned. One is an add-on for an existing Atari Mega ST; the other is a stand-alone computer containing an ST motherboard. Both share the same technical specifications.

Because Atari doesn't provide the necessary expansion slots, the add-on unit will require the ST to be dismantled to gain access to the expansion bus on its motherboard, resulting in twin boxes and twin power supplies. The stand-alone machine will be housed in a single box with a footprint similar to the Mega ST's,

continued

"Charity" blitter chip assists graphics creation.

but deeper. An ST motherboard installs underneath a similarly sized board containing the 20-MHz Transputer and its 4 megabytes of dynamic RAM; the Abaq video circuitry and blitter with 1 megabyte of dual-ported video RAM; a SCSI port for the 40-megabyte hard disk drive, and the expansion slots.

The Abaq offers fast, high-resolution graphics assisted by a custom blitter chip, code-named Charity. Charity is an entirely new design; it is not the Atari device used in previous Mega STs. It is being implemented using an 8500-gate, 2-micron, CMOS (complementary metal-oxide semiconductor) uncommitted logic array. Fifty working samples of the first revision have so far been made for development work. Charity performs block moves on two-dimensional rasters of color pixels. It employs 32-bit-wide data paths and shares the bus with the Transputer CPU; it can copy rasters to and from the full address range, not just within video RAM.

The chip normally reads and writes one address location at a time and can simultaneously handle 4 or 8 pixels, depending on the video mode. The blitter allows all the normal Boolean masking operations between source and destination for overlaying and transparency effects. It also permits tests on pixel values within a given range so that the programmer can distinguish absolute colors on the screen despite the possibly discontinuous mappings of the lookup table. Charity should perform general color blits at around 10 million pixels per second.

Charity also has a special pixel block mode (PBM) that can be used only when the destination raster lies entirely in video RAM. PBM permits 32 pixels to be written in one or two cycles—a process that gives an area-fill or line-drawing capability of from 64 to 128 million pixels per second (equivalent to about 100 full screens per second). PBM also puts single-color font data onto the screen extremely rapidly, enabling quick screen updating for desktop publishing applications.

The Abaq's video system has four display modes. Mode 0 furnishes a 1280- by 960-pixel display with 4 bits per pixel; mode 1, a 1024- by 768-pixel display with 8 bits per pixel; mode 2, a 640- by 480-pixel display with 8 bits per pixel, double buffered (i.e., two separate screens for animation effects); and mode 3, 512 by 480 pixels with 32 bits per pixel.

A 24-bit hardware color lookup table maps 8-bit inputs into 24-bit outputs. Full 8-bit digital-to-analog converters (DACs) are employed to provide the analog video signals to drive the color monitor's RGB guns.

In modes 1 and 2, you can choose the 256 displayed colors from a palette of 16 million. In mode 3, the color lookup table is bypassed and 8 video bits are sent directly to each DAC, giving a fixed palette of 16 million colors—the remaining 8 bits are used as overlay and tag bits. Overlay bits are decoded in hardware and can be used to support a number of hardware-encoded cursors, while the tag bits can be used by suitably written applications programs to mark separate screen areas for efficient object-oriented graphics and sprite effects.

Atari will be offering only one high-resolution monochrome monitor with a 146-MHz vertical scan rate for mode 0 operation in 16 shades of gray—features aimed at desktop publishing and CAD/CAM users. For other modes, off-the-shelf monitors such as the NEC MultiSync Plus or XL will suffice. Still under review is the question of color operation in mode 0—but the quality of monitor required would be very expensive.

So far, Abaq's developers have designed two kinds of Abaq expansion cards. The Transputer farm board contains four T800 Transputers with 1 megabyte of dynamic RAM each, while the memory expansion board contains 20 megabytes of DRAM. A four-slot Abaq could contain 17 Transputers or 84 megabytes of RAM, or combinations in between—for example, 13 Transputers and 24 megabytes of memory (three Transputer boards plus one memory board). No industry-standard bus has been adopted for these cards that can simply receive the Transputer memory bus signals. The Transputer links are not brought to the edge connector, but you can join them independently with point-to-point wiring to set up different configurations.

In the prototype machines I saw, the Abaq/ST interface was rudimentary, but in the finished machine, you will be able to use GEM (the Digital Research Inc. standard operating system software supplied with the Atari ST) on the Abaq screen, and access the Abaq hard disk and other SCSI peripherals from the Atari ST.

The Helios Operating System

The Abaq is a powerful enough graphics workstation, but it is the Helios operating system that will make this workstation extraordinary. The goal of Helios is to allow Abaqs to be networked together in such a way that all the processors in all the machines are potentially available to all users.

Because typical workstation users are happy with Unix, Helios is deliberately being designed to look as much like Unix as possible. The Helios shell looks exactly like the Unix C Shell and supports all the normal Unix commands. Internally, however, it works very differently from Unix in several respects: Helios has a distributed kernel versus Unix's centralized kernel; it does not need to spawn new processes in software because the hardware handles this procedure; and it names every system object, whereas Unix names only files and directories.

However, Perihelion has emulated Unix version 7 calls to the point where much of the software—especially the development tools—can be ported by little more than a recompilation. I have seen the MicroEMACS editor, running on an Abaq, ported using public domain C source code.

Thus, Perihelion is writing much of Helios in C rather than Occam; the rest is in Transputer assembly language. The in-house-produced C compiler is based on the excellent Norcroft portable compiler.

The Nucleus of Helios

Helios is a fully distributed operating system that works by message-passing. At a minimum, every Transputer in a Helios network must run a system program called the "nucleus," which consists of about 30K bytes of code. With its various workspaces, the nucleus needs about 100K bytes. The program is subdivided into four modules: the kernel, the processor manager, the loader, and the system library.

The kernel is responsible for managing all the Transputer's hardware resources; it implements the message-passing mechanism and allocates RAM to tasks from both the Transputer's on-chip RAM and the external DRAM. The kernel also provides a service called the *name server* (described in more detail later), which contains list-processing and semaphore services.

The processor manager creates new tasks, controls them while they run, and then terminates them and releases their resources. In Helios, a task is not the same as a Transputer process. It is built out of one or more concurrent Transputer processes and will contain other resources like open files, static data areas, and dynamic storage such as a stack and a heap.

Helios doesn't need to support processes as such, because on the Transputer they are provided and scheduled by the hardware. Spawning a new process requires just a couple of Transputer instructions. Thus, Helios needs no equivalent of the Unix `fork` procedure.

The loader is responsible for loading objects into the processor and unloading them when they are no longer needed. It translates program images and puts them into memory, loads resident modules for code sharing, and handles data objects such as fonts and other bit-mapped images.

continued

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The system library is a resident code module that supports the equivalent of the system calls in an ordinary operating system. All applications programs must talk to the machine through this library. Many tasks can share resident Helios modules, resulting in great code economy. The Helios `ls` command, for example, occupies 663 bytes compared to 11K bytes under Unix.

The system library also keeps track of the resources allocated to running tasks; a table of pointers to the task's resources is the first parameter passed in any Helios system call. A second library provides Unix-compatible system calls, thus localizing and isolating any Unix compatibility problems.

Server Tasks Are Transparent

The network hardware is uncomplicated and is based on buffered Transputer serial links that operate at up to 20 megabits per second. In the worst case, you will always have at least one Transputer in your own workstation. But when other users log off, you will be able to use the Transputers in the other workstations to accelerate your own software. Or there might be a large box of Transputers on the network, such as a Meiko Computing Surface, shared by all users—just as laser printers are currently shared by network users. First there were file and print servers. Now, Helios introduces us to the notion of a "compute server."

Helios tasks may communicate only through message-passing. By contrast, the individual processes within a task can communicate by any means a programmer may wish to devise. The overall Helios design is based on a client/server model with some similarities to that of AmigaDOS—no surprise, given that both designs are descended from the Cambridge Distributed Operating System. Applications tasks request services from system server tasks by sending them messages.

In Helios, server tasks can be running anywhere on the network and are totally transparent to the user and to applications programs. This transparency is achieved by the ability of the kernel's name-server task, which can search the network to locate other servers. Like files in an ordinary operating system, servers in Helios are called objects. When you type the `ls` command, you will see servers listed as well as files.

Running `ls` again on one of these server names will list its contents. If it is a disk server, you will get a directory of files. For another kind of server, you might get a list of running tasks. If you have the necessary access permissions, you could type `ls` followed by the path name of a disk belonging to another workstation in the network and it would be duly listed. From then on, the name of that disk drive would appear in the directory list for your own workstation, because the name server now knows its location.

Helios servers are written to be "stateless"; that is, the success of a request for a service never depends on the success of a previous request. Achieving statelessness involves some repetition of information; for example, every file read or write request must supply the name of the file and its position pointer. But the trade-off is that the system is inherently fault-tolerant; any request can be repeated until it succeeds.

The Message-Passing Mechanism

Helios' message-passing mechanism must be able to pass messages between tasks on different processors, as well as between tasks on the same processor. Helios handles this operation by sending messages to message "ports." These ports are software data structures that relate to the Transputer's hardware links in much the same way that tasks relate to processes. A message port located on a remote processor is represented in the sender processor by a surrogate port to which the message is sent.

This surrogate port contains a physical link address and passes the message to a port on a next-door-neighbor processor, which may itself be a surrogate port. The message is thus passed hand to hand until it is eventually received by a real message port. The message leaves a trail of port descriptors in each processor through which it passes, pointing back to its source. By default, the surrogate ports along the trail will be deleted to avoid wasting memory, but you can set a flag in the message header to preserve the ports and hence keep the route open for use by further messages.

If for some reason (e.g., a hardware or software failure) a message cannot be delivered to its destination, an exception is raised and returned to the sender for another try. If the exception itself fails to arrive, a timeout will occur on one of the ports. There are no routine acknowledgments of messages; they are assumed to have arrived safely if no exception is returned. Theoretically, it would be safer to have the receiver acknowledge every message, but such a process would double the time it takes to send a message. This trade-off can be justified by the high reliability of Transputer links compared to a conventional LAN.

You can build further error recovery into applications programs at a higher level. For example, the program could lock out dead links or processors (as it would bad disk sectors) and reroute messages through the good parts of the system.

While the Helios messaging system is simple and speedy, the link speed of 20 megabits per second is not fast compared to the speed with which a 10-MIPS Transputer accesses memory. Thus, message-sending is still a relatively slow operation. Tasks that need to have a predictable real-time response must either poll the reply port using a short timeout—so they are not suspended waiting for the reply—or else spawn a child process to watch the port for them.

Distributing Programs

Since there is no hardware memory protection available, Helios provides a software protection scheme based on *capabilities*. A capability is a 64-bit data structure that contains a checksum encrypted with an access mask.

This scheme operates all the way from the level of protecting data objects from the unwanted attentions of rogue tasks, to restricting human access to files. Whenever a task creates a new object, the system gives the object a unique encryption key with which it encrypts its creator's access mask and then returns the capability. A task can only access that object if it owns a valid capability containing the necessary access permission.

All client requests to servers must be accompanied by a valid capability—this process is rather like presenting a credit card. Helios allows only whole programs, rather than their component processes, to be assigned to separate processors. In this respect, Helios represents a regression from the highly parallel approach taken by Occam.

A native Occam program running on the bare hardware can have many component processes executed concurrently on different Transputers, enabling the implementation of highly parallel algorithms such as pipelines. The Helios approach, however, still allows three lesser levels of parallelism.

The first level is Unix-like; pipes connect small single-function programs such as file filters, or editors and compilers. A Helios routine called the task-force manager assigns each such program to a separate processor, if enough are available, and implements the pipes using real Transputer links. The processors can either come from the user's own cluster of private workstation processors, or be allocated from a shared pool just for the duration of the execution.

You can place frequently used programs, such as compilers, on a particular shared processor permanently and direct all invocations of the program to that processor. If a program is well behaved—if it doesn't corrupt memory belonging to other programs—this processor may be shared by several users. Other-

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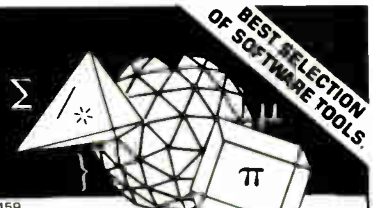

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wise, Helios never allows tasks from different users to be assigned to the same processor.

The second level of parallelism involves large programs that you can divide into modules and allocate to different processors. This division is often easy to perform, since many large programs are already written as a number of overlays. The process involves creating a blueprint file that holds a description of the application components with their memory requirements, relative placements, connections to other modules and so on. The task-force manager uses this file to place the components and execute the application.

It would be much better to have a task-force manager that could simply look at a program and decide how best to distribute it over the processors. Although this goal is the object of many current research projects, it lies well beyond the present state of the art.

The final level, with the finest granularity and highest degree of parallelism, is the Occam compatibility level. Helios can execute Occam programs by taking the components of an Occam `PLACED PAR` construct (a group of concurrent processes) and building a blueprint file for them, then allocating each component to a processor. Each component is made into a whole program by wrapping it in a cocoon of processes that interface to Helios system services and translating raw Occam channel communications into Helios messages.

Helios Development Tools

In addition to the C compiler already mentioned, Perihelion offers a Transputer assembler and linker and is working on a debugger that will allow one Transputer to monitor the activity of another, offering features that are normally found only in hardware debuggers. Other firms are preparing Transputer Pascal, FORTRAN, Lisp, and BCPL compilers, as well as a Helios-hosted Occam compiler.

Perihelion will supply graphics support for the programmer by porting Xwindows V11, the public domain Unix window manager that is fast becoming a standard; it has been adopted by large manufacturers such as Apollo and Hewlett-Packard. Perihelion hopes to have beta-test versions available by July. Helios will perform all graphics operations by sending messages to an Xwindows graphics server that drives the blitter. As an alternative to the C Shell, Xwindows will also be used to implement a windows/icons/mouse/pull-down-menus (WIMP) user interface.

Perihelion has written a number of disk servers. Several servers can be installed in the same system using different disk formats. Floppy servers for the IBM PC, Atari ST, and BBC Micro already exist, while the hard disk server uses a Unix 4.2 format, extended to include the Helios protection scheme.

The Future According to Transputers

The Abaq/Helios project promises to liberate the Transputer from its present confinement in the supercomputer laboratory to, at the very least, the engineering office and teaching lab. Although prices have not yet been fixed, at the time of the Abaq's announcement, Atari spokesmen said that the company hoped to keep the price below $5000.

Clearly, the Abaq is not yet the Transputer machine for the rest of us. But such a price would be relatively inexpensive for a workstation network that should provide at least as much power as the newest offerings from Sun and Apollo. And Helios could become the basis for even less expensive machines that will finally truly bring the Transputer into the personal computer arena. ■

Dick Pountain is a BYTE contributing editor, a technical author, and a software consultant living in London, England.

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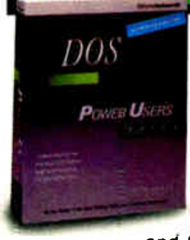

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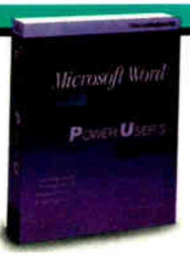

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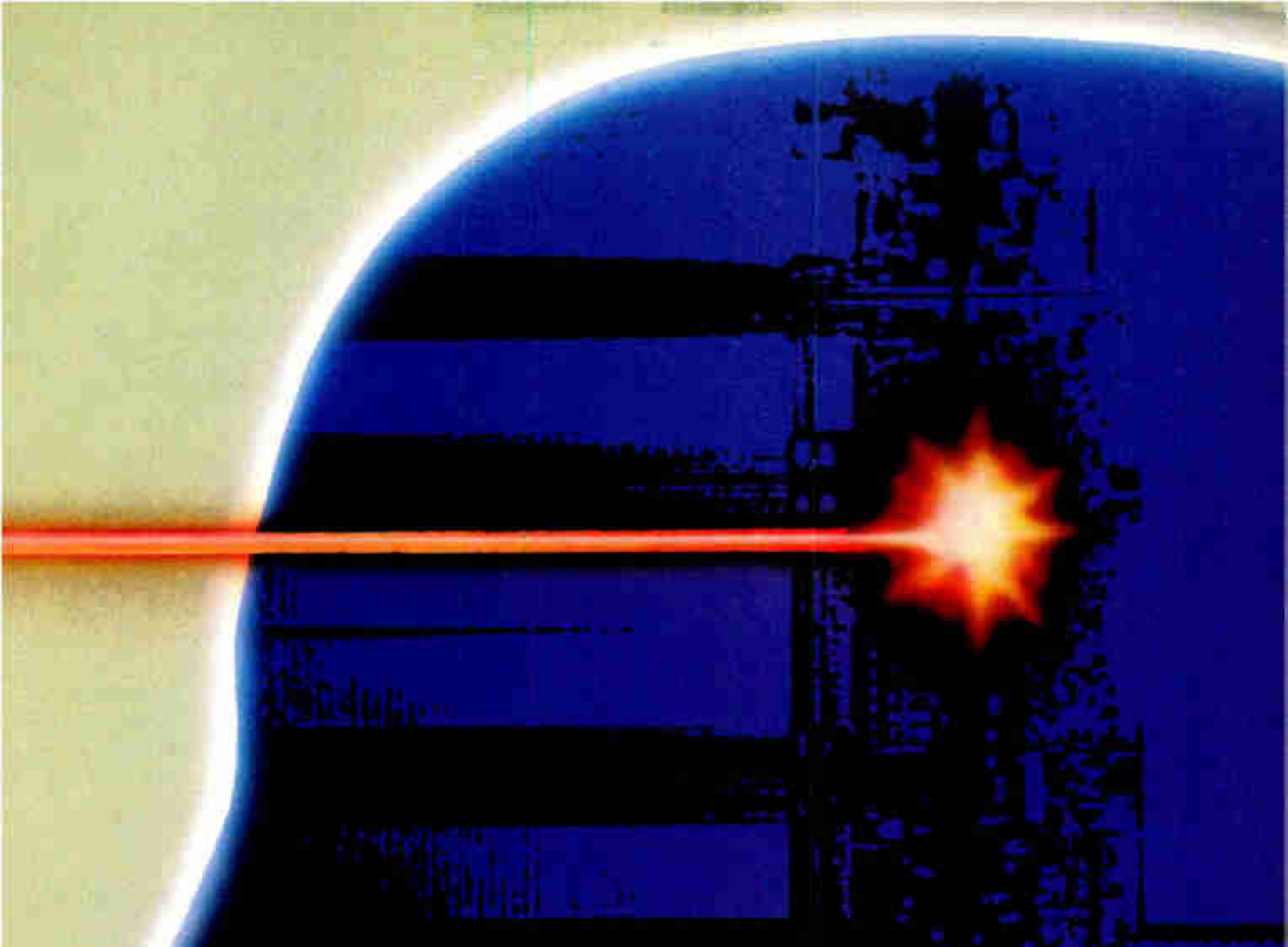

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Dynamic Memory Management in C

Here's how to use C's built-in memory functions to produce better programs, plus some debugging code to make using them easier

Memory management is the process by which programs keep track of where the data they need is stored in the computer's memory. When the correspondence between data and physical memory locations changes during the execution of a program, its memory management is said to be dynamic.

Some pitfalls are waiting for you when you use C's memory management tools, but there are techniques for avoiding them.

C Memory Management and Memory Functions

Much of the memory management done by C is transparent to the programmer. For example, the declaration `int i;` reserves one word of memory to store the value of the variable `i`. If this declaration occurs outside a function, then other functions can access `i`; in this case, `i` is an external, or global, variable. If the declaration occurs inside a function, the word used to store `i` is allocated on the stack. Here, the allocated memory is available inside the function, but discarded when the function returns, making it available for use by another function. This sophisticated memory management scheme requires no effort on your part: You simply declare a variable, and it is available wherever the declaration is in effect. In addition to the built-in memory management through global and local declarations, the standard C library contains several functions that give the programmer access to the heap. These functions are listed in table 1.

The `malloc()` function returns a pointer to a region of at least `size` contiguous bytes of memory that can be used in any way you see fit. `Free()` returns a block of memory to the heap that was obtained by `malloc()`. `Malloc()` and `free()` are the same as `new()` and `dispose()` in Pascal. `Realloc()` changes the size of a block of memory reserved by `malloc()`. The memory block requested can be larger or smaller in size. It is important to note that `realloc()` may modify the pointer to the memory block. If this happens, the contents of the original block (up to the smaller of either the old or the new block size) are copied to the new location. Finally, `calloc()` provides an alternative to `malloc()` when requesting a block. It differs from `malloc()` in two ways: It uses two arguments to specify the block size, and it zeros the contents of the allocated memory block.

Advantages of the Memory Functions

Why would anyone use these functions when C has built-in memory management for variables? One answer is that a C compiler can allocate only fixed amounts of memory for a program when it is compiled. For example, suppose you have written a program for sorting a list of numbers. Before the numbers are sorted, they are read into an array in memory that's declared as `double numbers[1000];`.

This array works fine until you need to sort a list of 1001 numbers. To fix the problem, you can change the declaration to `double numbers[5000];` and recompile the program. This solves the immediate problem of sorting the larger list, but it introduces a new problem: The rest of the memory reserved for the array goes to waste. Worse, the program won't load unless it has enough memory to allocate the entire array, whether or not all of the array is used. If the array is large enough, the program won't run at all on many microcomputers. Only those with lots of memory will work. You can avoid both problems by using `malloc()` or `calloc()` to dynamically allocate memory for the array, making it as large as possible on a given machine at run time. This would fail only when the data set is too large for the machine—a limitation that everyone must live with.

Unnecessary limits caused by fixed array sizes are all too common. For example, in MS-DOS, try setting the Path environment variable to a string of more than 127 characters. As in the previous example, using fixed-size arrays to store the command lines is wasteful, since you must make the array size large enough to hold the longest possible line. Listing 1 shows a routine called `getline()` that reads a line of any length. This routine avoids the wastefulness of fixed-size blocks by adjusting the

continued

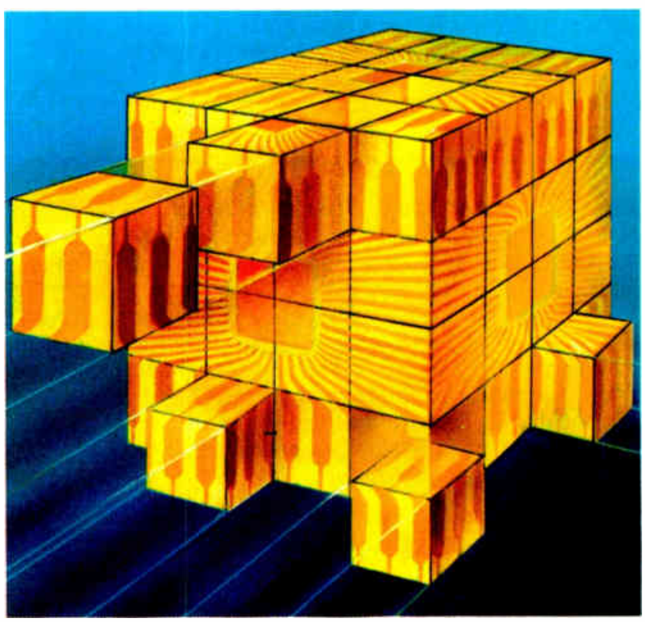


Illustration by Tom Centola © 1988

Table 1: *The common C language functions that access the heap.*

```
#include <stdlib.h>
```

Purpose: ANSI standard header containing declarations of memory management functions.

```
size_t
```

Purpose: The integral type (defined in `<stddef.h>`) of the result of the `sizeof` operator.

```
void        *malloc(size)
size_t      size;
```

Purpose: Dynamically allocates memory. The size of the memory requested, in bytes, is passed to `malloc()`. A pointer to the block is returned if the operation is successful; otherwise, `NULL` is returned.

```
void    free(pointer)
char    *pointer;
```

Purpose: Releases memory blocks allocated by `calloc()`, `realloc()`, or `malloc()`. The pointer to the block is passed to `free()`.

```
void        *realloc(oldptr, newsize)
void        *oldptr;
size_t      newsize;
```

Purpose: Modifies the size of an allocated memory block while preserving its contents. A pointer to the old block is passed to `realloc()`. A pointer to the new block is returned if the operation is successful; otherwise, `NULL` is returned. The pointer returned can be different from the one passed to `realloc()`:

```
void        *calloc(nitem, itemsize)
size_t      nitem;
size_t      itemsize;
```

Purpose: Similar in function to `malloc()`, except that the contents of the block are zeroed. The size of the allocated block (in bytes) is `nitem*itemsize`. A pointer to a block whose size can hold the items requested is returned if the operation is successful; otherwise, `NULL` is returned.

size of every block to the line it contains. It reads characters and stores them in an array created by `malloc()` until a new line character is read. If the array fills up, it is expanded by calling `realloc()`.

When blocks of memory are needed at different times, `malloc()` and `free()` allow the program to reuse memory. For example, the code fragment below can use the same memory (at different times) for an array of integers and an array of pointers. This can often reduce the total amount of memory required to run a program, or it can allow larger amounts of data to be processed in a given amount of memory.

```
char **s;
int *p;
/* Allocate space for an
   array of 1000 integers. */
p = (int *)malloc(1000*sizeof(int));
   ...
/* Finished with integers. */
free(p);
   ...
/* Allocate space for an
   array of 1000 pointers. */
s = (char **)malloc(1000*sizeof(char *));
   ...
/* Finished with pointers. */
```

The examples given so far have all dealt with simple arrays. The benefits of using `malloc()` and `free()` to perform dynamic memory management are multiplied when they're used with more complex data structures, such as linked lists and trees. While it is possible to store a tree in an array of node structures, you must keep track of which array elements contain active nodes and which are unused and available as new nodes. `Malloc()` does all the bookkeeping for you. To create an empty node structure, you simply execute

```
nodeptr = (struct node *)malloc(sizeof(struct node));
```

When the node is no longer needed, you use `free(nodeptr);` to get rid of it.

Disadvantages

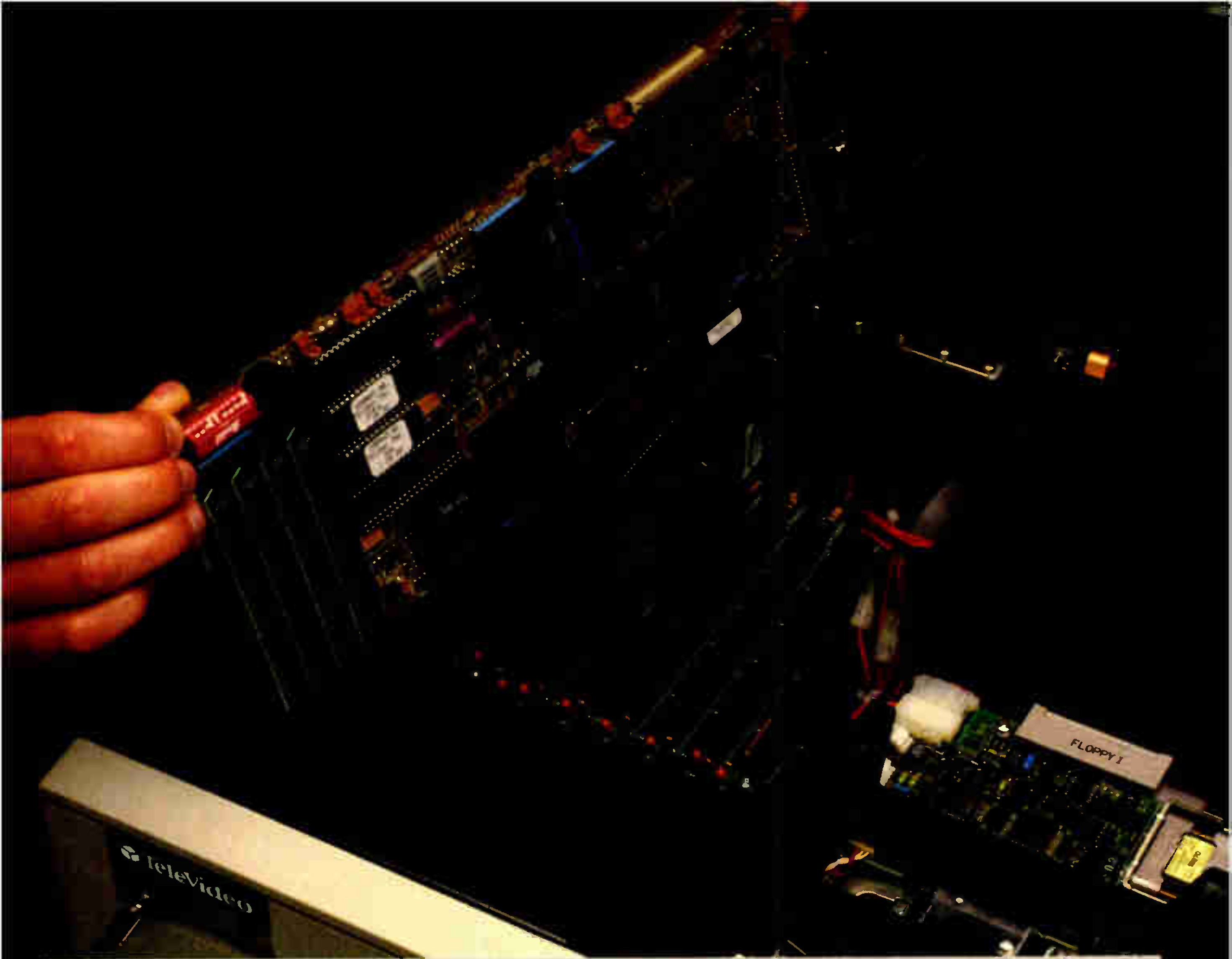
Like most things of value, the benefits of dynamic memory management are not without cost. The first drawback that comes to mind is increased overhead. This overhead turns out to be quite small. The memory allocated by `malloc()` is as efficient as any pointer in C. The extra work is required only when a block is created or released. The additional memory used by `malloc()` for bookkeeping is significant only if many very small blocks are being used.

Dynamic memory management's second cost is that debugging is more difficult. Exceeding the size of an allocated memory block is one of the toughest programming errors to find and correct. Adjacent areas of memory are written into as a result of this error, and you won't detect the damage until you attempt to use the contents of the overwritten memory. These modified values generate all sorts of strange bugs that don't point to the real problem. In the case of an array allocated at compile time, the variables assigned to memory adjacent to the offending array are determined by the declarations in the source code. Since related variables are often declared together, there is a good chance that the problem will be localized.

The location of objects in memory is not under your direct control when you use `malloc()`, and there is a good chance that completely unrelated data will be stored adjacent to one another in memory. Even worse, most implementations of `malloc()` store the data needed to maintain the free list adjacent to the allocated block. Overrunning the end of a block won't destroy data visible to you, but it corrupts the free list. As before, this causes problems when you attempt to allocate a new block of memory using the damaged portion of the free list, and the program may crash as a result—even while executing code that is far from the actual cause of the problem. This kind of bug is very difficult to locate.

The free list can also be damaged by calling `free()` with a pointer that wasn't obtained from `malloc()`. This error is easy to make when a program is allocating memory for many data structures. The seriousness of this error depends on the implementation of `free()`. Consistent with the lean and mean philosophy of C, most versions of `free()` do only minimal checking.

continued



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Listing 1: *The source code for* `getline.c`, *a routine that reads a line and adjusts storage to hold the line, regardless of its length.*

```
/* getline.c -- Read a line. */
#include <stdio.h>
#include <stdlib.h>
#include <stddef.h>

/* getline -- Read one line from file */
/* infile into a string allocated by  */
/* malloc. Return NULL on error,      */
/* otherwise a pointer to the string. */

#define MEMINCR  256    /* Increment in
                   size of memory block. */

char *getline(infile)
FILE *infile;
{
  char *r;
  size_t n,m;
  int c;

  n = 0;             /* # of bytes read. */
  m = MEMINCR;       /* Available space. */
  r = malloc(m+1); /* Allow room for \0 */
  do {
    if (--m == 0) {
      if ((r = realloc(r, n+MEMINCR+1)) ==
        NULL) {
          return NULL;
      }
      m = MEMINCR;
    }
    if ((c = getc(infile)) == EOF) {
      return NULL;
    }
    r[n++] = c;
  } while (c != '\n');
  r[n] = '\0';   /* Terminate the string. */
  if ((r = realloc(r, n+1)) == NULL) {
    return NULL;
  }
  return r;
}
```

This minimizes the overhead of calling `free()` but transfers the responsibility of writing correct code to the programmer.

Avoiding Bugs

Since programs using `malloc()` to manage memory are susceptible to some nasty bugs, the best course is to write correct code in the first place. By far the most effective way to minimize the number of bugs in your code is to think before you write. The extra time spent on careful design of the program and its data structures will be more than repaid when debugging the code.

Programmers often reject programming techniques that result in more reliable code because they believe (rightly or wrongly) that these techniques result in slower programs. This concern for efficiency is doubly misplaced. First, it comes at the wrong time. You should consider efficiency during the design phase, particularly in the choice of the algorithm you use. Second, efforts to improve performance are usually done in the wrong place. Execution speed is relevant only to those parts of a program that execute for a significant amount of time during the program's operation. In most programs, this is only a small fraction of the code. Finally, speed is of little importance if the

continued

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Listing 2: *A function to handle error-checking for calls to* `malloc()`. *If the request fails, the program is stopped after printing an error message; otherwise, the pointer returned by* `malloc()` *is passed to the program.*

```
/* mmalloc -- Allocate nbytes of memory using
malloc(). Exit if malloc() fails. */

#include <stdlib.h>
char * mmalloc(nbytes)
unsigned nbytes; {
  register char *s;

  if ((s = malloc(nbytes)) == NULL) {
    fprintf(stderr, "Out of memory!\n\
 Request for %u bytes failed.\n", nbytes);
    exit(1);
    /* Exit() could be replaced with a call
       to a garbage collection or compaction
       routine and the malloc retried. */
    }
    return s;    /* Return only if s points
               to a valid block of memory. */
}
```

program does not work correctly. The choice between a program that produces the wrong answer quickly and one that gives correct results more slowly is obvious.

Now consider some ways to make the use of `malloc()` more reliable. Always check the value returned by `malloc()` to verify that memory was actually allocated. It's a nuisance to have to write `if (malloc(...) == NULL) error(...);` every time you need to allocate some memory, especially when you're certain there is enough memory. You can avoid this inconvenience by using the function supplied in listing 2.

The idea of encapsulating the error-checking in a separate routine is a simple example of the general principle of information hiding. `Malloc()` itself provides another example. The details of how `malloc()` keeps track of the size and location of available memory blocks are hidden from the program calling `malloc()`. This has several advantages: Keeping the interface to the rest of the program simple minimizes the chance of making an error. The methods and data structures hidden inside a library routine can be thoroughly tested and verified, independently of any application.

A Debugging Tool

No matter how carefully you design and write your programs, sooner or later you will be bitten by one of the nasty bugs dynamic memory management makes possible. There is a debugging tool that will help you find the source of the problem.

The basic idea is this: Before every call to a memory management function, insert code that will make a copy of the sizes and locations of blocks allocated by `malloc()`. This copy is compared with the information maintained by `malloc()`. Any discrepancy is reported immediately. This lets you locate the source of the error at once instead of waiting for the delayed and often disastrous results of overwriting adjacent memory.

The debugging code is in the form of three routines (`tmalloc()`, `trealloc()`, and `tfree()`) that are called instead of the corresponding library functions. These routines are located in `memmchk.c`. The comments in `memmchk.c` tell you how to make these functions available to your program, and address implementation details.

To implement such a tool, you need to know how `malloc()` works. This violation of information-hiding results in a severe portability problem, since there are many ways to write a memory allocator. You would need a different version for every C compiler. I've used Kernighan and Ritchie's implementation of `malloc`, as published in their book, *The C Programming Language* (Prentice Hall, 1978, page 173), to guide the implementation of the debugging routines presented here. Since this book should be in every C programmer's library, you can use it to assist you in porting the debugging routines to a new compiler.

As described by K & R, the basic data structure used by `malloc()` is the free list, which is a linked list of available memory blocks. Each block in the list has an associated header structure containing the size of the block and a pointer to the next block in the list. Blocks that have been allocated and that the program is using are not included in this linked list, but they still have a header containing the size of the block. A call to `malloc()` results in a search of the free list to find a block large enough to satisfy the request. This block, or a portion of it, is then removed from the free list, and a pointer to it is returned to the caller. `Free()` inserts the block pointed to into the free list at the correct location and updates the link pointers in the header structures to maintain the free list. To prevent memory fragmentation, adjacent free blocks are merged. Only the structure of the header is important to the debugging tool. This structure is

```
    struct header {
    struct header *ptr;
         /* Link to next block. */
    unsigned int size;
         /* Size of block. */
};
```

Although the details differ, all the versions of `malloc()` I have seen use a variation of this algorithm. I've used the debug functions in `memmchk.c` successfully with Ecosoft Inc.'s C88 C compiler 4.05. I've also used Manx Software Systems' Aztec C86 C compiler 4.10, although I had to add K & R's version of `malloc` to use `memmchk.c` with it. If you have the source code for your library, you might want to tailor the `malloc()` checker in `memmchk.c` to your compiler.

In addition to checking the block size and location on every call to `free()` or `realloc()`, another check is performed: The number of blocks in the free list is counted every time a memory management routine is called. Since only one block at a time is added to or removed from the free list, any substantial change in the length of the free list between memory calls indicates that pointers connecting the linked list are corrupted.

Finally, there is a routine called `memlst()` to list all the currently allocated memory blocks. This can be useful if called at the end of your program. If all the allocated blocks are freed, it should not produce any output. If some blocks are still allocated, it indicates that you do not have memory management under complete control. The uncertainty about which blocks are in use and which are not can be a source of serious errors.

Using C's dynamic memory management functions results in programs that are portable and that adapt to the amount of memory available on the host computer. The disadvantages can be controlled by careful program design and the coding techniques I've described. Attention to program design and good programming style, especially important with dynamic memory management, will improve the reliability of any program. ■

Editor's note: *The C source code for the debugging tools is available in a variety of formats.* *See page 3 for details.* *To use the tools, you'll need a C compiler.*

David L. Fox of Golden, Colorado, is the chief scientist at Minimum Instruction Set Computer Inc. He has spent the last 4 years developing programmers' tools and expert systems.

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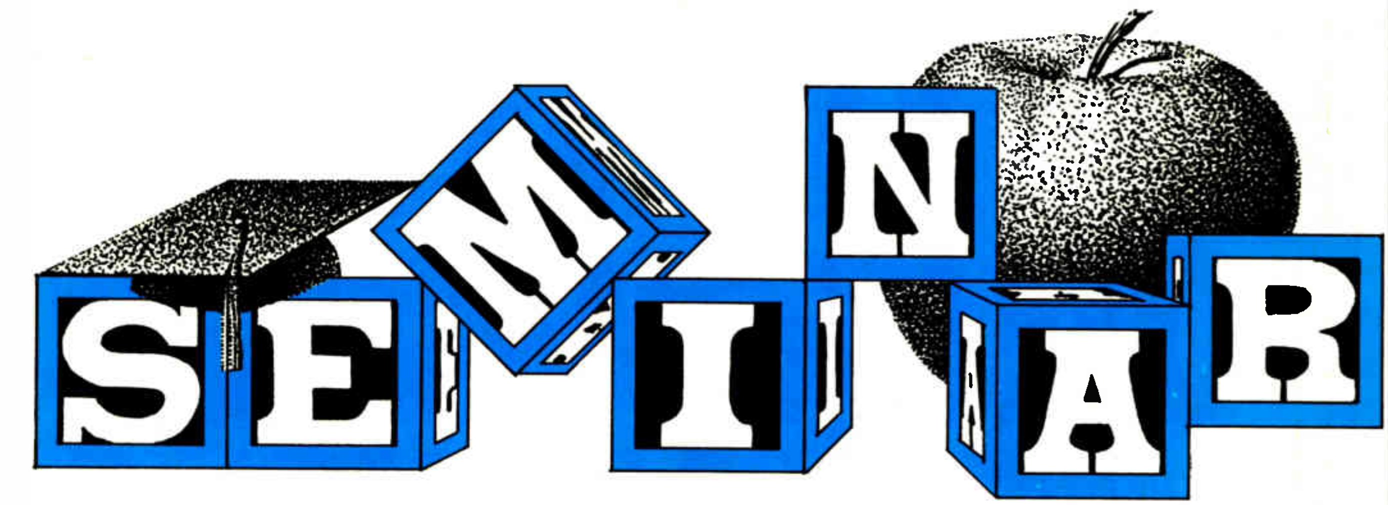

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- ■ Network Management — Keeping your Network Running
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puting at Chaos Manor. I agree that C compilers are getting better and more competitive. I have only three, but I find that they vary considerably in completeness and technical support.

My venture into the world of C has been as a self-taught hobbyist rather than as a professional. I am therefore more sensitive to and irritated by systems and documentation that assume all users are computer science graduates who write their own functions in assembly language to fill in the missing gaps in the product.

My sad experience with Borland's Turbo C is an example, even though you generously suggested it as a "clear choice for beginners and dilettantes." I am somewhere between these extremes, but I find this package one of the most deficient of the lot. Can you imagine a system that comes with two nice volumes of instructions and functions, yet doesn't contain one C function for even clearing the screen? In fact, the IBM PC version contains practically no screen functions whatsoever. You cannot locate cursor position, read the cursor column or line, or even scroll.

On the bright side of this competition, C Ware's excellent DeSmet C compiler and debugger provide no less than 17 screen-level functions to simplify the interface between the C program and the IBM PC and its clones. You can fold them into the standard function library with a simple routine.

When I wrote to Borland asking for help or information on the Turbo C deficiency, the company took more than 3 months to answer and then simply told me that no screen functions were provided because they were "not standard." To my amazement, Borland recommended that I buy these functions from another company. So much for Borland's support for what might otherwise be a useful compiler. I am now back and happy with my C Ware DeSmet C compiler, while Borland's inadequate product is gathering dust on my bookshelf. Let the nondilettante buyer beware.

Walter K. MacAdam
Hanover, NH

Thanks. As I said in my column, I have to base what I say about C compilers on what I'm told by people I farm them out to; I don't program in C, and I have little right to an opinion of my own. Perhaps the people I used to test Turbo C were too advanced to notice the problem?—Jerry

Does BYTE Slight Amiga?

Dear Jerry,

I'm somewhat surprised that your February column devoted so much space to the Atari Mega ST. I am the former owner of an Amiga 1000 and now the happy owner of an Amiga 2000.

I'm not anti-Atari. I just don't believe that you or the other writers who contribute articles to BYTE are giving the Amiga its due. I can understand how you might have trouble dealing with Commodore. I certainly have. I think, however, that the company seems to be getting its act together and appears to be more responsive to its customers. I wouldn't have bought another Amiga if I didn't think the company was on the right track. There were times I wished I'd purchased a Macintosh or any other computer, but I don't feel that way now.

Quite a few new third-party hardware products are now on the market or being developed for the Amiga. Significant software is showing up. I don't see any mention of it in BYTE. The last article of consequence was the Commodore A2000 product preview in March 1987. A lot has changed between then and now.

In the low-cost home market, Commodore offers the 500, a computer that stacks up quite well against the Ataris and in many respects offers a better, more expandable value. The 2000 has given the Amiga owner a machine whose expandability and flexibility are far-reaching: 68020 and 68030 cards, MS-DOS and possible OS/2 compatibility, possible Macintosh compatibility, 704- by 470-pixel resolution, a multiscan board, and rumored new Denise and Agnes upgrades, just to name some of the advantages.

I'd appreciate it if you'd see what could be done to bring the developments in this line of computers to the attention of BYTE readers. If you and any other writers for BYTE have serious objections or reservations concerning the Amiga, I wish you'd address them in the magazine. I'd hate to think that you would just ignore it.

John H. Harvey Jr.
Minneapolis, MN

I think you have two misconceptions. First, I rely on the BYTE people in Peterborough for support and information, but my column is an independent operation.

Second, I live in Hollywood, amidst huge stacks of hardware and software, and there's only me to deal with it all. I try to keep up with what's going on, but so much comes in that I'm hard-pressed to look at it all. The fact is that Atari takes the trouble to see that I get most of the interesting third-party hardware and software for its machines, and Commodore doesn't.

I recently got an Amiga 2000 and had a couple of Amiga experts over to help set it up; I'll have a report pretty soon. However, I can write only about what's here, and the Commodore machines I have are pure vanilla. On the Amiga 2000, the IBM PC half has exactly the same speed as the earliest PC, while the Amiga half is built around a 68000. No 68020 on the Amiga, and no way to run OS/2 on the PC. I wish I did have something with all the goodies you describe. Does anyone?—Jerry ■

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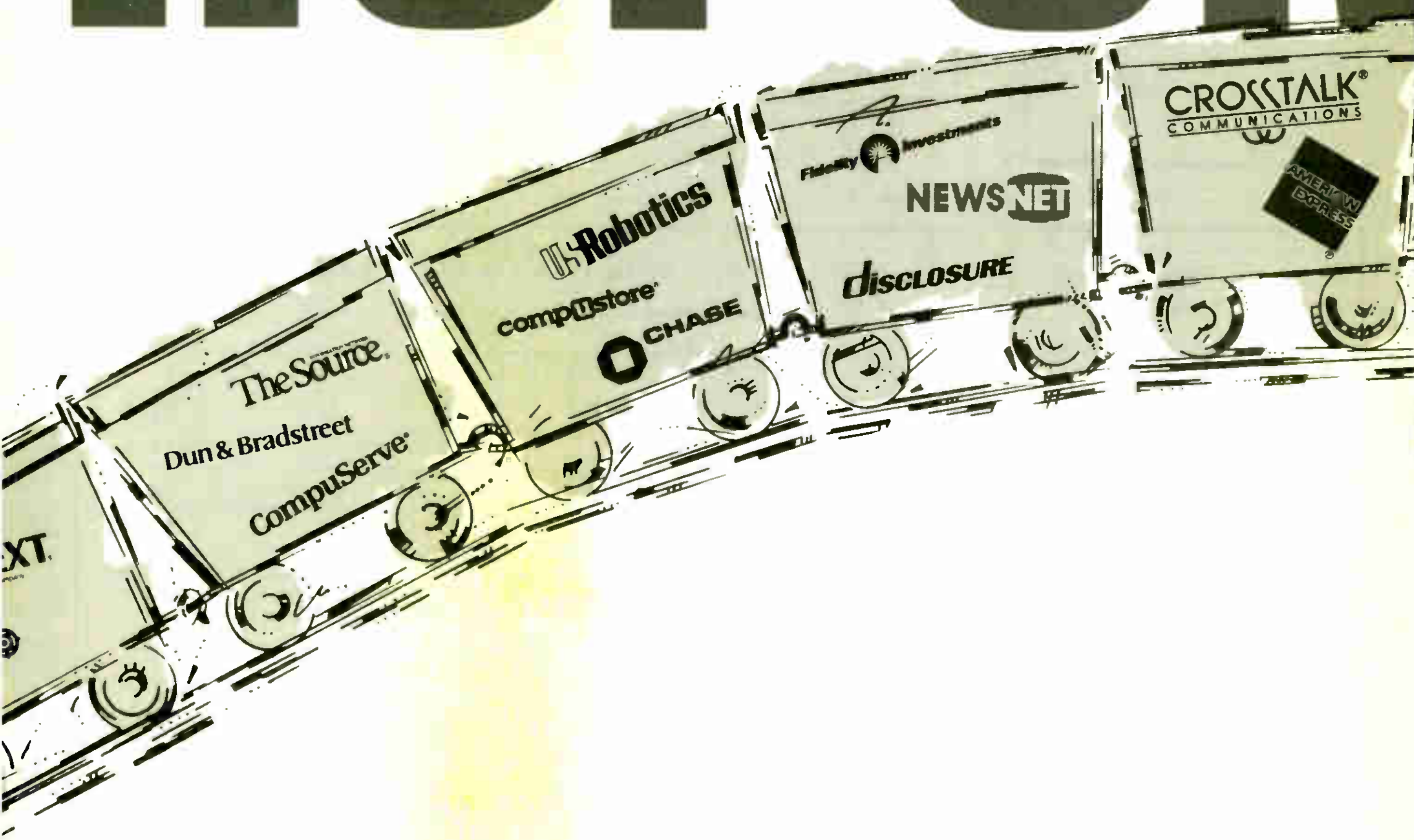
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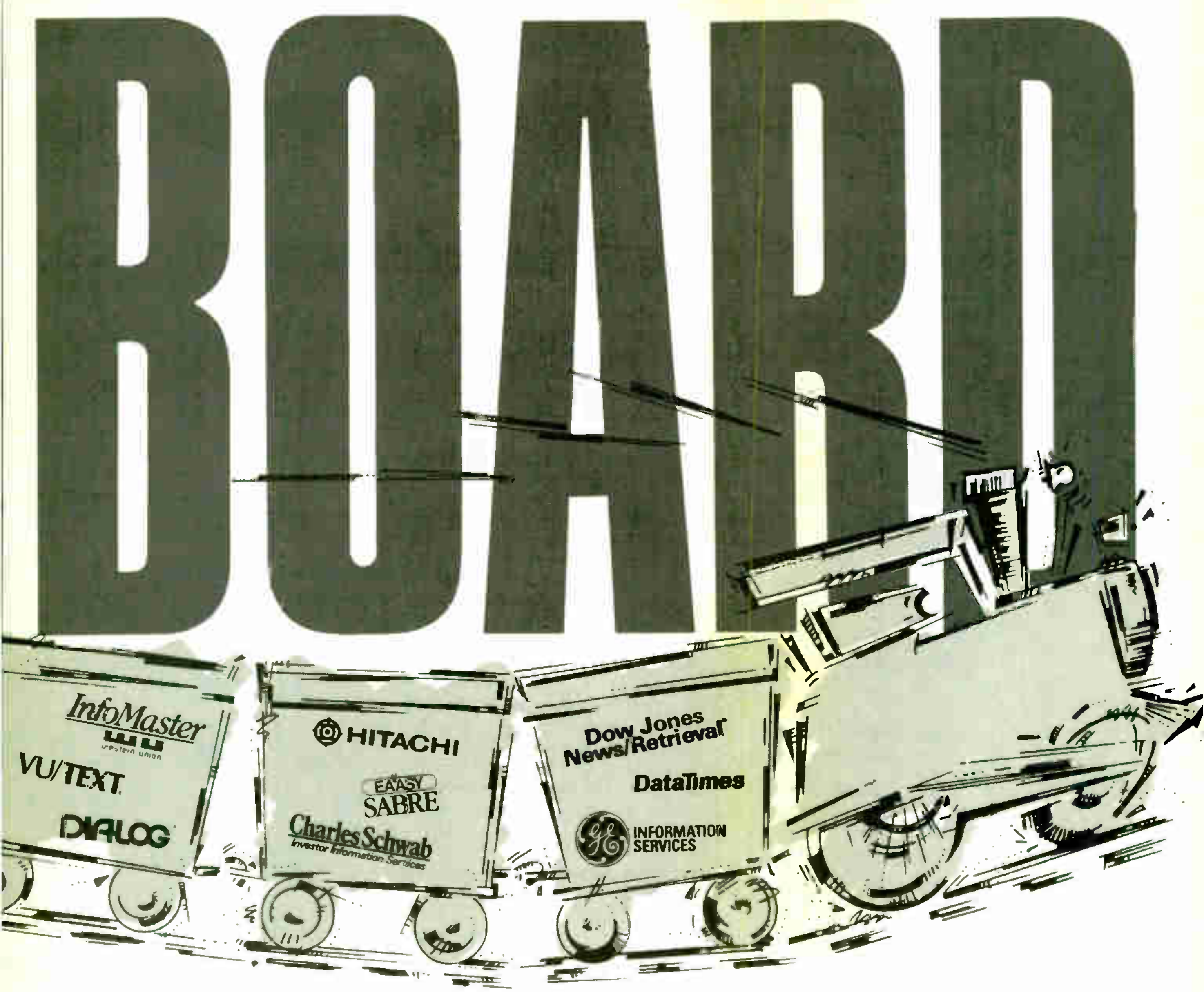

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Z80A-PIO	1.69
Z80A-SIO/0	5.75
Z80B	3.49
Z80B-CTC	3.95
Z80B-PIO	~~4.29~~ 3.95
6500/6800/68000 SER.	
6502	2.65
65C02(CMOS)	~~8.95~~ 7.75
6520	1.95
6522	3.95
6532	~~6.49~~ 5.49
6551	~~4.49~~ 2.95
65C802 (CMOS)	17.95
6800	1.95
6802	3.95
6810	1.25
6821	1.75
6840	3.95

6500/6800/68000 Cont.

Part No.	Price
6845	~~8.95~~ 2.95
6850	1.95
6852	1.49
MC68000L8	11.95
MC68000L10	13.95
MC68010L10	49.95
MC68020RC12B	169.95
MC68881RC12A	149.95
8000 SERIES	
8031	3.95
80C31	9.95
8035	1.95
8073	9.95
8080A	~~2.95~~ 2.49
8085A	2.49
8086	5.95
8086-2	6.95
8087(5MHz)	129.95
8087-1(10MHz)	229.95
8087-2(8MHz)	159.95
8088	~~6.49~~ 5.75
8088-2	~~8.95~~ 7.75
8116	4.95
8155	2.49
8155-2	3.49
8156	3.95
8202	5.95
8203	9.95
8212	2.29
8224	2.25

8000 SERIES Cont.

Part No.	Price
8228	2.95
8237-5	~~4.95~~ 4.49
8243	~~2.25~~ 1.75
8250A	6.49
8250B (For IBM)	6.95
8251A	1.89
8253-5	1.95
8254	4.95
8255A-5	1.89
8257-5	1.95
8259-5	2.25
8272	~~4.95~~ 3.95
8279-5	2.95
8741	9.95
8742	~~29.95~~ 22.95
8748 (25V)	7.95
8748H (HMOS) (21V)	9.95
8749	9.95
8751	39.95
8755	14.95
DATA ACQUISITION	
ADC0804LCN	~~3.49~~ 2.79
ADC0808CCN	5.95
ADC0809CCN	~~8.95~~ 3.69
ADC0816CCN	11.95
ADC1205CCJ-1	19.95
DAC0808LCN	1.95
DAC1008LCN	4.95
AY-3-1015D	4.95
AY-5-1013A	2.95

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Part No.		Price
8052AHBASIC	CPU w/BASIC Interpreter	$ 29.95
MC68008L8	32-Bit MPU (8-Bit Data Bus) ~~19.95~~	$ 16.95
MC68701	8-Bit EPROM Microcomputer	$ 14.95
MC68705P3S	8-Bit EPROM Microcomputer	$ 14.95
MC68705U3S	8-Bit EPROM Microcomputer	$ 10.95
80286-10	16-Bit Hi Performance MPU	$ 99.95
80287-8	Math Co-processor (8MHz)	$245.95
80287-10	Math Co-processor (10MHz)	$309.95
80387-16	Math Co-processor (16MHz) GRID ARRAY	$494.95
80387-20	Math Co-processor (20MHz) GRID ARRAY	$795.95

DYNAMIC RAMS

Part No.			Price
*4116-15	16,384 x 1	(150ns)	1.09
4128-20	131,072 x 1	(200ns) (Piggyback) ~~9.25~~	2.75
*4164-100	65,536 x 1	(100ns)	3.95
*4164-120	65,536 x 1	(120ns)	3.25
*4164-150	65,536 x 1	(150ns)	2.95
*4164-200	65,536 x 1	(200ns)	1.95
*TMS4416-12	16,384 x 4	(120ns)	7.49
*41256-80	262,144 x 1	(80ns)	13.95
*41256-100	262,144 x 1	(100ns)	12.95
*41256-120	262,144 x 1	(120ns)	11.95
*41256-150	262,144 x 1	(150ns)	10.95
*50464-15	65,536 x 4	(150ns) (4464)	9.95
*511000P-10	1,048,576 x 1	(100ns) 1 Meg	49.95
*514256P-10	262,144 x 4	(100ns) 1 Meg	89.95

STATIC RAMS

*2016-12	2048 x 8	(120ns)	3.95
2018-45	2048 x 8	(45ns) ~~6.95~~	5.49
2102	1024 x 1	(350ns)	.89
2114N	1024 x 4	(450ns)	.99
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
5101	256 x 4	(450ns) CMOS	1.95
*6116P-3	2048 x 8	(150ns) CMOS	3.95
*6116LP-3	2048 x 8	(150ns) LP CMOS	4.49
*6264LP-12	8192 x 8	(120ns) LP CMOS	6.89
*6264P-15	8192 x 8	(150ns) CMOS	5.89
*6264LP-15	8192 x 8	(150ns) LP CMOS	6.39
6514	1024 x 4	(350ns) CMOS	3.49
*43256-15L	32,768 x 8	(150ns) Low Power	12.95

EPROMS

TMS2516	2048 x 8	(450ns) 25V	6.95
TMS2532	4096 x 8	(450ns) 25V	6.95
TMS2532A	4096 x 8	(450ns) 21V	5.95
TMS2564	8192 x 8	(450ns) 25V	9.95
TMS2716	2048 x 8	(450ns) 3 Voltage ~~9.95~~	6.95
1702A	256 x 8	(1µs) ~~6.95~~	4.95
2708	1024 x 8	(450ns)	4.95
2716	2048 x 8	(450ns) 25V	3.75
2716-1	2048 x 8	(350ns) 25V	4.25
27C16	2048 x 8	(450ns) 25V (CMOS)	5.49
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	5.95
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	3.95
2764-45	8192 x 8	(450ns) 21V	2.95
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 21V	6.95
27128-25	16,384 x 8	(250ns) 21V	5.95
27128A-25	16,384 x 8	(250ns) 12.5V	5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	6.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.95
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)	7.95
27512-20	65,536 x 8	(200ns) 12.5V	13.49
27512-25	65,536 x 8	(250ns) 12.5V	11.95
68764	8192 x 8	(450ns) 25V	13.95

EEPROMS

2816A	2048 x 8	(350ns) 5V Read/Write	5.95
2817A	2048 x 8	(350ns) 5V Read/Write	7.95
2865A	8192 x 8	(250ns) 5V Read/Write	9.95
52B13 (21V)	2048 x 8	(350ns) 5V Read Only	1.49

COMMODORE CHIPS

Part No.	Price
LAG570	~~10.95~~ 9.95
WD1770	11.95
SI3052P	2.49
6502	2.65
6504A	1.95
6507	4.39
6510	9.95
6520	1.95
6522	3.95
6525	~~4.95~~ 3.49
6526	~~14.95~~ 12.95
6529	2.95
6532	~~6.49~~ 5.49
6545-1	~~4.95~~ 3.25
6551	~~4.49~~ 2.95
6560	10.95
6567	14.95
6569	24.95
6572	8.95
6581 (12V)	14.95
6582 (9V)	~~14.95~~ 9.95
8360	14.95
8501	10.95
8502	7.95
8563	15.95
8564	9.95
8566	24.95
8701	9.95
8721	14.95
8722	9.95
*251104-04	10.95
310654-05	9.95
318018-03	10.95
318019-03	10.95
318020-04	10.95
325302-01	10.95
325572-01	14.95
*82S100PLA**	15.95
901225-01	11.95
901226-01	11.95
901227-03	11.95
901229-05	11.95

*No specs available
**Note 82S100PLA = U17 (C-64)

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27128-45	128K EPROM (450ns) 21V	4.95
74LS612	Memory Mapper, Tri-State	11.95

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	~~.25~~ .19	74HC175	~~.69~~ .49
74HC02	~~.25~~ .19	74HC221	~~1.19~~ .89
74HC04	~~.29~~ .19	74HC240	~~.99~~ .69
74HC08	~~.29~~ .19	74HC244	~~.99~~ .69
74HC10	~~.29~~ .19	74HC245	~~.99~~ .79
74HC14	~~.49~~ .29	74HC253	~~.59~~ .49
74HC30	~~.29~~ .19	74HC259	~~.89~~ .49
74HC32	~~.29~~ .25	74HC273	~~.99~~ .69
74HC74	~~.99~~ .29	74HC373	~~.99~~ .65
74HC75	~~.99~~ .35	74HC374	~~.99~~ .65
74HC76	~~.45~~ .35	74HC595	~~1.29~~ 1.09
74HC85	~~.79~~ .55	74HC688	~~.99~~ .79
74HC86	~~.99~~ .35	74HC943	8.95
74HC123	~~.89~~ .69	74HC4040	~~.99~~ .79
74HC125	~~.49~~ .39	74HC4049	~~.59~~ .49
74HC132	~~.69~~ .39	74HC4050	~~.59~~ .49
74HC138	~~.49~~ .39	74HC4060	~~.99~~ .89
74HC139	~~.49~~ .39	74HC4511	~~1.29~~ 1.09
74HC154	~~1.49~~ 1.1[illegible]	74HC4514	~~1.79~~ 1.09
74HC163	~~.65~~ [illegible]	74HC4538	.89
74HC174	~~[illegible]~~ .49	74HC4543	~~1.19~~ .89

74HCT — CMOS TTL

74HCT00	~~.29~~ .17	74HCT139	~~.59~~ .35
74HCT02	~~.29~~ .17	74HCT157	~~.69~~ .35
74HCT04	~~.29~~ .17	74HCT174	~~.69~~ .35
74HCT08	~~.29~~ .17	74HCT175	~~.69~~ .39
74HCT10	~~.29~~ .17	74HCT240	~~.99~~ .89
74HCT32	~~.29~~ .21	74HCT244	~~.99~~ .59
74HCT74	~~.49~~ .25	74HCT245	~~1.19~~ .79
74HCT86	~~.49~~ .29	74HCT373	~~1.19~~ .55
74HCT138	~~.59~~ .35	74HCT374	~~1.19~~ .49

74C—CMOS

74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.79
74C08	.35	74C240	1.79
74C10	.35	74C244	1.79
74C14	.59	74C373	1.95
74C32	.35	74C374	1.95
74C74	.59	74C912	8.95
74C85	1.49	74C915	1.39
74C86	.35	74C920	6.95
74C89	5.49	74C921	6.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

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DS0026CN	1.95	LM1458N	.39
TL074CN	1.19	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.89
LM311N	.45	MC1648P	3.49
LM317T	.79	LM1871N	1.95
LM318N	.99	LM1872N	1.95
LM319N	1.29	LM1896N-1	~~1.49~~ .79
LM323K	3.95	ULN2003A	.79
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	26LS29	3.95
LM348N	.69	26LS31	1.19
LM350T	2.95	26LS32	1.19
LF351N	.39	26LS33	1.49
LF353N	.49	LM2901N	~~.99~~ .25
LF355N	.79	LM2907N	1.29
LF356N	.89	LM2917N (8 pin)	1.95
LF357N	1.09	MC3419CL	6.95
LM358N	.49	MC3446N	1.69
LM360N	2.19	MC3450P	1.95
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NE555V	.29	LM3916N	1.95
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LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
LM567V	.79	7815K (LM340K-15)	1.29
NE592N	.89	7805T (LM340T-5)	.49
LM741CN	.29	7812T (LM340T-12)	.49
LM747CN	.59	7815T (LM340T-15)	.49
MC1350P	1.09	7905K (LM320K-5)	1.35
MC1372P	1.95	7905T (LM320T-5)	.59
MC1377P	2.29	75472	.59
MC1398P	8.95	75477	.89
LM1414N	1.29	MC145106P	~~9.25~~ 2.49
		MC145406P	2.95

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Low Profile		Wire Wrap (Gold) Level #3	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

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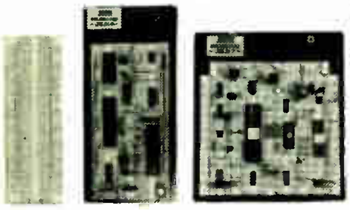

JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x ¾	200	0	$ 2.29
JE21	3¼ x 2⅛	400	0	$ 4.49
JE22	6½ x 1⅜	630	0	$ 5.95
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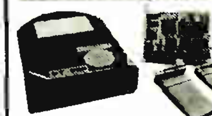

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- ST225K 20MB w/Controller (PC/XT)..... $269.95
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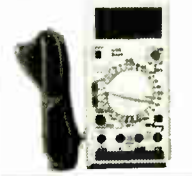

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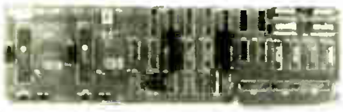

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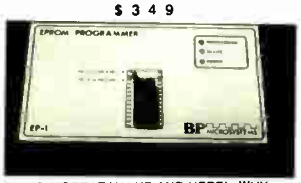

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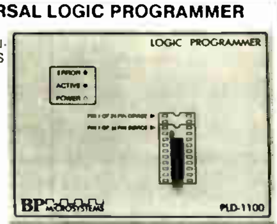

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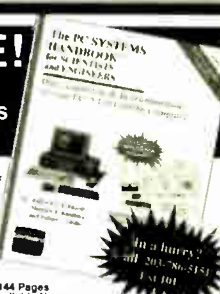

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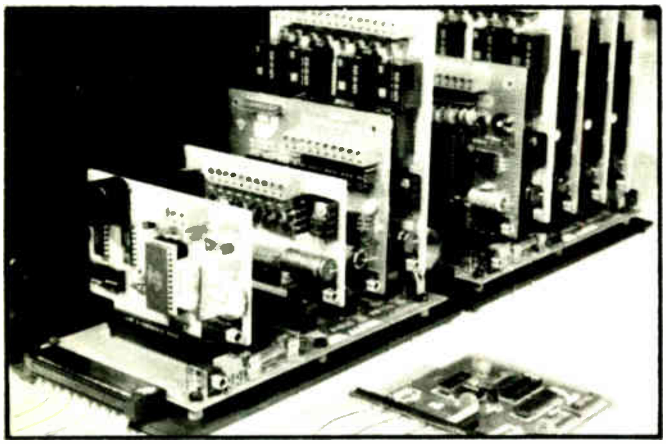

An A-BUS system with two Motherboards
A-BUS adapter (IBM) in foreground

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About the A-BUS:

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- A-BUS cards are shipped with power supplies (except PD-123) and detailed manuals (including schematics and programming examples).

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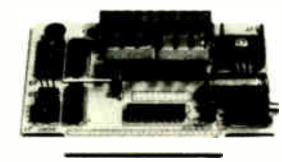
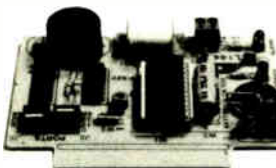
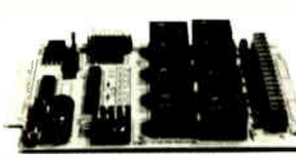


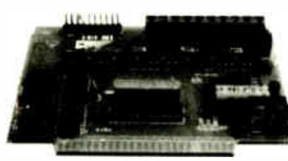
ST-143



CL-144



RE-140



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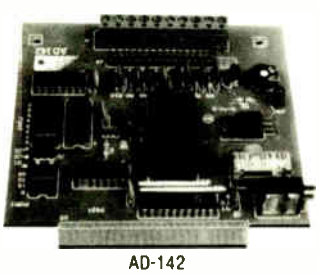

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San Diego, CA 92126
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RS232C IBM PC Compatible Paper Tape Transmitter/Model 612

Stops and starts on character at all speeds, uses manual control or X-on, X-off 90-260 volt, 50-60 Hz power. 50-9600 baud, up to 150 char/sec synchronous or asynchronous; gated internal or external clock. RS 232C, current loop or parallel output, reads 5-8 level tape, 7-11 frames per character, even or odd parity. Desk top or rack mount.

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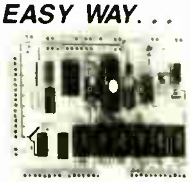

- *8 analog inputs*
- *8 contact (status) inputs*
- *8 relay driver outputs*
- *6 optional pulse accumulators*
- *Base Price $595.00*

The MOJAVE LMX I/O processor communicates with any computer or terminal in ASCII over RS-232 or over built in Bell 103 or Bell 202 modems. Operates over virtually any distance over dial up or over multi-drop radio or cable. A small battery can power the LMX for up to 4 years. Larger capacity I/O processors are available.

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- analog I/O from $1695

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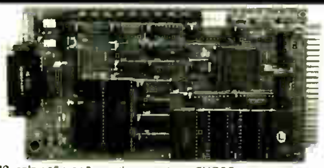
2863 152 Ave. N.E.
Redmond, WA 98052
Telex 510 601 3473

Circle 186 on Reader Service Card

MICROMINT'S Gold Standard in Single Board Computers & Controllers

Announcing

BCC180 – $395.00
MULTITASKING CONTROLLER



The **BCC180**, only 4.5" x 8.5" uses the same 64180 CMOS Z-80 instruction compatible processor as Micromint's SB180 and SB180FX single board computers. Configured primarily for process control w/384K of memory, 6 parallel I/O ports, console serial port, RS-232/422/485 selectable auxiliary serial port, and an interrupt driven ROM-resident multitasking BASIC 180 compiler, the **BCC180** uses the same 44-pin I/O expansion bus as Micromint's BCC 52 controller board.

PROCESSOR
- CMOS HD64180 9.216MHz 8-bit CPU 68 pin PLCC package

MEMORY
- Up to 384K bytes total memory on-board
- 128K of either static RAM (62256) or EPROM (27256)
- 256K dynamic RAM 4MM
- Full function 4K ROM monitor included

INPUT/OUTPUT
- Console RS-232 serial port with auto baud rate select to 19,200 baud
- Peripheral serial port 150-19,200 baud selectable RS-232, RS-422 or RS-485
- 48 bits bi-directional parallel I/O
- 64K I/O available through the BCC bus edge connector

DIMENSIONS and CONNECTIONS
- Dual 22-pin (0.156") edge connector
- Compatible with all Micromint BCC-series I/O expansion boards
- Two 20-pin headers for six bi-directional parallel ports
- 25 pin DB-25S for RS-232 console I/O
- 20 pin header for RS-232 auxiliary serial port
- 4 screw terminals for RS-422/485 connection

BCC180-1-20	9MHz assembled and fully socketed BCC180 Computer/Controller with 32K bytes of static RAM, ROM Monitor, BASIC-180 development software and user's manual	$395.00
	For additional 256K DRAM add $100.00	
BCC180-1	100 Quantity w/32K RAM, w/o Monitor ROM	$209.00

SB180FX —— $409.00
Single Board Computer

SB180FX TECHNICAL SPECIFICATIONS

PROCESSOR
- Hitachi HD64180, an 8-bit CPU in a 64 pin PLCC package
- Superset of Z-80 instruction set including hardware multiply
- Integrated Memory Management Unit with 512K bytes address space
- Dynamic RAM refresh
- Wait state generator
- Clocked serial I/O port
- 2 channel Direct Memory Access Controller
- 2 channel Asynchronous Serial Communication Interface
- 2 channel 16-bit Programmable Reload Timer
- 12 interrupts
- Dual bus interface to 68xx and 80xx support chips
- 6.144MHz, 9.216MHz and 12.288 MHz system operation

MEMORY
- 512K bytes dynamic RAM on board
- Memory externally expandable to 4 Mbyte RAM
- Either an 8K 2764, 16K 27128, or 32K 27256 EPROM usable
- Full function 4K ROM resident monitor

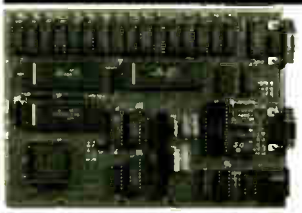
INPUT/OUTPUT
- Console RS-232 serial port with auto baud rate select to 38,400 baud
- Peripheral RS-232 serial port full hand shaking 150-38,400 baud
- Line printer parallel I/O port
- 24 bits bi-directional parallel I/O
- 19-bit address decoding, I/O port decoding and dual bus interface brought out to expansion bus connector
- Can be directly attached to GT180 640 x 480 color graphics adapter
- Fully implemented SCSI hard disk and communications bus interface

FLOPPY/HARD DISK INTERFACE
- Uses Standard Microsystems 9266 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
- Handles both FM encoded (single density) and MFM encoded (double density) data
- NCR 53C80 SCSI bus controller for hard disk or network communication

SOFTWARE COMPATIBILITY
- CP/M, ZRDOS, ZCPR3 Compatible

SB180FX-1	SB180FX 6.144 MHz computer board populated w/ 256K bytes RAM, 4K byte ROM monitor without SCSI chip. Add $50.00 for 9 MHz.	$409.00
SB180FX-1-30	SB180FX-1 computer board as described above with Z-System software including ZRDOS, ZCPR3, editor utilities, ZAS assembler and ZDM debugger, BIOS and ROM monitor sources, and BIOS for SCSI hard disk. Supplied on five 5¼" SB180 format DSDD disks.	$499.00

GT180 —— $395.00
Graphics Display System

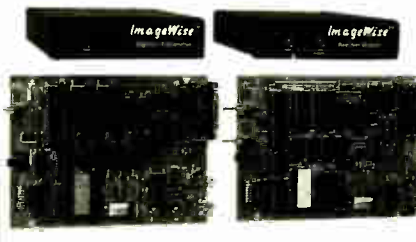


The **GT180** has both TTL RGB (red, green, blue, intensity) and analog RGB outputs, is totally compatible with virtually all standard and multiscan CRT monitors, and has a connector for an IBM PC keyboard.

The **GT180** offers these features:
- Advanced graphics controller provides intelligent link between computer and user
- Only 5.75" x 8", piggy backs on either an SB180 or SB180FX computer
- High resolution at a low cost: 640 x 480 with 16 of 4096 colors
- Hardware drawing commands: LINE, RECTANGLE, POLYLINE, POLYGON, CIRCLE, ELLIPSE, ARC, FILLED RECTANGLE, PAINT, PATTERN, WINDOW and COPY to name but a few
- Automatic translation of logical X-Y coordinates to physical frame buffer addresses
- Fast drawing speed of 2 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)	$395.00
GT180-2	Graphic Display Expansion Board (TTL RGB and Analog RGB)	$449.00

ImageWise™
Serial Digital Imaging System



MICROMINT INTRODUCES A STAND-ALONE SERIAL DIGITAL IMAGING SYSTEM! The MICROMINT **ImageWise™ Serial Digital Imaging System** is the most cost effective and versatile high performance grayscale video digitizing system on the market today. The ImageWise system has been designed to function as a standalone digitizer or as an integral component of a complete tele-imaging system. **ImageWise™'s** serially bit mapped digitized pictures give it almost universal compatibility with any computer capable of attaching to a modem or terminal. It is ideally suited for CAD/CAM, Desktop Publishing, automatic inspection, and security applications. Critical System functions such as image resolution and picture update can be controlled and commanded remotely. Images are transmitted and received serially, either compressed or uncompressed, and can be displayed, transmitted, stored, edited, or processed for use in a variety of industry standard application software.

IMAGEWISE SYSTEM SPECIFICATIONS
- NOT bus dependent — can function standalone
- True frame grabber — uses a high speed flash A/D converter and 64K bytes of static RAM to capture an image in 1/60th second
- Accepts any B/W or color NTSC video signal
- Stores pictures as 244 lines of 256 pixels, 64 levels grayscale
- Resolution of transmitted image is software selectable; all images are represented in 64 levels of gray scale
  - Selectable Resolutions
    - High 256x244x6
    - Med 128x122x6
    - Low 64x61x6
- Video Input: 1 volt peak-to-peak B&W or color 75 ohm termination
- Video Output: 75 Ohm 1.5 V peak to peak NTSC composite video
- Serial Input/Output: RS 232 – 8 bit, one stop bit, no parity 300 bps-57.6Kbps selectable data rate; Xon / Xoff Handshaking Switch selectable data compression (on/off)
- Modem compatible. Easily functions as a video telephone to send video images anywhere
- Video processing disk upload/download and display utilities provided for PC DOS and MS DOS machines

Optional PC Utilities Disk converts ImageWise™ files for use with popular Desktop and Paint Programs.

DT01	ImageWise Digitizer / Transmitter	$349.00
DR01	ImageWise Receiver / Display	$349.00

NEW LOW PRICE OEM-286 —— $620.00
complete PC/AT-CPU

Low Power!
Expansion Card Form Factor!
100% AT Compatible!

MICROMINT's **OEM-286** is a complete PC/AT-CPU and more. The **OEM-286** is the first low power, 100% AT compatible which has been specifically designed for OEM use within the industrial and business sectors. The **OEM-286** features the Zymos CMOS POACH set and 100% compatible Award BIOS. The development of the POACH chip set has allowed the 129 IC's on a standard AT to be reduced to 20 IC's and two SIMMS. What this means for you is:

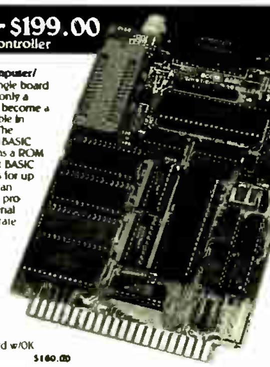
1) The overall size of a standard AT/CPU has been condensed into the expansion card form factor (13¼" x 5¼")
2) Power requirements are less then 1 A @ 5 volts
3) **OEM-286** plugs into a passive backplane for easy connection to other expansion peripherals

The **OEM-286** is available in both 8 and 10 Mhz versions and comes with the Award BIOS.

OEM-286 FEATURES
- 100% AT compatible
- 80286 Microprocessor 8 or 10 Mhz
- 80287 Co-Processor optional
- 64 Kbytes of ROM, can accommodate 128 Kbytes
- 512 Kbytes of RAM
- Keyboard Controller
- Expansion card size factor
- Standard interface to the System Expansion Bus
- Battery backed real time clock
- Award BIOS included

OEM-286/10	10MHz AT/CPU	$620.00
OEM-285/BP	8 SLOT PASSIVE BACKPLANE	$115.00
OEM-286/10	100 QUANTITY PRICE	$562.00

BCC52 —— $199.00
BASIC 52 Computer/Controller



The **MICROMINT BCC52 Computer/Controller** is a stand-alone single board microcomputer which needs only a power supply and terminal to become a complete system programmable in BASIC or machine language. The **BCC52** uses the Intel 8052AH BASIC microprocessor which contains a ROM resident 8K byte floating point BASIC interpreter. It contains sockets for up to 48K bytes of RAM/EPROM, an "intelligent" 2764/128 EPROM programmer, 3 parallel ports, a serial terminal port with auto baud rate selection, a serial printer port.

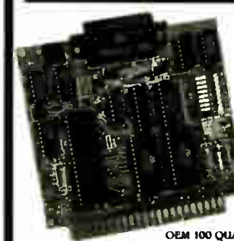
BCC52*
Basic-52 Computer/Controller
$199.00

OEM 100 QUANTITY PRICE
$149.00

BCC53
Multi Function Expansion Board w/OK adds 6 ports and 62K bytes **$160.00**

*NOW AVAILABLE IN INDUSTRIAL TEMPERATURE RANGE – CALL FOR INFORMATION

BCC11 ——— $139.00
Basic Controller



Features:
- Uses Z8 single chip microcomputer
- On board tiny basic interpreter
- 2 on board parallel ports & serial port
- 6 interrupts (4 external)
- Just connect a CRT and write control programs in Basic
- 6K Bytes of RAM or EPROM memory on board
- Baud rates 110-9600 bps
- Data and address bus available for 56K memory and I/O expansion
- Consumes only 1.5 watts at +5, +12 & −12V

BCC11*
BASIC System Controller
$139.00

OEM 100 QUANTITY PRICE $89.00

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BCC22 ——— $249.00
Term-Mite Smart Terminal

Why pay $500 or more for a smart terminal? The **TERM-MITE ST** offers you all of the following on a single board for less than ½ the price.

- Dimensions 4" x 6¼"
- 128 displayable characters
- 24 lines x 80 characters
- Separate transmit & receiver baud rates (110-19,200bps)
- CRT refresh at 50 - 60 Hz
- Supports scanned and encoded keyboards
- 11 Graphic characters
- 25th line reverse video status display
- 21 escape functions
- 14 control functions
- Directly drives composite video or separated sync monitor
- All functions are firmware controlled. Source code available

EDITING FEATURES: typeover, clear to screen to space or null, erase to end of page, erase to end of line, absolute cursor addressing
VIDEO ATTRIBUTES: reverse video, half intensity, double height, double width, underlined, blinking and blank characters
BUS CONFIGURATION: MICROMINT BCC compatible or no bus connection neccessary for stand-alone operation with parallel keyboard

BCC22	TERM MITE Smart Terminal Board	$249.00
BCC22K	PARALLEL Encoded ASCII KEYBOARD plugs directly into TERM-MITE	$ 79.00

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640K 8 MHz
10 MHz Optional
$650

1. 100% IBM XT-Compatible w/640K RAM on Board
2. Phoenix or Award BIOS Installed
3. One 12" High-Res. Amber Monitor (720 × 348)
4. Hercules Graphics Emulation Card
5. Intel 16-Bit 8088-2 Running at 4.77/8.0MHz
6. 10MHz Systems w/Intel 8088-1 Optional
7. Two DS/DD 360K Half-Height Direct Drives
8. 8 Fully IBM Compatible Expansion Slots Accept All IBM Parts
9. Runs All MS-DOS Programs Including 1-2-3, Flight Simulator, dBase III Plus, Autocad, WordStar, WordPerfect, etc.
10. Operates MS-DOS, PC-DOS, GW Basic, Novell, Xenix
11. Keyboard Selectable 4.77 and 8.0MHz
12. 150 Watts 110/220 VAC Power Supply w/Four Cables
13. Keyboard w/LEDs, Enlarged Return/Shift Keys and 84 Keys
14. Multi I/O Card: Controls Two Floppy Drives w/Printer Port/Game Port/Serial Port and an Optional 2nd Serial Port/Light Pen Port/Battery Backuped Real-Time/Calendar
15. 8087 Math Co-Processor Socket Installed on Board
16. Six EPROM Sockets Also Installed on Board
17. Power-On Self-Testing of System Components
18. Nickel-Plated, Enamel Coating, Heavy-Duty Metal Case w/Four Drive Slots and Speaker
19. Six Slots Still Available after Systems Configurations
20. Ready for 10/20/30/40/65MB Hard Disk Installations
21. Ready for Network/Multiuser Installations
22. Ready for Mouse/Joystick Interface
23. Fully Set-Up and Diagnostically Tested in America
24. Operating Manuals for Monitor, Keyboard, Motherboard, MGP Card, Multi I/O Card and the Operator
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BUS 88 w/20MB & One Floppy
Seagate ST-225, 65MS $900

BUS 286

10 MHz "1" Wait
12 MHz/16 MHz Optional
$1100

1. 100% IBM AT-Compatible, Accepts All IBM Parts
2. Fully Compatible Phoenix BIOS Installed
3. Intel 80286-10 Running 6 and 10 MHz
4. Optional 16MHz 80-Nanosecond RAM w/SI = 17.4
5. One Megabyte of 100-Nanosecond RAM on Board
6. Memory Expandable to 16MB w/Add-On Memory Cards
7. One 12" High-Res. Swivel-Based Amber Monitor (720 × 348)
8. Hercules Graphics Emulation Card w/Printer Port
9. Runs All MS-DOS Programs Including 1-2-3, Flight Simulator, dBase III Plus, Autocad, WordStar, etc.
10. Operates MS-DOS, PC-DOS, GW Basic, Novell, Xenix, Unix
11. 8 Expansion Slots: Six 16-Bit/Two 8-Bit
12. One Western Digital WD1003-WA2 Combined Hard-Disk/Floppy-Disk Controller Controls Two Hard Disks and Two Floppies
13. Enhanced Keyboard w/LEDs, Enlarged Return/Shift, 101 Keys
14. 200 Watts 110/220 VAC Power Supply w/Four Cables
15. Hardware Reset/Turbo Button Installed
16. One Fujitsu 1.2MB Half-Height High-Density FD (M2553K)
17. One Fujitsu DS/DD 360K Direct Drive M2551A
18. Real-Time Clock w/Battery-Backed CMOS Memory for System Configuration Data
19. One RS-232 Serial Card w/2nd Port Optional
20. Power-On Self-Testing of System Components
21. 80287 Math Co-Processor Socket Installed on Board
22. Nickel-Plated, Enamel Coating, Heavy-Duty, Lockable Case
23. Five Drive Slots Available w/Speaker Installed
24. Five Slots Available after Systems Configuration
25. Power/Hard Disk/Turbo Indicator Light Installed
26. Ready for OS/2 Systems Operations
27. Ready for 20/30/40/72/84/103/120/140MB Hard-Disk Systems
28. Ready for 20/40/60MB Tape Backup Installation
29. Ready for Network/Multiuser/Multitasking Interface
30. Ready for Mouse/Joystick Interface
31. Fully Set-Up and Diagnostically Tested in America
32. Operating Manuals for Monitor, Keyboard, Motherboard, MGP Card, Serial Card and the Operator
33. 30-Day Money-Back Guarantee
34. 20-Month Fully Warranted Labor and Parts
35. 72-Hour Burn-In Period
36. Ready for Immediate Delivery
37. Ship Worldwide via Federal Express, DHL, UPS or Air Cargo, Door-to-Door in Most Cases
38. Accept Overseas Telephone Orders w/VISA/Master/AE Card or Wire Transfers

BUS 286 w/20MB, Seagate ST-225, 65MS	$1150
BUS 286 w/30MB, Seagate ST-238, 65MS	1300
BUS 286 w/42MB, Seagate ST-251, 39MS	1700
BUS 286 w/84MB, Seagate ST-4096, 28MS	2100

BUS 386

One Megabyte 80NS
16 MHz "0" Wait
20 MHz "0" Wait Optional
$2300

1. 100% Compaq-Compatible
2. Phoenix 386 or Award 386 BIOS w/Setup Software
3. One MB Parity-Checked Static Column RAM of 80 Nanoseconds on Memory Card, 2-8-MB Piggy-Back Expansion Board Option, Allows Memory Expansion to 10MB Using 80-Nanosecond RAM Chips, Fully Compaq-Compatible Memory Bus
4. One 14" Swivel High-Res. (720 × 348) Flat-Screen Amber Monitor
5. Enhanced Keyboard w/LEDs, 101 Keys and Enlarged Return/Shift Keys
6. Hercules Graphics Emulator Card w/Parallel Port
7. Intel 32-Bit 80386-16 Microprocessor
   - Operating at 16MHz "0" Wait
   - Software-Selectable of Four Speeds: 4.77/6/8/16
8. Performance Rating: MIPS = 2.03, SI = 18.7, Landmark = 20.5
9. 80287/80387 Math Co-Processor Socket Installed
   - 80387 Is a 32-Bit Operation
   - 80387 Is Bootable to DOS/SCO Xenix System V/OS/2/PC-MOS 386
   - 80387 Runs with Turbo Pascal/Autocad Version 2.60/Full CAD/CAM Support
10. Eight Expansion Slots: 2 8-Bit, 5 16-Bit, 1 32-Bit
11. Operates OS/2, MS-DOS, PC-DOS, Unix V, Xenix & Windows/386
12. Runs All MS-DOS Software Including Lotus 1-2-3, WordStar, Autocad, Flight Simulator, dBase III Plus, Symphony, etc.
13. Software Utilities Including:
   - Relocatable EGA and System BIOS from ROM to RAM
   - Emulating the Lotus/Intel/Microsoft Expanded Memory Specification (LIM/EMS)
   - User Downloadable BIOS
   - Software-Selectable Speeds
14. Fully Compatible w/AT Mechanical Mounting Locations
15. Real-Time Clock w/Battery-Backed CMOS Memory for System Configuration Data
16. Three Address Modes
   - 8086-Compatible Real-Address Mode
   - Protected 80286 Virtual-Address Mode
   - Protected 80386 Virtual-Address Mode
17. Sixteen Interrupts
18. Seven Direct-Memory-Access (DMA) Channels
19. 64 Terabytes of Virtual Address Space
20. 32-Bit Internal-Address Bus and Memory Interface BIOS
21. Hardware Fixed-Point Multiply and Divide
22. AT-Compatible I/O Channel Timing
23. Pipelined Instruction Execution
24. 8742 Keyboard Controller Interfaces an AT Keyboard
25. 200 Watts 110/220 VAC Power Supply with Four Cables
26. One Fujitsu 1.2MB Half-Height High-Density FD (M2553K)
27. One Everex Magic I/O (EV-170) w/One Parallel and One Serial Port, 2nd Serial Port Optional
28. One Western Digital WD1003-WA2 Combined Hard-Disk/Floppy-Disk Controller Controls Two Hard Disks and Two Floppies
29. Speaker Interface Provided
30. Turbo-Speed/Hard-Disk/Power Indicator Lights Installed
31. Hardware Reset and Turbo Buttons Installed
32. Nickel-Plated, Enamel Coating, Heavy-Duty Lockable Case
33. Five Drive Slots Available for Five Half-Height Floppy or Hard-Disk Installations
34. Power-On Self-Testing of System Components
35. Five Slots Still Left Open after Systems Configuration
36. Ready for OS/2 Systems Operations
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38. Ready for 20/40/60MB Tape-Backup Installation
39. Ready for Network Multiuser/Multitasking Systems
40. Ready for Network File Servers
41. Ready for Mouse/Joystick Interface
42. Operating Manuals for Monitor, Keyboard, Motherboard, MGP Card and Magic I/O Card
43. 30-Day Money-Back Guarantee
44. 20-Month Fully Warranted Labor and Parts
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49. Accept Overseas Telephone Orders w/VISA/Master/AE Card or Wire Transfers

BUS 386 w/20MB, Seagate ST-225, 65MS	$2550
BUS 386 w/43MB, Seagate ST-251, 65MS	2800
BUS 386 w/65MB, Seagate ST-277, 39MS	3050
BUS 386 w/84MB, Seagate ST-4096, 28MS	3250
BUS 386 w/103MB, Priam ID-100, 16MS	3100

OPTIONAL FEATURES

1. 20MHz Systems w/Intel 80386-20 Microprocessor w/MISP = 2.83, SI = 23.0, Landmark = 25.3
2. 25MHz Systems Will Be Available Soon
3. Baby-Sized 386 w/Cache Memory of 35-Nanosecond RAM
4. RAM Expansion Board of 2MB, 4MB, 8MB
5. Twin BIOSes: Phoenix 386/Award 386 on Motherboard
6. VGA Systems w/Auto Switch VGA Card (800 × 600), Add $1500
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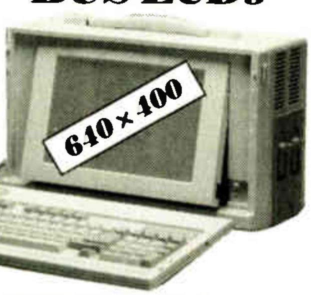

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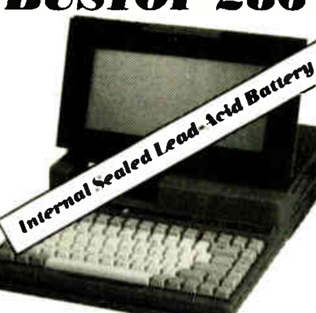

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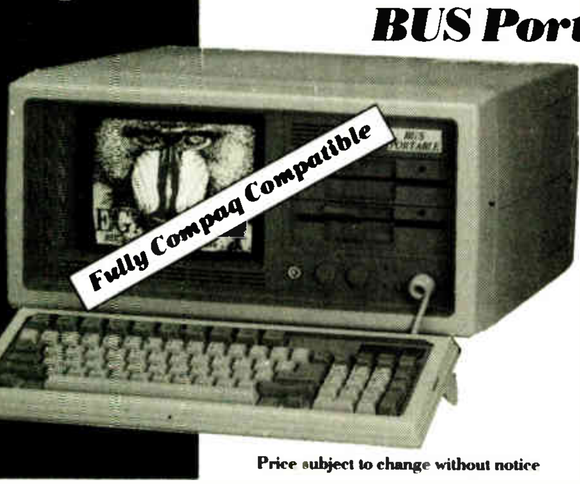

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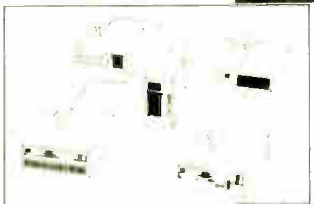

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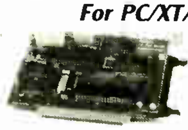

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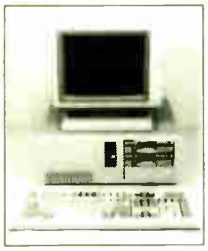

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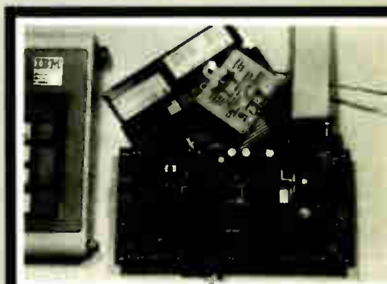

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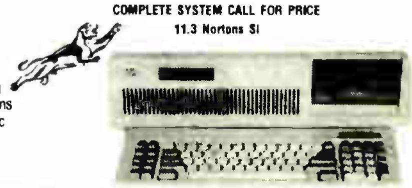

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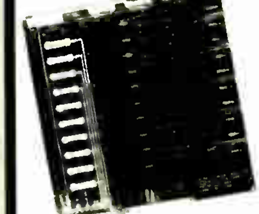

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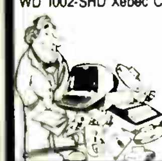

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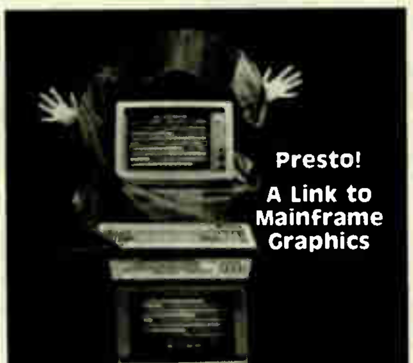

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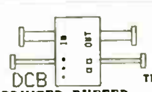

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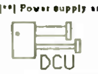

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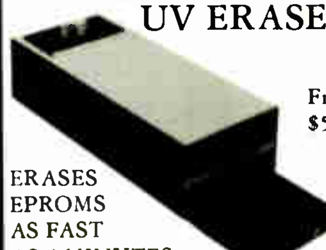

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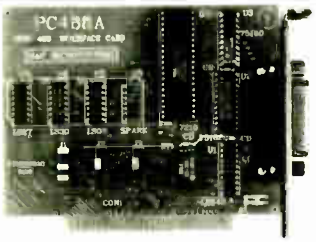

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41256	256Kx1	60 ns	10.95
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41256	256Kx1	120 ns	10.50
41256	256Kx1	150 ns	9.25
41264	+ 64Kx4	120 ns	13.50
EPROM			
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27C512	64Kx8	200 ns	14.95
27256	32Kx8	250 ns	7.50
27128	16Kx8	250 ns	6.95
STATIC RAM			
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5864LP-12	8Kx8	120 ns	6.95

640K MOTHERBD UPGRADE: Zenith 150, IBM PC XT, Compaq Portable & Plus; hp Vectra

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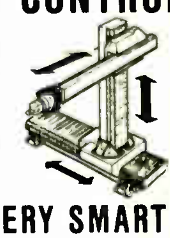

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- ☐ 49 high level commands in plain English.
- ☐ Macros. Battery backup for memory.
- ☐ Learn mode with optional "Teach Pendant"
- ☐ 4 axis simultaneous control. You select the ramps units, speeds, drive types,...
- ☐ Input for Limit Switches, Panic button, etc.
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- ☐ Works with any computer with a Centronics port or with the Alpha Products A-BUS system

See page 341 for details of the SC-149

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- Hi-res graphics card
- Parallel printer port ...... add **$148**

Option B
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- Hi-res graphics card
- Parallel printer port...... add **$298**

Option C
- Hard disk drive
- Dual hard disk controller

30 MB for XT add **$298** 40 MB For PC/XT/AT add **$498**

intel Math Coprocessors

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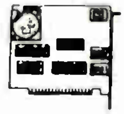
8087-1 $198	80287-6 $178
80287-8 $228	80287-10 $268
80387-16 $438	80387-20 $728

PC Mouse
Mechanical Mouse w/software $58
Mouse Systems serial $98
Mouse Systems Buss $98
Fastrap Trackball $98

1200 Baud Deluxe Modem


$68

- Including free software
- Hayes compatible ½ slot card
- On-board speaker

1200 baud external $98
2400 baud ½ card internal ... $148
2400 baud external $168

30 MB Hard Disk
Complete kit with controller


$298

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20 MB Card $328
40 MB for AT $398
40 Mb PC/XT Kit $498
60 MB for AT $898
80 MB for AT $998
120 MB for AT $2298
Mountain 40 MB Tape $698

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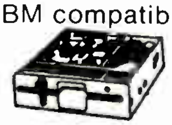
Half height, IBM compatible


$68

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1.2 MB for AT $98
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List Price $529

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EPSON LQ-2500 .... Call

EPSON 9 Pin


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LX-800 Call

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EPSON EX-800 .... Call

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PDP 2 MB RAM card $648
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Extra Toner Cartridge $98

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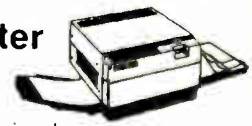

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*Interface required
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- HP compatible*
- Standard or legal size

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HM6116-3	2048x8	(150ns)(CMOS)	1.85
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.45
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HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49
HM43256LP-15	32768x8	(150ns)(CMOS)(LP)	12.95
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2716-1	2048x8	(350ns)(25V)	3.95
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2732	4096x8	(450ns)(25V)	3.95
2732A	4096x8	(250ns)(21V)	3.95
2732A-2	4096x8	(200ns)(21V)	4.25
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2764	8192x8	(450ns)(12.5V)	3.49
2764-250	8192x8	(250ns)(12.5V)	3.69
2764-200	8192x8	(200ns)(12.5V)	4.25
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27128	16384x8	(250ns)(12.5V)	4.25
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27256	32768x8	(250ns)(12.5V)	5.95
27512	65536x8	(250ns)(12.5V)	11.95
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xxV=Program Voltage

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- 200 NS
- CMOS DESIGN FOR LOW POWER

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8155	2.49
8155-2	3.95
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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
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8243	1 95	8279-5	2.95
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8253-5	1 95	8287	3.95
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74LS03	18	74LS124	2 75	74LS244	69
74LS04	16	74LS125	39	74LS245	79
74LS05	18	74LS126	39	74LS251	49
74LS08	18	74LS132	39	74LS253	49
74LS09	18	74LS133	49	74LS257	39
74LS10	16	74LS136	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
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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
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74LS51	.17	74LS166	.95	74LS377	.79
74LS73	.29	74LS169	.95	74LS390	1.19
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7400	.19
7402	.19
7404	.19
7406	.29
7407	.29
7408	.24
7410	.19
7411	.25
7414	.49
7416	25
7417	.25
7420	.19
7430	.19
7432	.29
7438	.29
7442	.49
7445	.69
7447	.89
7473	.34
7474	.33
7475	.45
7476	.35
7483	.50
7485	.59
7486	.35
7489	2.15
7490	.39
7493	.35
74121	.29
74123	.49
74125	.45
74150	1.35
74151	.55
74153	.55
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2.0 MHz

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3.0 MHz

6502B	4.25

Z-80

2.5 MHz

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4.0 MHz

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6.0 MHz

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10.738635	1.95
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74F02	.35
74F04	.35
74F08	.35
74F10	.35
74F32	.35
74F64	.55
74F74	.39
74F86	.55
74F138	.79
74F139	.79
74F253	.89
74F157	.89
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
74S244	1.49
74S280	1.95
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74S288	1.69
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74S373	1.69
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CMOS/HIGH SPEED CMOS

4001	.19	4066	.29	74HC154	1.09
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
4025	.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	.99
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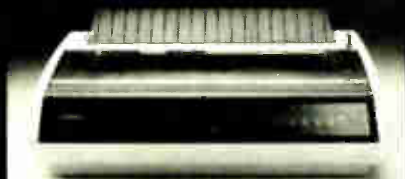

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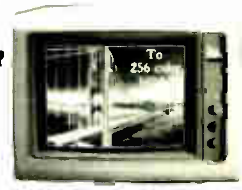

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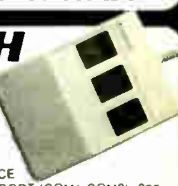

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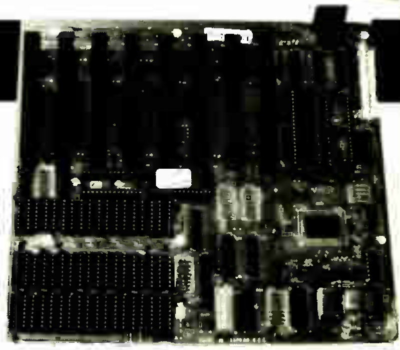

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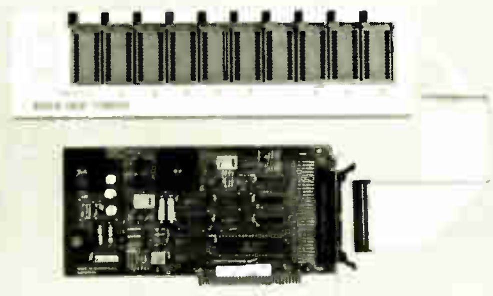

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EDITORIAL INDEX BY COMPANY

Index of companies covered in articles, columns, or news stories in this issue
Each reference is to the first page of the article or section in which the company name appears

COMING UP IN BYTE

PRODUCTS IN PERSPECTIVE:

Just as the need for more memory has been growing, the demand for more disk-storage capacity is also growing. Our **Product Focus** for July will feature 40-megabyte hard disk drives that offer an access speed of 30 milliseconds or faster. We'll also look at several 40-megabyte hard disk cards that offer an alternative for upgrading disk storage.

A **system review** compares five IBM PC AT–compatible computers, all of which run faster than the standard 8-MHz IBM PC AT and come in at lower prices.

Hardware reviews: Orchid Technology's ColorVue SE board brings color to the Macintosh SE. The only board of its kind so far, it's designed to let Mac SE owners hook up color monitors, run their applications in color, and print color hard copy.

Most owners of IBM PC AT–compatible and 80386 computers should have no problem running OS/2 when they decide to switch. IBM PC owners, though, don't have this option with their standard system, since OS/2 does not run on the PC's processor. Two new boards, though, promise to bring OS/2 compatibility to PC compatibles. Microsoft's Mach 20 board and Sota Technology's MotherCard 5.0 both add an 80286 processor to a PC.

Multitasking alternatives on 80386 systems are covered in **software reviews**. We will review three noteworthy packages: Concurrent DOS 386 from Digital Research, VM/386 from IGC, and ProBas from Hammerly.

Application reviews are MicroGraphic's Designer for MS-DOS systems, a powerful graphics-oriented program, and Newspace, a file-compression utility for the IBM PC.

Products found in **Short Takes** for July will include Soft PC, UR/Forth, Condor: Build Your Own, Ogivar 286 Portable, GrandView, EasyTalk, and Choice Words.

IN DEPTH:

We will spotlight **multitasking on 80386-based computers**. Using the power of these machines to perform simple tasks like word processing or database management is a little like cracking walnuts with a sledgehammer. So much of the computer's "brainpower" is sitting idle that, if machines could get bored, these units would be in tears most of the time. What can you do, though? An elegant solution is to have your machine do lots of things at the same time. The problem with that answer has heretofore been that, when you pile lots of tasks onto the same processor, it slows way down. There are ways of getting around that, and we'll tell you about them.

FEATURES:

Features will include a piece on Integrated Services Digital Network, or **ISDN**, a rapidly advancing communications technology that allows digital data, voice, and sometimes even video to be carried directly over the switched telephone network. Dick Pountain will report on the newest Transputer processor innovation—a chip called **Viper**—to come out of the British Isles. It promises to seriously challenge the traditional structures of computer design. Additionally, in the **Circuit Cellar**, Steve Ciarcia will present the second part of his brain-wave-monitor construction project.

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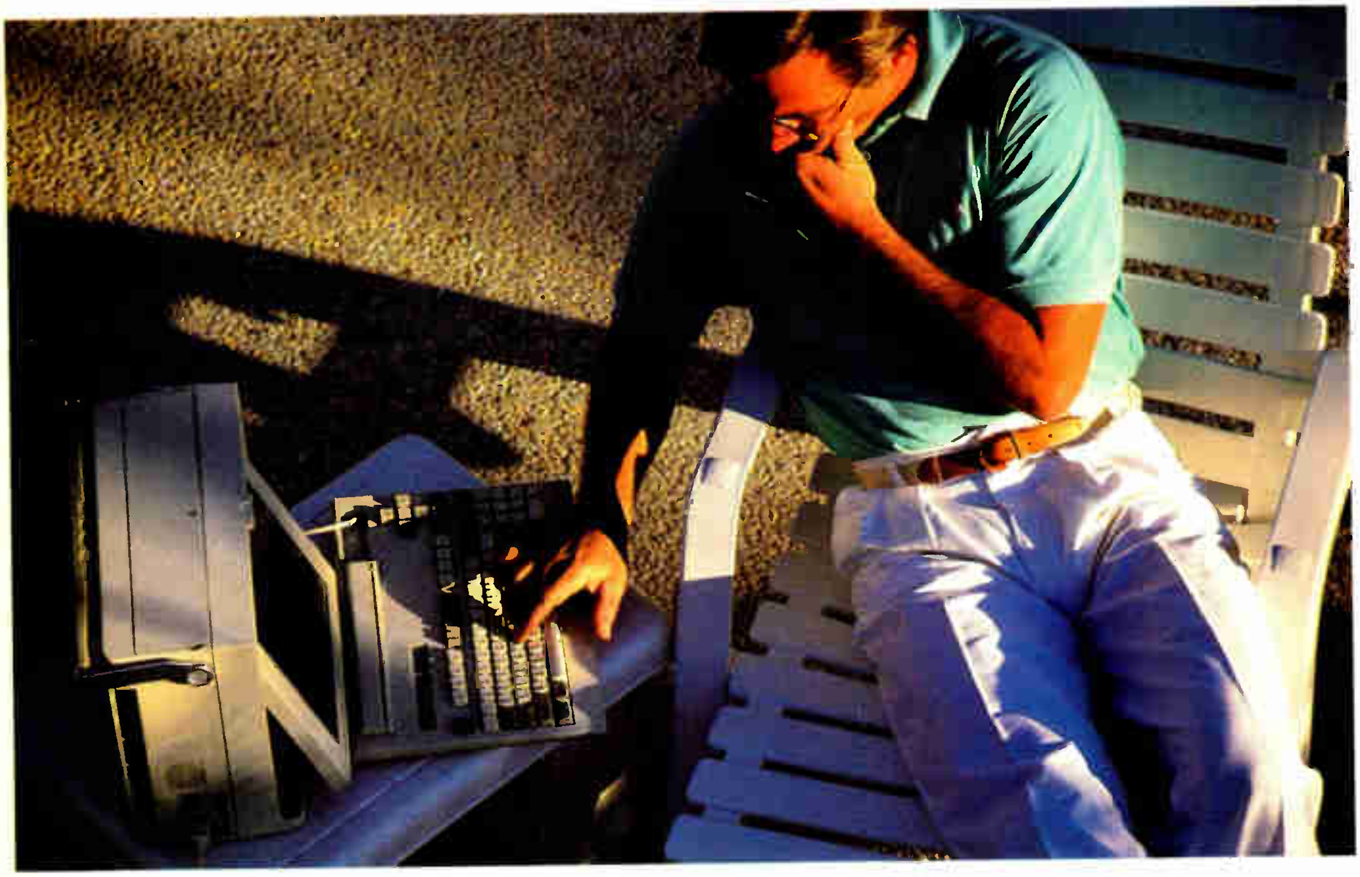

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